وزارة الصحة

National Neonatal Protocol

A Manual of Neonatal Care in Palestine

A Manual for Palestinian Nurseries, NICUs and Obstetric Wards

For Residents, Pediatricians, Neonatologists and Neonatal Nurses:

Towards Better Survival and Better Neurodevelopmental Outcomes

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من الشعب الياباني

From the People of Japan

Forward by Palestinian Minister of Health

Newborns are our country's most vulnerable population. They deserve the highest possible standards of care to optimize their survival rate and outcomes. Accordingly, securing national level priority for newborn health and reducing infant and child mortality is a high priority for the Ministry of Health.

While the vast majority of neonatal deaths are preventable, neonatal mortality is the major contributor to infant and under-five mortality. To accelerate progress in this area and reduce infant and child mortality, a greater focus is needed on improving the quality of neonatal care. Therefore, a national neonatal protocol manual has been prepared to eliminate preventable neonatal deaths ensuring that no newborn or child is left behind.

To ensure sustainable development in neonatal care, this document reflects the Ministry's recognition of this matter and the consensus reached to come up with a standardized neonatal care protocol for all health institutions, including Palestinian hospitals in both the government and private sectors. As children are our next generation, we hope this manual will bring about a significant leap in the care of our newborns towards a higher survival rate and an opportunity for potential development, and a better quality of life.

We would like to acknowledge and extend our gratitude to all those involved in this process, particularly the team that carried out this task, which was led by Dr. Hatem Khammash, the Director of the Neonatal Department at Al Makased Hospital , which is one of the top neonatal units in the country. In addition, Dr. Amir Atawneh from Al Makased, the Gaza team specifically, Dr. Nabil Barquni and Dr. Shireen Abed, Ms. Maha Awwad the Director of Woman Health Department at the Ministry of Health, and the World Health Organization (WHO).

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Acronyms and Abbreviations

AAP	American Academy of Pediatrics
ABO	Blood groups
ABR	Auditory Brain Stem Reponses
ACOG	American College of Obstetricians and Gynecologists
ACTH	Adrenocorticotropic Hormone
ADH	Antidiuretic Hormone
AED	Anti-Epileptic Drug
AFASS	Acceptable, Feasible, Affordable, Sustainable, and Safe
AGA	Appropriate for Gestational Age
ALT	Alanine Transaminase
ANC	Absolute Neutrophil Count
Apgar	Appearance, Pulse, Grimace, Activity, Respiratory Effort
APTT	Activated Partial Thromboplastin Time
ASD	Atrial Septal Defect
AST	Aspartate Transaminase
ATN	Acute Tubular Necrosis
AV	Atrioventricular
A/C	Assist/Control
BFHI	Baby-Friendly Hospital Initiative
BP	Blood Pressure
BPD	Bronchopulmonary Dysplasia
BSA	Body Surface Area
BUN	Blood Urea Nitrogen
C	Celsius
CAH	Congenital Adrenal Hyperplasia
CB	Conjugated Bilirubin
CBC	Complete Blood Cell Count
CDC	Centers for Disease Control and Prevention
CH	Congenital Hypothyroidism
CHARGE	Coloboma of the Iris, Choroid, and/or Microphthalmia, Heart Defect, Atresia of Choanae, Retarded Growth and Development, Genitourinary Abnormalities, Ear Defects
CHD	Congenital Heart Disease
CHF	Congestive Heart Failure
CMV	Cytomegalovirus
CNS	Central Nervous System
CONS	Coagulase-Negative Staphylococci
CPAP	Continuous Positive Airway Pressure
CRIES	Crying, Requires oxygen saturation, Increased vital signs, Expression, and Sleeplessness
CRP	C-Reactive Protein
CSF	Cerebrospinal Fluid
CT	Computed Tomography

CVP	Central Venous Pressure
DDH	Developmental Dysplasia of the Hip
DIC	Disseminated Intravascular Coagulation
DINAMAP	Automated Blood Pressure Machine
DNA	Deoxyribonucleic Acid
EA	Esophageal Atresia
EBM	Expressed Breast Milk
ECF	Extracellular Fluid
ECG	Electrocardiography
ECMO	Extracorporeal Membrane Oxygenation
EEG	Electroencephalography
EH	Epidural Hemorrhage
ELBW	Extremely Low Birth Weight
EMG	Electromyography
EMLA	Eutectic Mixture of Local Anesthetics
EOS	Early-Onset Sepsis
ESR	Erythrocyte Sedimentation Rate
ETT	Endotracheal Tube
FDP	Fibrin Degradation Product
FiO2	Fraction of Inspired Oxygen
FFP	Fresh Frozen Plasma
FRC	Functional Residual Capacity
GA	Gestational Age
GALT	Galactose-1-Phosphate Uridyl Transferase
GBS	Group B β-Hemolytic Streptococcus
GER	Gastroesophageal Reflux
GERD	Gastroesophageal Reflux Disease
GFR	Glomerular Filtration Rate
GGT	Gamma-Glutamyl Transpeptidase
GI	Gastrointestinal
GIR	Glucose Infusion Rate
GIT	Gastrointestinal Tract
GM	Germinal Matrix
GMH	Germinal Matrix Hemorrhage
HAI	Healthcare-Associated Infections
HBIG	Hepatitis B Immunoglobulin
HBV	Hepatitis B Virus
Hct	Hematocrit
HDN	Hemorrhagic Disease of the Newborn
HELLP	Hemolytic Anemia, Elevated Liver Enzymes, and Low Platelet Count
HIE	Hypoxic Ischemic Encephalopathy
HIV	Human Immunodeficiency Virus
HMD	Hyaline Membrane Disease
HMF	Human Milk Fortifier
HR	Heart Rate
HSV	Herpes Simplex Virus

HSV-1	Herpes Simplex Virus Type 1
IAP	Intrapartum Antimicrobial Prophylaxis
ICF	Intracellular Fluid
IDM	Infants of Diabetic Mothers
IEM	Inborn Errors of Metabolism
IM	Intramuscular
IMV	Intermittent Mandatory Ventilation
INR	International Normalized Ratio
IPH	Intraparenchymal Hemorrhage
IPPV	Intermittent Positive Pressure Ventilation
ITP	Idiopathic Thrombocytopenic Purpura
IUGR	Intrauterine Growth Restriction
IV	Intravenous
IVH	Intraventricular Hemorrhage
IVIG	Intravenous Immunoglobulin
IWL	Insensible Water Loss
I&O	Input and Output
I:E	Ratio Inspiratory Time/Expiratory Time Ratio
I:T	Ratio Immature/Total Neutrophil Ratio
KMC	Kangaroo Mother Care
LBW	Low Birth Weight
LES	Lower Esophageal Sphincter
LGA	Large for Gestational Age
LOS	Late-Onset Sepsis
LP	Lumbar Puncture
L/S	Lecithin/Sphingomyelin
MAP	Mean Airway Pressure
MAS	Meconium Aspiration Syndrome
MCT	Medium Chain Triglycerides
MOH	Ministry of Health
MRI	Magnetic Resonance Imaging
MRSA	Methicillin-Resistant Staphylococcus Aureus
NCPAP	Nasal Continuous Positive Airway Pressure
NEC	Necrotizing Enterocolitis
NFCS	Neonatal Facing Coding System
NG	Nasogastric
NGO	Non-Governmental Organization
NICU	Neonatal Intensive Care Unit
NIH	National Institutes of Health
NIPS	Neonatal Infant Pain Scale
NKH	Non-Ketotic Hyperglycinemia
NMDA	N-Methyl D-Aspactate
NNS	Non-Nutritive Sucking
NO	Nitric Oxide
N-PASS	Neonatal Pain Agitation and Sedation Scale
NPO	Nothing Per Orem (Nothing by Mouth)

NRP	Neonatal Resuscitation Program
NTE	Neutral Thermal Environment
OTC	Ornithine Transcarbamolase
PAF	Platelet Activating Factor
PCR	Polymerase Chain Reaction
PDA	Patent Ductus Arteriosus
PEEP	Positive End Expiratory Pressure
PFO	Patent Foramen Ovale
PHHI	Persistent Hyperinsulinemic Hypoglycemia of Infancy
PIE	Pulmonary Interstitial Emphysema
PIH	Pregnancy Induced Hypertension
PIP	Peak Inspiratory Pressure
PIPP	Premature Infant Pain Profile
PN	Parenteral Nutrition
PO	By Mouth
PPHN	Persistent Pulmonary Hypertension of the Newborn
PPV	Positive Pressure Ventilation
PSV	Pressure Support Ventilation
PT	Prothrombin Time
PTT	Partial Thromboplastin Time
PTU	Propylthiouracil
PTV	Patient-Triggered Ventilation
PUV	Posterior Urethral Valve
PVD	Post-Hemorrhagic Ventricular Dilation
PVHI	Periventricular Hemorrhagic Infarction
RBC	Red Blood Cell
RDS	Respiratory Distress Syndrome
Rh	Blood Type
Rh-EPO	Recombinant Human Erythropoietin
RNA	Ribonucleic Acid
ROM	Rupture of Membranes
ROP	Retinopathy of Prematurity
RR	Respiratory Rate
SAH	Subarachnoid Hemorrhage
SC	Subcutaneous
SCM	Sternocleidomastoid Muscle
SDH	Subdural Hemorrhage
SGA	Small for Gestational Age
SGH	Subgaleal Hemorrhage
SIADH	Syndrome of Inappropriate Release of Antidiuretic Hormone
SIDS	Sudden Infant Death Syndrome
SIMV	Synchronized Intermittent Mandatory Ventilation
SIPPV	Synchronized Intermittent Positive Pressure Ventilation
SLE	Systemic Lupus Erythematosus
SSC	Skin-To-Skin Contact
SVT	Supraventricular Tachycardia

TAR	Thrombocytopenia with Absent Radii
TBW	Total Body Water
TEF	Tracheoesophageal Fistula
TG	Triglycerides
TGA	Transposition of the Great Arteries
Te	Expiratory Time
Ti	Inspiratory Time
TMS	Tandem Mass Spectrometry
TORCH	Toxoplasmosis, Other, Rubella Virus, Cytomegalovirus, Herpes Simplex Virus
TPN	Total Parenteral Nutrition
TR	Tricuspid Regurgitation
TRH	Thyrotropin-Releasing Hormone
TSB	Total Serum Bilirubin
TSH	Thyroid Stimulating Hormone
TTN	Transient Tachypnea of the Newborn
UAC	Umbilical Artery Catheter
UCB	Unconjugated Bilirubin
UDPG-T	Uridine Diphosphate Glucuronyl Transferase
UNICEF	United Nations Children's Fund
USAID	U.S. Agency for International Development
VACTERL	Vertebral Anomalies, Anal Atresia, Cardiac Defect, Tracheoesophageal Fistula with Esophageal Atresia, Renal Dysplasia, Limb Anomalies
VEGF	Vascular Endothelial Growth Factor
VG	Volume Guarantee
VLBW	Very Low Birth Weight
VLCFA	Very-Long-Chain Fatty Acids
VSD	Ventricular Septal Defect
Vt	Tidal Volume
VWD	Von Willebrand Disease
VWF	Von Willebrand Factor
VZIG	Varicella-Zoster Immune Globulin
VZV	Varicella-Zoster Virus
V/Q	Ventilation/Perfusion
WBC	White Blood Cell
WHO	World Health Organization

Introduction

Despite numerous advances in decreasing childhood mortality, neonatal mortality remains one of the largest contributors to under-five mortality in Palestine. Neonatal health and survival remain a major challenge in the West Bank and Gaza.

In Palestine, there is a unique opportunity to develop and implement best practices in care for those in the earliest stage of life. The Ministry of Health (MOH), UNICEF and WHO have strongly prioritized decreasing maternal and neonatal mortality, and this impetus has led to the creation of the present protocols.

The following guidelines offer national standardization of neonatal care in Palestine. The knowledge and guidance found within these protocols offer those caring for newborns important resources and methods for reducing mortality and morbidity in the first month of life. In addition, these guidelines affirm the vitality of the Baby-Friendly Hospital Initiative (BFHI), early essential newborn care and neuroprotection, which have significant impact on the long-term neurodevelopmental outcomes of Palestinian children.

The protocol consists of four sections: Section A addresses normal nursery and well newborn protocols; Section B provides labor ward and resuscitation guidelines; Section C provides neonatal intensive care protocols, including care for premature babies, management of respiratory, cardiovascular and gastrointestinal problems, among others; and Section D provides relevant nursing protocols.

There remains much to be done in improving the quality of care provided to newborns and their mothers in order to achieve the needed reduction in infant mortality and morbidity and improvement in overall neonatal health. May this publication contribute to improving awareness and knowledge around neonatal care for all those involved in the health sector, and to improving the lives of Palestinian population as a whole.

SECTION A: Normal Nursery and Well Newborn Protocols

Early Essential Newborn Care

"EENC is the recommended care for mothers and newborns during labor, delivery and immediately after birth. Evidence shows that these practices dramatically improve neonatal outcomes and shall be delivered to every newborn. The EENC guide (WHO/WPRO 2014) has been adapted to the Palestinian context:

EENC - First Embrace - Clinical Practice Pocket Guide (MoH, 2018)

Early Essential Newborn Care: Summary Table

I. Preparing for birth

Intervention	Action
TIME BAND: Upon arrival of the woman to the facility	
	Introduce yourself to the woman. Obtain pregnancy history and birth plan. Identify the companion(s) of choice. Perform proper handwashing. Examine the woman, check for pallor and take her BP, HR, RR and temperature. Assess fetal heart rate. Assess presence of labor and stage**.**
TIME BAND: Upon confirmation labor has begun	
	Check results of woman's lab tests including hemoglobin, blood group, RH, hepatitis, syphilis, RPR or VDRL and HIV. Fill out WHO partograph. If the diastolic blood pressure (DBP) is ≥ 90 mmHg on two readings AND ≥2+ proteinuria, STABILIZE the woman. If diastolic BP ≥ 110 mmHg AND +3 proteinuria OR diastolic BP ≥ 90 mmHg AND +2 proteinuria AND ANY of the following: - severe headache - visual disturbance - epigastric pain START magnesium sulfate. If the gestational age is < 34 weeks: - START antenatal steroids: - Betamethasone 12 mg IM q 24 hours x 2 doses OR - Dexamethasone 6 mg IM q 12 hours x 4 doses. - START tocolytics to slow down labor, if no contraindications. - START antibiotics for pPROM. - CALL for help; inform neonatal unit staff. - Prepare for resuscitation and management of a preterm baby. If there are any of the following: - Maternal temperature > 38^{o} C - Foul smelling vaginal discharge - Ruptured membranes > 18 hours

	START IM OR IV ANTIBIOTICS. If late labor, deliver then REFER. - Start prophylactic antibiotics on the newborn. If any of the following are present: - The fetus in transverse lie, - Vaginal bleeding (If yes, DO NOT perform internal exam), - Continuous contractions, - Constant pain between contractions, - Sudden and severe abdominal pains, - A horizontal ridge across the lower abdomen, STABILIZE and REFER accordingly for caesarean section. If labor has lasted for more than 24 hours or the cervical dilatation is at the WHO partograph action line: STABILIZE and do vacuum / forceps extraction.
TIME BAND: During labor	
	Encourage birth companion(s) to be present. Encourage the woman to: - move around and assume a position she is comfortable in, - take in light snacks and oral fluids, - empty her bladder. Every 30 mins – plot HR, contractions and fetal HR. Every 4 hours – plot temperature, BP and cervical dilatation.
TIME BAND: Prepare for the birth	
	Ensure privacy. Ensure that delivery area is between 25^{o} C–28^{o} C using a non-mercury room thermometer. Test whether the delivery area is draft-free. Eliminate draft if present, e.g. turn off fans and/or air-conditioning units. Introduce yourself to the mother and her companion of choice or support person. Review with her what care to expect for herself and her newborn in the immediate postpartum period. Wash hands with clean water and soap. Place a dry cloth, on her abdomen or within easy reach. Prepare the following: - Clean linen or towel(s), - Bonnet, - Syringe,

	- Ampule of 10 IU of oxytocin, - Basin with 0.5% chlorine solution for decontamination, - Sterile umbilical clamp or tie, - Sterile instrument clamp, - Sterile scissors. Prepare newborn resuscitation area: - Clear a flat, firm surface. - Check that resuscitation equipment including bag and masks and a suction device (preferably single-use) are within reach, clean and functional.
TIME BAND: Prior to delivery at perineal bulging, with presenting part visible (second stage of labor, perineal phase)	
Prepare for the delivery	Perform proper handwashing. Put on sterile double gloves if lone birth attendant. Allow the mother to push as she wishes with contractions. Do not perform routine episiotomy. Episiotomy should be considered only in the case of: - complicated vaginal delivery (breech, shoulder dystocia, vacuum or forceps extraction), - scarring in the female genitalia or poorly healed third or fourth degree tears, - fetal distress. Provide good perineal support with controlled delivery of the head.

II. Immediate newborn care (the first 90 minutes)

Intervention	**Action**
TIME BAND: Within the first 30 sec	
Dry, assess and provide warmth	Call out time of birth. Deliver the baby onto the dry cloth. Immediately dry the baby within the first 5 secs after birth, as follows: - Use a clean, dry cloth and thoroughly dry the baby. Wipe the eyes, face, head, front, back, arms and legs. - Do a quick check of newborn's breathing while drying. - Remove wet cloth and place in skin to skin contact. Cover the baby and mother with a clean warm cloth. Cover the baby's head with a bonnet. *NOTE:* *Do not do routine suctioning.* *During the first 30 seconds:* *Do not suction unless the mouth/nose is/are blocked.* *Do not suction meconium unless the baby is not vigorous.*

TIME BAND: 30 sec to three minutes	
If after thorough drying and stimulation (as close to 30 seconds as possible), newborn is gasping or is not breathing: Start positive pressure ventilation	Call for help. Clamp and cut the cord. Transfer to warm, firm surface. Inform the mother in a kind and gentle tone that the newborn has difficulty breathing and that you will help the baby to breathe. Start ventilation.
If breathing or crying, continue skin-to-skin contact	If baby is breathing normally or crying, avoid manipulation such as routine suctioning that may cause trauma or introduce infection. Postpone routine procedures like weighing, measurements. Continue skin-to-skin contact on mother's abdomen. Keep the newborn prone on the mother's abdomen or chest skin-to-skin. Turn the baby's head to one side. Keep the newborn's back covered with a blanket and head with a bonnet. Notes: - Do not separate newborn from the mother as long as the newborn is well – does not exhibit severe chest in-drawing, gasping or apnea or severe malformation and the mother does not need urgent medical stabilization, e.g. emergent hysterectomy. - Do not wipe off the vernix if present. - Do not bathe the newborn earlier than 24 hours of life. - If identification band is used, place on ankle. - If the newborn **must** be separated from his/her mother, clamp and cut the cord and put the baby on a warm surface in a safe place close to the mother.
Inject the mother with oxytocin	Explain to the mother that you will be injecting her with oxytocin to make her uterus contract and protect her from excessive bleeding. After excluding a second baby, inject oxytocin 10 IU IM. If a trained second health worker is available, s/he should inject the oxytocin. Put soiled instruments into a decontaminating solution.
Assist with multiple births	If there is another baby/-ies, get help. Deliver the next baby. Manage as in multi-fetal pregnancy.
Do appropriately timed cord	Ensure gloves are sterile when touching or handling the cord; If single health worker with double sterile gloves, remove the first set of gloves prior to touching or handling the cord. If other health worker, wash hands and

clamping and cutting	use sterile gloves. Clamp and cut the cord after cord pulsations have stopped, between 1-3 minutes, as follows: - Apply a sterile plastic clamp or tie around the cord at 2 cm from the umbilical base. - Drain the cord of blood by stripping away from the baby. - Apply the second clamp at 5 cm from the umbilical base (or 3 cm from the first clamp). - Cut close to the first clamp or tie using sterile scissors. - Apply a second tie if there is oozing blood. Put soiled instruments into a decontaminating solution.
TIME BAND: Within 90 mins from birth	
	Leave the newborn on mother's chest in skin-to-skin contact with the baby's head turned to one side and mother in a semi-upright position. Observe the newborn. Only when the newborn shows feeding cues (e.g. opening of the mouth, tonguing, licking, rooting), suggest to the mother to encourage her baby and nudge him/her towards the breast. Provide breastfeeding support to ensure good positioning and attachment. If attachment or suckling is not good, try again and reassess. Do not leave the mother and newborn alone. Monitor breathing and warmth. If the baby has signs of illness or does not show readiness to feed, i.e., feeding cues within 90 minutes, EXAMINE the newborn and MANAGE urgent conditions. If the breast is engorged, express a small amount of breast milk before starting breastfeeding to soften the nipple area so that it is easier for the baby to attach. Notes: - *Do not touch the newborn unless there is a medical indication.* - *Do not give sugar water, formula or other prelacteals.* - *Do not give bottles or pacifiers.* - *Do not throw away colostrum.* - *If the mother is HIV positive, take measures to prevent mother-to-child transmission (PMTCT), do counselling and testing.*
Provide additional care for a small baby or twin	For a visibly small newborn or a baby born > one month early: - Encourage the mother to keep the small newborn in skin-to-skin contact with her as much as possible. - Provide extra blankets to keep the baby warm. - If mother cannot keep the baby skin-to-skin because of complications, wrap

	the baby in a clean, dry, warm cloth and place in a cot. Cover with a blanket. Use a radiant warmer if room below 28^{o} C. - Do not bathe the small baby. Ensure hygiene by wiping with a damp cloth but only after 24 hours. Prepare a very small baby (< 1.5 kg) or a baby born > two months early for referral. Keep the baby in skin-to-skin contact or in an incubator while waiting for referral. *Note:* - *LBW neonates weighing >1200 g who do not have complications should be maintained in skin-to-skin contact with the mother immediately after birth and after drying them thoroughly to prevent neonatal hypothermia*.

III. Essential newborn care from 90 min to six hours

Intervention	Action
TIME BAND: From 90 mins to six hours	
Examine the baby	After the baby has detached from the breast: - Wash hands. - Thoroughly examine the baby. - Put an identification tag around the ankle. - Weigh the baby and record. Explain to the mother that you will be examining her baby and checking for birth injuries and/or malformations, especially those that need additional care or early referral. Check for breathing difficulty: - Normal breathing rate is 30–60 per minute. - Check for grunting. - Check for chest in-drawing. Check the baby's temperature: - Normal axillary temperature of 36.5^{o} C to 37.5^{o} C. Check the baby's eyes: - Is there redness, swelling or pus draining? Check the baby's umbilicus: - Is there oozing blood? Check for abdominal distention. Look at the head, trunk and all limbs of the baby. Check for possible birth injury:

	- Bumps on one or both sides of the head. - Bruises, swelling on the buttocks. - Abnormal position of legs (after breech extraction) or asymmetrical arm movement or arm that does not move. If present: - Explain to parents that this does not hurt the newborn, is likely to disappear in a week or two and does not need special treatment. - Gently handle the limb that is not moving. - Do not force the legs into a different position. Look for fracture: - Swelling. - Baby crying when part touched or manipulated. - If suspected fracture, refer. Look for malformations: - Club foot (talipes). - Odd looking, unusual appearance. - Open tissue on head, abdomen or back. - No anal opening. - Other abnormal appearance. If present: - Cover any open tissue with sterile gauze before referral and keep warm. - Place a nasogastric tube and keep it open during referral if abdominal malformation or no anal opening. Look at the baby's skin: - Cuts or abrasions. Look into the baby's mouth: - Cleft palate or lip. Inform the mother of your examination findings. Reassure her as necessary. If the baby: - Weighs <1800 g, - Is not feeding well, - Has a danger sign, MANAGE urgent conditions as follows: - Start resuscitation if necessary. - Re-warm and keep warm during referral for additional care. - Give first dose of ampicillin and gentamycin. - Stop any bleeding. - Give oxygen if available.

	Refer for special treatment and/or evaluation. Help the mother to breastfeed. If not successful, teach her alternative feeding methods, always with breastmilk.
Give vitamin K prophylaxis Inject hepatitis B and BCG vaccinations at birth	Wash hands. Explain to the mother that you will be injecting vitamin K to prevent bleeding, hepatitis B vaccine to prevent her baby from catching an infection of the liver that can cause cancer later in life, and BCG vaccine to prevent serious infections due to tuberculosis. Explain to her that there may be soreness at the injection site or other minor side effects but that these are uncommon and that the benefits of getting the injections far outweigh the risks. Inject a single dose of vitamin K (phytomenadione) 1 mg IM. Inject hepatitis B vaccine IM and BCG intradermally per national guidelines. Ensure that there is no excessive bleeding before you leave the newborn and mother. Wash hands. Record the injections. If the baby has other problems: MANAGE other problems accordingly. Note: Neonates requiring surgical procedures, those with birth trauma, preterm newborns and those exposed *in utero* to maternal medication known to interfere with vitamin K are at especially high risk of bleeding and must be given vitamin K 1 mg IM.
Dry cord care	Wash hands. Instruct the mother to: - Fold diaper below the stump. Keep cord stump loosely covered with clean clothes. - Put nothing on the stump. - If stump is soiled, wash it with clean water and soap. Dry it thoroughly with a clean cloth. - Explain to the mother that she should seek care if the umbilicus is red or draining pus. - If probability of infection or poor hygiene is highly suspected, advise mother to use 4% chlorhexidine.

	- Teach the mother to treat local umbilical infection three times a day.
	  o Wash hands with clean water and soap.
	  o Gently wash off pus and crusts with boiled and cooled water and then soap.
	  o Dry the area with clean cloth.
	  o Wash hands.
	  o If pus or redness worsens or does not improve in two days, refer urgently to the hospital.
	
	Notes:
	- Do not bandage the stump or abdomen.
	- Avoid touching the stump unnecessarily.

Provide additional care for a small baby or twin	If the newborn is delivered before 32 weeks gestation or weights <1500 g, refer to specialized hospital. If the newborn is delivered 1–2 months earlier or weighs 1500–2500 g (or visibly small where scale not available), see Additional care for small newborns. Notes: - Encourage the mother to keep her small baby in skin-to-skin contact. - If mother cannot keep the baby in skin-to-skin contact because of complications, another family member (grandmother or father) should be instructed on how to do so. - Do not bathe the small baby. Keep the baby clean by wiping with a damp cloth but only after 24 hours. - Measure the newborn's temperature every 2 hours until stable, then every six hours.

IV. Care prior to discharge (but after the first 90 minutes)

Intervention	Action
TIME BAND: After 90 minutes of age but prior to discharge	
Advice on stay in the facility	Advise the mother that after her uncomplicated vaginal birth, she and her healthy newborn should receive care in the birthing facility for at least 24 hours.
Support unrestricted, on demand breastfeeding, day and night	Keep the newborn in the room with his/her mother, in her bed or within easy reach. Do not separate them. Support exclusive breastfeeding on demand, day and night. Assess breastfeeding in every baby before planning for discharge. Ask the mother to alert you if with difficulty breastfeeding. Praise any mother who is breastfeeding and encourage her to continue exclusively. Explain that exclusive breastfeeding is the only feeding that protects her baby

	against serious illness. Define that exclusive breastfeeding means no other food or water except for breast milk. Notes: - Do not discharge if baby is not feeding well. - Do not give sugar water, formula or other liquids. - Do not give bottles or pacifiers.
Ensure warmth of the baby	Ensure the room is warm (25^{o} C–28^{o} C) and draft-free. Explain to the mother that keeping baby warm is important for the baby to remain healthy. Keep the baby in skin-to-skin contact with the mother as much as possible. Dress the baby or wrap in a soft dry clean cloth. Cover the head with a bonnet for the first few days, especially if baby is small. If a thermometer is not available, assess warmth every four hours by touching the baby's feet; if feet are cold, use skin-to-skin contact, add extra blanket and reassess.
Washing and bathing (hygiene)	Wash your hands. Wipe the baby's face, neck and underarms with a damp cloth daily. Wash the buttocks when soiled. Dry thoroughly. Bathe after 24 hours (after checking the baby's temperature), ensuring that the room is warm and draft-free, using warm water for bathing and thoroughly drying the baby, then dressing and covering after the bath. If the baby is small, ensure that the room is warmer when changing, wiping or bathing him/her.
Sleeping	Let the baby sleep on his/her back or side. Keep the baby away from smoke and from people smoking.
Look for danger signs	Re-examine the baby before discharge Look for signs of serious illness: - stopped feeding well, - convulsions, - fast breathing (>60 breaths per min) apnea or difficult breathing, - severe chest in-drawing, - no spontaneous movements, - raised temperature > 37,5 ^{o}C, - low temperature < 35,5 ^{o}C, - Oozing or bleeding from umbilical stump. If any of the above is present, consider possible serious illness.

	MANAGE urgent conditions. - Start resuscitation, if necessary. - Re-warm and keep warm during referral for additional care. - Give first dose of IM/IV ampicillin and gentamycin antibiotics. - Stop bleeding. - Give oxygen, if available.

Look for signs of jaundice and local infection	Look at the skin. Is it yellow?
	- Observe in good daylight. Jaundice will look more severe if observed in artificial light and may be missed in poor light.
	- Refer urgently, if jaundice present:
	  - On face of <24 hour old newborn,
	  - On palms and soles at any age,
	  - In preterm babies.
	- Encourage breastfeeding.
	- If feeding difficulty, give expressed breast milk by cup.
	
	Look at the eyes: Are they swollen and draining pus?
	- If present, give antibiotic for eye infection.
	- Teach mother to treat the eyes.
	- Follow up in two days. If pus or swelling worsens or does not improve, refer urgently.
	- Assess and treat mother and her partner for possible gonorrhea.
	
	Look at the umbilicus:
	- What has been applied to the umbilicus?
	- Advise the mother on proper cord care.
	- Is there redness, pus draining or hardness of the skin around the umbilicus? Refer the baby urgently to neonatal unit.
	- If the umbilicus is draining pus, then consider possible serious illness. Give the first dose of two IM antibiotics. Refer baby urgently to neonatal unit.
	
	Look at the skin, especially around the neck, armpits, inguinal area:
	- Are there pustules? Refer the baby urgently to the neonatal unit.
	- Is there fluctuant swelling? Consider abscess or cellulitis and urgently refer for evaluation.
	
	Look into the baby's mouth. If whitish lesions are present:
	- Consider oral thrush due to a yeast infection. Remember to observe a breast feed and examine the mother's breasts for signs of yeast infection.
	- Prescribe Nystatin 1 ml every 6 hours for 5 days and teach the mother how to treat at home.

Discharge instructions	Provide counseling. Do a thorough examination prior to discharge. Discharge no earlier than 24 hours after birth. Promote birth registration and timely vaccinations according to national guidelines. Counsel the mother on prompt recognition of the following danger signs, and to return or go to hospital immediately if baby has any of the following: - stopped feeding well, - convulsions, - fast breathing (breathing rate ≥ 60 per minute), - severe chest in-drawing, - no spontaneous movement, - fever (temperature >37.5 °C), - low body temperature (temperature <35.5 °C), - any jaundice in first 24 hours of life, or yellow palms and soles at any age. The family should be encouraged to seek health care early if they identify any of the above danger signs in between postnatal care visits.
Schedule home visits	All babies should be examined within 24 hours after birth. At least three additional postnatal contacts are recommended for all mothers and newborns Schedule routine visits as follows: - Between 72 hours – 7 days of life, - 1 month, - In each vaccination visit. Advise newborn screening tests per national guidelines. Schedule additional follow up visits depending on baby's problems: - After two days – if with breastfeeding difficulty, Low Birth Weight in 1st week of life, red umbilicus, skin infection, eye infection, thrush or other problems, or - After seven days – if Low Birth Weight discharged more than a week of age and gaining weight adequately. Home visits after birth are recommended for care of the mother and newborn. These home visits can be done by midwives

Reference: World Health Organization, *Early Essential Newborn Care, Clinical Practice Pocket Guide,* 2014.

Cord around Neck at Time of Delivery (Nuchal Cord)

When an umbilical cord becomes wrapped around the neck, the loop is referred to as the nuchal cord. The term "nuchal" relates to the nape or back of the neck

- A nuchal cord might interrupt blood flow, oxygen, and nutrients to the fetus and cause complications.
- Fortunately, most nuchal cords will resolve before delivery.
- Even in cases where they do not resolve, the potential for problems is low.
- The main causes are excessive fetal movements, an abnormally long umbilical cord, a weak cord structure, excessive amniotic fluid and having twins or multiples.
- The most common risk from a nuchal cord is decreased heart rate of the baby during delivery. This is usually the result of reduced oxygen and blood flow through the entangled cord during contractions. Even if there is a decreased heart rate, most babies will still be born healthy.
- In most cases there is loose nuchal cord but in rare instances it can be tight.
- The most important thing is to do thorough physical exam of the baby after birth – if the baby has normal physical exam, there is no need to intervene.
- Sometimes there may be facial congestion due to capillary and venous stasis. In these cases, you may need to take CBC to check hemoglobin and platelets.

Reference:

Peesay M. Cord around the Neck Syndrome. Review Article, *BMC Pregnancy and Childbirth*. 2012;12 (Suppl. 1): A6.

Physical Examination of the Newborn

Use a systematic approach to examine the newborn where possible. A recommended systematic approach is 'head to toe' and 'front to back.' Undress the newborn down to the nappy as it is not possible to fully examine a dressed baby for all abnormalities.

Table 1 includes aspects of the clinical assessment and possible indications for further investigation or follow up. Indications for urgent follow-up are identified but the list is not exhaustive. Use clinical judgment when determining the need and the urgency of follow-up for all abnormal or suspicious findings.

Table 1: Newborn examination

Aspect	Clinical assessment	Indications for further investigation ☑ ***Urgent** follow-up*
General appearance	While the newborn is quiet, alert, not hungry or crying observe: ○ Skin cooler/warmth/perfusion ○ State of alertness/responsiveness ○ Activity ○ Range of spontaneous movement ○ Posture ○ Muscle tone	• Dysmorphic features
Growth status and feeding	Document on the appropriate centile charts: ○ Weight ○ Length ○ Head Circumference	• Document weight loss
Skin	• Color • Trauma • Congenital or subcutaneous skin lesions • Edema	☑ ***Any jaundice at less than 24 hours of age*** ☑ ***Central cyanosis*** • Petechiae not fitting with mode of birth or newly appearing or associated with purpura • Pallor • More than 3 café-au-lait spots in a Caucasian, more than 5 in a black African newborn • Multiple hemangioma • Hemangioma on nose or forehead (in distribution of ophthalmic division of trigeminal nerve) • Hemangioma or other midline skin defect over spine • Edema of feet (consider Turner syndrome)
Head	• Shape and symmetry • Scalp • Anterior and posterior fontanelle • Sutures • Scalp lacerations/lesions	☑ ***Enlarged, bulging or sunken fontanelle*** • Microcephaly/macrocephaly ☑ ***Subgaleal hemorrhage*** • Caput/cephalohematoma (consider potential for jaundice) • Fused sutures
Face	Symmetry of structure, features and movement	• Asymmetry on crying
	Eyes ○ Size and structure ○ Position in relation to the nasal	• Hazy, dull cornea • Absent red reflex • Pupils unequal, dilated or

	bridge ○ Red eye reflex	constricted • Purulent conjunctivitis • Yellow sclera
	Nose ○ Position and symmetry of the nares and septum	• Nasal flaring ☑ ***Nasal obstruction especially if bilateral*** • Dacryocyst
	Mouth ○ Size, symmetry and movement ○ Shape and structure ▪ Teeth and gums ▪ Lips ▪ Palate (hard/soft) ▪ Tongue/frenulum	• Cleft lip/palate • Mouth drooping
	• Ears ○ Position ○ Structure including patency of the external auditory meatus ○ Well-formed cartilage • Jaw size	• Unresponsive to noise • Absent external auditory canal or microtia • Drainage from ear
Neck	• Structure and symmetry • Range of movement • Thyroid or other masses	• Masses/swelling • Neck webbing
Shoulders, arms and hands	• Length • Proportions • Symmetry • Structure and number of digits	• Swelling over clavicle/fractured clavicle • Hypotonia • Palsy (e.g. Erb's palsy, Klumpke's paralysis) • Contractures • Palmar crease pattern
Chest, Cardiorespiratory	• Chest ○ Chest size, shape and symmetry ○ Breast tissue ○ Number and position of nipples • Respiratory ○ Chest movement and effort with respiration ○ Respiratory rate ○ Breath sounds • Cardiac ○ Pulses – brachial and femoral ○ Skin color/perfusion ○ Heart rate ○ Heart rhythm ○ Heart sounds ○ Pulse oximetry (optional)	☑ ***Signs of respiratory distress*** ☑ ***Apneic episodes*** • Variations in rate, rhythm or regularity • Murmurs • Poor color/mottling ☑ ***Weak or absent pulses*** ☑ ***Positive pulse oximetry***
Abdomen	• Shape and symmetry • Palpate for enlargement of liver, spleen, kidneys and bladder • Bowel sounds • Umbilicus including number of arteries • Tenderness	☑ ***Organomegaly*** ☑ ***Gastroschisis/exomphalos*** ☑ ***Bilious vomiting*** • Inguinal hernia • Less than 3 umbilical vessels • Erythema or swelling at base of umbilicus onto anterior abdominal wall

Genitourinary	• Has the newborn passed urine?
	• Male genitalia
	  ○ Penis including foreskin
	  ○ Testes (confirm present bilaterally and position of testes) including any discoloration
	  ○ Scrotal size and color
	  ○ Other masses such as hydrocele
	• Female genitalia (discuss pseudomenses)
	  ○ Clitoris
	  ○ Labia
	  ○ Hymen
		☑ ***No urine passed within 24 hours***
		☑ ***Ambiguous genitalia***
		☑ ***Bilateral undescended testes***
		☑ ***Testicular torsion***
		• Hypospadias, penile chordee
		• Penile torsion greater than 60%
		• Micropenis (stretched length less than 2.5 cm)
		• Unequal scrotal size or scrotal discoloration
		• Testes palpable in inguinal canal

Anus	• Has the newborn passed meconium? • Anal position • Anal patency	☑ ***No meconium passed within 24 hours***

Hips, legs and feet	• Use Ortolani and Barlow's maneuvers
	• A firm surface to examine hips is necessary
	• Assess legs and feet for:
	  ○ Length
	  ○ Proportions
	  ○ Symmetry
	  ○ Structure and number of digits
		• Risk factors for hip dysplasia: breech presentation, fixed talipes, fixed flexion deformity, severe oligohydramnios, 1st degree relative with developmental hip dysplasia
		• Positive/abnormal Barlow's and/or Ortolani maneuvers
		• Hypotonia/contractures
		• Fixed talipes

Back	• Spinal column • Scapulae and buttocks for symmetry • Skin	• Curvature of spine • Non-intact spine • Tufts of hair or dimple along intact spine

Neurologic	• Observe throughout:
	  ○ Behavior
	  ○ Posture
	  ○ Muscle tone
	  ○ Movements
	  ○ Cry
	• Examine reflexes
	  ○ Moro
	  ○ Suck
	  ○ Grasp reflex
		• Weak, irritable, high pitched cry
		• No cry
		• Does not respond to consoling
		• Inappropriate carer response to crying
		• Absent/exaggerated reflexes
		☑ ***Seizures***
		☑ ***Altered state of consciousness***

Isolated abnormalities

The following abnormalities are usually of no concern when isolated (3 or more such abnormalities are of concern):

- Folded-over ears,
- Hyperextensibility of thumbs,
- Syndactyly of second and third toes,
- Single palmar crease,
- Polydactyly, especially if familial,
- Single umbilical artery,
- Hydrocele,
- Fifth finger clinodactyly,
- Simple sacral dimple just above the natal cleft (less than 2.5 cm from anus and less than 5 mm wide),
- Single café-au-lait spot,
- Single ash leaf macule,
- Third fontanelle,
- Capillary hemangioma apart from those described in table above.

Well Baby Nursery Comprehensive Care

This protocol is based upon the strongest up-to-date evidence in neonatology – see references at bottom of the protocol.

Well Baby Nursery (WBN) is intended for term and near-term infants who are sufficiently stable for rooming-in with their mothers. All infants admitted to the WBN must satisfy all of the following criteria:

- Gestation ≥ 35 weeks (babies of 34-35 weeks can be kept in nursery if stable and after consultant decision)
- Birth weight ≥ 2000 grams
- No major congenital anomalies
- Temperature is stable without the need of an incubator or warmer
- No need for continuous electronic cardio-respiratory monitoring
- No need for intravenous lines, nasal/oral gastric tubes, or similar interventions

Breastfeeding

Breastfeeding (BF) is to be encouraged. Our goal is to assure that all families who decide to breastfeed their infants will have a successful and satisfying experience.

Please note the following:

- Infants are to be put to breast as soon after birth as feasible for both mother and infant, ideally within the first hour after birth.
- Breastfeeding mother-infant pairs are encouraged to room-in together on a 24-hour basis.
- Encourage the infant to nurse whenever the infant is hungry or as often as the infant wants, to feed every 2-3 hours for a minimum of 8 feedings per 24 hours is also a reasonable approach.
- No supplementary dextrose solutions or milk is to be given unless ordered by a physician for medical indications.

Bathing

- Tub-Baths are preferred more than sponge baths for the first 2 weeks or until the umbilical cord completely falls off and the umbilicus has healed.
- The bath water at approximately 37.8°C (100°F) is safe to use.
- An unperfumed, mild soap should be used and kept on a soap dish or paper towel, not added to the water. Before the bath, the newborn should be wrapped in a blanket, with a T-shirt and diaper on, to keep her or him warm and secure.
- Soap is not to be used on the face.
- Time of bathing: first bathing should be delayed for first 24 hours as recommended globally.

Vitamin K1 Administration

- ❖ Every neonate should receive a single parenteral 0.5-1.0 mg dose of vitamin K IM after 1 hour of birth for prevention of vitamin K deficiency bleeding (Hemorrhagic Disease of the Newborn).- delayed to after first hour to allow time for skin to skin care.
- ❖ Orally administered vitamin K has not been shown to be as effective and puts infants at risk for late onset vitamin K deficiency bleeding, which is associated with a higher incidence of intracranial hemorrhage.

Eye Prophylaxis

- ❖ Eye prophylaxis against gonococcal opthalmia neonatorum is necessary.
- ❖ A sterile ophthalmic ointment containing 0.5% erythromycin should be administered after the first hour of life in order not to interrupt skin to skin contact or until first breast feeding.

Hyperbilirubinemia

Refer to hyperbilirubinemia and jaundice protocol.

Serum bilirubin or transcutaneous bilirubin has to be checked for every newborn at least once before discharge and even more than that for babies at risk.

Hepatitis B Vaccine and Immunoglobulin

- Immunoprophylaxis:

  - ✓ Infants of mothers who are known to be hepatitis B surface antigen (HBsAg) negative should be immunized per the usual schedule of infant immunizations
  - ✓ For infants of mothers who are HBsAg positive, give HepB Vaccine and hepatitis B immune globulin (HBIG) before age 12 hours. Complete the HepB Vaccine series in the first 6 months.
  - ✓ Infants of mothers with unknown HBsAg status:

    A. Term infants:
    - ❖ HepB Vaccine before age 12 hours..
    - ❖ If mother is found to be HBsAg positive, give HBIG before age 7 days.
    - ❖ Complete HepB Vaccine series in the first 6 months.

    B. Preterm infants (BW < 2 kg):
    - ❖ HepB Vaccine and HBIG before age 12 hours.
    - ❖ If mother is found to be HBsAg positive, complete 3 additional doses of HepB Vaccine series per usual preterm schedule.
    - ❖ For preterm babies (BW< 2 kg), administer 3 additional vaccine doses per the usual preterm immunization schedule.
    - ❖ HBIG only effective if given within 7 days of birth.
    - ❖ HepB Vaccine series is highly effective alone.

Note: Breastfeeding by HBsAg positive mother is not known to increase risk of transmission and, therefore, is not contraindicated.

References:

1. Benitz et al, AAP Committee of Fetus and Newborn, Hospital Stay for Healthy Term Newborn Infants, *Pediatrics*, 2015, Vol 135/issue 5.
2. USCF Children's Hospital, *Intensive Care Nursery House Staff Manual: Cross-Covering the Well Baby Nursery Guideline*, 2004.
3. Royal Children's Hospital of Melbourne, *Clinical Guidelines/Neonate*, Ehandbook, March 2018.
4. WHO and UNICEF, *The Revised Baby Friendly Hospital Initiative Implementation Guidance: Protecting, Promoting and Supporting Breastfeeding in Facilities Providing Maternity and Newborn Services*, 2018.
5. Canadian Pediatric Society, *Guidelines for Vitamin K Prophylaxis in Newborns*, Updated 2018.
6. Ministry of Health. *Immunization Schedule for Palestine*, Update of 2012.
7. Schillie S, et al. Prevention of Hepatitis B Virus Infection in the United States: Recommendations of the Advisory Committee on Immunization Practices. *MMWR Recomm Rep* 2018; 67 (No. RR-1):1–31.
8. Journal of Obstetric, Gynecologic & Neonatal Nursing 2004 "Tub bathing versus Traditional Sponge Bathing for the Newborn

Breastfeeding Procedure and Maternal Support

The purpose of this protocol is to promote and support breastfeeding practices in Palestinian units as part of the Baby Friendly Hospital Initiative lead by UNICEF.

What is good about breastfeeding?

- Breast milk provides all the nutrients that a baby needs for the first six months of life to grow and develop.
- Breast milk continues to provide high-quality nutrients and helps protect against infection up to two years of age or more.
- Breast milk protects babies from infections and illnesses.
- Babies find breast milk easy to digest.
- The baby's body uses breast milk efficiently.
- Breastfeeding can contribute to birth spacing.
- Breastfeeding helps the mother's uterus to contract, reducing the risk of bleeding after birth.
- Breastfeeding lowers the rate of breast and ovarian cancer in the mother.
- Breastfeeding promotes a faster return to mother's pre-pregnancy weight.
- Breastfeeding promotes the emotional relationship, or bonding, between mother and infant.

Risks for not to breastfeed

- Babies may get sick more often with diarrhea, malnutrition and pneumonia and are at increased risk of dying.
- Babies do not get natural protection from illnesses.

Equipment

Extra pillow, comfortable chairs, foot stools, and hat for the baby

Preparation

1- Explain benefits of BF (direct or even expressed breast milk).
2- Rooming-in (baby with his mother all time).
3- No supplementary water or milk will be given unless specifically ordered by the physician, If supplements are ordered, they should be administered via slow syringe, syringe and finger, or a cup to avoid nipple confusion.

Procedure (see breastfeeding leaflets with illustrations)

1- Position the mother comfortably, well supported with pillows. Remind her to bring the baby to her breast rather than leaning forward to the baby.
2- For the best way to ensure adequate body position for baby and mother, observe these items:
   - ❖ Mother relaxed and comfortable
   - ❖ Baby's body close, facing the breast
   - ❖ Baby's head and body straight
   - ❖ Baby's chin touching the breast

- ❖ Baby's bottom supported

3- Have the mother hold her breast with four fingers below the nipple/areola and the thumb above.
4- Baby reaches for the breast if hungry. If not hungry, baby roots for the breast.
5- Be sure that the baby explores the breast with tongue and is calm and alert at the breast, With a sleepy baby, unwrap the baby, encourage lots of skin-to-skin contact between mom and baby, and have mom rest with her baby near her breast so that the baby can feel and smell the breast.
6- Encourage mom to watch for feeding cues. The earliest sign is drooling, followed by mouth opening, tonguing, licking, rooting and biting of fingers or hand).
7- When suckling starts, be sure that good latching-on the breast occurs by checking these items:
   - ❖ Mouth wide open
   - ❖ Lower lip turned outwards
   - ❖ Tongue cupped around breast
   - ❖ Cheeks round
   - ❖ More areola above baby's mouth
   - ❖ Slow deep sucks, bursts with pauses
   - ❖ Can see or hear swallowing
8- Be sure that adequate emotional bonding is found by checking these items:
   - ❖ Secure, confident hold
   - ❖ Face-to-face attention from mother
   - ❖ Much touching by mother
9- Keep the baby for 10 to 20 minutes on the first breast. The infant may feed only a few minutes on the second breast or not at all.
10- Burp the infant (sitting up on lap or over the shoulder).
11- After feeding, check mother’s breast for the following items:
   - ❖ Breasts soft after the feed
   - ❖ Nipples stand out, protractile
   - ❖ Skin appears healthy
12- Babies are probably getting enough milk if:
   - ✓ They are nursing at least eight times in 24 hours.
   - ✓ The number of wet diapers increases daily by a minimum of one additional diaper until the fifth day after birth; after day 5, the infant should have six to eight wet diapers.
   - ✓ Their stools are beginning to lighten in color by the third day after birth, or have changed to yellow no later than a day.
   - ✓ They are relaxed at the end of the feeding and sleep until the next feeding is due (at least an hour).

References:

1- WHO and UNICEF, *The Revised Baby Friendly Hospital Initiative Implementation Guidance: Protecting, Promoting and Supporting Breastfeeding in Facilities Providing Maternity and Newborn Services*, 2018.

2- WHO, *Counseling for Maternal and Newborn Health Care: A Handbook for Building Skills*, Breastfeeding Session, 2013.

3- Canadian Pediatric Society, *Nutrition for the Healthy Term Infants, Birth to Six Months*, Canadian Pediatric Society Guidelines, Posted 2013, Reaffirmed 2018.

4- American College of Obstetricians and Gynecologists, *Breastfeeding in Underserved Women: Increasing Initiation and Continuation of Breastfeeding*, ACOG Guidelines, Committee Opinion, 2013.

No Urine Output in 24-48 Hours

Definition

One hundred percent of healthy premature, full-term, and post-term infants void by 24 hours of age.

Immediate questions

1. **Is the bladder palpable?** If a distended bladder is present, it is usually palpable.
2. **Has bladder catheterization been performed?** Catheterization determines whether urine is **present in** the bladder. It is commonly done in more mature infants.
3. **What is the blood pressure?** Hypotension can cause decreased renal perfusion and urine output.
4. **Has the infant ever voided? Did the infant void and was it not recorded on the bedside chart?** If the infant has never voided, consider bilateral renal agenesis, renovascular accident, or obstruction. Approximately 13–21% of infants void in the delivery room.
5. **Did the mother have oligohydramnios?** One of the etiologies of oligohydramnios (decrease in amniotic fluid) can be caused by a decrease in fetal urine production.
6. **Is there gross hematuria?** Gross hematuria suggests intrinsic renal disease.
7. **What medications was the mother on during her pregnancy?** Certain medications (ACEI, NSAIDS), if given to the mother during her pregnancy, may interfere with fetal nephrogenesis.
8. **Does the infant have a congenital renal disease? Did the prenatal ultrasound suggest kidney disease?** Acute renal failure in the newborn may have a prenatal onset.

Management

Always consider hypovolemia, sepsis, congenital renal anomalies, and neurogenic bladder.

1- History and physical exam according to questions above.
2- Lab workup: CBC, BUN, creatinine, electrolytes, blood gases.
3- Abdominal ultrasound should be performed.
4- Treat according to underlying cause.
5- Must admit to NICU for strict observation.

Reference:

1- Gomella TL et al., *Neonatology: Management, Procedures, On-Call Problems, Diseases and Drugs*, 7th edition, 2013.
2- Warren el al, Care of the Well Newborn, Review Article, *Pediatrics in Review*, 2012.

No Stool in 48 Hours

Definitions

- Ninety-nine percent of term infants, 100% of post-term infants, and 76% of premature infants (majority are >32 weeks) pass a stool in the first 24 hours of life.
- The majority of preterm infants have delayed passage (37% in 24 hours, 32% beyond 48 hours, and 99% by 9 days.)
- The time when the first meconium stool passes has been used as a marker for normal gastrointestinal functioning.
- Delay can occur because of gestational immaturity, a severe illness, a bowel obstruction, or other causes.
- When meconium is not passed by 48 hours of life, the possibility of an anatomic or neuromuscular abnormality must be considered, such as Hirschsprung disease.

History

1- Gestational age?
2- Never passed or passed then stopped?
3- Maternal drugs, such as Mg sulfate.
4- Physical exam: **abdominal distension**, associated down syndrome features, hypothyroid features,

Investigations

If meconium doesn't pass in 48 hours in a baby who is feeding properly, consider the following:

1- CBC, CRP and blood culture, as sepsis induced ileus can cause this.
2- Electrolytes, Mg and calcium.
3- Thyroid function tests.
4- Abdominal X-rays; if any suspicion about intestinal pathology, may need contrast enema and surgical consultation.
5- Spinal ultrasound and if suspecting any abnormality, MRI may be needed.

Reference:

Gomella TL et al., *Neonatology: Management, Procedures, On-Call Problems, Diseases and Drugs*, 7th edition, 2013.

Newborn Blood Spot Testing (Screening)

- Newborn blood spot (NBS) screening identifies babies who may have rare but serious conditions.
- For the small number of babies affected, early detection, referral and treatment can help to improve their health and prevent severe disability or even death.
- Without early treatment, the conditions screened for can result in permanent brain damage and serious learning disabilities.
- Good quality blood spots are those where the circle is filled and evenly saturated by a single drop of blood that soaks through to the back of the blood spot card.
- Obtain pre-transfusion blood spot samples as previous blood transfusions can affect results.
- What do we screen for? Many diseases can be screened for by blood spot cards:
  - Sickle cell disease (SCD), cystic fibrosis (CF), congenital hypothyroidism (CHT)
  - Six inherited metabolic diseases (IMDs) such as phenylketonuria (PKU)
- In Palestine we only screen for:
  - Phenylketonuria (PKU)
  - Congenital hypothyroidism (CHT)
- When to do it (timing)?
  - Between 72 hours and day 5
  - Not before 36 hours
  - In some centers not less than 3 days

References:

1. UK National Screening Committee, *Standards for Newborn Blood Spot Screening*, Updated 2013.
2. Perinatal Services BC, *Neonatal Guideline: Newborn Metabolic Screening*, Provincial Health Services Authority, BC, Canada. 2018.

Newborn Hearing Screening

- Hearing loss is one of the most common congenital anomalies, occurring in approximately 2-4 infants per 1000.
- 50% of infants born with hearing loss have no known risk factors.
- The occurrence of hearing loss has been estimated to be more than twice that of other screenable newborn disorders combined.

Risk factors for newborns are as follows:

- Family history of permanent childhood sensorineural hearing loss
- Prematurity
- TORCH infections
- Craniofacial anomalies
- Neonatal jaundice, ventilation, aminoglycoside infusion
- Postnatal infections, such as meningitis
- Findings associated with a syndrome known to be associated with hearing loss

Methods of Screening

- Auditory brainstem response (ABR), otoacoustic emissions (OAEs), and automated ABR (AABR) testing have all been used in newborn hearing-screening programs.
- The 2 methods used in most universal hearing-screening programs are automated OAEs and AABR.

Otoacoustic emissions

- OAEs are used to assess cochlear integrity and are physiologic measurements of the response of the outer hair cells to acoustic stimuli.
- They serve as a fast objective screening test for normal preneural cochlear function.
- OAEs are fast, efficient, and frequency-specific measurements of peripheral auditory sensitivity.
- The effectiveness of the test is reduced by
  - ✓ Contamination with low-frequency ambient noise in a busy nursery,
  - ✓ Vernix in the ear canal,
  - ✓ Any middle ear pathology.
- OAEs are not a sufficient screening tool in infants who are at risk for neural hearing loss (e.g., auditory neuropathy/dyssynchrony).
  - ➢ Any infant in the NICU or in the hospital for more than 5 days should undergo an ABR screening so that the presence of auditory neuropathy is not missed.
  - ➢ OAE measurements, are usually normal in infants and children with this type of hearing loss.

Diagnostic auditory brainstem response

- Diagnostic ABR tests can be used to determine:
  - The degree of hearing loss.
  - The nature of the loss.

- Not efficient for a screening program. ABR techniques should be used for follow-up diagnostic procedures.

Follow-up testing

- Infants who do not pass an initial hearing screening at birth should return for follow-up testing within 1 month.
- This follow-up allows for multiple testing sessions, medical intervention, parent counseling, and appropriate amplification measures to be initiated before the age of 6 months.
- Any infant with one risk factor or more should undergo diagnostic ABR even if OAE screening is normal.

References:

1. Vohr BR, *Screening the Newborn for Hearing Loss*, UpToDate, 2018. https://www.uptodate.com/contents/screening-the-newborn-for-hearing-loss.
2. CDC, *Hearing Screening: Recommendations and Guidelines*, 2017.

Sacral Dimples

Background

Shallow sacral dimples are a normal variant in 4.3% infants and Occult Spinal Dysraphisms are unlikely in blind ending dimples and pits within the natal cleft. Routine ultrasound of the spine is not indicated.

Which sacral dimples or pits can be safely ignored and parents reassured?

- Simple sacral dimples/pits (solitary dimple, < 5 mm in diameter, situated in the midline and < 25 mm from anus).

Which sacral dimples or pits should we worry about?

- Complex sacral dimples or pits (multiple cutaneous markers in combination, > 5 mm in diameter, situated above the natal cleft and > 25 mm from anus, base of the pit shows a discharging sinus).
- Abnormal antenatal ultrasound scans of spinal column.
- Associated suspicious signs or symptoms:
    - Neurological (weakness, spasticity or loss of sensation – difficult to demonstrate in neonates).
    - Urological.
    - Orthopedic (scoliosis, pes cavus, talipes, congenital dislocation of the hip).
- If abnormal ultrasound or any neurologic or urologic sigs – need to do spine MRI.

References:

1. Gomella TL et al., *Neonatology: Management, Procedures, On-Call Problems, Diseases and Drugs*, 7th edition, 2013.
2. Sunnybrook Hospital, *NICU Protocol*, 2015 Updates.

Developmental Dysplasia of the Hip (DDH)

Introduction

Screening for DDH is part of the Newborn and Infant Physical Examination (NIPE).

Screening for DDH

All babies are offered a newborn exam to be completed before discharge from nursery:

- Questions to the parents to identify risk factors for DDH and a thorough examination for hip abnormalities.
- Ortolani and Barlow tests, to detect an unstable hip, or a hip that is dislocated or subluxed but reducible. IT will not detect irreducible hip, which is best detected by identifying limited abduction of the flexed hip.

Criteria for urgent ultrasound screening (≤2 weeks)

- Abnormal examination
- Difference in leg length
- Knees at different levels when hips and knees bilaterally flexed
- Difficulty abducting hip to 90°
- Asymmetry of skin folds in the buttocks and posterior thighs when baby is in ventral suspension
- Palpable 'clunk' when undertaking Ortolani or Barlow maneuvers

Criteria for non-urgent screening (≤6-8 weeks)

Normal examination but risk factors for DDH:

- ✓ Family history of first degree relative with DDH
- ✓ Breech presentation during pregnancy at ≥ 34 weeks
- ✓ Structural foot abnormality
- ✓ Significant intrauterine molding
- ✓ Birth weight >5 kg
- ✓ Oligohydramnios
- ✓ Multiple pregnancy
- ✓ Prematurity
- ✓ Neuromuscular disorders
- ✓ Female gender

Process

- Preterm babies to be scanned at term +4 weeks.
- Babies with normal hip scan require no further action and will be re-examined at their 6-8 week check.
- Babies with abnormal hip scan require an expert consultation at age ≤8 weeks.

References:

1. Hansen AR, *Cloherty and Stark's Manual of Neonatal Care*, 8th edition, 2017,
2. Gomella TL et al., *Neonatology: Management, Procedures, On-Call Problems, Diseases and Drugs*, 7th edition, 2013.
3. Auckland District Health Board, *Newborn Services Clinical Guideline*, NZ, 2018 Update.

Early Onset Sepsis

Definition:

Systemic inflammatory response syndrome (SIRS): Systemic inflammatory response to a variety of clinical insults, manifested by 2 out of 4 criteria, 1 of which must be abnormal temperature or abnormal leukocyte count:

1. Temperature instability (core temperature <36 or >38.5°C)
2. Tachypnea >2 SD above the mean for age
3. HR >2 SD above the mean for age
4. Leukocyte count elevated or depressed for age or >10% immature neutrophils.

Sepsis: SIRS plus suspected or proven evidence of infection.

Severe sepsis: Sepsis combined with organ dysfunction.

Septic shock: Severe sepsis plus the persistence of hypoperfusion or hypotension for >1 hour despite adequate fluid resuscitation or a requirement for inotropic agents or vasopressors.

Multiple organ dysfunction syndrome (MODS): Presence of altered organ function so that homeostasis cannot be maintained without medical intervention.

Guidelines:

- If clinical concerns about possible early-onset neonatal infection arise during pregnancy or in the first 72 hours after birth (for example, in relation to risk factors or clinical indicators):

    - ✓ Tell the baby's parents and carers.
    - ✓ Explain the reason for concern (including the nature of early-onset neonatal infection).
    - ✓ Discuss the preferred options for management (for example, observation, investigations or antibiotic treatment).

Risk factors:

- Maternal GBS positive
- Previous baby with invasive GBS and unknown current maternal GBS status
- PPROM >18 hours
- Preterm labor <37 weeks and unknown GBS status.
- Inadequate intrapartum antibiotic prophylaxis (adequate if given more than 4 hours of ampicillin, penicillin or cefazolin- any other duration or antibiotic is considered inadequate).

- In babies given antibiotics because of risk factors for infection or clinical indicators of possible infection, measure the C-reactive protein concentration 18–24 hours after administration of antibiotics.
- A web-based Neonatal Early-Onset Sepsis Calculator (Fig 1B) (https://neonatalsepsiscalculator.kaiserpermanente.org) that includes recommended clinical actions to be taken at specific levels of predicted risk, is currently widely used as an acceptable method to assess newborn at risk of GBS sepsis. Go to the website and calculate the risk and identify actions after entering the specified variables.
- Preterm infants (<35 weeks) at highest risk for EOS: Infants born preterm because of cervical insufficiency, preterm labor, PROM, intraamniotic infection, and/or acute and otherwise unexplained onset of nonreassuring fetal status are at the highest risk of EOS and GBS EOD. The administration of GBS IAP may decrease the risk of infection among these infants, but the most reasonable approach for those is to take blood culture and start empirical antibiotic treatment.
- Preterm infants (<35weeks) who are born due to non-infectious maternal disease or placental insufficiency: It is acceptable not to take labs and not to start antibiotics if they are clinically stable. Once they develop any symptoms, take blood culture and start antibiotic treatment.

Reference for following figures 1 and 2:

Puopolo KM, Lynfield R, Cummings JJ, AAP Committee on Fetus and Newborn, AAP Committee on Infectious Diseases. Management of Infants at Risk for Group B Streptococcal Disease. *Pediatrics*. 2019; 144(2):e20191881.

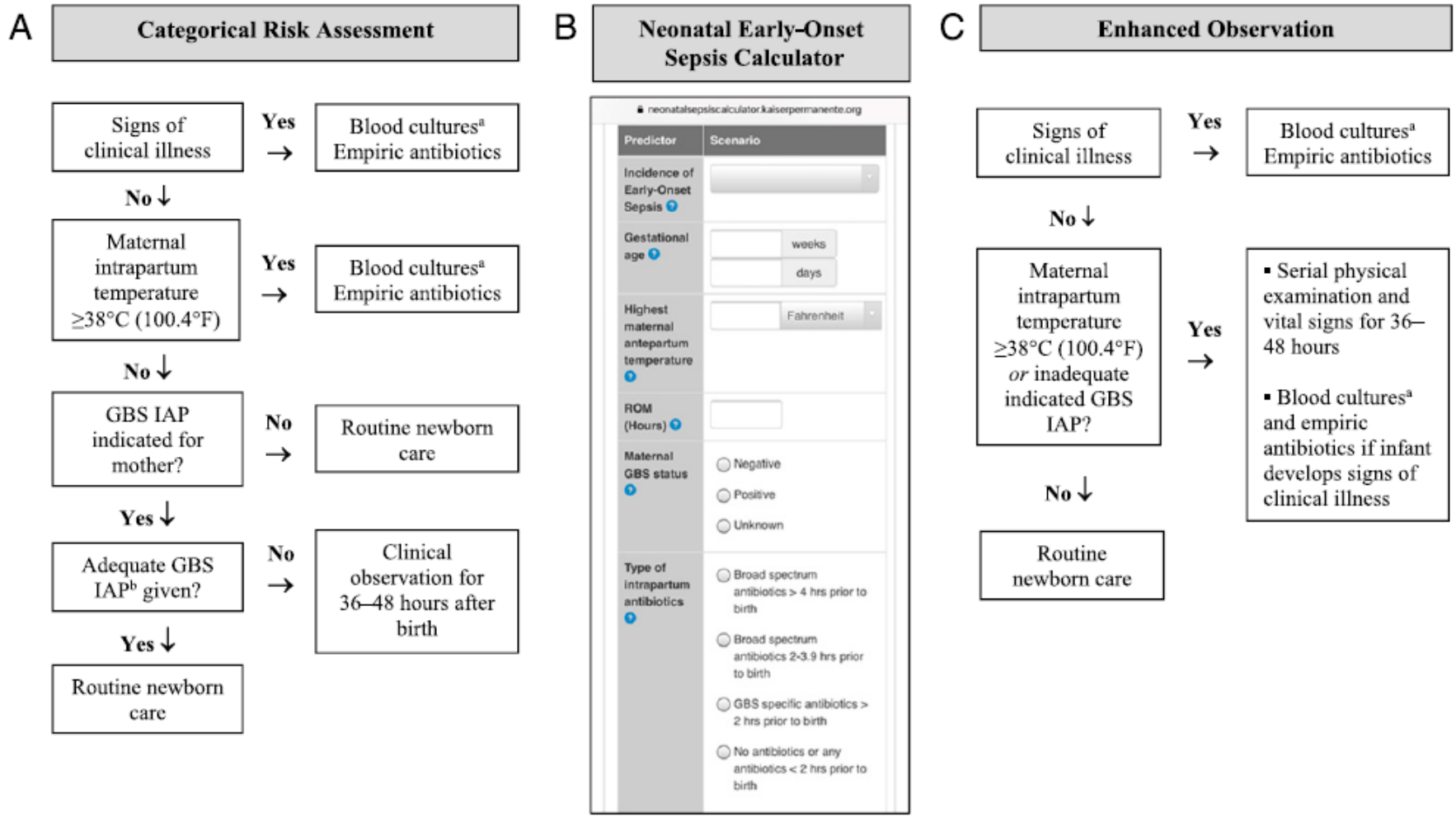


FIGURE 1

Options for EOS risk assessment among infants born ≥35 weeks' gestation. A, Categorical risk assessment. B, Neonatal Early-Onset Sepsis Calculator. The screenshot of the Neonatal Early-Onset Sepsis Calculator (https://neonatalsepsiscalculator.kaiserpermanente.org/) was used with permission from Kaiser-Permanente Division of Research. C, Enhanced observation. [a] Consider lumbar puncture and CSF culture before initiation of empiric antibiotics for infants who are at the highest risk of infection, especially those with critical illness. Lumbar puncture should not be performed if the infant's clinical condition would be compromised, and antibiotics should be administered promptly and not deferred because of procedure delays. [b] Adequate GBS IAP is defined as the administration of penicillin G, ampicillin, or cefazolin ≥4 hours before delivery.

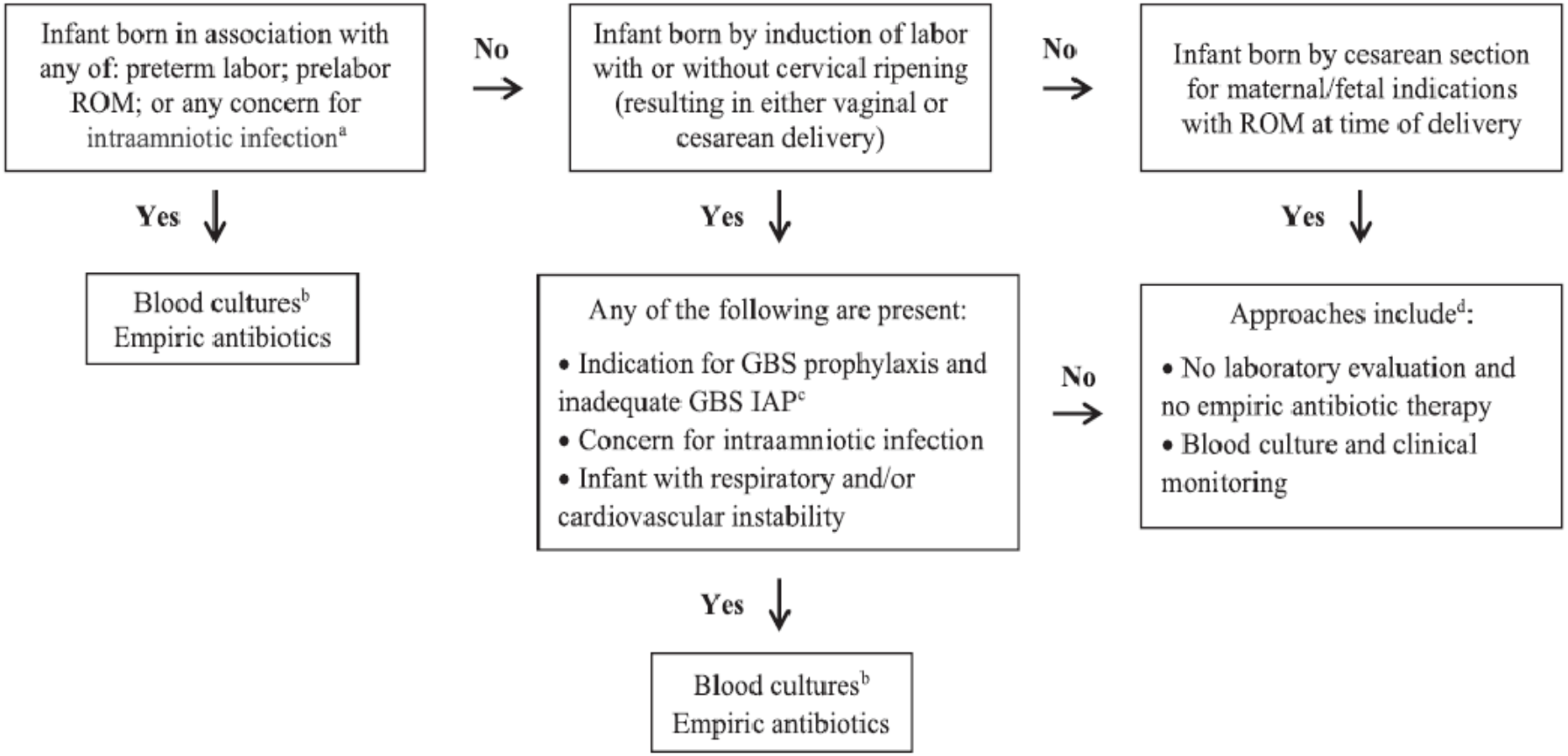


FIGURE 2

EOS risk assessment among infants born ≤34 weeks' gestation. [a] Intraamniotic infection should be considered when a pregnant woman presents with unexplained decreased fetal movement and/or there is sudden and unexplained poor fetal testing. [b] Lumbar puncture and CSF culture should be performed before initiation of empiric antibiotics for infants who are at the highest risk of infection unless the procedure would compromise the infant's clinical condition. Antibiotics should be administered promptly and not deferred because of procedural delays. [c] Adequate GBS IAP is defined as the administration of penicillin G, ampicillin, or cefazolin ≥4 hours before delivery. [d] For infants who do not improve after initial stabilization and/or those who have severe systemic instability, the administration of empiric antibiotics may be reasonable but is not mandatory.

When to do LP?

- Consider performing a lumbar puncture (see table below)

When to stop antibiotics?

In babies given antibiotics because of risk factors for infection or clinical indicators of possible infection, consider stopping the antibiotics at 36 hours if:

- The blood culture is negative,
- The initial clinical suspicion of infection was not strong,
- The baby's clinical condition is reassuring with no clinical indicators of possible infection,
- The levels and trends of C-reactive protein concentration are reassuring.

Duration of treatment?

- Positive blood culture: 10-14 days;
  - Group B Strep: 10 days
  - Gram negative: 10-14 days
  - Listeria: 21 days
- Meningitis: 14-21 days
- Negative blood culture, consider stopping antibiotics after 36-48 hours.
- if baby was unwell and when the suspicion of sepsis is high, clinicians should consider continuing antibiotic therapy for a course of 5-10 days despite negative blood cultures.

Early onset sepsis <72 hours of age: Which babies need treatment?

One "red flag" of the following, in any infant (irrespective of intrapartum antibiotic prophylaxis):

1- Suspected or confirmed maternal infection requiring intravenous antibiotics from 24 hours before to 24 hours after delivery.

2- Suspected or confirmed infection in a co-twin/triplet.

3- Respiratory distress starting more than 6 hours after birth.

4- Need for mechanical ventilation in a term baby.

5- Signs of shock

6- Seizures.

Or

Two or more risk factors/clinical indicators form the tables above.

Perform investigations and start antibiotic treatment. Do not delay starting antibiotics pending the test results.

Investigations	Antibiotics
Blood culture before administering the first dose. C-reactive protein concentration at presentation. Lumbar puncture for CSF before starting antibiotics if it is thought safe to do so and: 1- There is a strong clinical suspicion of infection, 2- There are clinical symptoms or signs suggesting meningitis e.g. seizures, 3- A positive blood culture (except coagulase negative Staph sepsis in which the incidence of meningitis is very low), 4- Laboratory data strongly suggestive of sepsis e.g. significantly high CRP(>40 mg/dl), or 5- Worsening clinical status while on antibiotic therapy.	If a baby needs antibiotic treatment, it should be given as soon as possible and always within 1 hour of the decision to treat. Use benzyl penicillin and aminoglycoside (usually gentamycin) for empirical treatment of suspected early infection, unless microbiological surveillance data reveal local bacteria and resistance patterns indicating the need for different antibiotics.
Meningitis is diagnosed if a lumbar puncture has any of the following: • Positive Gram stain or positive culture, or • More than 22 white blood cells/L. If performing the lumbar puncture would unduly delay starting antibiotics, perform it as soon as possible after starting antibiotics. Postpone LP while initiating antibiotics if the baby's condition is unstable (cardiopulmonary compromise) or if bleeding tendency.	If there is microbiological evidence of Gram-negative bacterial sepsis, add another antibiotic to the penicillin and gentamicin regimen that is active against Gram-negative bacteria (e.g. cefotaxime). If Gram-negative infection is confirmed, stop ampicillin.
Indications for repeat LP *(2012 AAP):* 1. if the patient has not responded clinically after 2-3 days and is experiencing seizures or continued fever, 2. Before stopping antibiotics in patients with more complicated courses, 3. Gram-negative bacterial meningitis Do not routinely perform urine microscopy or culture as part of the investigation for early-onset infection. Other cultures (as indicated): • Skin and eye swabs only if clinical signs of infection (take skin swabs only if clinical signs of localized infection). • Gastric aspirate cultures (at birth only), • Tracheal aspirate culture (in intubated patients with pneumonia and in overwhelming early-onset sepsis).	If meningitis is suspected from lumbar puncture but the causative pathogen is unknown (for example, because the CSF Gram stain is uninformative), treat with intravenous ampicillin/amoxicillin and cefotaxime. Continued therapy is based on cultures/sensitivity, clinical condition and progress.

References:

1. Puopolo KM, Lynfield R, Cummings JJ, AAP Committee on Fetus and Newborn, AAP Committee on Infectious Diseases. Management of Infants at Risk for Group B Streptococcal Disease. *Pediatrics*. 2019; 144(2):e20191881.
2. Committee on Infectious Disease American Academy of Pediatrics. Group B Streptococcal Infections. In: Pickering LK, Baker CJ (Eds.), *Red Book: 2012 Report of the Committee on Infectious Diseases*, 29th ed., American Academy of Pediatrics, Elk Grove Village. 2012.
3. Gaza Neonatal Network. *Early-Onset Sepsis*, Gaza NN Protocols, May 2014.
4. Polin RA, Committee on Fetus and Newborn. Management of Neonates with Suspected or Proven Early-Onset Bacterial Sepsis. *Pediatrics* 2012; 129:1006.
5. Nizet V, Klein JO. Bacterial Sepsis and Meningitis. In: Remington JS et al (Ed), Infectious Diseases of the Fetus and Newborn Infant, 7th ed., Elsevier Saunders, Philadelphia. 2010.
6. Verani JR, McGee L, Schrag SJ, Division of Bacterial Diseases, National Center for Immunization and Respiratory Diseases, Centers for Disease Control and Prevention (CDC). Prevention of Perinatal Group B Streptococcal Disease--Revised Guidelines from CDC, 2010. *MMWR Recomm Rep* 2010; 59:1.
7. Hofer N. Zacharias E. Müller W. Resch B. Early-Onset Neonatal Sepsis: Current Insights and New Tasks. *Neonatology* 2012;102:25–36.

Umbilical Cord Care

1. Delayed cord clamping after birth have been affirmed to have very beneficial effects on morbidity and mortality rates – clamping should be delayed till the cord becomes pulseless or for maximum of 3 minutes in a vigorous well newborn.
2. Use proper hand hygiene and sterile blade to cut the cord.
3. Clamp at 2 cm from the baby abdominal wall.
4. Regarding routine care, dry cord care is the option but in case you suspect poor hygiene or in home delivery setting, use diluted chlorhexidine.
5. Instruct the mother to:

    - Keep cord stump loosely covered with clean clothes;
    - Fold diaper below the stump;
    - Put nothing on the stump;
    - Wash the stump with clean water and soap only if it is soiled and dry it thoroughly with a clean cloth;
    - Seek care if the umbilicus is red or draining pus;
    - Treat local umbilical infection 3 times a day;
    - Wash hands with clean water and soap;
    - Gently wash off pus and crusts with boiled and cooled water, and then soap; dry the area with a clean cloth.

6. Always upon checking or examining a baby, look for signs of omphalitis including swelling and redness of the skin around, foul smell, pus and other non-specific signs of neonatal infection.
7. If omphalitis is suspected, the baby needs admission and parenteral antibiotics.

References:

1. Wong, DL, *Whaley & Wong's Nursing Care of Infants and Children*, (10th edition), 2015, Mosby, St. Louis.
2. Association of Women's Health, *Obstetric and Neonatal Nurses: Evidence-based Clinical Practice Guideline: Neonatal Skin Care*, ed. 3, Washington, DC, 2013.

Neonatal Jaundice

Definitions:

Neonatal hyperbilirubinemia in infants ≥ 35 weeks gestation is defined as total serum bilirubin > 95th percentile in hour-specific normogram.

Severe neonatal hyperbilirubinemia is defined as total serum bilirubin > 25 mg/dL and is associated with risk of bilirubin-induced neurologic dysfunction (BIND).

Acute Bilirubin encephalopathy (ABE): describes the acute manifestations of BIND.

Kernicterus: describes the chronic and permanent sequelae of BIND.

Prolonged hyperbilirubinemia: Jaundice lasting more than 14 days in term babies and more than 21 days in preterm babies.

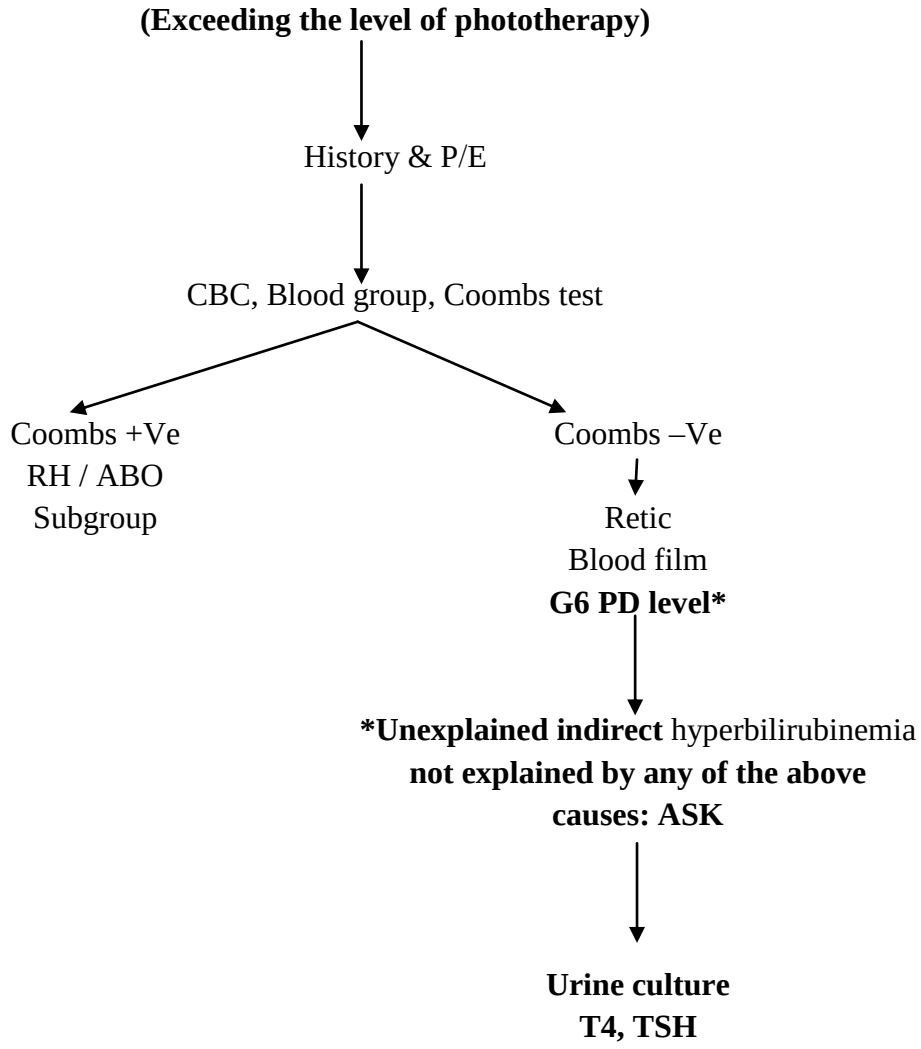
Features suggestive of pathologic jaundice:

1. Jaundice recognized in the first 24 hours.
2. Total serum bilirubin > 95th percentile in hour-specific normogram.
3. Rate of rise of TB greater than 0.2 mg/dL/hour.
4. Prolonged hyperbilirubinemia.
5. Direct hyperbilirubinemia (> 2mg/dL or > 20% of total if TSB > 5mg/dL),

Evaluation of jaundice (unconjugated)

1. Initial evaluation:
    - Total and direct bilirubin
    - Blood type and Rh (infant & mother)
    - Hematocrit - Direct Antiglobulin (Coombs) Test on infant
2. Later evaluation (as indicated):
    - RBC smear, reticulocyte count (if evidence or suspicion of hemolytic disease)
    - Urinalysis, urine culture (unexplained > 5 days old)
    - Thyroid function tests, G6PD assay, Hgb electrophoresis

Clinical algorithm for pathologic indirect hyperbilirubinemia in the first 2 weeks of life



Management of unconjugated hyperbilirubinemia

1. Healthy term newborn:

Recent data suggest that even healthy term infants may suffer mild neurologic damage with bilirubin concentrations >20-22 mg/dL.

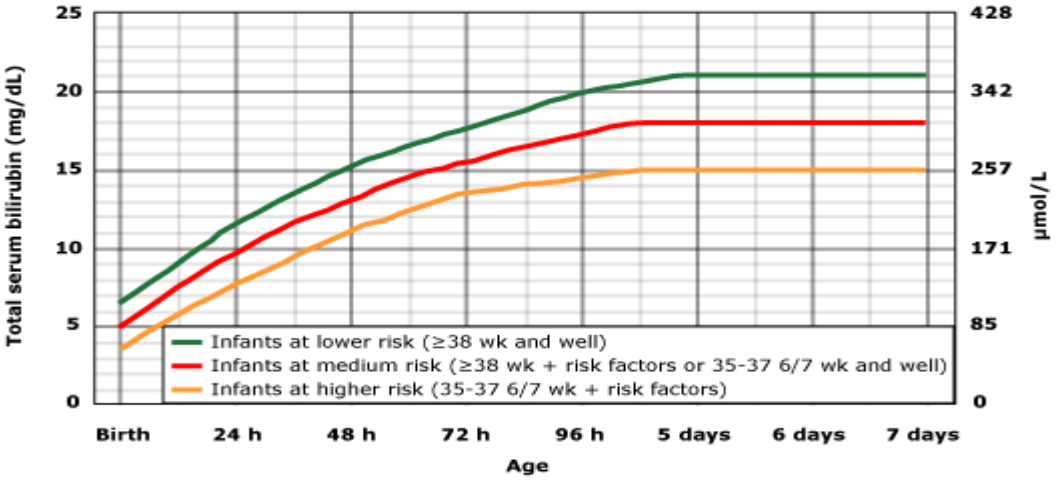
2. Sick term newborns: Start therapies at lower total serum bilirubin levels.

3. Preterm infants: Because of increased risk of bilirubin encephalopathy, therapy should be started at lower bilirubin concentrations.

NB: In general, for premature babies < 1.8 kg, bilirubin should not be allowed to exceed the infant's weight in kg x 10 (e.g., for 1.0 kg infant, keep bilirubin <10 mg/dL).

- ❖ Phototherapy as per guideline
- ❖ Exchange transfusion as per guideline
- ❖ IVIG when there is immune hemolytic disease and bilirubin is 1-3 below exchange level

Nomogram of hour-specific serum total bilirubin (STB) concentration in healthy term and near-term newborns

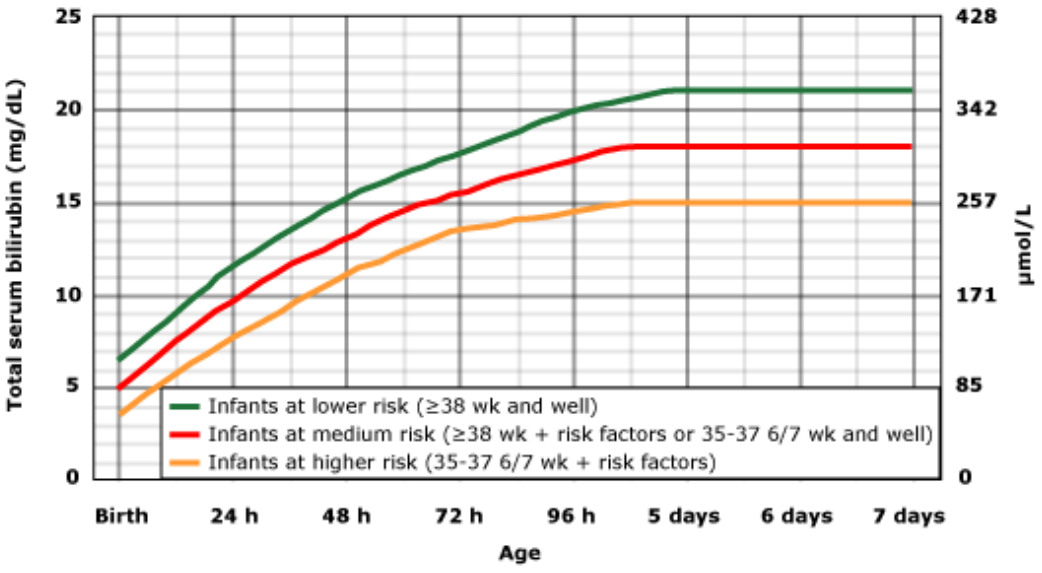


- The red, blue, and green lines denote the 95th, 75th, and 40th percentiles, respectively.
- Risk zones are designated according to percentile: high (STB ≥ 95th), high intermediate (95th > STB ≥ 75th), low intermediate (75th > STB ≥ 40th), and low (STB < 40th).
- Infants with values in the high risk zone are at increased risk for the development of clinically significant hyperbilirubinemia requiring intervention.

GUIDELINES FOR USE OF PHOTOTHERAPY IN PRETERM INFANTS <1 WEEK OF AGE

Weight (g)	Phototherapy (mg/dL)	Consider Exchange Transfusion (mg/dL)
500–1000	5–7	12–15
1000–1500	7–10	15–18
1500–2500	10–15	18–20
>2500	>15	>20

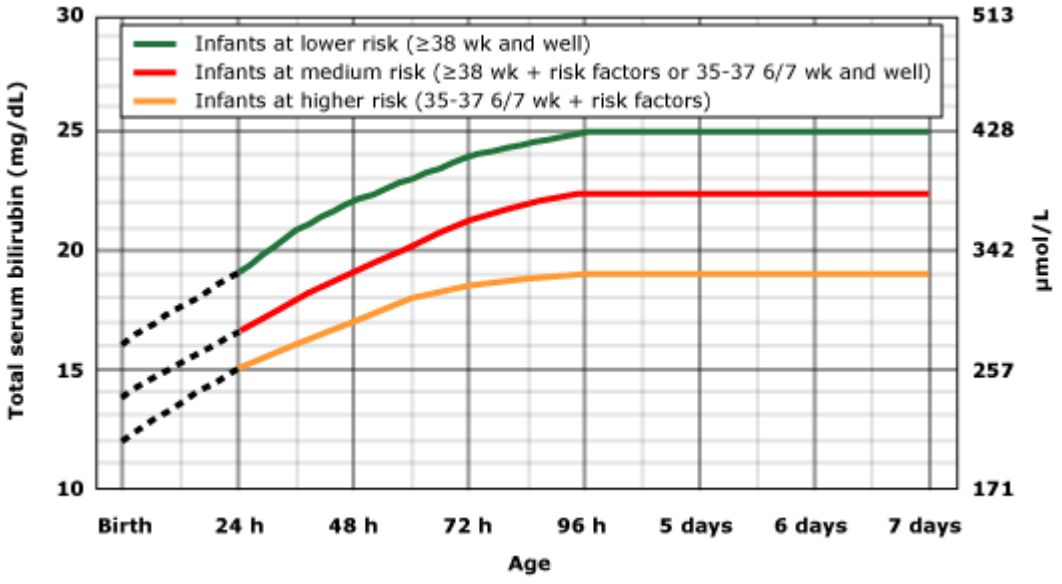
Guidelines for phototherapy in hospitalized infants of 35 or more weeks gestation



- Use total bilirubin. Do not subtract direct reacting or conjugated bilirubin.
- Risk factors include isoimmune hemolytic diseases, G6PD deficiency, asphyxia, significant lethargy, temperature instability, sepsis, acidosis, or albumin <3.0 g/dL (if measured).
- For well infants 35-37 6/7 week can adjust TSB levels for intervention around the medium risk line. It is an option to intervene at lower TSB levels for infants closer to 35 weeks and at higher TSB levels for those closer to 37 6/7 week.
- It is an option to provide conventional phototherapy in hospital or at home at TSB levels 2-3 mg/dL (35-50 mmol/L) below those shown but home phototherapy should not be used in any infant with risk factors.
- Note: These guidelines are based on limited evidence and the levels shown are approximations. The guidelines refer to the use of intensive phototherapy which should be used when the TSB exceeds the line indicated for each category.
- Infants are designated as "higher risk" because of the potential negative effects of the conditions listed on albumin binding of bilirubin, the blood-brain barrier, and the susceptibility of the brain cells to damage by bilirubin.

There is no recommended guidelines from the AAP for infants less than 35 weeks gestation – use table for recommendations of phototherapy and exchange transfusion according to infant weight.

Guidelines for exchange transfusion in infants 35 or more weeks gestation



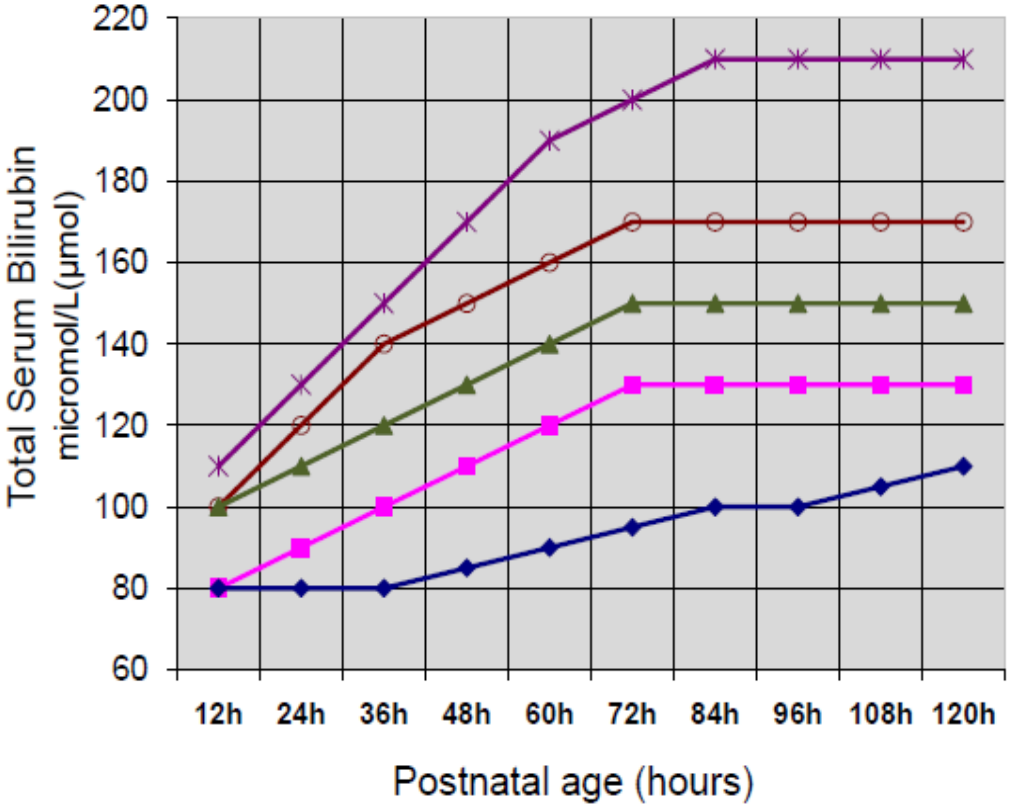
- The dashed lines for the first 24 hours indicate uncertainty due to a wide range of clinical circumstances and a range of responses to phototherapy.
- ***Immediate exchange transfusion is recommended if*** infant shows signs of acute bilirubin encephalopathy (hypertonia, arching, retrocollis, opisthotonos, fever, high pitched cry) or if TSB is ≥5 mg/dL (85 µmol/L) above these lines.

- Risk factors include: isoimmune hemolytic disease, G6PD deficiency, asphyxia, significant lethargy, temperature instability, sepsis, and acidosis.
- Measure serum albumin and calculate B/A ratio. Use total bilirubin. Do not subtract direct reacting or conjugated bilirubin. If infant is well and 35-37 6/7 week (median risk), can individualize TSB levels for exchange based on actual gestational age.
- Note that these suggested levels represent a consensus of most of the committee but are based on limited evidence, and the levels shown are approximations.
- During birth hospitalization, exchange transfusion is recommended if the TSB rises to these levels despite intensive phototherapy. For readmitted infants, if the TSB level is above the exchange level, repeat TSB measurement every 2 to 3 hours and consider exchange if the TSB remains above the levels indicated after intensive phototherapy for 6 hours.

There is no recommended guidelines from the AAP for infants less than 35 weeks gestation – use table for recommendations of phototherapy and exchange transfusion according to infant weight.

Phototherapy guidelines for premature baby: each 1mg/dl = 18mmol/L

SickKids Phototherapy Guidelines for infants < 35 weeks and/or < 2500g



- 34w-34w6days or 2000-2400g
- 32w-33w6days or 1500-1999g
- 30w-31w6days or 1250-1499g
- 28w-29w6days or 1000-1249g
- <28w or <1000g

1. The purpose of phototherapy is to prevent the need for exchange transfusion.
2. The serum bilirubin should decrease by 17-34 µmol/L within 4-6 hours with phototherapy.
3. Use total serum bilirubin: do not subtract direct or conjugated bilirubin.
4. Use gestational age rather than birthweight if gestational age is accurate.
5. In the presence of risk factors use one line lower (the gestation below) until < 1000 grams.
6. Risk Factors: isoimmune hemolytic disease, G6PD deficiency, asphyxia, sepsis, acidosis, hypoalbuminemia.

Providing & Discontinuing Phototherapy

Optimal phototherapy demands the use of irradiance in the 425-475 nm band delivered to as much of the infant's surface area as possible. If possible, place phototherapy lights at a distance of 10 to 15 cm from the infant if using phototherapy units that are safe from this distance. (**ATTENTION:** halogen phototherapy lamps should **NOT** be positioned closer to the infant than manufacturer recommendations due to the risk of burns. If used, follow manufacturer recommendations).

Standard phototherapy [irradiance ~10µW/cm²/nm]
Start when total serum bilirubin (TSB) is ≥ the line according to gestational age or weight.

Intensive phototherapy [~irradiance ≥30µW/cm²/nm]
Start when TSB is > 17-34 µmol/L above the line according to gestational age or weight.

For infants requiring intensive phototherapy, consider using a fiber-optic pad or light-emitting diode [LED] mattress ("bili-blanket") under the infant to expose as much surface area as possible.

Discontinuing Phototherapy: after assessment of risk factors (i.e. cause and age at which phototherapy was started), *consider* discontinuing phototherapy when the bilirubin level falls below the level at which it was initiated. Check serum bilirubin level 6-12 hours after discontinuing phototherapy to assess for rebound.

Guidelines adapted from:
1. Horn AR et al. S Afr Med J 2005;96:819.
2. Maisels MJ, McDonagh AF. N Engl J Med 2008;358:920-8.
3. Maisels, MJ, Watchko JF.Arch Dis Child Fetal Neonatal Ed.2003;88:F459.
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Approach to neonatal cholestasis

I- Detailed history and physical examination

- Age of the infant? – Evaluate for cholestasis if jaundice after 2 weeks, except in normal breast-fed neonates (at 3 weeks).
- What is the color of urine and stools?
- Have any risk factor been identified? (TPN, LBW, sepsis...)

II- Laboratory studies

1. Assess the extent of hepatobiliary dysfunction: Total and conjugated bilirubin, SGPT, SGOT, serum alkaline phosphatase, and gamma-glutamyl transpeptidase (GGTP), PT, PTT, serum albumin and glucose, blood ammonia.
2. Other studies to look for the cause, include: CBC, urinalysis with testing for reducing substances (to evaluate galactosemia), thyroid function tests, bacterial cultures of urine and blood, TORCH, Acid-base status as initial step in the evaluation for metabolic disease.
3. Further tests: alpha-1 antitrypsin, and screening for cystic fibrosis (sweat chloride or mutation analysis), metabolic screen.

III- Imaging studies

- Ultrasonography – as a general rule, abdominal ultrasonography is commonly used as the initial test.
- CXR – check for cardiovascular or situs anomalies that may suggest biliary atresia.
- Scintigraphy – hepatobiliary scintigraphy with technetium-labeled iminodiacetic acid analogs (HIDA) can be helpful for distinguishing biliary atresia from neonatal hepatitis and other causes of cholestasis.
- Pretreatment for five days with phenobarbital (5 mg/kg per day) increases the accuracy of this test by enhancing isotope excretion

IV- Additional tests

- ERCP, MRCP, duodenal aspirate – not routinely recommended.
- Liver biopsy – If the results are equivocal and biopsy was performed when the infant was <6 weeks of age, repeat biopsy may be necessary.
- Exploratory laparotomy and operative cholangiography-should be considered if all previous tests are inconclusive and biliary atresia needs to be diagnosed.

Referral to a pediatric gastroenterologist is recommended for all infants with cholestasis of unknown etiology.

Management

1. Treatment of the cause

2. Dietary:
    - Special formula as MCT-based oil (ex: Progestimil) and supplementation with fat-soluble vitamins (ADEK)
3. Medications:
    - Ursodeoxycholic acid: 20 mg/kg/d in divided doses PO.
    - Cholestyramine: 240 mg/kg/d in 3 dived doses PO.
4. Surgery:
    - Hepatic portoenterostomy (Kasai procedure) is the treatment of choice for biliary atresia and should be performed in the first 45-60 days of life.
    - Liver transplantation for advanced liver failure.

References:

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3. Gomella TL et al., *Neonatology: Management, Procedures, On-Call Problems, Diseases and Drugs*, 7th edition, 2013.
4. Auckland District Health Board, *Newborn Services Clinical Guideline*, NZ, 2018 Update.
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Antenatal Diagnosis of Hydronephrosis

- ANH is present if the Anteroposterior diameter (APD) is ≥4 mm in second trimester and ≥7 mm in the third trimester.

Classification	Renal pelvic anteroposterior diameter (APD)	
	Second trimester	Third trimester
Mild	<7 mm	<10 mm
Moderate	7-10 mm	10-15 mm
Severe	> 10 mm	> 15 mm

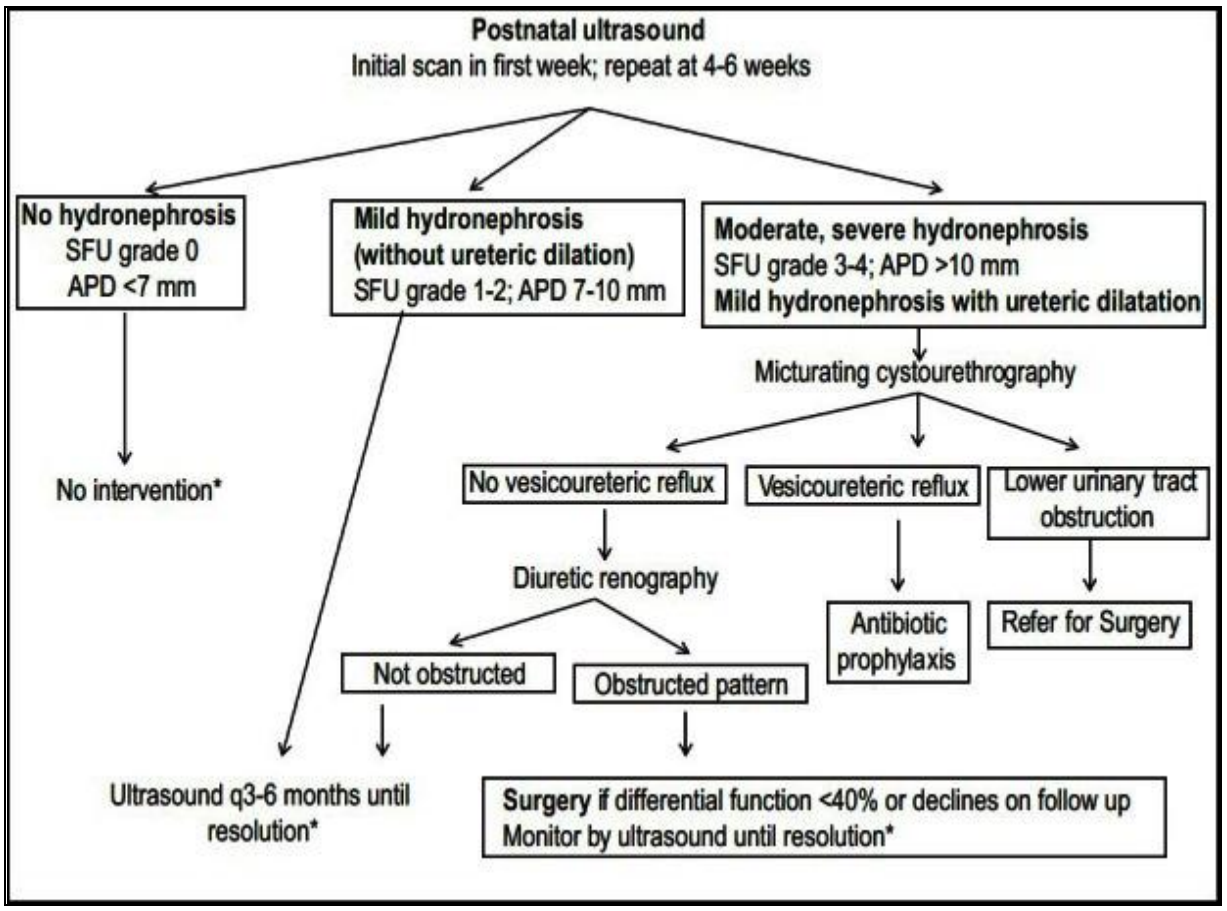
- In fetuses with unilateral hydronephrosis, at least one follow-up ultrasound should be performed in the third trimester.
- All newborns with history of ANH should have postnatal ultrasound examination within the first week of life.
- In neonates with suspected posterior urethral valves, oligohydramnios or severe bilateral hydronephrosis, ultrasonography should be performed within 24-48 hours of birth.
- In all other cases, the ultrasound should be performed preferably within 3-7 days, or before hospital discharge.
    - Neonates with normal ultrasound examination in the first week of life should undergo a repeat study at 4-6 weeks.
    - Infants with isolated mild unilateral or bilateral hydronephrosis (APD < 10 mm or SFU grade 1-2) should be followed-up by sequential ultrasound alone, for resolution or progression of findings.

Micturating cystourethrogram (MCUG)

- MCUG should be performed in patients with unilateral or bilateral hydronephrosis with renal pelvic APD > 10 mm, SFU grade 3-4 or ureteric dilatation.
    - MCUG should be performed early, within 24-72 hours of life, in patients with suspected lower urinary tract obstruction. In other cases, the procedure should be done at 4-6 weeks of age.
    - We recommend MCUG for infants with antenatally detected hydronephrosis who develop a urinary tract infection.

Antibiotic prophylaxis

a. We recommend that parents of all infants with antenatal or postnatal hydronephrosis be counseled regarding the risk of urinary tract infections and need for prompt management.
b. We recommend that infants with postnatally confirmed moderate or severe hydronephrosis (SFU 3-4; renal APD > 10 mm) or dilated ureter receive antibiotic prophylaxis while awaiting evaluation.
c. We recommend that all patients detected to have VUR receive antibiotic prophylaxis through the first year of life.



References:

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2- Capolicchio JP, Braga LH, Szymanski KM. Canadian Urological Association/Pediatric Urologists of Canada Guideline on the Investigation and Management of Antenatally Detected Hydronephrosis, *Can Urol Assoc J*. 2018 Apr;12(4):85-92.

3- Baskin LS, *Postnatal Management of Fetal Hydronephrosis*, UpToDate, 2017, http://enjoypregnancyclub.com/wp-content/uploads/2017/06/Postnatal%20management%20of%20fetal%20hydronephrosis.pdf.

4- Schlomer BJ, Copp HL, Antenatal Hydronephrosis, *NeoReviews*, November 2013, Vol 14 / Issue 11.

Hypoglycemia

Definition:

The definition of hypoglycemia (controversial): is a blood glucose level (BGL) < 45 mg/dl.

Persistent hypoglycemia:

Persistently low glucose beyond the first 48 hours of life or the requirement of parental glucose infusion to treat hypoglycemia beyond 48 hours of life.

- Asymptomatic hypoglycemia is a common transient problem in most neonates.
- Symptomatic hypoglycemia is an emergency and requires intravenous treatment.
- Symptoms include
    - CNS excitation: irritability, jitteriness, seizures.
    - CNS depression: hypotonia, lethargy, poor feeding, apneas.
    - Non-specific: temperature instability, sweating, tachycardia.
- The fetus under normal conditions derives all its glucose from the mother.
- At birth most infants are able to mobilize glycogen, initiate gluconeogenesis and produce glucose at a rate of 4-6 mg/kg/min. This is usually adequate to maintain euglycemia (normal blood glucose).
- Persistent or recurrent hypoglycemia (>2 episodes of hypoglycemia) warrants further investigation.

The cause/risk factors for hypoglycemia can be divided into:

Inadequate supply or reduced glycogen stores	Increased utilization	Hormone/Metabolism imbalance
Prematurity	Infection	Persistent hyperinsulinemia hypoglycemia of infancy
Small for gestational age	RDS	Inborn errors of metabolism
Poor feeding	Hypothermia	Pancreatic tumor
	Perinatal asphyxia	Congenital adrenal hyperplasia
	Hypothermia	Hypopituitarism
	Erythroblastosis fetalis	Syndromes: Beckwith-Wiedemann

Babies <37 weeks' gestation:

Management of these babies should follow the guidance below

- Use blood glucose threshold of 45 mg/dl.
- Continue to monitor blood sugar pre-feed until 4 consecutive values > 45 mg/dl.
- Screen ALL infants <37 weeks for hypoglycemia.
- Use nasogastric (NG) feeds in preference to IV fluids for a well-baby who is unable to take sufficient milk volumes orally.
- If baby 34-36+6 weeks is unable to tolerate NG feeds, admit to NICU for IV fluids.

Babies ≥37 weeks' gestation:

- Follow the guidance below which is based on *Identification and Management of Neonatal Hypoglycemia in the Full Term Infant*.

Risk factors for hypoglycemia:

Infants at risk of hypoglycemia that require early energy provision and BGL monitoring:

- Infants of mother's with diabetes (insulin-dependent, type 2 DM or GDM).
- Infants that are small for gestational age (below the 10th percentile).
- Preterm infants (less than 37 weeks gestation).
- Infants large for gestational age (>90th centile).
- Infants of mother's who have received antenatal steroids, beta-blockers
- Hemolytic disease and polycythemia

Clinical signs suggestive of hypoglycemia:

Presence of ≥1 of the following clinical signs/diagnoses is an indication to measure blood glucose:

- Perinatal acidosis (cord arterial or baby pH <7.1 and base deficit ≥-12)
- Hypothermia (≤36.5°C) not attributable to environmental factors
- Suspected/confirmed early neonatal sepsis
- Cyanosis, apnea
- Altered level of consciousness, seizures, hypotonia, lethargy, high-pitched cry
- Abnormal feeding behavior (not waking for feeds, not sucking effectively, appearing unsettled, demanding very frequent feeds), especially after a period of feeding well, may be indicative of hypoglycemia.
- Jitteriness (excessive repetitive movements of ≥1 limb which are unprovoked and not in response to stimulus) is common and is not by itself an indication to measure blood glucose.

Measurement of blood glucose:

- Whole blood glucose (blood gas analyzer) or plasma glucose (biochemistry lab) should be performed.
- For at risk infants:
    - First sample done pre-second feed (2-3 hours of age).
    - If infant feeding well and plasma glucose level (PGL) ≥ 45mg/dl, then repeat PGLs 6 hourly (pre-feed) – if 2 consecutive PGLs are ≥ 45 mg/dL, then stop regular monitoring and test only if infant becomes symptomatic.

Initial management of baby at risk of hypoglycemia:

- Ensure baby is kept warm and commence skin-to-skin contact.
- Ensure baby offered feed within first hour.
- Encourage early first breast feed followed by 3 hourly feeds/more frequent if demanding.
- If poor breast feeding, consider supplemented enteral feeding 3 hourly.
    - Start at 60-80 mL/kg/day or 12.5 mL/kg/feed if not contra-indicated.
- If enteral feeding is not possible, admit to NICU and give IV 10% Glucose.

- Start at 60-80 mL/kg/day (providing 4.9 mg/kg/min of glucose).
- Goal: PGL ≥ 50mg/dl in the first 48 hours, PGL ≥ 60 mg/dl after 48 hours.

Management of hypoglycemia:

Asymptomatic infants with PGL 30-45 mg/dl

Enteral feeding:

- Start enteral feeding at 60-80 mL/kg/day if no contra-indications.
- If persistent or recurrent, then increase feed volume to 15 mL/kg/feed.
  - Provides GIR of 7 mg/kg/min; total fluids 120 mL/kg/day.
  - Consider more regular feeds (2 hourly).
  - If no contraindications, then feeds can be fortified.
- Admit to NICU if:
  - PGL remains between 30-45 mg/dl despite the increased feeds to 15 mL/kg/feed (***THIRD READING IS LOW***).
  - Infant is symptomatic (lethargic with inadequate feeds, seizure).

Parenteral Supplementation

- If unable to obtain IV access, consider glucagon (IM 100 micrograms/kg) and UVC.
- Commence IV supplementation with 10% dextrose at 80-100 mL/kg/day (5.6-7 mg/kg/hour).
- Consider bolus of 2 mL/kg of 10% dextrose.
- Monitoring:
  - Repeat BGL after 30 minutes of treatment; if normal then check at 3 hours.
  - If 30 minute and 2 consecutive 3 hour**ly** BGL are normal, then can monitor 6 hourly.

Asymptomatic Infants with PGL < 30mg/dl

Admit to NICU immediately for IV supplementation.

- Take hypoglycemia screen if it does not delay treatment significantly.
- Commence IV supplementation with 10% dextrose at 100-120 mL/kg/day (**7-8.3** mg/kg/hour).
  - If unable to obtain IV access then consider glucagon (IM 100 micrograms/kg) **and UVC**. or buccal dextrose 40% gel 200 mg/kg (0.5 mL/kg of 40% gel).
  - Consider bolus of 2 mL/kg of 10% dextrose.
  - If hypoglycemia continues then aim to increase GIR by 2-3 mg/kg/min (increase total fluids by 20-30 mL/kg/day or increase dextrose concentration by 2.5-5%).
  - If needing > 12.5% dextrose, then central access is required.
- Monitoring:
  - Recheck BGL at 30 minutely intervals until PGL is ≥ 45 mg/dL.
  - Once BGL is ≥ 45 mg/dl, check 3 hourly.
  - If 2 consecutive 3 hourly BGL are normal, then can extend to 6 hourly BGLs.

Symptomatic infants – seizures, reduced consciousness

Admit to NICU for urgent IV supplementation.

- Take hypoglycemia screen if it does not delay treatment significantly.

- Commence IV supplementation with 10% dextrose at 100-120 mL/kg/day (7-8.3 mg/kg/hour).
    - If unable to obtain IV access then consider glucagon (IM 100 micrograms/kg). or buccal dextrose 40% gel 200 mg/kg (0.5 mL/kg of 40% gel).
    - Give bolus of 2 mL/kg of 10% dextrose; repeat until seizure has stopped.
- Monitoring:
    - Recheck PGL at 15-30 minutely intervals until PGL is ≥ 45mg/dl.
    - Once BGL is ≥ 45 mg/dl, check 3 hourly.
    - If 2 consecutive 3 hourly BGL are normal, then can extend to 6 hourly BGLs.

Investigations for hypoglycemia:

Indications:

- Persistent hypoglycemia
- Severe hypoglycemia (<20 mg/dl) at any time
- Signs of acute neurological dysfunction and blood glucose < 45 mg/dl at any time

Investigations:

Perform the following investigations during the period of hypoglycemia:

- Blood:
  Glucose, insulin, cortisol, growth hormone, fatty acids, ketone bodies, carnitine, acylcarnitine profile, amino acids, ammonia, lactate
- Urine:
  Ketones, organic acids
- Review need to screen for/treat sepsis (see Infection in the first 72 hours of life guideline).
- Further investigations based on results of initial screen and following specialist advice.

Persistently low blood glucose measurement:

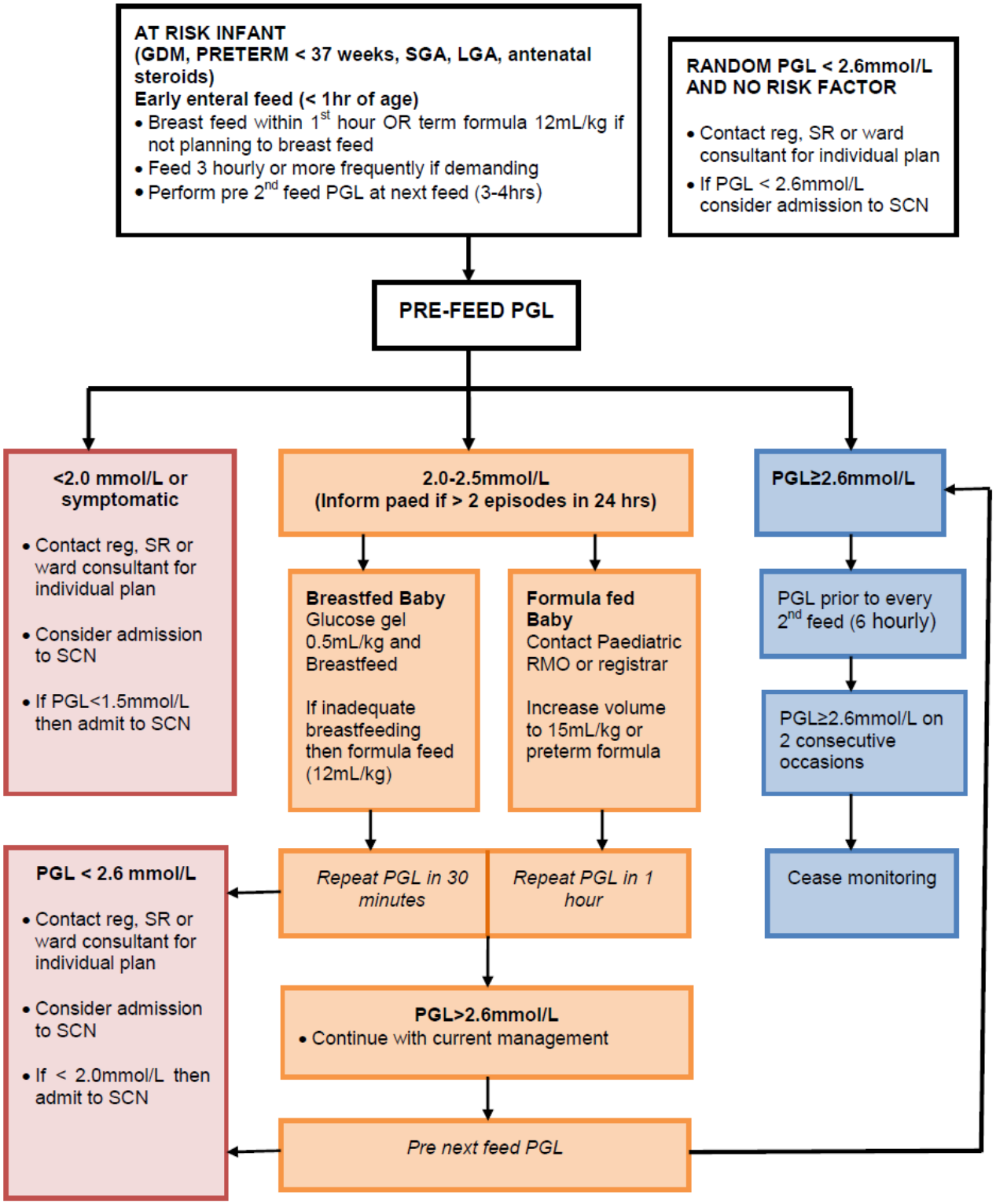
- Defined as >2 measurements < 40 mg/dl after the first 48 hours of life
- May be the first sign of hyperinsulinism or another metabolic disorder characterized by hypoglycemia
- If blood glucose concentration remains low on ≥3 occasions in the first 48 hours, despite adequate energy provision and a feeding plan, or a glucose dose >8 mg/kg/min (glucose 10% 115 mL/kg/day infusion) is required, suspect hyperinsulinism.
- If GIR > 10 mg/kg/min is needed, consider glucagon infusion at 10-20 mic/kg/hr.
- Glucocorticoids: hydrocortisone is considered in infants requiring dextrose ≥12 mg/kg/min. dose 2-6 mg/kg/day divided in 2-3 doses PO/IV for 1-2 days only unless having adrenal insufficiency.
- If hyperinsulinism suspected or confirmed, aim to maintain blood glucose >3.0 mmol/L
    - Hyperinsulinism confirmed if paired insulin and glucose measurements taken whilst hypoglycemic give a glucose: insulin ratio <0.3, or if insulin >10 picomole/L when glucose <40 mg/dl.
    - If baby is suspected of having hyperinsulinism, give glucose >12.5% infusion via a central line to obtain GIR of up to 10-12 mg/kg/min.
    - Consult endocrinology service and start:

        - Oral diazoxide: 10–25 mg/kg/24 hours given in divided doses every 6 hours.
        - A long-acting somatostatin analog: Octreotide is administered subcutaneously every 6–12 hours in doses of 20–50 μg in neonates and young infants.
    - Partial or near-total pancreatectomy if unresponsive to medical therapy (not optimal therapy).

Calculation of glucose infusion rate (GIR):
Glucose infusion rate in mg/kg/min = % glucose x fluid volume in mL/kg/day / 144 or % glucose x fluid rate (in mL/hour) / weight x 6

If >12.5% glucose required, give via a central line (see Umbilical venous catheter insertion and removal and Long line insertion guidelines).

(GIR = Concentration% X Rate (ml/hour)/6Xweight)


AT RISK INFANT
(GDM, PRETERM < 37 weeks, SGA, LGA, antenatal steroids)
Early enteral feed (< 1hr of age)
• Breast feed within 1st hour OR term formula 12mL/kg if not planning to breast feed
• Feed 3 hourly or more frequently if demanding
• Perform pre 2nd feed PGL at next feed (3-4hrs)
RANDOM PGL < 2.6mmol/L AND NO RISK FACTOR
• Contact reg, SR or ward consultant for individual plan
• If PGL < 2.6mmol/L consider admission to SCN
PRE-FEED PGL
<2.0 mmol/L or symptomatic
• Contact reg, SR or ward consultant for individual plan
• Consider admission to SCN
• If PGL<1.5mmol/L then admit to SCN
2.0-2.5mmol/L
(Inform paed if > 2 episodes in 24 hrs)
Breastfed Baby
Glucose gel 0.5mL/kg and Breastfeed
If inadequate breastfeeding then formula feed (12mL/kg)
Formula fed Baby
Contact Paediatric RMO or registrar
Increase volume to 15mL/kg or preterm formula
PGL≥2.6mmol/L
PGL prior to every 2nd feed (6 hourly)
PGL≥2.6mmol/L on 2 consecutive occasions
Cease monitoring
PGL < 2.6 mmol/L
• Contact reg, SR or ward consultant for individual plan
• Consider admission to SCN
• If < 2.0mmol/L then admit to SCN
Repeat PGL in 30 minutes
Repeat PGL in 1 hour
PGL>2.6mmol/L
• Continue with current management
Pre next feed PGL

References:

1- Rozance PJ, Hay Jr. WW, New Approaches to Management of Neonatal Hypoglycemia, *Matern Health Neonatol Perinatol*. 2016; 2: 3.

2- Kelly JC, Murata P, *AAP Sets Guidelines for Neonatal Hypoglycemia*, Medscape, 3/17/2011.

3- Geneva Foundation for Medical Education and Research, *Obstetrics and Gynecology Guidelines: Neonatal Hypoglycemia*, https://www.gfmer.ch/Guidelines/Neonatology/Neonatal_hypoglycemia.htm

4- Thompson-Branch A, Havranek T, Neonatal Hypoglycemia, *Pediatrics in Review*, April 2017, Vol 38 / Issue 4. https://pedsinreview.aappublications.org/content/38/4/147

Developmental Care in Normal Newborn

Tips to enhance neurodevelopment of newborn in nurseries

1- Enhance exclusive breast feeding (or feeding of expressed breast milk) and avoid formula feeds unless ordered by physician for certain recommendations.

2- Room in with the mother and try to maximize time of skin to skin contact.

3- Avoid all unnecessary heel sticks and sampling.

4- Use pre-procedural pain management maneuvers through using buccal dextrose gel or colostrum.

Comforting techniques include:

- Non-nutritive sucking (cotton bud with breast milk).
- Sucrose can only be used for procedural pain as heelstick or venipuncture
- Containment of infant's arms and or legs (Positioning or swaddling or gently holding hands together on chest and/or holding legs tucked up).
- Grasping a finger.

5- Limit environment noise and light as much as possible.

6- Use of Positioning or nesting to provide boundaries whilst ensuring a safe sleeping environment.

7- Clustering of cares encourages a minimum handling approach and protects periods of deep sleep.

Discharge from normal nursery

Before discharge of a baby from normal nursery to home you have to do a discharge checklist:

1- Age must be >24 hours, typically 48-72 hours for well babies.

2- Baby has no danger signs for disease.

3- Physical exam by physician within 6 hours before discharge at maximum; if done before more than 6 hours, the baby must be examined again.

4- Feeding well and mother should be satisfied about feeding of the baby.

5- Must have passed urine and stool.

6- Weight loss should be less than 8-10% from birth weight at time of discharge. Excessive weight. loss can be a sign for poor intake or other condition.

7- Baby should have passed critical congenital heart disease screening.

8- If any labs have been taken, they should be reviewed by physician, like serum bilirubin, platelets and hemoglobin.

9- Safe social and mental background of the caring persons/parents (not drug abusers, no mental or psychological problems).

References:

1- Gardner S et al. *Merenstein and Gardner's Handbook of Neonatal Intensive Care*. 8th ed., 2015, St. Louis, London, Syelrey: Mosby.

2- Kenner C and McGrath JM, *Developmental Care of Newborns and Infants*, 2nd Edition, 2010.

3- Symington et al. "Developmental care for promoting development and preventing morbidity in preterm infants"

Critical Congenital Heart Disease Screening

Some infants with CCHD are discharged from the nursery to home, where they quickly decompensate. To improve early detection of CCHD, we recommend that CCHD screening be added to the uniform newborn screening panel.

- All newborns at risk for undetected CCHD should be screened.
- Screening should begin after 24 hours of age or shortly before discharge if the baby is less than 24 hours of age. Waiting until 24 hours of life will decrease the false-positive results.
- The screening should occur in the right hand and either foot. If using only one pulse oximeter, test one right after the other.
- The baby passes screening if the oxygen saturation is 95% or greater in the right hand and foot and the difference is three percentage points or less between the right hand and foot.
- The screen is immediately failed if the oxygen saturation is less than 90% in the right hand. If the oxygen saturation is greater than 90% and less than 95% in the right hand and foot, or there is more than a three percent difference between the right hand and foot, then repeat the screen in one hour and follow the same process as above. Rarely, some babies will require three screens.
- A baby whose oxygen saturation is from 90% to less than 95% in either the right hand and foot, or who has more than a three percent difference between the right hand and foot after the third screen, will be considered to have failed screening.
- What should we do if failed screening?
    - ✓ The first step is to examine the infant to make sure the baby is hemodynamically stable.
    - ✓ Then begin the process of evaluation for hypoxemia. Depending on the status of the baby, this could involve evaluating for sepsis or pneumonia.
    - ✓ Any signs or symptoms of congenital heart defect should prompt rapid evaluation, including potential urgent echo and transfer to a center with advanced care capabilities.
    - ✓ If the baby is asymptomatic and otherwise well, with no obvious cause for hypoxemia, a cardiologist or neonatologist should be consulted and an echocardiogram should be performed.
    - ✓ Newborns should not be discharged home until the underlying reason for hypoxemia has been identified or the hypoxemia has resolved.
    - ✓ Remember, these babies will often appear normal and have no clinical findings other than the low oxygen saturation. Still, a careful and thorough evaluation is necessary.

- Does passing the screening means there is no CCHD?
  - ✓ As with any screening test, both false positives and false negatives can occur.
  - ✓ Health care providers should not consider a passed normal CCHD screen to mean that the baby does not have CCHD.
  - ✓ It is critical to remember that CCHD screening does not detect all cases of serious congenital heart defect. For example, coarctation of the aorta can be life threatening in early infancy, but may not be associated with hypoxemia.
- The seven primary targets for CCHD screening are:
  - Hypoplastic left heart syndrome
  - Pulmonary atresia with intact ventricular septum,
  - TGA, Truncus arteriosus, Tricuspid atresia
  - Tetralogy of Fallot, Total anomalous pulmonary venous return

References:

1- Kemper et al. Strategies for Implementing Screening for Critical Congenital Heart Disease. *Pediatrics.* 2011; 128:e1-8.

2- American Academy of Pediatrics, *Critical Congenital Heart Defect (CCHD) Screening Resource for Primary Care Providers*, 2012.

Neonatal Conjunctivitis

Conjunctivitis is a potentially blinding condition with associated systemic manifestations.

Recognition and assessment

- Conjunctival redness
- Swelling of conjunctiva and eyelids
- Purulent or mucopurulent discharge

Differential diagnosis

- Sticky eye with blocked tear duct in which there is no inflammation of the conjunctiva
- Congenital glaucoma in which there is corneal opacity
- Swelling of the conjunctiva and eyelids as part of preseptal or orbital cellulitis

Etiology

- **Bacterial**
    - Staphylococcus aureus
    - Hemophilus influenzae
    - Streptococcus pneumoniae
    - Serratia spp, E. Coli, Pseudomonas spp
    - Neisseria gonorrhoeae – typical onset aged 0–5 days; mild inflammation with sero-sanguineous discharge to thick, purulent discharge with tense edema of eyelids
    - Chlamydia trachomatis – typical onset aged 5–14 days; mild to severe swelling with purulent discharge (may be blood-stained)
- **Chemical:** silver nitrate
- **Viral:** herpes simplex virus (HSV)

Management

- Sticky eye/blocked tear duct:
    - 4-6 hourly eye toilet using sterile saline
    - Cooled, boiled tap water acceptable for home use
- Suspected conjunctivitis (see signs above):
    - Swab for:
        - Gram stain and bacterial culture and sensitivities
        - If other suspicions of HSV (e.g. vesicles etc.), viral swab
        - Chlamydia swab (specific for Chlamydia PCR)
    - Treat both Eyes with:
        - Frequent eye toilet as necessary
        - Chloramphenicol 0.5% eye drops
        - Fusidic acid 1% eye drops for staphylococcus
    - Presentation within first 24 hours suggests gonococcal infection

Subsequent management

In severe non-resolving cases:

- Take throat and eye swabs for viral culture (viral transport medium).
- If herpes suspected, look for other signs of herpetic infection:
    - Treat suspected herpes with IV acyclovir for 14 days.
    - Refer to ophthalmology.
- Neisseria gonorrhea suspected:
    - Request Gram stain and culture.
    - Swab in viral transport media for PCR.
    - Assess baby for septicemia.
- Neisseria gonorrhea confirmed:
    - Give single dose cefotaxime 100 mg/kg IV stat.
    - For severe cases, frequent sodium chloride 0.9% irrigation of the eyes and continue treatment with cefotaxime IV for up to 5 days (consultant decision).
    - Refer to ophthalmology.
    - If due to Neisseria gonorrhea or chlamydia, discuss referral to the genitourinary medicine services.
- Chlamydia result positive:
    - Treat with
        - Azithromycin 20 mg/kg single dose, or
        - Erythromycin 12.5 mg/kg/dose orally 6 hourly for 2 weeks.
        - This will treat the conjunctivitis and prevent most cases of chlamydia pneumonitis.
    - Refer mother and partner to genitourinary medicine for immediate treatment.

Gonococcal versus chlamydial conjunctivitis

Gonococcal	**Chlamydial**
2-5 days incubation	5-14 days incubation
Transmission vaginal or from contaminated fingers after birth	Transmission vaginal or from contaminated fingers after birth
Mild inflammation with sero-sanguineous discharge Progression to thick, purulent discharge with tense edema of eyelids	Varies from mild inflammation to severe swelling of eyelids with copious purulent discharge
Complications include corneal ulceration and perforation Meningitis and sepsis	Corneas rarely affected 1 in 5 untreated will develop chlamydial pneumonitis

References:

1- Birmingham and Midland Eye Centre, *Treatment of Ophthalmic Infection* (BMEC/Ophth/09), 2013.
2- Auckland District Health Board, *Newborn Services Clinical Guideline*, NZ, 2018 Update.
3- Goldman MA. Treatment and Prevention of Ophthalmia Neonatorum. *Can Fam Physician*. 2013;59(11):1187–1190.

Identifying Newborn with Danger Signs

Illness in the newborn can become serious quickly and put the baby's life in danger. The mother and family members must know how to recognize danger signs in the newborn that require immediate care by a qualified health care provider. As soon as someone sees even one of these danger signs, the baby should be taken immediately to a health service provider, day or night. Ensure that the baby is kept warm and fed during the journey.

Danger signs in the newborn

1. Trouble feeding and has less energy	• Sucks less or poorly, or refuses to breastfeed. Doesn't act hungry; sleeps through feedings. • Looks sluggish and drowsy; moves less or only when stimulated; sleeps longer than normal and does not wake easily when aroused.
2. Fits	• Abnormal movements in a baby. • These movements may not be obvious (abnormal stare, blinking of eyes, unusual movement of lips) or may be more obvious (abnormal tightening of feet or jerking of arms).
3. Baby too cold or too hot	Compare baby's temperature to your own. • If baby's belly and feet are cold, baby may be sick. Warm baby quickly by placing on mother's bare chest and covering with blankets. The baby will warm up, but if he or she still looks unwell, this is a warning sign. • Baby will feel hot to the touch compared to your own temperature. Face and body may look flushed. Cool by taking off baby's clothes briefly. If baby is still too hot, or looks unwell, this is a warning sign.
4. Trouble breathing	Breathes too fast; chest and belly have a rocking motion; grunting.
5. Umbilical redness	• A moist cord with redness or swelling around the base of the cord is often the first sign. • This can become serious quickly. The redness can spread and there can be swelling, pus discharge, and a bad odor. The belly can swell.
6. Jaundice, skin pustules, and/or red swollen eyes with drainage	• Yellow coloring of the skin and eyes is a sign of jaundice. Take the baby outside and press firmly on the soles of his/her feet. If you see a yellow color, this is a warning sign. • Light yellow pus-filled bumps (pustules) are a sign of skin infection. • In a serious eye infection, eyelids will appear swollen and red with yellow pus drainage.

Any baby with one or more of these signs should be evaluated for one or more of the following, as guided by history and physical exam:

- ✓ Infection
- ✓ Congenital heart disease
- ✓ Possible metabolic disease
- ✓ Intestinal obstruction
- ✓ Liver disease
- ✓ Bleeding diathesis and anemia
- ✓ Congenital adrenal hyperplasia
- ✓ Possible ongoing shock

Management:

1- Check vital signs.

2- Stabilize the baby before transfer (ABCs).

3- Transfer to appropriate facility (NICU or pediatric ward).

4- Counsel the parents.

5- Call for help in emergency situations like pending shock or arrhythmia.

References:

1- Ekwochi U, et al. Knowledge of Danger Signs in Newborns and Health Seeking Practices of Mothers and Care Givers in Enugu State, South-East Nigeria. *Ital J Pediatr*. 2015;41:18. Published 2015 Mar 21. doi:10.1186/s13052-015-0127-5.

2- Palestinian Ministry of Health. Identifying Newborn with Danger Signs, MOH Booklet, 2013.

SECTION B: Labor Ward and Resuscitation Guidelines

Labor Ward Calls

1- Encourage obstetric team to warn neonatal team of expected problems well in advance.
2- Decide:
   - Who should attend (e.g. first on-call, middle grade or consultant).
   - Degree of urgency.
3- Delivery rooms should be prepared for resuscitation station. If not, be sure that there is emergency bag for main resuscitation equipment present and all residents and nurses have easy access to it.

Neonatal team should attend the following deliveries:

1. Non-reassuring electronic fetal monitoring (EFM) trace.
2. Significant fresh meconium in liquor.
3. Caesarean section.
4. Major congenital abnormalities (minor abnormalities will wait until working hours).
5. Vacuum extraction or instrumental deliveries.
6. Preterm delivery <36 weeks.
7. Abnormal antenatal scans.
8. Low-birth-weight baby.

The following factors may require neonatal team to attend birth or assess baby soon after birth:

A. Maternal illness likely to affect baby: diabetes mellitus / systemic lupus erythematous / myasthenia gravis / myotonic dystrophy / hepatitis B carriage.
B. Suspected sepsis treated with IV antibiotics.
C. Maternal medications that may affect baby, e.g. antidepressants.

Reference:

Bedside Clinical Guidelines Partnership, *Neonatal Guidelines 2017-19*, Staffordshire, Shropshire and Black Country Neonatal Operational Delivery Network and Southern West Midlands Neonatal Operational Delivery Network.

Antenatal Neonatal Counselling

- Decisions regarding care of sick or extreme premature infants should ideally be well informed, ethically sound, and consistent within medical teams, and consonant with the parents' wishes.
- The approach should be shared decision-making with the family, guided by considering both the likelihood of death or morbidity and the parents' desires for their unborn child.
- If a decision is made not to resuscitate, providing comfort care, encouraging family bonding, and palliative care support are appropriate.
- This counselling should include not only expected outcomes for the infant but also a discussion of available options.
- Because of the uncertain outcomes for infants born at 23 to 24+6 weeks' gestation, it is reasonable that decision-making regarding the delivery room management be individualized and family centered, taking into account known fetal and maternal conditions and risk factors as well as parental beliefs regarding the best interest of the child.
- In Palestine (West Bank), according to our experience, age of viability would not be less than 24 weeks in best centers, and gestational age of 25 weeks is the most appropriate limit at our setting.
- In Palestine (Gaza Strip), according to our experience, age of viability would not be less than 24 weeks in best centers, and gestational age of 26 weeks is the most appropriate limit at our setting.
- For any premature baby or any baby with antenatal diagnosis of congenital anomaly, antenatal counselling regarding outcomes and management options should be essential part of neonatal care.
- For counselling, a form (antenatal neonatal counselling) has been developed and attached with the supplementary material of this protocol and it has to be available as an official form in each unit.
- This counselling can play an important role in the training and learning process of residents and physicians.

Neonatal Resuscitation

Effective resuscitation requires anticipation, adequate preparation of equipment and personnel, and teamwork.

At every delivery, there should be at least one person capable of initiating resuscitation, whose only responsibility is the baby.

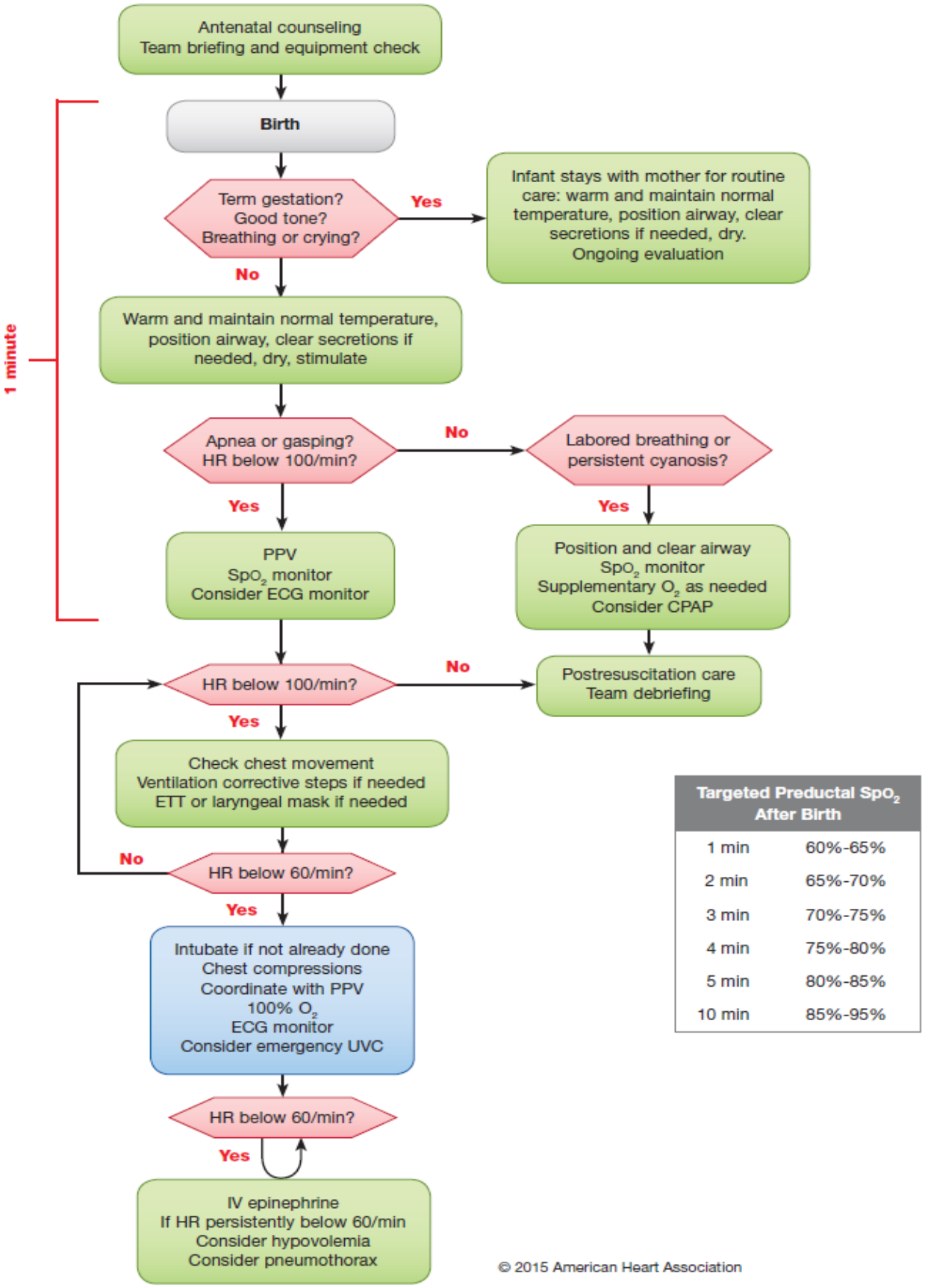
<table>
<tr><th colspan="2">Perinatal risk factors increasing the likelihood of neonatal resuscitation</th></tr>
<tr><th colspan="2">Antepartum risk factors</th></tr>
<tr><td>• Gestational age < 36 weeks.
• Gestational age > 41 weeks
• Preeclampsia or eclampsia – maternal hypertension
• Multiple gestation
• Fetal anemia</td><td>• Polyhydramnios
• Oligohydramnios
• Fetal hydrops
• Fetal macrosomia
• Intrauterine growth restriction
• Significant fetal malformations or anomalies
• No prenatal care</td></tr>
<tr><th colspan="2">Intrapartum risk factors</th></tr>
<tr><td>• Emergency caesarean delivery
• Forceps or vacuum-assisted delivery
• Breech or other abnormal presentation
• Category II or III fetal heart rate pattern
• Maternal general anesthesia
• Maternal magnesium therapy
• Placental abruption</td><td>• Intrapartum bleeding
• Chorioamnionitis
• Narcotics administered to mother within 4 hours of delivery
• Shoulder dystocia
• Meconium-stained amniotic fluid
• Prolapsed umbilical cord</td></tr>
<tr><td colspan="2">Any normal pregnancy may become high risk at the onset of previously unexpected or undetected intrapartum complications.</td></tr>
</table>

- Resuscitation equipment, supplies, and drugs **(see equipment checklist below)** should always be readily available, functional, and assembled for immediate use in a designated location prior to every delivery.

Equipment checklist	
• Warmth	• Preheated warmer
	• Warm towels or blankets
	• Temperature sensor and sensor cover for prolonged resuscitation
	• Hat
	• Plastic bag or plastic wrap (less than 32 weeks' gestation)
	• Thermal mattress (less than 32 weeks' gestation)
• Clear airway	• Bulb syringe
	• 10F or 12F suction catheter attached to wall suction, set at 80 to 100 mm Hg
	• Meconium aspirator
• Auscultation	• Stethoscope
• Ventilation	• Flowmeter set to 10 L/min
	• Oxygen blender set to 21% (21%-30% if 35 weeks' gestation)
	• Positive-pressure ventilation (PPV) device
	• Term- and preterm-sized masks
	• 8F feeding tube and large syringe
• Oxygenation	• Equipment to give free-flow oxygen
	• Pulse oximeter with sensor and cover
	• Target oxygen saturation table
• Intubation	• Laryngoscope with size-0 and size-1 straight blades (size 00, optional)
	• Stylet (optional)
	• Endotracheal tubes (sizes 2.5, 3.0, 3.5)
	• Carbon dioxide (CO_2) detector
	• Measuring tape and/or endotracheal tube insertion depth table
	• Waterproof tape or tube-securing device
	• Scissors
	• Laryngeal mask (size 1) and 5-mL syringe
• Medications	• 1:10,000 (0.1 mg/mL) epinephrine
	• Normal saline
	• Supplies for placing emergency umbilical venous catheter and administering medications
	• Electronic cardiac (ECG) monitor leads and ECG monitor

- Prepare to facilitate normal transition or provide neonatal resuscitation by performing the following:
  - Conduct a pre-briefing to review pregnancy history and designate roles among the resuscitation team.
  - Prepare the mother for skin-to-skin care and preheat the radiant warmer..
  - Assemble basic supplies: warm linens, head covering for infant, suction device, cord clamp, and appropriate personal protection.
  - Check suction equipment for function; set the vacuum regulator control not to exceed 100 mm Hg.
    - Turn on the air/oxygen flow to the ventilation.

See next page – Algorithm of NRP 2015



Targeted Preductal SpO_2 After Birth	
1 min	60%-65%
2 min	65%-70%
3 min	70%-75%
4 min	75%-80%
5 min	80%-85%
10 min	85%-95%

Notes:

- **For babies born with meconium in the amniotic fluid routine suction below cords is no more recommended unless the baby is flaccid and not responding well to PPV**
- **Naloxone is no more recommended for babies of mothers received opiates, as it may cause seizures, pulmonary edema and myocardial depression, instead continue PPV till the baby starts breathing spontaneously.**

References:

1- American Heart Association and American Academy of pediatrics. *Textbook of Neonatal Resuscitation*, 7th ed.. 2016, USA: Library of Congress Catalog.
2- Gardner S et al. *Merenstein and Gardner's Handbook of Neonatal Intensive Care*. 8th ed., 2015, St. Louis, London, Syelrey: Mosby.

SECTION C: Neonatal Intensive Care Protocols

PART I: Admission, Discharge and Referral Protocols

Referral Protocol among Palestinian Hospitals in the West Bank and Gaza

Purpose:

Clinical protocol for referrals in neonatal services is deemed necessary to outline eligibility of any referral decision and to provide a road map for clinicians taking care of sick newborns to identify easily which cases have to be referred and where to be referred.

This protocol was intended to create a levelling system for NICUs in Palestine, depending on equipment, trained nurses, doctors, neonatologists and presence of other pediatric and surgical subspecialties in certain centers. This levelling system can make it easier for the decision maker to identify resources in the country that can guarantee standard care for certain newborns among governmental and nongovernmental hospitals.

Leveling system:

Hospitals that have neonatal units in the West Bank and Gaza Strip are categorized to levels according to human resources, equipment and their ability to provide a standard management. These levels can be categorized from level 1 to level 4 according to the following criteria:

Indicator	Criteria	Level 1	Level 2	Level 2 M	Level 3	Level 4
		Criteria satisfied				
Neonatal admission	Hospital accepts VLBW neonates	--	--	√	√	√
	Hospital accepts ELBW neonates	--	--	--	√	√
Equipment	Hospital has a C-PAP **and/or** mechanical ventilator	--	√	√	√	√
	Hospital can keep neonate on mechanical ventilator for 48 hours or more	--	--	√	√	√
Staff	Hospital has neonatologists	--	--	--	√	√
	Hospital has pediatricians	√	√	√	√	√
	Hospital has pediatric **medical** sub-specialties	--	--	--	√	√
	Hospital has pediatric **surgical** sub-specialties	--	--	--	--	√

Guideline for referral of neonates and pregnant women

The best ambulance to transfer a baby is the mother

The best incubator for the baby is the uterus

World Health Organization
occupied Palestinian territory

المعهد الوطني الفلسطيني للصحة العامة
The Palestinian National Institute of Public Health

Referral Guidelines for Pregnant Patients

Cases		West Bank	Level 3 and 4 Units
• Gestation age <30 weeks • Antenatal diagnosis of congenital anomalies or metabolic disorders • Multiple pregnancy (3 and above)		North	• MoH Hospital: Rafidia Hospital
		Middle	• MoH Hospital: Palestine Medical Complex • Private Hospital: Istishari Hospital • NGO Hospital: Al-Makassed Hospital
		South	• NGO Hospitals: Palestine Red Crescent Society (Hebron), Holy Family Hospital
		Gaza	• MoH Hospitals: Shifa Hospital, Al-Tahreer Nasser Hospital
• Mothers with preterm labor, membrane rupture, or bleeding in preterm pregnancy at a gestational age of 30-34 weeks, or the estimated fetal weight is 1250-1750 gm • Mothers of babies prenatally diagnosed with congenital anomalies that do not require intensive care, provided service is present • Multiple pregnancy (twins) • Mothers with a medical or surgical condition requiring intensive and close medical attention regardless of gestational age		West Bank	Level 2M and 3 Units
		North	• MoH Hospitals: Rafidia Hospital, Jenin Hospital, Thabet Thabet Hospital • Private Hospitals: Nablus Specialized Hospital, Arab Specialized Hospital • NGO Hospitals: Etihad Hospital, St. Luke's Hospital
		Middle	• MoH Hospital: Palestine Medical Complex • Private Hospital: Istishari Hospital • NGO Hospitals: Al-Makassed Hospital, Red Crescent Hospital (Ramallah)
		South	• NGO Hospitals: Holy Family Hospital, Palestine Red Crescent Society (Hebron), Al-Ahli Hospital
		Gaza	• MoH Hospitals: Shifa Hospital, Al-Tahreer Nasser Hospital

Referrals of newborns

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The Palestinian National Institute of Public Health

Referral Guidelines for Neonatal Patients

Cases

- Gestational age <30, birth weight <1250 gm (perinatal transfer preferred)
- Multiple pregnancy (triplet and higher order)
- Asphyxia - cooling therapy within 6-12 hours
- Major congenital problems requiring life support and surgical intervention, such as diaphragmatic hernia or congenital heart disease (perinatal transfer preferred)
- Metabolic problems requiring comprehensive evaluation and management
- All unexpected cases of sick babies that require advanced support after birth, such as cases of shock or persistent pulmonary hypertension
- Persistent pulmonary hypertension requiring advanced ventilation and ionotropic support or inhaled nitric oxide

- Referral to Al-Makassed preferred as inhaled inhaled nitric oxide is available
- If case is not very severe, patient can be referred to any of the Level 3 or 4 units given that cardiology consult/echocardiography service is available

West Bank	Level 3 and 4 Units
North	• MoH Hospital: Rafidia Hospital
Middle	• MoH Hospital: Palestine Medical Complex • Private Hospital: Istishari Hospital • NGO Hospital: Al-Makassed Hospital
South	• NGO Hospitals: Palestine Red Crescent Society (Hebron), Holy Family Hospital
Gaza	• MoH Hospitals: Shifa Hospital, Naser Pediatric Hospital

- Birth weight 1250-1750 gm
- Gestational age 30-34 weeks, more than 1750 gm but requires life support
- Congenital and doesn't require life support (assuming needed service is available)
- Cases of early onset neonatal infection proven or suspected
- Phototherapy and possible exchange transfusion for severe hyperbilirubinemia
- Hypoglycemia of newborn that warrants IV fluids and investigation

Patients can be admitted to a Level 2M unit if space is available or patient is from that region. These hospitals lack advanced ventilation options, certain drugs, pediatric sub-specialties, and surgeons. Availability of surfactant in unit is essential before referral of any case with respiratory presentation or cases eligible for Level 2 care.

West Bank	Level 2M, 3, and 4 Units
North	• MoH Hospitals: Rafidia Hospital, Jenin Hospital, Thabet Thabet Hospital • Private Hospitals: Nablus Specialized Hospital, Arab Specialized Hospital • NGO Hospitals: Etihad Hospital, St. Luke's Hospital
Middle	• MoH Hospital: Palestine Medical Complex • Private Hospital: Istishari Hospital • NGO Hospitals: Al-Makassed Hospital, Red Crescent Hospital (Ramallah)
South	• NGO Hospitals: Caritas Baby Hospital, Holy Family Hospital, Palestine Red Crescent Society (Hebron), Al-Ahli Hospital
Gaza	• MoH Hospitals: Shifa Hospital, Naser Pediatric Hospital, Gaza European Hospital, Al-Tahreer Nasser Hospital

Transport Protocol

Introduction

The aim of a safe transfer policy is to ensure the highest standard, streamlined care. In the majority of cases, transfer will be performed by a dedicated transfer team but, in certain cases, the referring team may perform the transfer.

Aim:

Safe passage of newborn from one location to another:

- ✓ Transport of critically ill baby from NICU to higher level NICU
- ✓ Transport of stabilized growing newborn from higher level NICU to Intermediate care unit

Process:

ALL cases need to be transferred in a safe environment (skilled team, transport equipment, ambulance).

In All cases, you can follow ACCEPT model:

- ✓ **Assessment**: Assess breathing, airway, circulation, and try to stabilize before getting into ambulance, Examples:
    - o If on CPAP or FiO2 >40% or RDS score of >5 intubate, if on ETT fix it properly.
    - o Thermal regulation especially LBWt infants (use warm pads, pre-warmed incubator, plastic wraps for ELBWt infants).
    - o Secure IV lines (central and peripheral lines very well).
    - o If there are signs of hemodynamic instability, give fluids bolus and start inotropes accordingly.
    - o Keep medication and fluid infusions during transport (i.e. fluids and inotropes of prostaglandin).
    - o Vitamin K should be given (if not already given after birth) before transport.
    - o Monitor temperature throughout transport process.
    - o Discuss the process with parents.
- ✓ **Control:** Identify a qualified person for emergency situation who can deal with any situation that may develop during transport.
- ✓ **Communication:** The referring center should provide all related information to the center of referral, including demographics, history, exam, current status and medications.
- ✓ **Evaluation** of the urgency of transfer (within hours, the same day or can wait longer?)

- ✓ **Preparation and packing**: Transport equipment, secure tubes and lines, oxygen source. Baby must be secured in the transport incubator.
- ✓ **Transport:** Before leaving, recheck equipment, vital signs and record them. Ensure temperature of ambulance to be warm enough. If any deterioration happens during transport, better to stop at any safe place and work with baby for safety of the team.

References:

1- Auckland District Health Board, *Newborn Services Clinical Guideline*, NZ, 2018 Update.
2- Bedside Clinical Guidelines Partnership, *Neonatal Guidelines 2017-19*, Staffordshire, Shropshire and Black Country Neonatal Operational Delivery Network and Southern West Midlands Neonatal Operational Delivery Network.

1- Neonatal Transport Checklist

Patient Name_____ Referral Date_____

Referring Hospital_____ Referring Doctor_____

Referral Diagnosis_____

DOB_____ *Birth Time_____ *Birth Weight_____

*GA_____ Present Weight_____ Allergies_____

*Apgars_____ Parents Name_____

Parents Phone_____

Cultures (include date obtained):

Blood_____ Urine_____ CSF_____

ETT_____ Other_____

Laboratory Data (include date & time):

CBC_____

Diff/Plts_____

Electrolytes_____

Oxygenation/Ventilation:_____

FiO2_____ Hood_____ NC_____ LPM____

CPAP_____ Face Mask_____

Mechanical Ventilation_____

Vent Settings_____

ETT Size_____ Lip-Tip_____

X-ray Placement_____

Latest ABG: (date/time)_____

Present Status:

VS: T_____ HR_____ RR _____ BP _____

Level of Consciousness_____

Glucose_____ HCT_____

Last Void (time) _____ Last Stool (time)_____

Last Fed (time/type/amount)_____

Immunization _____ Vitamin K _____

Discharge Summary _____

Medications:

Name	Dose	Route	Time	Last given dose

IV Access/ Arterial

Type	Site	Fluid type	Rate	X ray position for central lines

Admission Criteria to NICU

Avoid unnecessary separation of mother and baby.

Decide level of care according to local protocol.

Cases to be admitted should fulfil one or more of the following criteria:

1. Any newborn who needs resuscitation at birth for >10 minutes &/or cord pH <7.0.
2. Any preterm less than 35 weeks (babies 34-35 weeks can be kept in nursery if stable, consultant decision needed).
3. Any newborn with B.W $\leq$ 2 kg.
4. Any newborn with RD &/or cyanosis, regardless of GA.
5. Apnea/cyanotic episodes.
6. Any critically ill neonate who needs NICU management (ex: respiratory support, inotropes. etc.)
7. Any newborn with major congenital anomalies that is most likely to threaten immediate survival.
8. Any newborn with jaundice appearing within the 24 hours of life.
9. Babies for mothers with high-risk factors for early onset sepsis (ex: maternal fever, PROM >18 hours, UTI).
10. Any Baby with family history of neonatal deaths (suspected IEM).
11. Signs of encephalopathy.
12. Any neonate with seizures.
13. Any unwell baby.
14. Vomiting & abdominal distension.
15. Hypoglycemia not responding to feeding.
16. Neonatal abstinence syndrome requiring treatment.

Discharge Criteria from NICU:

1. Age: postconceptional age of at least 35 weeks.
2. Weight: weight on discharge at least 2000 gm (earlier discharge of 1800- 2000, only by consultant decision).
3. Physiologic stability of the infant indicating that the neonate is ready for discharge:
   - Vital signs should be within normal range for the 24 hours preceding discharge:
     - ✓ Respiratory rate less than 60 breaths/min
     - ✓ Heart rate of 100 to 160 beats/min
     - ✓ Axillary temperature of 36.5° to 37.4° C measured in an open crib with appropriate clothing and normal ambient temperature (24 to 25ºC).
   - Demonstrates maturity of respiratory control without episodes of apnea and bradycardia with at least 5 days after the discontinuation of methylxanthine therapy.
   - Demonstrates mature oral feeding skills (breast or bottle): Twenty-four hours of successful feeding with ability to coordinate sucking, swallowing, and breathing while feeding. Each feeding shouldn't take more than 30 minutes for caretaker and infant's comfort.
   - Demonstrates a consistent pattern of appropriate weight gain: goal of at least 15 g/day.
   - Adequate urine output and stool passage.
4. Parental readiness and acquisition of the skills required for home care of their infant:
   - This includes demonstration of feeding techniques, positioning, medication administration, and respiratory treatments (if needed).
   - Some may need additional training in gastrostomy and/or tracheostomy care and in the use of cardiorespiratory monitoring equipment.
5. Review of the hospital course:
   - The results of diagnostic studies, such as cranial ultrasound examinations and echocardiograms, including those that require outpatient follow-up, should be reviewed.
   - If possible, subspecialty consultants who will provide follow-up care should see the infant prior to hospital discharge

PART II: Prematurity and Care of Premature Baby Protocols

Babies Born at Margins of Viability

Introduction

- ➢ Outcomes for premature babies at borderline viability improve with each additional week of gestational age.
- ➢ Ultrasound-estimated fetal weight within a week before delivery of <500 g at any gestation between 22+0 and 24+6 weeks is associated with a very poor outcome.
- ➢ Ultrasound carried out in first trimester of pregnancy is the most reliable method of estimating gestational age.
- ✓ Once baby is delivered, further resuscitation and management decisions should be made in baby's best interests, taking into account clinical condition at birth, e.g. heart rate, breathing, weight, severity of bruising to skin etc.; obtain urgent senior advice.
- ✓ Discussion with parents before birth, if possible, should precede any action, preferably by obstetric and pediatric teams jointly.
- ✓ Document all discussions in case records.

Management

- ➢ An experienced neonatologist/pediatrician ideally to be present at delivery of extremely premature babies (<27 completed weeks' gestation) and assess whether the physical appearance and size of the infant are consistent with the presumed gestational age.
- ➢ For babies born at 24-25+6 weeks in a resource-limited setting, where maternal or postnatal referral for such babies is difficult, decision about initiation of resuscitation of such babies should be a consultant opinion.

≥25 weeks' gestation

- ✓ Unless baby has a severe abnormality incompatible with any significant period of survival, initiate intensive care and admit to neonatal intensive care unit (NICU).
- ✓ Be prepared to provide full, invasive, intensive care and support from birth and admit to NICU, unless parents and clinicians agree that, in view of baby's condition (or likely condition) or response to initial resuscitation, intensive care is not in his/her best interests.

<25 weeks' gestation

- ✓ Discuss with parents national and local statistical evidence for survival in babies with range of disabilities found in this age group.
- ✓ Explain that statistics indicate most babies born <25 weeks' gestation are likely to die and a significant proportion of survivors are likely to have some form of neurological impairment.

24+0 to **24+6 weeks' gestation**

- ✓ Be prepared to provide full, invasive, intensive care and support from birth and admit to NICU, unless parents and clinicians agree that, in view of baby's condition (or likely condition) or response to initial resuscitation, intensive care is not in his/her best interests.

23+0 to **23+6 weeks' gestation**

- ✓ Give consideration to parents' wishes regarding resuscitation and invasive intensive care treatment.
- ✓ However, when condition at birth indicates that baby will not survive for long, clinicians are not legally obliged to proceed with treatment that is wholly contrary to their clinical judgment, if they consider treatment would be futile.

<23 weeks' gestation

- ✓ Resuscitation should not occur in routine clinical practice.
- ✓ Any attempt to resuscitate babies born at this gestational age should take place only within the context of an approved research study with caretakers consent as a must.

When intensive care is not given, clinical team must provide palliative care until baby dies.

References:

1- Sunnybrook Hospital, *NICU Protocol*, Toronto, 2015.
2- Auckland District Health Board, *Newborn Services Clinical Guideline*, NZ, 2018 Update.
3- American College of Obstetricians and Gynecologists, Society for Maternal-Fetal Medicine. Obstetric Care consensus No. 6: Periviable Birth. *Obstet Gynecol* 2017; 130:e187.
4- Mercurio MR, Periviable birth (Limits of Viability),.UpToDate, 2019.

Golden Hour for Premature Babies Born <30 Weeks

The care preterm babies receive within the first few hours and days of life has a significant impact on their long-term outcomes..

Aim: To stabilize baby and perform all procedures required within the first hour of life.

Before delivery

Nurses	Doctors
• Identify nurse responsible for admission and redistribute existing babies. • Ensure incubator set up and pre-warmed with humidity set at maximum. • Check monitor and appropriate connections. • Set oxygen saturation limits at 90-94%. • Ensure that appropriate size face masks are available. • Prepare suction and catheters. • Ensure that transport incubator tube (ETT) sizes 2.5 and 3.0 are available. • Set up trolley for umbilical arterial catheter (UAC) and umbilical venous catheter (UVC) beside incubator. • Prepare infusion fluids for UAC and UVC. • Take resuscitation bag and saturation monitor to delivery. • Prepare Trans-warmer mattress.	• Physician is responsible for early care of babies <28 weeks gestation. • Counsel parents appropriate to gestation. • <26 weeks: discuss delivery with consultant, who will attend whenever possible. • Prescribe infusions for UAC and UVC. • Check resuscitator in delivery suite. • Ensure overhead heater switched on (if manual mode used observe closely for overheating, servo is always preferred). • Set peak inspiratory pressure (PIP) at 20 cm H_2O and FiO2 at 0.21-0.3. • Check that saturation monitor and probe are available. • Check ECG monitor and leads (if available). • Prepare plastic bag.

After delivery

Nurses	Doctors
• Keep baby warm with plastic bag and hat. • Assist with resuscitation. • Accurate time-keeping, including resuscitation and procedures. • Attach oxygen saturation probe to right hand. • Attach ECG leads (if available). • Assist with ETT fixation. • Set up transport incubator and transfer baby to it. • Ensure baby labels are in place before	• Competent doctor to attend. • If baby uncompromised, delay clamping of cord till it becomes pulseless or for max of 3 minutes, keeping baby warm. • If baby compromised, cut cord immediately and take baby to resuscitation. • Place baby in plastic bag. • Use warmed humidified gases and thermal mattress as required. • Cover baby's head with appropriate size

transport.
• Ensure midwives have taken cord gases.
• Transfer baby to NNU.
	warmed hat.
	• Assess color, tone, heart rate and breathing.
	• If baby is breathing regularly, commence CPAP at 5-6 cm H_2O.
	• If baby is not breathing regularly, give 5 inflation breaths at 20-25 cm H_2O using T-piece and face mask.
	• Monitor response: check heart rate, color and respiratory effort.
	• If no improvement and no chest rise check for corrective steps (MRSOPA)
	• If baby does not start to breathe (but chest moving with inflation breaths), give ventilation breaths with pressure of 20/5 and rate of 40-60/min.
	• If heart rate is not above 100 bpm or falls, observe chest movement and if poor, increase pressures to 25/5. Observe chest movement throughout and consider reducing inspiratory pressure if necessary (e.g. to 16-18).
	• When heart rate > 100 bpm or chest movement seen, check saturation monitor and adjust FiO2 aiming to bring saturation close to NLS guidance.
	• If continued IPPV is necessary, intubate.
	• If unit policy is to give surfactant on labor ward, ensure appropriate ETT position and fix securely before administering surfactant.
	• Review baby once placed in transport incubator:
	  ○ Air entry
	  ○ Color
	  ○ Heart rate
	  ○ Saturation.
	• Complete joint resuscitation record and obtain signature from maternity team.
	• Show baby to parents.
	• Senior member of staff to talk briefly to parents.

First hour

Nurses	Doctors/ANNPs

• Aim for at least 1:1 nursing care for first hour.
• Transfer to incubator in plastic bag.
• Weight baby in plastic bag.
• Leave baby in plastic bag until incubator reaches adequate humidity.
• Attach baby to ventilator or CPAP driver and reassess ABC.
• If ventilated, pre-warm surfactant and prepare surfactant administration equipment (e.g. Trach Care Mach ^{TM}).
• Monitor heart rate and saturation.
• Record blood pressure + baseline observations.
• Do not use ECG leads on babies <26 weeks gestation.
• Measure axillary temperature on arrival.
• Insert nasogastric tube (NGT).
• Assist doctor/ANNP with lines.
• Give vitamin K.
• Give first dose of antibiotics.
• Commence prescribed infusions – do not wait for X-ray confirmation of umbilical lines.
	• Reassess ABC.
	• Split tasks between doctors/nurses.
	• Prescribe weight-dependent drugs and infusions, and vitamin K.
	• Write blood test form.
	• Prepare blood bottles.
	• Start admission notes.
	• Check ETT position clinically and administer surfactant if not previously given on labor ward.
	• Check ventilation – review tidal volume and chest movement.
	• Commence with tidal volume of 5 ml/kg.
	• PIP not important, providing there is a flow sensor.
	• If not oxygenating/ventilating, consider increasing tidal volumes.
	• If tidal volume >5 mL/kg or vigorous chest movement, reduce PIP without waiting for first gas.
	• Check saturation and adjust FiO2 to keep saturation 90-94%.
	• Insert UAC and UVC through hole in plastic bag- if it took longer time to insert may introduce fluids through a PIV till you insert lines to avoid hypoglycemia).
	• Commence infusions as soon as line secured.
	• Take blood for:
	  ○ FBC, blood group, culture, ABGs, glucose
	• Defer peripheral IV cannula insertion unless unable to gain umbilical access.
	• Once lines inserted, request X-rays.
	• Document:
	  ○ ETT position
	  ○ NGT length
	  ○ UAC and UVC positions at time X-ray taken
	• Write X-ray report in notes.
	• Update parents and document in notes.

References:

1- Sunnybrook Hospital, *NICU Protocol*, Toronto, 2015.
2- Auckland District Health Board, *Newborn Services Clinical Guideline*, NZ, 2018 Update.
3- Sharma D. Golden Hour of Neonatal Life: Need of the Hour. *Matern Health Neonatol Perinatol*. 2017;3:16.

Pain Management in NICU

Introduction

- ✓ Discomfort, pain or stress can be associated with routine care and invasive procedures.
- ✓ Babies are unable to report pain. Use observational skills and clinical judgment.

Key recommendations

- Routine assessments to detect pain using a validated assessment tool.
- Reduce number of painful procedures.
- Prevent/reduce acute pain from invasive procedures using non-pharmacological and pharmacological methods.
- Anticipate and treat post-operative pain.

Symptoms and signs

- Lack of behavioral responses does not exclude pain.
- Sudden pain and distress may indicate acute deterioration, e.g. bowel perforation.
- Physiological changes cannot be sustained long-term.

Pain assessment

- Assess within 1 hour of admission.
- Frequency of further assessments will depend on baby's clinical condition, underlying diagnosis and pain score.

Pain assessment tools

Premature Infant Pain Profile (PIPP)

Process	Indicator	0	1	2	3	Total Score
Chart	Gestational age	36 weeks or more	32-35 weeks, 6 days	28-31 weeks, 6 days	Less than 28 weeks	
Observe infant for 15 seconds	Behavioral state	Active, awake, eyes open, facial movement	Quiet, awake, eyes open, no facial movement	Active, sleep, eyes closed, facial movements	Quiet, sleep, eyes closed, no facial movements	
Observe baseline heart rate & oxygen saturation for 30 seconds	Heart rate maximum	0 beats per minute increase	5-15 beats per minute increase	15-24 beats per minute increase	25 beats per minute increase	
	Oxygen saturation minimum	92-100%	89-91%	88-85%	< 85%	
Observe infant's facial actions for 30 seconds	Brow bulge	None	Minimum	Moderate	Maximum	
	Eye squeeze	None	Minimum	Moderate	Maximum	
	Nasolabial furrow	None	Minimum	Moderate	Maximum	

- ***Score 0-6 generally indicates the infant has minimal or no pain: No action.***
- ***Score 7-12 generally indicates slight to moderate pain: Institute comfort measures.***
- ***Score >12 may indicate severe pain: Pharmacological intervention.***

Frequency of assessment

- **All** babies to have pain assessment within 1 hour of admission; score generated will dictate frequency of assessment.
- **Intensive care**: Hourly with observations.
- **High dependency**: 4-hourly or if signs of distress/discomfort.
- **Special care**: As condition dictates or subsequently if signs of distress/discomfort.
- **Post-operatively**: Hourly for first 8 hours, then 4-hourly until 48 hours post-op (more frequently if signs of distress/discomfort).

Pain management

Indications

- ✓ Birth trauma; Iatrogenic injury; before, during and after **any** painful procedure
- ✓ Severe illness, e.g. NEC, meningitis
- ✓ To aid ventilation
- ✓ Babies undergoing therapeutic hypothermia
- ✓ Post-operatively
- ✓ End-of-life care
- ❖ Begin with non-pharmacological techniques. If moderate-severe pain evident (exceptions include post-surgery, severe illness, major injury, congenital malformations and palliative care), progress to pharmacological agents

Non-pharmacological pain relief

- Gently repositioning baby, light swaddling (blanket/nest)
- Comfort/containment holding (nesting)
- Reducing light, noise, and activity around baby
- Soothing voice during and after procedures, nappy change
- Non-nutritive sucking (dummy or gloved finger)
- Kangaroo care, breastfeed, sucrose or mother's expressed breast milk (MEBM)

Reassess after 30 min

- ➢ If pain score in upper range, institute comfort measures and administer prescribed analgesia/seek medical review.
- ➢ If score continues to rise, consider increasing dose of analgesia and reassess after 30 min.
- ➢ If clinical concerns, medical review.

Sucrose

- ➢ Sucrose 24% solution and breast milk provide a quick, short-term analgesic effect.
- ➢ Non-nutritive sucking increases effectiveness.
- ➢ Use in conjunction with measures mentioned above.
- ➢ May be given to ventilated babies with care.

- Ineffective if not given orally.

Contraindications to sucrose

Do not use	May not be effective
• < 28 weeks gestation – use MEBM • High risk of NEC – use MEBM • Nil-by-mouth (if due to surgical problem, sucrose may be appropriate. Discuss with surgeon) • Sedated or on other pain medications • Diabetic mother (until blood glucose stabilized) • Known carbohydrate malabsorption or enzyme deficiency	• Baby with neonatal abstinence syndrome • Baby just been fed • Exposed to chronic in-utero stress • > 6 months

Administration

- Maximum 8 doses in 24 hours.
- Avoid risk of choking/aspiration – ensure baby is awake.
- Drop dose onto tongue, buccal membrane, or dummy and **wait 2 min** before starting procedure.
- For procedures lasting >5 min, repeat dose (maximum 2 further doses).

Gestation	Dose of sucrose 24%
28 -30^{+6} weeks	0.1 mL (max 0.3 mL per procedure)
≥ 31^{+0} weeks and 1000 – 2000 g	0.2 mL (max 0.6 mL per procedure)
≥ 2000 g	0.5 mL (max 1.5 mL per procedure)

Suggested medication for procedures

- Fentanyl, Morphine (don't use in hypotensive baby), muscle relaxant when indicated.
- Don't use Midazolam in premature babies as it may intervene with the brain development.

References:

1. Auckland District Health Board, *Newborn Services Clinical Guideline*, NZ, 2018 Update.
2. Hansen AR, *Cloherty and Stark's Manual of Neonatal Care*, 8th edition, 2018..
3. SickKids Hospital, *NICU Protocol*, Toronto, 2016.
4. Hall RW, Anand KJ. Pain Management in Newborns. *Clin Perinatol*. 2014;41(4):895–924. doi:10.1016/j.clp.2014.08.010.

Developmental Care for Premature Babies

- Developmental care is an approach to individualized care of infants to maximize neurological development and reduce long-term cognitive and behavioral problems.

- While advances in perinatal care have resulted in decreased mortality rates in preterm neonates, morbidity rates remain significantly high.

Goals:

A. Infant: early screening and detection of Neurodevelopmental disabilities in prematurely born infants

The goals of developmental care for the infant are to:

- Reduce stress,
- Conserve energy and enhance recovery,
- Promote growth and wellbeing,
- Protect sleep,
- Support emerging behaviors at each stage of neurodevelopmental maturation.

B. Family

The goals of developmental care for the family are to:

- Encourage and support parents in the primary caregiver role,
- Enhance family emotional and social wellbeing.

Concepts:

Developmental care refers to interventions that:

- Support the behavioral organization of the individual infant,
- Enhance physiological stability,
- Protect sleep rhythms,
- Promote growth and maturation.

Developmental care interventions include:

- Optimal handling and positioning measures,
- Reduction of noxious environmental stimuli,
- Cue-based care.

Interventions:

1- Limiting environmental noise

- Monitoring and reducing noise levels should be encouraged. The threshold for cochlear damage for adults is 80-85 decibels, and the newborn will have a lower threshold than this

as the immature cochlear is more sensitive. In the nursery, noises of this magnitude include closing portholes with a snap or placing bottles on the top of the incubator.

- Background noise should not exceed an hourly Leq 40-45 DB.

Noise reduction tips

- Avoid tapping on or writing on incubators, and close incubator doors and portholes carefully.
- Encourage staff and visitors to talk quietly.
- Set monitor alarm limits and tone at appropriate levels and try to silence alarms as soon as possible.
- Purchase equipment with a low noise criterion.

2- Limiting environmental light

- Constant bright light in the nursery can interfere with natural diurnal rhythms and overstimulate the infant.

Light reduction tips

- Maintain appropriate individualized lighting.
- Use adjustable light levels within each baby cot plus procedure light for observation and procedures.
- Monitor ambient light levels.
- Shield infants from bright light with cot covers, eye covers and dimmed lights.
- Reduce light levels generally in the nursery, maintaining a safe level for accurate clinical observation as necessary.
- Make use of available natural lighting.

3- Positioning

Infants should be provided with developmentally supportive positioning to optimize musculoskeletal development and behavioral organization. The primary goals of positioning should include:

- A variety of symmetrical postures (supine/prone/side lying).
- Trunk flexion, shoulder and hip flexion and adduction.
- Shoulder protraction, hands near face.
- Neutral alignment of ankles and hips.
- The use of swaddling or nesting to provide boundaries whilst ensuring a safe sleeping environment- encourage Back to sleep policy to reduce SIDS especially after discharge.
- Use head water/gel pillows for infants less than 34 weeks (with respiratory monitoring).

4- Parental involvement

Parents should be involved in decisions about interventions where possible. This promotes their understanding of their infant's behavior and allows them also to practice cue-based care. This

allows them to experience positive interactions with their baby and empowers them to recognize behavioral cues and become more confident caring for their baby.

5- Cue-based care and clustering of cares

This involves caring for the infant while recognizing the behavioral cues or stress responses and providing an appropriate strategy such as timeout or modification of care as appropriate

Clustering of cares encourages a ***minimum handling approach*** and protects periods of deep sleep by minimizing the number of times an infant needs to be woken up or disturbed.

6- Sleep protection

As sleep is the main organizational state of the preterm baby, sleep protection is very important for optimal brain development. Sleep deprivation can have long term effects on growth and development. Understanding the infant's unique sleep/wake cycle and providing cue-based and clustered cares enables longer periods of uninterrupted sleep.

7- Minimize Stressful or painful procedures (pain management protocol)

8- Feeding support

Provide support for breastfeeding or alternatives as required.

9- Non-nutritive sucking

Provides opportunity for self-calming and is helpful in the transition to suck feeds. Offer the infant opportunities to suck on a dummy/pacifier or other suitable object, such as a (gloved) finger or their own hands and fingers.

10- Staffing practices

Provide continuity of caregivers whenever possible. Develop caregiver groups for longer stay infants.

11- Handling:

- Contain the infant using hands or a light swaddle to keep them in a flexed and contained position.
- Move infant slowly and keep them in contact with the supporting surface whenever possible.
- Ensure opportunity for positive touch is given to the infant by parents and caregivers.

12- Noxious stimuli

Minimize infant’s exposure to noxious stimuli such as strong fragrances, open alcohol swabs outside the incubator, clinical procedures and adhere to lighting and noise guidelines.

13- Kangaroo care

Provide opportunities for kangaroo care when possible. Kangaroo care is early, prolonged and continuous skin-to-skin contact between a parent and a low-birthweight infant. Kangaroo care has been shown to:

- Improve state organization,
- Reduce oxygen needs, improve respiratory patterns,
- Reduce apneas and bradycardias,
- Improve thermal regulation,
- Enhance parent infant bonding and a parental sense of competence,
- Enhance cognitive and motor development.

Kangaroo care can be used to facilitate early breast contact/feeding or be used for the simple pleasure of closeness, attachment and bonding.

References:

1- Kenner C and McGrath JM, *Developmental Care of Newborns and Infants*, 2nd Edition, 2010.

2- Als H, McAnulty GB. The Newborn Individualized Developmental Care and Assessment Program (NIDCAP) with Kangaroo Mother Care (KMC): Comprehensive Care for Preterm Infants. *Curr Women's Health Rev*. 2011;7(3):288–301.

Retinopathy of Prematurity

Retinopathy of prematurity (ROP) screening

- Retinopathy of prematurity (ROP), a proliferative disorder of the developing retinal blood vessels in preterm infants, may lead to poor visual acuity or blindness.

- Stages

Stage 1	Demarcation line separating avascular from vascularized retina
Stage 2	Ridge arising in region of demarcation line
Stage 3	Extraretinal fibrovascular proliferation/neovascularization extending into the vitreous
Stage 4	Partial retinal detachment
Stage 5	Total retinal detachment
Plus disease	Increased vascular dilatation and tortuosity of posterior retinal vessels in at least two quadrants of the retina
Pre-plus disease	More vascular dilatation and tortuosity than normal but insufficient to make the diagnosis of plus disease
Type 1 ROP	Zone I – any stage ROP with plus disease as well as stage 3 ROP without plus disease
	Zone II – stage 2 or 3 ROP with plus disease
Type 2 ROP	Zone I – stage 1 or 2 ROP without plus disease
	Zone II – stage 3 ROP without plus disease

Screening

- Neonates with birth weight of <1501 g or less and/or gestational age of <32 weeks or less (as defined by the attending neonatologist).
- In our setting:
    - Preterm neonates (≤36 weeks) receiving ventilation or significant supplemental O2.
    - Special attention should be paid to larger preterm neonates at risk of ROP who receive frequent RBC transfusions or exchange transfusions to treat anemia of prematurity or Rh hemolytic disease of the newborn.

Examination

- Ophthalmological notes should be made after each ROP examination.
- Pupil dilatation is done by using
    - A combination of Phenylephrine 2.5% and Cyclopentolate 0.5% eye drops. 1 drop of each only in each eye at 60 mins before the examination. Repeat the dose 5 minutes after the initial dose. Some babies with dark colored eyes may require a third dose 5 minutes after the second dose.
- All babies <32 weeks' gestation age or birth weight <1501 g should have their first ROP screening examination prior to discharge.

Timing of first examination

- Any preterm neonate of gestational age of 27 weeks or less should have the first fundus examination at postmenstrual age of 31 weeks.
- Any preterm neonate of gestational age of 28 weeks or more should have the first fundus examination at 4–6 weeks of chronological (postnatal) age.
- Any eligible stable preterm neonate planned for discharge prior to the scheduled fundus examination should have the first fundus examination before the time of discharge.

	Age at First examination	
Gestation Age (GA) at Birth	**Corrected GA (in weeks)**	**Age (in weeks)**
22 weeks	31	9
23 weeks	31	8
24 weeks	31	7
25 weeks	31	6
26 weeks	31	5
27 weeks	31	4
28 weeks	32	4
29 weeks	33	4
30 weeks	34	4
31 weeks	35	4
Older gestation < 1250g	GA + 4 weeks	4

Adapted from American Academy of Paediatrics.

Follow-up examinations as scheduled by experienced ophthalmologist.

ROP treatment

Treatment may also be initiated for the following retinal findings:

- Zone I ROP: Any stage with plus disease
- Zone I ROP: Stage 3 – no plus disease
- Zone II ROP: Stage 2 or 3 with plus disease

✓ Anti-vascular endothelial growth factor (anti-VEGF) therapy is a recent development in the treatment of ROP

- ✓ Intravitreal injection of bevacizumab (Avastin), a recombinant humanized monoclonal antibody, was shown to be more effective than conventional laser therapy in decreasing the recurrence of zone I but not posterior zone II ROP.
- ✓ The first post-operative examination should take place 5–7 days after treatment and should be continued weekly for signs of decreasing activity and regression.
- ✓ Re-treatment or seeking another opinion should be done 10–14 days after initial treatment when there has been a failure of the ROP to regress.

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References:

1- Al-Amro SA et. al Practical Guidelines for Screening and Treatment of Retinopathy of Prematurity in Saudi Arabia, *Saudi J Ophthalmol*. 2018 Jul-Sep; 32(3): 222–226.
2- AAP, *Updated Recommendations on Retinopathy of Prematurity*, AAP News, November 26, 2018.
3- AAP, *Retinopathy of Prematurity: AAP Updates Screening Policy*, Medscape. Monday, July 1, 2019.

PART III – Respiratory Problems and Ventilation

Neonatal Respiratory Distress

Respiratory problems are the most common problem seen in NICU, especially in preterm infants.

Birth initiates a dramatic change from the intrauterine state, in which the placenta is the primary organ of respiration, to life outside the uterus, in which the lung is the organ of gas exchange.

Causes of respiratory distress in the newborn

Pulmonary causes

- TTN.
- RDS.
- Pneumonia.
- MAS.
- Air leak syndromes.
- Pulmonary hemorrhage.

Extra-pulmonary causes

- Cardiac causes:
    - CHD (i.e., cyanotic or acyanotic).
    - CHF.
- PPHN.
- Neurological causes (e.g., prenatal asphyxia, meningitis).
- Diaphragmatic disorders (e.g., congenital diaphragmatic hernia, diaphragmatic paralysis).
- Chest wall deformities.
- Metabolic causes (e.g., hypoglycemia, hypothermia, or hyperthermia).
- Disturbances of acid-base equilibrium (e.g., metabolic acidosis).
- Hematological causes (e.g., anemia, polycythemia).

Management of neonatal respiratory distress

The initial approach to a neonate with respiratory distress, regardless of etiology, consists of:

- Relieving cyanosis with supplemental oxygen and providing assisted ventilation, if needed.
  A neonate with obvious respiratory distress needs continuous monitoring with pulse oximetry to decide when intubation and mechanical ventilation are required.
- Obtaining a chest radiograph to assist in diagnosis and to identify complications such as pneumothorax that may require urgent treatment.
- Providing an appropriate fluid management.
- Correction of any metabolic abnormalities (e.g., acidosis, hypoglycemia), if present.
- Providing adequate nutrition. In general, infants with sustained RRs over 60 breaths per minute should not be fed orally; these infants should be maintained on gavage feedings.
- Obtaining a blood culture and beginning antibiotic coverage with ampicillin and gentamicin while awaiting the results of the culture, in case of a preterm infant with respiratory distress or a term infant with respiratory distress that persists longer than four

to six (4-6) hours, or if sepsis or pneumonia is suspected by history or physical examination.
- Providing an appropriate specific therapy that is directed at the underlying disorder.

Respiratory distress syndrome

Introduction:

RDS is the commonest respiratory disorder in preterm infants. The clinical diagnosis is made in preterm infants with respiratory difficulty that includes tachypnea, retractions, grunting respirations, nasal flaring and need for ↑ FiO2.

In the last three decades, introduction of antenatal steroids and exogenous surfactant has greatly improved outcomes in RDS; however, it remains a principal clinical problem.

Epidemiology:

RDS affects 40,000 infants each year in the US and accounts for approximately 20% of neonatal deaths. RDS typically affects premature infants.

Clinical:

- Respiratory difficulty at birth that gets progressively worse
- Cyanosis (blue coloring)
- Flaring of the nostrils
- Tachypnea (rapid breathing)
- Grunting sounds with breathing
- Chest retractions (pulling in at the ribs and sternum during breathing)

Diagnosis:

- Clinical and radiological findings.

Prophylactic measures:

- Antenatal steroids preferably betamethasone given 24 hours to one week prior to delivery.
- Try to delay unnecessary preterm delivery of scheduled cases as much as possible like multiples and maternal disease.

Treatment:

- Respiratory support (see respiratory support protocol)
- Surfactant (see surfactant section)
- Fluids
- Nutrition

References:

1- Polin R, Yoder M, *Workbook in Practical Neonatology*, 5th edition, 2014. Saunders.
2- Donn SM, Sinha SK. (Eds.), *Manual of Neonatal Respiratory Care*, 2017, Springer.
3- Rimensberger P, *Pediatric and Neonatal Mechanical Ventilation: From Basic to Clinical Practice*, 2015, Springer.

Mechanical Ventilation and Oxygen Therapy

Always try not to intubate unless really indicated and if so try to extubate as early as possible

Conventional PPV:

Always volume targeted ventilation is preferred to be used in neonates and premature babies over pressure controlled, a VT of 4-6ml/kg and a set maximum PIP of 25-30 cm H2O

- In infants, PPV is usually pressure-limited and time-cycled (if new machines are available volume targeted ventilation is much better option).
- This means that no more than the pre-set pressure can be generated and that respiratory rate is set by adjusting inspiratory (Ti) and expiratory (Te) times.
- With each breath, there is a PIP (VT in volume targeted), a PEEP, and a PAW.
- Raising PEEP increases FRC (in most cases) and reduces/prevents atelectasis. If PIP is not changed, raising PEEP reduces tidal volume and lowering PEEP increases tidal volume, when ventilation is pressure-limited.
- Prolonging Ti allows more time for expansion of the lungs and is useful to treat widespread atelectasis. With localized atelectasis, a long Ti may worsen the infant's condition by over-expanding non-atelectatic areas of lung and reducing venous return and pulmonary blood flow.
- It is seldom necessary to use gas flows >10 L/min. Flows of 6 to 8 L/min are usual.
- Tidal volume is generated by the difference between PIP and PEEP. Changing PIP or PEEP independently of the other may increase or decrease tidal volume.
- Oxygenation is primarily a function of FiO2 and PAW (mean airway pressure).
- Changes in PAW during a single breath by changing one or each of the following: (1) inspiratory flow, (2) PIP, (3) Ti, and (4) PEEP.
- Ti is usually set at 0.3 to 0.4 sec (almost always).
- As lung disease improves (especially after surfactant administration), reduce ventilator pressures to prevent lung injury.
- With each change in ventilator settings, document the infant's responses in **SpO2** and arterial blood gas tensions.
- Measurements of arterial pH and blood gas tensions should be made 15-30 min after each ventilator change during the acute phase of the disease.
- Major Modes – SIMV, AC, PSV, SIMV+PSV.

Table 1: Adjustment of ventilation

Condition	Management Strategies
High $PaCO_2$ (>55 mmHg)	Increase ventilator rate, if Ti & Te are not too short Increase PIP Consider decreasing PEEP, if >5 cmH_2O
Low or normal $PaCO_2$	Decrease PIP, decrease rate
Low PaO_2	Increase FIO_2 (see Table 1) Increase $\overline{P}_{AW}$ by raising PEEP (or Ti, PIP and/or flow)
High PaO_2	Decrease FIO_2 Decrease PEEP (see Table 1).

Table 2: Relation between FiO2 requirement and PAW to be set

FIO_2	Mean Airway Pressure
<0.25	5
0.25-0.30	6-7
0.31-0.40	7-9
0.41-0.50	8-10
0.50-0.60	9-11
>0.6	>10

References:

1- Rimensberger P, *Pediatric and Neonatal Mechanical Ventilation: From Basic to Clinical Practice*, 2015, Springer.
2- USCF Benioff Children's Hospital, *Intensive Care Nursery House Staff Manual, Mechanical Ventilation*, 2004.
3- Polin R, Yoder M, *Workbook in Practical Neonatology*, 5th edition, 2014. Saunders.

Continuous Positive Airway Pressure (CPAP)

Definition

Non-invasive respiratory support utilizing continuous distending pressure during inspiration and expiration in spontaneously breathing babies

Benefits

- Improves oxygenation
- Reduces work of breathing
- Maintains lung volume
- Lowers upper airway resistance
- Conserves surfactant

Indications

- Early onset respiratory distress in preterm babies
- Respiratory support following extubation
- Respiratory support in preterm babies with evolving chronic lung disease
- Recurrent apnea (in preterm babies)
- Atelectasis
- Tracheomalacia

CPAP following extubation

- Consider in babies of <32 weeks' gestation.

Contraindications

- Any baby fulfilling the criteria for ventilation
- Irregular respirations
- Pneumothorax without chest drain
- Nasal trauma/deformity that might be exacerbated by use of nasal prongs
- Larger, more mature babies often do not tolerate application of CPAP devices well
- Congenital anomalies:
    - Diaphragmatic hernia
    - Choanal atresia
    - Tracheoesophageal fistula
    - Gastroschisis

Types of CPAP

1. Standard CPAP
2. Two-level CPAP
3. Bubble CPAP

Pressure range

- Start at 5-6 cm H_2O initially and increase by 1 cm H_2O increments.

- Optimum pressure depends on illness type and severity – watch baby and use lowest pressure required to improve work of breathing.

High pressures (≥10 cm H_2O) may restrict pulmonary blood flow, increase air leak risk and cause over-distension.

CPAP 'failure'

'Failure of CPAP' implies a need for ventilation. Consider intubation for preterm babies on CPAP if any of the following apply:

- FiO2 >0.4
- Marked respiratory distress
- Persistent respiratory acidosis
- Recurrent significant apnea
- Irregular breathing

Checks: Before accepting apparent CPAP 'failure' exclude:

- Pneumothorax
- Insufficient pressure
- Insufficient circuit flow
- Inappropriate prong size or placement
- Airway obstruction from secretions
- Open mouth

Complications

- Erosion of nasal septum: reduce risk by careful prong placement and regular reassessment.
- Gastric distension: benign, reduce by maintaining open nasogastric tube.

Weaning CPAP

When

- Start when baby consistently requiring FiO2 <0.30, pressure 5 cm H_2O and stable clinical condition.
- If nasal tissue damage is significant, consider earlier weaning

How: 'Pressure reduction' or 'Time off'

- **Pressure reduction**
  - More physiological approach although can increase the work of breathing if pressure is too low.
  - Has been shown to be quicker than ‘time off’ mode.
  - Wean pressures in steps of 1 cm H_2O every 12–24 hours till pressure reaches 3 cm H_2O
  - If no deterioration, discontinue CPAP after 24 hours of 4 cm H_2O and minimal oxygen requirement.

- **Time off CPAP**
  - Plan using 2 x 12 or 3 x 8 hour time periods
  - The following regimen of cycling CPAP can be adapted to individual situations:
  -

Day 1	1 hour off twice a day (1 off, 11 on)
Day 2	2 hour off twice a day (2 off, 10 on)
Day 3	3 hour off twice a day (3 off, 9 on)
Day 4	4 hour off twice a day (4 off, 8 on)
Day 5	6 hour off twice a day (6 off, 6 on)
Day 6	Off CPAP

Note: High-flow humidified oxygen therapy

- Increasingly used as non-invasive respiratory support.
- Offers theoretical advantages over CPAP in ventilating upper airway spaces and producing less nasal tissue damage.
- When weaning CPAP, consider using 5–6 L/min of high-flow humidified oxygen rather than low-flow nasal cannulae oxygen or lower pressure CPAP.

Failure of weaning

- Increased oxygen requirement,
- Increasing frequency of apneas,
- Increasing respiratory distress and/or worsening respiratory acidosis.

References:

1- Rimensberger P, *Pediatric and Neonatal Mechanical Ventilation: From Basic to Clinical Practice*, 2015, Springer.
2- Polin R, Yoder M, *Workbook in Practical Neonatology*, 5th edition, 2014. Saunders.

High Frequency Oscillatory Ventilation (HFOV)

Definition:

High frequency oscillatory ventilation (HFOV) is a method of mechanical ventilation that employs supra-physiological breathing rates and tidal volumes that are frequently less than dead space.

Ventilation strategies:

The preferred method used in the application of high frequency ventilation is the high lung volume strategy.

- This means that with higher mean airway pressure, alveolar recruitment and elimination of atelectasis there is improved oxygenation (high lung volume strategy).
- Low lung volume strategies should NOT be used.

The table below documents differences between HFOV and Conventional ventilation (CV):

Differences	***Conventional***	***HFOV***
Respiratory Rates	0-150/min	180-900/min
Tidal Volume	4-20 ml/kg	0.1 -3 ml/kg
Alveolar pressure	0-50 cm H_2O	0.1-5 cm H_2O
End expiratory volume	Normalized	Low
Gas flow	Low	High

Indications

- Rescue following failure of conventional ventilation (e.g. PPHN, MAS).
- To reduce barotrauma when conventional ventilator settings are high.
- Air leak (pneumothorax, PIE).

Terminology

Frequency	High frequency ventilation rate (Hz, cycles/sec)
MAP	Mean airway pressure (cm H_2O)
Amplitude	Delta P or Power is the variation around the MAP

Mechanism

Oxygenation and CO2 elimination are independent.

Oxygenation depends on MAP and FiO2	MAP provides constant distending pressure equivalent to CPAP, inflating the lung to constant and optimal lung volume, maximizing area for gas exchange and preventing alveolar collapse in the expiratory phase
Ventilation (CO2 removal) depends on amplitude	The wobble superimposed around the MAP achieves alveolar ventilation and CO2 removal

Management

Initial settings on HFOV MAP

Optimal (high) lung volume strategy (aim to maximize recruitment of alveoli)	• If changing from conventional ventilation, set MAP 2-4 cm H2O above MAP on conventional ventilation • If starting immediately on HFOV, start with MAP of 8 cm H2O and increase in 1-2 cm H2O increments until optimal SpO2 achieved • Set frequency to 10 HZ
Low volume strategy (aim to minimize lung trauma)	• Set MAP equal to MAP on conventional ventilation • Set frequency to 10 Hz

Optimal (high) volume strategy is preferred but consider low volume strategy when air leaks are present.

Amplitude (delta P on SLE ventilator)

- Gradually increase amplitude until chest is seen to wobble well.
- Obtain early blood gas (within 20 min) and adjust settings as appropriate.
- Frequency 8-12 in term, and 10-14 in premature.

Making adjustments once HFOV established

	Poor oxygenation	**Over-oxygenation**	**Under-ventilation**	**Over-ventilation**
Either	Adjust MAP (+/- 1-2 cm H_2O)*	Decrease MAP (1-2 cm H_2O) when FiO2 <0.4	Increase amplitude	Decrease amplitude
Or	Increase FiO2	Decrease FiO2	Decrease frequency (2nd line)	Increase frequency (2nd line)

Chest X-ray

- Within 1 hour to determine baseline lung volume on HFOV (aim for 8 ribs at midclavicular line).
- If condition changes acutely and/or daily to assess expansion/ETT position, repeat chest X-ray.

Troubleshooting on HFOV

Chest wall movement

- Suction indicated for diminished chest wall movement indicating airway or ETT obstruction.
- Always use an in-line suction device to maintain PEEP.
- Increase FiO2 following suctioning procedure.

- MAP can be temporarily increased by 2-3 cm H_2O until oxygenation improves.

Low PaO_2

- Suboptimal lung recruitment
    - Increase MAP
    - Consider chest X-ray
- Over-inflated lung
    - Reduce MAP: does oxygenation improve? Check blood pressure
    - Consider chest X-ray
- ETT patency
    - Check head position and exclude kinks in tube
    - Check for chest movement and breath sounds
    - Check there is no water in ETT/T-piece
- Air leak/pneumothorax, transillumination: urgent chest X-ray

High $PaCO_2$

- ETT patency and air leaks (as above)
    - Increase amplitude: does chest wall movement increase?
- Increased airway resistance (MAS or BPD) or non-homogenous lung disease: is HFOV appropriate?

Persisting acidosis/hypotension

- Over-distension
    - Exclude air leaks; consider chest X-ray
    - Reduce MAP: does oxygenation improve?

Spontaneous breathing

- Usually not a problem but can indicate suboptimal ventilation (e.g. kinking of ETT, build-up of secretions) or metabolic acidosis.

Weaning

- Reduce FiO2 to <0.4 before weaning MAP (except when over-inflation is evident).
- When chest X-ray shows evidence of over-inflation (>9 ribs), reduce MAP.
- Reduce MAP in 1-2 cm decrements to 8-9 cm 1–2 hourly or as tolerated.
- If oxygenation is lost during weaning, increase MAP by 3-4 cm and begin weaning again more gradually. When MAP is very low, amplitude may need increasing.
- In air leak syndromes (using low volume strategy), reducing MAP takes priority over weaning the FiO2.
- Wean the amplitude in small increments (5-15%) depending upon PCO_2

Do not wean the frequency

- When MAP <8 cm H_2O, amplitude 20–25 and blood gases satisfactory, consider switching to conventional ventilation or extubation to CPAP.

References:

1- Rimensberger P, *Pediatric and Neonatal Mechanical Ventilation: From Basic to Clinical Practice*, 2015, Springer.
2- USCF Benioff Children's Hospital, *Intensive Care Nursery House Staff Manual, Mechanical Ventilation*, 2004.
3- Polin R, Yoder M, *Workbook in Practical Neonatology*, 5th edition, 2014. Saunders.

Surfactant Replacement Therapy

- ❖ Early CPAP and selective administration of surfactant is preferable to routine intubation and prophylactic surfactant.
- ❖ Early administration of natural surfactant decreases the risk of acute pulmonary injury and neonatal mortality.
- ❖ Use of INSURE (INtubate–SURfactant–Extubate to CPAP) technique for early surfactant administration reduces the need for ventilation and improves survival.
- ❖ Natural surfactant preparations are superior to protein-free synthetic preparations containing only phospholipids for reducing mortality and air leaks.
- ❖ Multiple rescue doses result in greater improvements in oxygenation and ventilatory requirements, a decreased risk of pneumothorax and a trend toward improved survival.

Indications

- Intubation should be reserved for babies who have not responded to positive pressure ventilation via face mask. Babies who require intubation for stabilization should be given surfactant.
- Babies with RDS should be given rescue surfactant early in the course of the disease. A suggested protocol would be to treat babies ≤26 weeks' gestation when FiO2 requirements >0.30 and babies >26 weeks' when FiO2 requirements >0.40.
- INSURE (INtubation-SURfactant-Extubation) should be considered for infants who are failing on CPAP.
- Less Invasive Surfactant Administration (LISA) or Minimally Invasive Surfactant Therapy (MIST) may be used as alternatives to INSURE for spontaneously breathing infants.
- A second and sometimes a third dose of surfactant should be administered if there is evidence of ongoing RDS such as persistent oxygen requirement and need for MV.

Other babies that can be considered for surfactant therapy (after discussion with consultant):

- Ventilated babies with meconium aspiration syndrome (may need repeat dose after 6–8 hours).
- Term babies with pneumonia and less compliant lungs.

Procedure

Preparation

- Calculate dose of surfactant required and warm to room temperature.
- Ensure correct endotracheal tube (ETT) position.
    - Check ETT length at lips.
    - Listen for bilateral air entry and look for chest movement.
    - If in doubt, ensure ETT in trachea using laryngoscope and adjust to ensure bilateral equal air entry.

- Chest X-ray before first dose.
- Invert surfactant vial gently several times, without shaking, to re-suspend the material.
- Draw up required dose.

Instillation

- With baby supine, instill prescribed dose down ETT.
- Wait for recovery of air entry/chest movement and oxygenation between boluses.

Post-instillation care

- Do not suction ETT for first 6 hours after instillation (routine frequent suction is not indicated in surfactant-deficiency disease for 48 hours, can be done if there is signs of blockade of ETT).
- Be ready to adjust ventilator/oxygen settings in response to changes in chest movement, tidal volume and oxygen saturation.

Subsequent management

- If baby remains ventilated at FiO2 >0.3 with a mean airway pressure of >7 cm H_2O, give further dose of surfactant 6-12 hours after first dose.
- Third dose should be given only at request of attending consultant.

References:

1- Rimensberger P, *Pediatric and Neonatal Mechanical Ventilation: From Basic to Clinical Practice*, 2015, Springer.
2- Polin R, Yoder M, *Workbook in Practical Neonatology*, 5th edition, 2014. Saunders.

Apnea of Prematurity

Definition

Apnea is defined as no effective respiratory effort for 20 seconds or shorter if associated with bradycardia <100 bpm, cyanosis or pallor.

Classification:

1. Central apnea: a pause of alveolar ventilation due to immaturity of neurological controls. There is a complete cessation of both chest movement and airflow.
2. Obstructive apnea: a pause in alveolar ventilation due to obstruction of the upper airway (usually at the level of the pharynx). There may or may not be respiratory effort but there is no airflow – not detected by motion sensing monitors (10-25% of all apnea).
3. Mixed apnea: a combination of central and obstructive apnea (50-75% of all apnea).

Apnea of prematurity:

- Is a diagnosis of exclusion <37 weeks.
- Apnea occurs in:
    - Most infants < 30 weeks
    - About 50% of infants at 30-32 weeks
    - About 10% of infants at 34 weeks
- Apnea usually resolves by the time the infant is 36 weeks of postmenstrual age.
- Infants at risk of apnea should have cardiorespiratory monitoring +/- oxygen saturation monitoring. Alarms should be set appropriately with heart rate 100 beats per minute and apnea delay at 20 seconds. When alarms are triggered, the infant should be assessed for color, perfusion, position, respiratory rate and effort, heart rate, oxygen saturation and state.
- Consider causes other than apnea of prematurity if apnea occurs in:
    - Term, near-term babies >34 weeks,
    - On day 1 of life in preterm <34 weeks,
    - After 7 days of age in preterm <34 weeks.

Investigations

- A thorough physical examination is mandatory with emphasis on cardiorespiratory and neurological status.
- Usually a septic screen and blood glucose estimation will be required.
- Further tests are determined by the need to look for specific conditions causing or aggravating apnea.

Management

- **Managing the acute apneic episode**
  1. Stimulate, e.g. tickle or flick the feet or stroke the abdomen.

2. Position the neck in a neutral position or slightly extended to minimize airway obstruction.

4. Bag and mask ventilation if still no response, using the amount of oxygen the infant was receiving prior to the apnea (not 100%). Only increase the concentration of oxygen (by steps of 5-10%) if the infant's condition fails to improve despite effective bag and mask ventilation.

5. Use ongoing positive pressure ventilation if there is still no response.

- **Managing specific causes**
  Treatments will depend on the specific cause of the apnea.

- **Symptomatic management:**
  - Attention should be given to positioning the infant to avoid obstruction of the upper airway.
  - Feeds may be given more frequently as smaller boluses to avoid excessive distension of the stomach.
  - Some infants benefit from maintaining their thermal environment in the lower part of the neutral thermal range.
  - Positive pressure ventilation: CPAP; if failed try biphasic CPAP.
  - When uncontrolled by other means, intubation and positive pressure ventilation will be required.

Pharmacological management

Dosages	Theophylline (orally) / aminophylline (IV infusion)	Caffeine citrate (dose expressed as caffeine base)
Loading dose	6 mg/kg	A loading dose of 20 mg/kg of caffeine citrate (equivalent to 10 mg/kg caffeine base) is given intravenously, or enterally.
Dose	2.5 mg/kg/dose every 12 hours (increased if necessary to 3.5 mg /kg/dose 12 hourly) staring 24 hours after initial dose	5 to 10 mg/kg per dose (equivalent to 2.5 to 5 mg/kg caffeine base) is started 24 hours after the loading dose, which can also be administered either intravenously or orally.
Side effects	Jitteriness, irritability, seizures, hyperglycemia, vomiting, abdominal distension/feeding intolerance, electrolyte imbalances	Irritability, Seizures, tachycardia, hypertension, hypo-/hyperglycemia, fluid and electrolyte imbalance, GI irritation

- **When to stop the medication?**
  Medication is usually stopped when the infant is ≥34 weeks gestation and apnea free for 1 to 2 weeks. Monitoring is continued for a further week after medication is stopped. Data are lacking on when to discontinue caffeine therapy. You may consider discontinuing caffeine earlier between 32 and 34 weeks and there have been no apneic episodes requiring intervention for approximately five days. It takes up to seven days for caffeine

to be totally eliminated from the neonate, so it should be stopped at least 5 days before discharge.

References:

1- Gaza Neonatal Network, *Apnea of Prematurity*, Gaza Neonatal Network Protocols 2015.
2- Auckland District Health Board, *Newborn Services Clinical Guideline*, NZ, 2018 Update.
3- Schmidit et al, *Caffeine for Apnea of Prematurity*, RCT, 2006.

Chronic Lung Disease

Definition

	Gestational age	
	<32 weeks	≥32 weeks
Time of assessment	36 weeks CGA or discharge	>28 days, but <56 days postnatal age or discharge
Treatment with oxygen	≥28 days	≥28 days
	Bronchopulmonary dysplasia	
Mild	In air at 36 weeks CGA or discharge	In air by 56 days postnatal age or discharge
Moderate	<30% oxygen at 36 weeks CGA or discharge	<30% oxygen at 56 days postnatal age or discharge
Severe	≥30% oxygen +/- CPAP or ventilation at 36 weeks CGA or discharge	>30% oxygen +/- CPAP or ventilation at 56 days postnatal age or discharge

Target saturations ≥94% at 36 weeks CGA.

Investigations at time of assessment.

- Blood gas
- Chest X-ray: homogenous opacification of lung fields developing after first week of life or coarse streaky opacities with cystic translucencies in lung fields.
- Echocardiography to rule out pulmonary hypertension or structural pathology
- Electrocardiography to rule out pulmonary hypertension
- Overnight oximetry study

Treatment

Preventive measures as Optimizing ventilation strategies

- Volume-targeted/volume-guarantee ventilation is preferred mode for surfactant-deficient lung disease.
- If using pressure limited ventilation, use lowest possible ventilator pressures to deliver appropriate tidal volumes to minimize volutrauma/barotraumas.

Optimize nutrition

- Ensure adequate calorie intake (≥120 kcal/kg/day) because of increased work of breathing.
- If growth unsatisfactory, involve dietitian.
- Avoid fluid overload.

Corticosteroids

- If ventilator-dependent and requiring increasing or persistently high oxygen intake, consider using corticosteroids.

- Treatment with corticosteroids (dexamethasone/hydrocortisone) is a consultant-led decision.
- Inform parents of potential short-term and long-term adverse effects.
- Obtain oral consent and record in notes.
- The DART protocol for dexamethasone administration of intravenous dexamethasone (cumulative dose 0.89 mg/kg) is as follows:
    - 0.075 mg/kg per dose 12 hourly for three days, then,
    - 0.05 mg/kg per dose 12 hourly for three days, then,
    - 0.025 mg/kg per dose 12 hourly for two days, then,
    - 0.01 mg/kg per dose 12 hourly for two days, then cease.
- If respiratory status worsens after initial improvement, consider repeating course of corticosteroids.

Monitoring while on corticosteroids

- Daily BP and urinary glucose.

Diuretics

- Use of diuretics to improve lung function. Diuretics of choice are chlorothiazide and spironolactone (use of spironolactone can be guided by serum potassium). Stop if no response in 1 week.

Monitoring treatment

Continuous

- Aim for SpO2 of 90–94% until 36 weeks CGA.
- After 36 weeks CGA, maintain SpO2 ≥94% to prevent pulmonary hypertension.
- Warm and humidify supplemental oxygen unless on low-flow oxygen.
- Monitor weight and head growth.
- Assess for gastro-esophageal reflux.
- Aim to stop diuretic therapy before discharge.

Discharge and follow-up

- If still oxygen-dependent at time of discharge.
- Long-term neuro-developmental and respiratory follow-up.

References:

1. Eichenwald EC, *Bronchopulmonary Dysplasia*, UpToDate, April 2019.
2. Sunnybrook Hospital, *NICU Protocol*, Toronto, 2015.

Air Leak Syndromes

The air leak syndromes, such as pneumomediastinum, pneumothorax, pulmonary interstitial emphysema (PIE) and pneumopericardium, comprise a spectrum of diseases with the same underlying pathophysiology.

Over-distension of alveolar sacs or terminal airways leads to disruption of airway integrity, resulting in dissection of air into the surrounding spaces.

These syndromes are most commonly seen in infants with lung diseases who are on ventilator supports; however, they can also occur spontaneously.

The more severe the lung disease, the higher is the incidence of pulmonary air leak.

Risk factors

- Ventilatory support.
- Lung over distention from high tidal volume (volutrauma) is more injurious than high peak inspiratory pressure (PIP) (barotrauma).
- MAS.
- Surfactant therapy without decreasing pressure support in ventilated infants.
- Vigorous resuscitation.
- Prematurity with stiff lungs.
- Pneumonia.

Types

Pneumothorax

- Pneumothorax refers to a collection of gas or air in the pleural sac resulting in collapse of the lung on the affected side. It may be seen as an isolated finding or may be associated with other forms of lung disease (particularly RDS and MAS).
- Spontaneous pneumothorax:
    - May be asymptomatic or only mildly symptomatic (i.e., tachypnea and increasing O_2 needs, progressing to classic signs of respiratory distress).
    - If the infant is on ventilatory support, he/she will have sudden onset of clinical deterioration characterized by cyanosis, hypoxemia, hypercarbia, and respiratory acidosis associated with decreased breath sounds and shifted heart sounds.
- Tension pneumothorax:
    - This is a life-threatening condition caused by air in the pleural space that is under pressure.
    - With tension pneumothorax, compression of major veins and decreased cardiac output occurs, and signs of obstructive shock will be evident.
    - In this circumstance, urgent drainage prior to a radiograph is mandatory.
- A chest X-ray may show just minimal differences in lucence of lung fields (in the case of spontaneous pneumothorax) or may show jet black lung and shift of mediastinum to the opposite side (in the case of tension pneumothorax).

Pulmonary interstitial emphysema (PIE)

- PIE is dissection of air into the perivascular tissues of the lung. This interstitial air can be localized or can spread to involve a significant portion of the lung.
- PIE is most commonly seen in small preterm infants with significant RDS, usually in the first 48 hours of life.
- With over distention of the alveoli, rupture may occur and there may be dissection of the air into the interstitial tissues. Air can dissect towards the hilum and the pleural surface through connective tissue surrounding the lymphatics and pulmonary vessels or through the lung interstitium. Pneumothorax and pneumomediastinum may occur.
- PIE affects pulmonary mechanics by decreasing compliance and enhancing ventilation/perfusion (V/Q) mismatch. BPD is a common sequel.
- Chest X-ray may reveal radiolucencies that are either linear or cyst-like in nature. Linear lucencies radiate from the lung hilum and the cyst-like lucencies vary from 1 to 4 mm in diameter.

Pneumomediastinum

- Pneumomediastinum is defined as free air or gas contained within the mediastinum, almost invariably originating from the alveolar space or the conducting airways.
- Pneumomediastinum can occur with aggressive ETT insertion or Nasogastric feeding tube insertion, neonatal lung disease, mechanical ventilation, or chest surgery or other invasive procedures such as in TEF.

Pneumopericardium

- Pneumopericardium is the least common form.
- Air accumulates in the pericardium around the heart with gradual heart compression and tamponade. Pneumopericardium should be suspected in any ventilated newborn with acute hemodynamic deterioration.

Others

- Pneumoperitoneum.
- Subcutaneous emphysema.
- Systemic air embolism.

Clinical manifestations

- Clinical diagnosis is based on the presence of respiratory distress or sudden deterioration in the infant's clinical status with an alteration in vital signs such as cyanosis or bradycardia.
- In cases with unilateral pneumothorax, asymmetry of the thorax will be noted with hyper-resonant chest on percussion and shift of mediastinum to the opposite side.

Investigations

- Blood gas analysis may show respiratory and/or metabolic acidosis with hypoxemia.

- Chest X-ray (anterior-posterior and lateral views) is the gold standard test for diagnosis of air leak and differentiation of the type.
- With the transillumination test, using a fiber-optic light source to the side of the chest, in pneumothorax cases the light will spread all over the affected side. This test is more sensitive in preterm babies as they have thin chest walls.

N.B.: Needle aspiration should be done for suspected cases of pneumothorax with deteriorating general condition until intercostal tube is inserted.

Management

- Prevention:
    - Judicious use of ventilatory support; close attention to distending pressures, both PIP and positive end expiratory pressure (PEEP); inspiratory time; and appropriate weaning of ventilatory support as the clinical condition improves.

- General management of respiratory distress (as mentioned before).

- Specific therapy:
    - *Conservative therapy*: Close observation of the degree of respiratory distress as well as oxygen saturation, without any other intervention aiming at spontaneous resolution and absorption of air. This management plan can be used more in spontaneous pneumothorax and non-ventilated cases.
    - Decompression of air leak according to the type (intercostal tube insertion in case of pneumothorax).

References:

1- Hansen AR, *Cloherty and Stark's Manual of Neonatal Care*, 8th edition, 2017.
2- Gleason CA, Devaskar SU (Ed.), *Avery's Diseases of the Newborn*, 9th edition, 2012.
3- Gomella TL et al., *Neonatology: Management, Procedures, On-Call Problems, Diseases and Drugs*, 7th edition, 2013.
4- Auckland District Health Board, *Newborn Services Clinical Guideline*, NZ, 2018 Update.

Persistent Pulmonary Hypertension of the Newborn (PPHN)

Definition

- Failure of normal postnatal fall in pulmonary vascular resistance.
- Leads to right-to-left shunting and subsequent hypoxia.
- Can be primary (idiopathic) or secondary.
- Severe hypoxemia.
- Complex condition with varied causes and degrees of severity.
- Echocardiogram: structurally normal heart (may show right ventricular hypertrophy), right-to-left or bidirectional shunt at PFO and/or patent ductus arteriosus (PDA).

Idiopathic

- Degree of hypoxia disproportionate to degree of hypercarbia.
- Mild lung disease (in primary/idiopathic PPHN).

Secondary

May be associated with:

- Severe lung disease [e.g. meconium aspiration (MAS), surfactant deficiency].
- Perinatal asphyxia.
- Infection [e.g. group B streptococcal (GBS) pneumonia].
- Structural abnormalities: pulmonary hypoplasia, congenital diaphragmatic hernia, A-V malformations, congenital cystic adenomatoid malformation (CCAM).
- Maternal drugs: aspirin, non-steroidal anti-inflammatory drugs, SSRIs.

Clinical features

- Usually present in first 12 hours of life.
- SpO2 <95% or hypoxia (PaO2 <6 kPa) in FiO2 1.0.
- Mimics cyanotic heart disease.
- CVS: tricuspid regurgitant murmur, right ventricular heave, loud second heart sound and systemic hypotension.
- Idiopathic PPHN: respiratory signs mild or absent.
- Secondary PPHN: features of underlying disease.

Investigations

- Blood gas shows hypoxemia (PaO2 <6 kPa) (mmHg value = kPa value x 7.50062) with oxygenation index <20 (underlying disease will produce a mixed picture).
- SpO2 >5% difference in pre and postductal saturations (pre > post).
- Hyperoxia test (100% oxygen for 5 min).
- SpO2 may improve to ≥95% in early stage or may not respond, i.e. staying <95% in established PPHN (as in cyanotic heart disease).

- Chest X-ray: variable findings depending on underlying diagnosis (normal or minimal changes in idiopathic PPHN).
- Electrocardiograph: often normal. Can sometimes show tall P waves in lead 2/V1/V2 or features of RVH (i.e. tall R waves V1/V2, right axis deviation or upright T waves in V1/V2).
- Echocardiogram (although not mandatory for initial diagnosis and management) is useful:
    - To exclude cyanotic heart disease,
    - To assess pulmonary pressure,
    - To evaluate ventricular function,
- One or more of the following confirm PPHN in presence of normal cardiac structures:
    a) Significant tricuspid regurgitation,
    b) Dilated right side of heart,
    c) Right-to-left shunting across PFO and/or PDA,
    d) Pulmonary regurgitation.

Management

Aims of management are to:

- Decrease pulmonary vascular resistance,
- Increase systemic blood pressure,
- Treat any underlying condition.

General measures

- Minimal handling, nurse in quiet environment.
- Sedation, pain management and possibly muscle relaxants
- Secure arterial and central venous access.
- Maintain normal temperature, biochemistry and fluid balance.
- Keep Hb ≥120 g/L.
- Give antibiotics (sepsis, particularly GBS, is difficult to exclude).
- Surfactant may be beneficial in MAS or GBS sepsis.
- If perfusion poor, fluid bolus (sodium chloride 0.9% 10 mL/kg).

Ventilation

- Use conventional ventilation to start with (targeted tidal volume 5-6 mL/kg).
- Use sedation and muscle relaxation in babies with high ventilatory and oxygen requirements and/or ventilator asynchrony.
- PaCO2 4.5-5.5 kPa (accept up to 6 kPa in parenchymal lung disease). Avoid hypocarbia.
- Start in 100% oxygen and reduce as tolerated. Maintain SpO2 at 96-100% and PaO2 at 10-12 kPa.
- High frequency oscillatory ventilation (HFOV) may further improve oxygenation.
- Monitor oxygenation index (OI).

Inotropes

- Use inotropes early (*consider milrinon*).

- In significant PPHN, adrenaline or noradrenaline can be useful in increasing systemic blood pressure without increasing pulmonary vascular resistance.
- Maintain systemic mean BP 45-55 mmHg in term baby and systemic systolic BP 60-70 mmHg or above estimated pulmonary pressures.

Pulmonary vasodilatation

- If OI >20 or needs 100% oxygen, or significant PPHN on echo, use inhaled nitric oxide (NO) as a selective pulmonary vasodilator.
- There is no good evidence supporting use of Magnesium sulfate for PPHN in neonates

Severe and resistant PPHN not responding to conventional management may benefit from ECMO.

Criteria for considering ECMO:

- Baby born ≥34 weeks or ≥2 kg with PPHN,
- Not responding or OI >30 despite NO, inotropes and/or HFOV, or
- Unable to maintain BP with inotropes or persistent need for adrenaline/noradrenaline infusion, or
- No significant progression after 3 days.

Criteria for ECMO

- Baby born ≥34 weeks or ≥2 kg with PPHN,
- Oxygenation index >40,
- Reversible lung disease (<10 days high pressure ventilation),
- No lethal congenital malformation.

Exclusion criteria (if in doubt, discuss with ECMO team)

- Major intracranial hemorrhage,
- Irreversible lung injury or mechanical ventilation >10 days,
- Lethal congenital or chromosomal anomalies,
- Severe encephalopathy,
- Major cardiac malformation.

References:

1- Stark et al, *Persistent Pulmonary Hypertension of the Newborn*, UpToDate, Dec 2018.
2- Hansen AR, *Cloherty and Stark's Manual of Neonatal Care*, 8th edition, 2017.
3- Gleason CA, Devaskar SU (Ed.), *Avery's Diseases of the Newborn*, 9th edition, 2012.
4- Gomella TL et al., *Neonatology: Management, Procedures, On-Call Problems, Diseases and Drugs*, 7th edition, 2013.
5- Auckland District Health Board, *Newborn Services Clinical Guideline*, NZ, 2018 Update.

Congenital Diaphragmatic Hernia (CDH)

Introduction

CDH is a congenital defect in the diaphragm resulting in herniation of abdominal contents into the thoracic cavity; associated with a high risk of mortality and morbidity. A combination of hypoplasia and abnormal morphology of the pulmonary vasculature leads to severe respiratory insufficiency and increased risk of developing persistent pulmonary hypertension.

Recognition and assessment

Antenatal diagnosis

- Delivery to be planned at level III neonatal intensive care unit (NICU).
- Pediatric surgeon to provide antenatal counselling.
- Neonatal team to meet parents before delivery.

Postnatal diagnosis

- In some babies, the lesion develops later in gestation; these babies tend to have a better prognosis.
- Postnatal presentation can be with clinical features ranging from inability to resuscitate baby at birth to incidental finding on chest X-ray.

In cases diagnosed postnatally, there may be early respiratory distress in association with a scaphoid abdomen and heart sounds shifted usually to the right. Mask inflation will often cause deterioration as air is delivered into herniated gut resulting in cardiorespiratory embarrassment.

Investigations

- Pre and post ductal SpO2
- Chest X-ray
- Arterial blood gas
- Echocardiogram

Immediate management at delivery

Key principles

- Intubate all antenatally diagnosed babies promptly (intubation to be carried out by most experienced and reliable operator present).
- Optimize endotracheal tube position and size, aiming for little or no leak, with largest size tube feasible.
- Do not give mask ventilation.
- Maintain low peak pressure <25 cm H_2O to avoid lung damage.
- Avoid high airway pressures.
- Establish adequate perfusion and oxygenation.
- Aim for pre ductal SpO2 85-95%.

- Insert large gauge 8-10 Fr nasogastric tube.
- Aspirate at least every 5 min to decompress stomach until baby is established on ventilation, then place on free drainage.
- Examine baby for other associated abnormalities:
    - Cardiac
    - Trisomy 18/21
    - Urogenital
    - Musculoskeletal

Management on NICU

Babies with CDH fare better with minimal handling.

- Weigh baby.
- Ventilate on HFOV, or SIMV TTV if well.
- Sedation: morphine 20 micrograms/kg/hour and muscle relaxant.
- Umbilical venous and arterial catheters.
    - If not possible to site umbilical arterial catheter (UAC), insert peripheral arterial line.
- Monitor pre and post ductal SpO2.
- On admission, maintain arterial blood pressure at normal level for gestational age.
- Cardiac echocardiogram (ideally within 6 hours of birth) to:
    - Exclude associated congenital cardiac disease,
    - Assess right ventricular function,
    - Look for evidence of persistent pulmonary hypertension,
    - Identify patent ductus arteriosus and assess shunting.
- Avoid peak pressures >25 cm H_2O.
    - If greater peak pressures required to maintain preductal SpO2 >85%, discuss HFOV with consultant.

HFOV [see Ventilation: high frequency oscillatory (HFOV) guideline]

- Initial setting:
    - MAP: 12 cm H_2O (do not increase >16 cm H_2O),
    - Rate/frequency: 10 Hz, delta P 25.
- Chest X-ray 1 hour after commencing HFOV.
    - If >8 rib spaces visible, lungs are hyper-inflated: reduce MAP.

Systemic blood pressure support

- Invasive blood pressure monitoring required.
- In the presence of PPHN, maintain mean arterial pressure >55 mmHg.
- Treat hypotension or poor tissue perfusion (rising lactate, urine output <1 mL/kg/hour) with sodium chloride 0.9% 10-20 mL/kg fluid bolus.
- In persistent hypotension give inotropes:
    - Start dobutamine 10 microgram/kg/min and increase to 20 microgram/kg/min.
    - Start dopamine at 10 microgram/kg/min.

    - If hypotension persists, increase to 20 microgram/kg/min.
- If right ventricular failure on echocardiogram, start adrenaline.

Metabolic acidosis

- Review vasoconstrictor effects versus benefits of inotropes.
- Correct metabolic acidosis with sodium bicarbonate; give full correction over 12-24 hours.

References;

1- Hansen AR, *Cloherty and Stark's Manual of Neonatal Care*, 8th edition, 2017.
2- Gleason CA, Devaskar SU (Ed.), *Avery's Diseases of the Newborn*, 9th edition, 2012.
3- Gomella TL et al., *Neonatology: Management, Procedures, On-Call Problems, Diseases and Drugs*, 7th edition, 2013.
4- Auckland District Health Board, *Newborn Services Clinical Guideline*, NZ, 2018 Update.

Congenital Chylothorax

Definition:

Chylothorax is caused by disruption or obstruction of the thoracic duct that results in leakage of chyle (lymphatic fluid of intestinal origin) into the pleural space. Incidence is 1 in 10,000 births. Mortality is 10-30%.

Drainage of congenital chylothorax results in the loss of lymphocytes and bears a high risk of sepsis, malnutrition and electrolyte disturbance.

Causes:

It is usually idiopathic but may be associated with Turners, Downs and most commonly encountered after cardiac surgery.

Management:

Antenatal management:

- Refer to a tertiary maternity unit: Consider thoracentesis or pleural-amniotic shunts to prevent pulmonary hypoplasia.

After Birth

- Provide respiratory support as necessary.
- Investigations: CXR shows pleural effusion. Consider ultrasound to estimate the size of the effusion.
- If there is significant respiratory compromise (RR>60, O2 Saturations <92%, FiO2 >40%, requiring CPAP or ventilation), insert a chest drain to drain pleural fluid.
- Biochemical analysis of fluid indicates chylothorax: Triglycerides >100 mg/dl and total cell count of >1000 cells/ml with >80% lymphocytes.
- If infant is not feeding, triglycerides and chylomicrons may be normal. Total cell count & lymphocyte count may be used for diagnosis.
- Check FBC with differential for evidence of lymphopenia.

Ongoing management:

- Refer to a tertiary neonatal unit/ children hospital.
- Investigations: Echocardiogram, chromosomal analysis, TORCH.
- Medium chain triglyceride formula (Monogen) or TPN for 4 weeks. If clinical deterioration or failure to resolve after 24 hours, consider insertion of further chest drain.
- After 5 days conservative management if fails to resolve, start Octreotide (1-10 ug/kg/hour IV gradually).
- When stopping to drain chyle from chest tube, wean over 48 hours.
- Refractory cases (without resolution after 2 weeks conservative management) require cardiothoracic surgical assessment.

- Surgical interventions include pleurodesis, thoracic duct ligation and pleuroperitoneal shunt.
- Administer immunizations as normal.

References:

1- Bedside Clinical Guidelines Partnership, *Neonatal Guidelines 2017-19,* Staffordshire, Shropshire and Black Country Neonatal Operational Delivery Network and Southern West Midlands Neonatal Operational Delivery Network.

2- Auckland District Health Board, *Newborn Services Clinical Guideline*, NZ, 2018 Update.

Hydrops Fetalis

Definitions:

- Diagnostic criteria are: fluid in at least two body cavities (pleural space, pericardial space, peritoneal space, skin or placental enlargement).
- Immune Vs, non-immune.
- Immune hydrops is mainly caused by Rh isoimmunization (refer to Rh isoimmunization treatment).
- High mortality rates despite optimal treatment (up to 60%).

Delivery and resuscitation:

All babies with hydrops fetalis diagnosed antenatally should be delivered in a tertiary center with level 4 NICU.

It is important to prepare equipment before delivery (including chest tubes, high frequency ventilation).

Causes:

A very long list of causes: 25% of cases are due to cardiovascular problems, including fetal arrhythmia or congenital heart disease, chromosomal anomalies, congenital infections, hematological genetic and metabolic causes. 20% of cases remain idiopathic.

Investigations:

1- CBC, hemoglobin electrophoresis if evidence of anemia.
2- Biochemistry including liver and kidney function.
3- ECG and echocardiography.
4- TORCH profile and viral PCR if CMV IgM is positive.
5- Ultrasound of the chest and abdomen.
6- X-rays of the chest, abdomen and skeletal survey in some cases.
7- Karyotype and DNA for separation.
8- Specific metabolic testing according to metabolic disease department consultation.

Treatment:

Immediate neonatal management

- An expert team, including a neonatal consultant must attend delivery of a baby diagnosed with having hydrops fetalis as resuscitation and stabilization can be difficult.
- Manage according to Neonatal resuscitation program(NRP)).

Ventilation

- Ensure adequate oxygenation and ventilation, consider chest tubes.

- May require high frequency oscillatory ventilation [see High frequency oscillatory ventilation (HFOV) guideline] and muscle relaxation.
- If pulmonary hypertension present, may require nitric oxide (see Nitric oxide guideline).

Cardiovascular system

- Use inotropes to support heart and blood pressure
- If intravascular fluid depletion, give colloid.
- Strict fluid balance.
- If severe compromise may require further pleural and ascitic taps.

References:

1- Bedside Clinical Guidelines Partnership, *Neonatal Guidelines 2017-19,* Staffordshire, Shropshire and Black Country Neonatal Operational Delivery Network and Southern West Midlands Neonatal Operational Delivery Network.
2- Auckland District Health Board, *Newborn Services Clinical Guideline,* NZ, 2018 Update.

Oxygen Saturation Targets in NICU

Supplemental oxygen must always be monitored.

There are risks of too little or too much oxygen.

1. Preterm infants are at risk of ROP with high levels.
2. Term infants are at risk of pulmonary hypertension if hypoxemic.
3. Babies with chronic lung disease are at risk of pulmonary vascular disease if hypoxic.

Infants	Saturation Range	Alarm Limits
Preterm <36 weeks	90-94%	89-95%
Term (≥ 36 weeks) or post-term	90-99% **In the first 24 hours, 95-99%**	90-99% **In the first 24 hours, 95-99%**
CLD **AND** 36 weeks PMA	90-95%	88-96%

- Always wean FiO2 whenever max target limit has been reached.
- Target Fio2 is always 21%.

Reference:

Auckland District Health Board, *Newborn Services Clinical Guideline*, NZ, 2018 Update.

Pulmonary Hemorrhage in Premature Infants

Definition:

Pulmonary hemorrhage is an acute, catastrophic event characterized by discharge of bloody fluid from the upper respiratory tract or the endotracheal tube. The incidence is 1 in 1,000 live births.

When evident clinically, P-Hem is usually massive, is associated with bleeding in other sites, involves more than one third of the lungs, and has a high mortality rate.

Etiology & pathogenesis:

Prematurity is the most common risk factor. Hypothermia, infection, and Respiratory Distress Syndrome are strongly associated factors.

Clinical features:

The onset of P-Hem is characterized by oozing of bloody fluid from the nose and mouth or endotracheal tube with associated rapid worsening of the respiratory status, cyanosis and, in severe cases, shock. Bleeding may be noted from other sites. Radiographic findings range from patchy infiltrates to complete opacification of lung fields. Hematocrit of the P-Hem fluid is usually 15 to 20% less than blood.

Treatment & outcome:

1- Immediate treatment of P-Hem should include tracheal suction, oxygen and positive pressure ventilation.
2- To assist in decreasing P-Hem, mean airway pressure should be increased, either by a relatively high PEEP (i.e., 6 to 10 cm H_2O) or by high frequency ventilation.
3- Correct underlying abnormalities, especially disorders of coagulation.
4- When blood loss is large, prompt blood transfusion may be needed to maintain an adequate circulating blood volume.

The outcome is dependent on the cause of P-Hem.

Mortality is 30 to 40% in best centers and reaches 60% in very preterm infants.

Reference:

Gomella TL et al., *Neonatology: Management, Procedures, On-Call Problems, Diseases and Drugs*, 7th edition, 2013.

Babies Affected by Intrauterine Growth Restriction (IUGR)

Definitions and classification:

- AGA, appropriate for gestational age: Birth weight is between 10th and 90th percentile for infant's gestational age (GA).
- LGA, large for gestational age: Birth weight >90th percentile for GA.
- SGA, small for gestational age: Birth weight <10th percentile for GA. Other definitions are sometimes used for SGA, including <3rd percentile for GA or more than 2 S.D below the mean.
- IUGR vs. SGA: IUGR refers to deviation and reduction in expected fetal growth Pattern. Multiple adverse conditions inhibit normal fetal growth potential. Not all IUGR infants are SGA.

Asymmetric vs. symmetric growth retardation:

Most growth retarded infants have asymmetric growth restriction with a relative "head sparing" effect.

This asymmetric growth is more commonly due to extrinsic influences that affect the fetus later in gestation, such as preeclampsia, chronic hypertension, and uterine anomalies.

Postnatal growth after IUGR depends on cause of growth retardation, postnatal nutritional intake, and social environment.

Symmetric growth retardation affects all growth parameters. In the human brain, most neurons develop prior to the 18th week of gestation. Early gestational growth retardation would be expected to affect the fetus in a symmetric manner, and thus have permanent neurologic consequences for the infant.

Examples of etiologies for symmetric growth retardation include genetic or chromosomal causes, early gestational intrauterine infections (TORCH) and maternal alcohol use.

Assessment and management:

- Treat asphyxia if present.
- Measure weight, head circumference and length to categorize the type of IUGR.
- Careful physical examination for anomalies and dysmorphic features.
- Blood glucose and hematocrit to detect hypoglycemia and polycythemia.
- Serum Ca++, WBC count with differential and platelet count.
- Infants with IUGR due to placental factors have ↑ O2 consumption. This ↑ insensible water loss to a variable degree (as much as 20-30%). Compensate for this by increasing IV fluid intake.

- These infants may also need greater intake (>150 mL/kg/d and >100 kcal/kg/d) to achieve adequate growth.
- Further workup and treatment depends on abnormalities identified on history and physical examination: TORCH profile, placental pathology, genetic consult.

Reference:

Hansen AR, *Cloherty and Stark's Manual of Neonatal Care*, 8th edition, 2017.

Late Preterm Infant – Care and Management

Late preterm infants are infants born at a gestational age between 34 0⁄7 weeks and 36 6⁄7 weeks. They have higher morbidity and mortality rates than term infants (gestational age ≥37 weeks) due to their relative physiologic and metabolic immaturity, even though they are often the size and weight of some term infants.

"Late preterm" has replaced "near term" to describe this group of infants, since near term incorrectly implies that these infants are "almost term" and only require routine neonatal care.

Risks associated with the late preterm infant

The late preterm infant is at increased risk of the following:

1. Hypoglycemia.
2. Hypothermia.
3. Respiratory distress and/or apnea.
4. Sepsis.
5. Hyperbilirubinemia.
6. Feeding difficulties.
7. Poor weight gain.
8. Psychosocial issues.

Birth suite management

- A pediatrician or clinician with experience in neonatal resuscitation should be in attendance if the gestation is 34.0 - 36.6 weeks or the baby is expected to have a birth weight < 2.5 kg.
- Provide immediate skin-to-skin contact with mother, dry infant on mother's chest.
- If no respiratory distress, attempt feeding within the first hour of life, and subsequently feed 3 hourly.
- Perform weight and blood glucose level (BGL) prior to leaving birthing suite (within 2-4 hours of birth) or BGL earlier if clinical signs of hypoglycemia.
- Determine if small for gestational age, appropriate for gestational age, or large for gestational age.
- Hourly axillary temperatures and vital signs should be performed for 4 hours from birth.
- Identify maternal or fetal risk factors that may impact the infant's ability to transition to extra-uterine life, and /or impact the ability for these babies to be managed on the post-natal ward.

Observations

Vital signs

- The baby should have temperature, heart rate and respiratory rate/effort performed following admission to the ward and then prior to feeds for at least 24 hours.
- Assessment of level of activity and color should be documented with vital signs.

- Any abnormal vital signs should be reported to the pediatric team for medical review.
- Temperature checks should continue before each feed.

Weighing of baby

- The baby should be weighed after the first hour to allow time for skin to skin contact.
- A weight loss of greater than 10% requires a medical review and feeding plan instigated.
- After day 3, it is expected that the baby will gain at least 10g/kg/day.
- Babies of 34 - 35.6 week's gestation at birth should not be discharged until they have regained their birth weight.
- Babies 36 - 36.6 week's gestation at birth should not be discharged unless they are gaining weight and heading back towards their birth weight.
- More mature babies (weighing < 2.5 kg) should not be discharged until they are approaching birth weight.
- Consider the need for fortification or supplementation of breast milk or formula if infant is not meeting targeted weight gains.

Temperature control

- The newborn baby may require an extra blanket or cardigan to stay warm (on top of a singlet, nappy, jump suit, blanket).
- The baby should only have their first bath once their observations and blood glucose levels are normal.
- If the baby's temperature remains ≤ 36.0°C despite warming (e.g., radiant heater), they should have a medical review and be admitted to the NICU.
- Staff need to be aware that temperature instability may be a sign of sepsis and should be reported to the medical team for further investigation.

Feeding the late preterm infant

- Breastfeeding is recommended and should be supported and encouraged.
- Breastfed babies should not be offered complementary feeds unless frequent (at least 3 hourly) breastfeeding is associated with:
    - Hypoglycemia,
    - There is significant weight loss (>10% birth weight), or
    - Poor weight gain despite frequent breastfeeding.
- The baby should be fed as soon as stable within the first hour after birth and 3 hourly until they have regained their birth weight.

Parent education

Provide ongoing support and education for parents (feeding, clothing, bathing, sleep position, weight gain).

Discharge of the late preterm infant

The baby may be discharged home when the following criteria are met:

- Baby is medically stable, assessed by pediatrician.
- Most often ≥ 36 weeks corrected age.
- Has had adequate weight gains and approaching birth weight.
- Feeding well at the breast and / or bottle or cup.
- Sucking all feeds for 48 hours.
- Temperature maintained for 48 hours.
- Age appropriate urine and stool output.
- Parent(s) are agreeable to taking the baby home and able to manage daily care.
- Parents are supported and encouraged to contact the hospital if they have any concerns following discharge.
- Arrangements are made for pediatric follow up.

References:

1- Hansen AR, *Cloherty and Stark's Manual of Neonatal Care*, 8th edition, 2017.
2- Gleason CA, Devaskar SU (Ed.), *Avery's Diseases of the Newborn*, 9th edition, 2012.
3- Gomella TL et al., *Neonatology: Management, Procedures, On-Call Problems, Diseases and Drugs*, 7th edition, 2013.

PART IV: Cardiovascular Problems

Hypotension in Neonatal Population

Background

Hypotension is a common problem in the neonatal period and is associated with multiple adverse outcomes, including increased mortality, intraventricular hemorrhage, adverse neurodevelopmental outcomes and increased incidence of hearing loss. Nevertheless, there is no clear evidence that treating isolated hypotension in the first 24 hours of life improves outcome.

Definition:

There is no universal definition of 'normal' blood pressure for neonates; a frequently used definition of hypotension is that of a mean blood pressure below the gestational age in weeks, or alternatively a value below the 5th or 10th centile in a birth weight and gestational age reference range. Blood pressure itself is a poor marker for the more important consideration of systemic blood flow, but it is the only measure available to us easily in the neonatal unit.

Clinical significance

1- **In a well-baby**, i.e. one that is passing urine, has good perfusion, is easy to ventilate, is not acidotic, does not have a high lactate, or is not septic, taking the mean blood pressure as around the gestational age is appropriate. Alternatively use the birth weight and the table below.

Birth weight	**10^{th} percentile for mean blood pressure**
500-750 grams	26 mmHg
750-1000 grams	28 mmHg
1000-1250 grams	29 mmHg
1250-1500 grams	30 mmHg
2000-2999 grams	32 mmHg
3000-3999 grams	36 mmHg
4000 grams	42 mmHg

If the blood pressure is lower than these criteria, treat it.

Birth weight	**Average mean arterial blood pressure**
500-750 grams	35 mmHg
750-1000 grams	38 mmHg
1000-1250 grams	39 mmHg
1250-1500 grams	40 mmHg
2000-2999 grams	41 mmHg
3000-3999 grams	47 mmHg
4000 grams	52 mmHg

Technical Issues and considering possible causes

Invasive monitoring is the most accurate. Cuff blood pressures are usually higher than arterial line readings, anywhere up to 15 mmHg, and may be falsely reassuring.

Consider:

Patent ductus arteriosus, hypovolemia, blood loss, pneumothorax, sepsis (particularly in persistent or late hypotension), adrenocortical insufficiency in extreme prematurity, high mean airway pressure on mechanical ventilation, intraventricular hemorrhage, necrotizing enterocolitis, metabolic disorders, electrolyte problems and congenital heart disease.

Treatment guideline:

Normal Saline	Give one to two boluses of 10-15 ml/kg over 20 minutes. Equal response to 5% albumin infusion but fewer repeat doses of volume were needed and a lower weight gain was seen over 48 hours, with no difference in serum [Na+] in the one trial. Saline similar to albumin/FFP in effect. Volume (albumin in the published paper) is less consistent at increasing BP than dopamine and starting dopamine should not be delayed if hypotension persists.
Dopamine	Start at 5 mcg/kg/min and increase incrementally to a maximum of 20 mcg/kg/min. Increases BP. More consistent response at a lower dose with a bigger increase in BP than dobutamine.
Dobutamine	Start at 5 mcg/kg/min and increase incrementally to a maximum of 20 mcg/kg/min. Dobutamine is added to dopamine in persistently hypotensive infants, when the dopamine dose has been increased to 10-20 mcg/kg/min. Some evidence that improves systemic blood flow better than dopamine.
4% Albumin	This is an alternative to Normal Saline. There is limited data on the relative merits of each in the treatment of neonatal hypotension. A small study showed a trend towards increased mortality in those treated with albumin consistent with the findings in larger adult studies.

Blood	Use ‘whole’ blood as volume support if the baby is also relatively anemic. If volume expansion is desired, do not give furosemide with the blood.
Hydrocortisone	2.5 mg/kg IV 4 hourly x 2 then 6 hourly x 48 hours, then 1.25 mg/kg 6 hourly x 48 hours, then 0.625 mg/kg 6 hourly x 48 hours. Not for routine use. Consider in preterm infants with refractory hypotension who may have relative adrenocortical insufficiency. Increases BP a little less consistently but to a greater extent than with dopamine.
Dexamethasone	0.1-0.25 mg/kg/dose. Studies of dexamethasone for ventilator dependence shows a fairly rapid increase in BP and ability to wean off inotropes.
Adrenaline	100-300 nanograms/kg/minute, incrementally, higher doses occasionally required. 1. May be considered as additional therapy in refractory hypotension such as septic shock or asphyxial cardiac compromise. 2. As effective as dopamine as single therapy at low doses but with increased side effects. Use with caution and only after a decision by a specialist.
Noradrenaline	0.05-0.5 mcg/kg/min, incrementally. Primarily raises systemic vascular resistance. It may produce a reflex reduction in cardiac output and can produce coronary artery changes. Very little (if anything) published on its use in the newborn. Use with caution and only after a decision by a specialist.

References:

1- Batton B et al, Use of Antihypotensive Therapies in Extremely Preterm Infants. *Pediatrics* 2013;131.
2- Hansen AR, *Cloherty and Stark's Manual of Neonatal Care*, 8th edition, 2017.
3- Gaza Neonatal Network, *Gaza Neonatal Network Protocols*, Revised 2014.

Duct-Dependent Congenital Heart Disease Lesions

Duct-dependent congenital heart disease can be broadly divided into 3 categories:

- Mixing lesions, e.g., transposition of great arteries. Usually presents as cyanosis (‘blue baby’).
- Obstruction to pulmonary circulation, e.g., pulmonary or tricuspid atresia, Fallot’s tetralogy, critical pulmonary stenosis. Usually presents as cyanosis (‘blue baby’).
- Obstruction to systemic circulation, e.g., HLHS, critical aortic stenosis, coarctation of aorta, interrupted aortic arch. Usually presents as poor perfusion (shock).

Differential diagnosis of central cyanosis ('blue baby') or persistently low SpO2 (<95%)

Cyanosis is the abnormal blue discoloration of skin and mucous membranes.

Without echocardiography, clinical distinction between significant persistent pulmonary hypertension (PPHN) and a duct-dependent pulmonary circulation can be extremely challenging, If duct-dependent lesion, discuss commencing prostaglandin with a consultant even if in doubt about cause.

- Cardiac causes of central cyanosis
    - Duct-dependent lesions (see above)
    - Other cardiac conditions e.g., anomalous pulmonary venous drainage, Fallot’s tetralogy, truncus arteriosus, etc.
- Respiratory causes of central cyanosis
    - Persistent pulmonary hypertension
    - Other respiratory conditions, e.g., congenital pneumonia, pneumothorax, meconium aspiration, congenital diaphragmatic hernia, respiratory tract obstruction
- Other rare causes of central cyanosis
    - Methemoglobinemia

Differential diagnosis of babies presenting with poor perfusion (shock)

- Cardiac causes of shock
    - Duct-dependent lesion (see above)
    - Other cardiac causes, e.g., arrhythmias (supraventricular/ventricular) tachycardia), cardiomyopathy etc.
- Other causes of shock
    - Sepsis, bleeding, dehydration, metabolic

Recognition and assessment of duct-dependent lesions

- In-utero (antenatal) diagnosis:
    - Deliver at neonatal intensive care unit (NICU) equipped for serious congenital heart disease.

    - Stabilize before non-urgent transfer to regional pediatric cardiac center for full cardiology assessment.
    - If urgent septostomy anticipated for closed or small (restrictive) atrial septum, cardiologists may recommend delivery at tertiary center.
    - Neonatal team meet parent(s) pre-delivery.
    - In some cases of HLHS or complex congenital heart disease, comfort care plan may be in place antenatally – clarify with cardiac team and parents before delivery.
    - When delivery expected, notify on-call neonatal consultant and pediatric cardiology team.
- Postnatal:
    - Some babies, particularly if left heart lesion developed later in gestation, will present when duct closes.
    - Can happen at any time during neonatal period and early infancy.
    - Baby often asymptomatic before duct closes.
    - A baby presenting with cyanosis or shock is a neonatal emergency requiring consultant input. These babies can deteriorate very quickly.
- Symptoms and signs of duct-dependent cardiac disease:
    - Central cyanosis and/or SpO2 <95%,
    - Poor perfusion and shock,
    - Weak or absent femoral pulses,
    - Usually limited signs of respiratory distress,
    - Murmur (in some),
    - Hepatomegaly or other signs of cardiac failure.

Investigations

- Chest X-ray
    - Oligemia/plethora/congenital anomaly
    - 'Classic' appearance (e.g. 'boot-shaped' heart) is unusual
- Blood gas including lactate
- Echocardiogram if available
- Blood pressure in right upper limb and a lower limb (>20 mmHg difference between upper and lower limb is abnormal)
- Preductal (right upper limb) and postductal (lower limb) saturations (SpO2 of <95% in both limbs or >3% difference is significant)
- Hyperoxia test to differentiate between respiratory (parenchymal) and cardiac cause of cyanosis including baseline saturation (and blood gas if arterial line in situ)
    - Place baby in 100% ambient oxygen for 10 min.
    - If there is respiratory pathology, PaO2 >150 make cyanotic CHD unlikely.

Immediate management

- Discuss commencement of prostaglandin infusion urgently with consultant.
- Discuss urgently with cardiac center.
- Immediate post-delivery and resuscitation.

- If antenatally diagnosed duct-dependent lesion, neonatal team should be present at delivery.
- If baby requires resuscitation do not delay.
- Check SpO2 using pulse oximetry.
- Once stable, transfer baby to NICU immediately in transport incubator (if on saturation monitor, SpO2 75–85% should be acceptable for babies with antenatal diagnosis of duct-dependent cyanotic heart lesion).
- If cyanotic heart lesions suspected and not confirmed postnatally, manage initially by trying to achieve maximum SpO2 possible.
- Stable babies with normal breathing and SpO2 ≥75% may not require intubation.

Management in NICU

- Aim to maintain patency of (or open a closed) ductus arteriosus, and optimize systemic perfusion
- Commence prostaglandin infusion (as per antenatal plan if known) through peripheral IV line, or long line:
    - 2 venous lines access recommended to ensure reliable infusion.
    - Unless access extremely difficult, avoid umbilical venous line [cardiac unit may need umbilical venous catheterization (UVC) for septostomy].
- Use dinoprostone (prostaglandin E2, prostin E2).
    - Start IV infusion at 5-15 nanogram/kg/min as indicated; dose may be increased up to 50 nanogram/kg/min if no response within 1 hour.
    - If dinoprostone not available, use prostaglandin E1 (Alprostadil).
    - Make fresh solution every 24 hours.
    - If apnea occurs secondary to a prostaglandin infusion, intubate baby but do not reduce infusion dose.
- Discuss management with cardiac team.
- Echocardiogram if available.

Monitor

- SpO2, Heart rate and ECG, blood gases (including lactate) and avoid acidosis, blood pressure (preferably using a peripheral arterial cannula – avoid umbilical lines).
- Avoid hypothermia.
- Ventilation:
    - Severe hypoxemia, acidosis and cardiorespiratory failure
    - Apnea after starting prostaglandin infusion dose >20 nanogram/kg/min
    - Features of high pulmonary flow in case of HLHS
    - Elective ventilation, if preferred by pediatric cardiologist or retrieval team lead
    - Technique:
        - Use sedation/muscle relaxants as needed.
        - Avoid hyperventilation, can increase pulmonary blood flow.
        - Use supplemental oxygen judiciously if SpO2 <75%.
        - Aim for: SpO2 75–85% (although many will run higher in room air).

- Inotropes:
    - If signs of peripheral under-perfusion, discuss using fluid boluses and inotropes (e.g. dobutamine, milrinone etc.) with cardiac center.
    - Arrange local echocardiography (if available) to assess contractility.

Restrictive atrial septum

Signs:

- Severe cyanosis.
- Cool peripheries.
- Pallor.
- Respiratory distress.
- X-ray signs of oligemic lung with relatively normal heart size.
- In contrast, if atrial septum is nonrestrictive, pulmonary congestion with cardiomegaly and prominent right heart border is likely.
- May require balloon atrial septostomy as an urgent procedure.

High pulmonary blood flow (especially in left-sided lesions such as HLHS)

Presentation

If there is too much pulmonary blood flow due to pulmonary 'steal' phenomenon, baby may have:

- High or near normal saturations,
- Metabolic acidosis with a rising lactate,
- Low blood pressure (especially low diastolic),
- Cool peripheries.
- Tachycardia.

Management

- Aim is to improve perfusion and acidosis by balancing systemic versus pulmonary circulation.
- Discuss urgently with cardiac center.
- Intubate and ventilate (technique as above).
- Fluid boluses and inotropes as needed.

References:

1- Altman CA, *Identifying Newborns with Critical Congenital Heart Disease*, UpToDate, 2015, https://www.uptodate.com/contents/identifying-newborns-with-critical-congenital-heart-disease.
2- Cucerea M. et. al, Congenital Heart Disease Requiring Maintenance of Ductus Arteriosus in Critically Ill Newborns Admitted at a Tertiary Neonatal Intensive Care Unit, *J Crit Care Med* (Targu Mures). 2016 Oct; 2(4): 185–191.
3- Tomar M. Neonatal Cardiac Emergencies: Evaluation and Management. J Intensive & Crit Care 2016, 2:1.

Patent Ductus Arteriosus

Persistent patency of the ductus arteriosus (PDA) is a failure of functional ductal closure by 48 hours or anatomical closure by age of 3 weeks.

Factors associated with delayed closure:

- Prematurity (significant PDA affects 30% of VLBW babies)
- Lack of antenatal corticosteroid prophylaxis
- Surfactant-deficient lung disease
- Hypoxemia
- Volume overload

Adverse effects of PDA

- Hemodynamic consequences of left-to-right shunt in preterm babies can prolong ventilatory support and are associated with mortality and morbidity (CLD, pulmonary hemorrhage, IVH, NEC, and ROP).
- Increased pulmonary blood flow (leading to increased work of breathing and respiratory deterioration).
- Reduced systemic blood flow (leading to acidosis and hypotension).

Symptoms and signs

- Can be absent even in the presence of a significant duct in first 7 days of life.
- A significant left-to-right shunt is suggested by:
    - Bounding pulses and wide pulse pressure (i.e. >25 mmHg).
    - Hyperdynamic precordium (excessive movement of precordium).
    - Low-pitched systolic or continuous murmur over left upper sternal edge (absence of a murmur does not exclude significant PDA).
- Signs of cardiac failure (tachypnea, tachycardia, hepatomegaly, pulmonary edema, generalized edema etc.)
- Poor perfusion (hypotension, poor capillary refill, mottled skin and persistent acidosis).
- Increased or persistent ventilatory requirements.

Investigations

- SpO2 monitoring
- Chest X-ray (cardiomegaly? pulmonary plethora?).
- Echocardiography: to detect duct-dependent cardiac lesions and other cardiac pathologies that is difficult to exclude clinically.
    - If considering treatment with prostaglandin inhibitor
    - Echocardiographic assessment of significant PDA includes:
        - Size of PDA (>1.5 mm),
        - Volume loading of left atrium (LA/aorta ratio >1.5),
        - Volume loading of left ventricle,

- Velocity and flow pattern of ductal flow.

Immediate treatment

General measures

- Optimize oxygenation by appropriate ventilatory management.
  - Use of a higher PEEP (i.e. ≥5 cm H_2O) can help minimize effects of pulmonary edema and risk of pulmonary hemorrhage.
- Treat anemia – maintain Hb ≥10.0 g/L with blood transfusion (consider concurrent dose of furosemide IV).
- Before starting medication, restrict fluid intake to 60–80% (e.g. from 150 mL/kg/day to 90-120 mL/kg/day).
- If fluid overload or pulmonary edema, give 1 dose of furosemide IV.

Specific measures

- Aim to convert hemodynamically significant PDA into insignificant PDA as complete duct closure may take weeks or months.
- Pharmacological treatment with prostaglandin inhibitor to initiate closure.

Ibuprofen

- The drug of choice in UK (Indomethacin is not currently available in the UK).
  - Best used aged ≤2 weeks but can be effective ≤6 weeks.
  - Given to babies born <34 weeks' gestation with significant PDA – on clinical and/or echocardiographic assessment.
  - Includes ventilatory/CPAP dependent babies or PDA with hemodynamic effects (i.e. cardiac failure or poor perfusion).
  - Monitor babies with non-significant PDA carefully and treat if becomes significant.
- Contraindications to ibuprofen:
  - Duct-dependent cardiac lesion.
  - Significant renal impairment: urine output <1 mL/kg/hour or creatinine >120 micromol/L.
  - Significant thrombocytopenia, i.e., platelet count <50 $x10^9$ /L (course started or next dose given only after platelet transfusion).
  - Suspected or definite necrotizing enterocolitis (NEC).
  - Active phase of significant bleeding (gastrointestinal or severe intracranial – treat coagulopathy before starting).
- Dose:
  - Calculate carefully and prescribe individually on single dose part of prescription chart so that contraindications are checked before each dose.
  - Administer in accordance with Neonatal Formulary.
  - Ibuprofen has similar efficacy to indomethacin but fewer renal side effects (can be used in babies with mild or previous renal dysfunction).
  - The standard dosing of ibuprofen for PDA closure for both oral and intravenous administration is an initial dose of 10 mg/kg followed by two additional doses of 5

mg/kg given at 24-hour intervals. Ibuprofen is typically given as an intravenous (IV) preparation in developed countries.

- However, the IV preparation is expensive and many nurseries in developing countries use oral ibuprofen for PDA closure. In a systematic review, it appears that the oral administration of ibuprofen is equally as effective as IV administration.

Indomethacin

- Initial dose of Indomethacin 200 micrograms, followed by 100 or 200 micrograms per dose every 24 hours.
- A repeat echocardiogram should be performed within 24 hours of the third dose and a further 2 doses of indomethacin given if the DA remains patent.
- Contraindicated in renal failure, thrombocytopenia (platelets < 60) or in infants with hypocoagulation (for these infants, we administer a course of acetaminophen (paracetamol) when it is decided that directed pharmacologic therapy should be given).
- Indomethacin is not a contraindication to feeding.
- If the DA remains patent, a second course of indomethacin may be used, preferably at the higher dose.
- Infants are very unlikely to respond to a third course.

Paracetamol

- There is growing evidence for the efficacy of paracetamol in DA closure but no evidence to suggest superiority to indomethacin and not been shown to protect against IVH.
- The safety profile of paracetamol is better than indomethacin.
- Paracetamol may also be considered:
    - When Indomethacin is contraindicated.
    - In infants who have previously not responded to indomethacin.
- A five day course of 15 mg/kg 6 hourly is recommended.

Subsequent management

Monitoring pharmacological treatment

Check before each dose:

- Creatinine (maintained <120 micromol/L)
- Urine output (maintained >1 mL/kg/hour)
- Platelet count (kept ≥50 x 10^9/L with platelet infusions if needed)
- Concomitant nephrotoxic drug, e.g., gentamicin/vancomycin (monitor levels carefully or use alternative non-nephrotoxic drug)
- Feed tolerance (feeds cautiously initiated or continued during treatment – briefly stopped during actual infusion)
- Clinical signs of PDA and baby's progress
- Echocardiography (if clinically indicated), repeated after 2–3 days of completion
- Fluid gradually liberalized after treatment based on:
    - Daily weight (weight gain suggests fluid retention)

- Serum sodium (dilutional hyponatremia common)

Persistence or recurrence of asymptomatic PDA

- Persistence of murmur does not necessarily indicate return of PDA.
- Echocardiogram sometimes demonstrates physiological branch pulmonary stenosis.
- If baby with asymptomatic murmur is making progress, plan echocardiography before discharge to decide follow-up.

Persistent significant PDA and surgical referral

- If PDA significant after 48 hours of completion of first course of prostaglandin inhibitor, use second course of ibuprofen.
- If PDA still significant but baby making progress (i.e. can be extubated or come off CPAP):
  - Commence regular diuretics (furosemide + amiloride/spironolactone) to help control hemodynamic,
  - Monitor closely.

If PDA still significant and baby ventilatory or CPAP dependent, discuss with cardiac center for surgical ligation when:

- Prostaglandin inhibitor contraindicated.
- Prostaglandin inhibitor not indicated (≥34 weeks with cardiac failure not controlled by diuretics).
- Prostaglandin inhibitor ineffective (usually after giving second course).

Discharge policy for persistent PDA

- If PDA persistent clinically or echocardiographically at discharge or at 6 weeks follow-up, arrange further follow-ups in cardiac clinic (locally or at cardiac center depending on local practice).
- If PDA reviewed locally still persistent at aged 1 year or if clinically significant during follow-up (cardiac failure or failure to thrive), refer to pediatric cardiologist at regional cardiac center to consider closure.
- First option is usually catheter closure.
  See Algorithm below

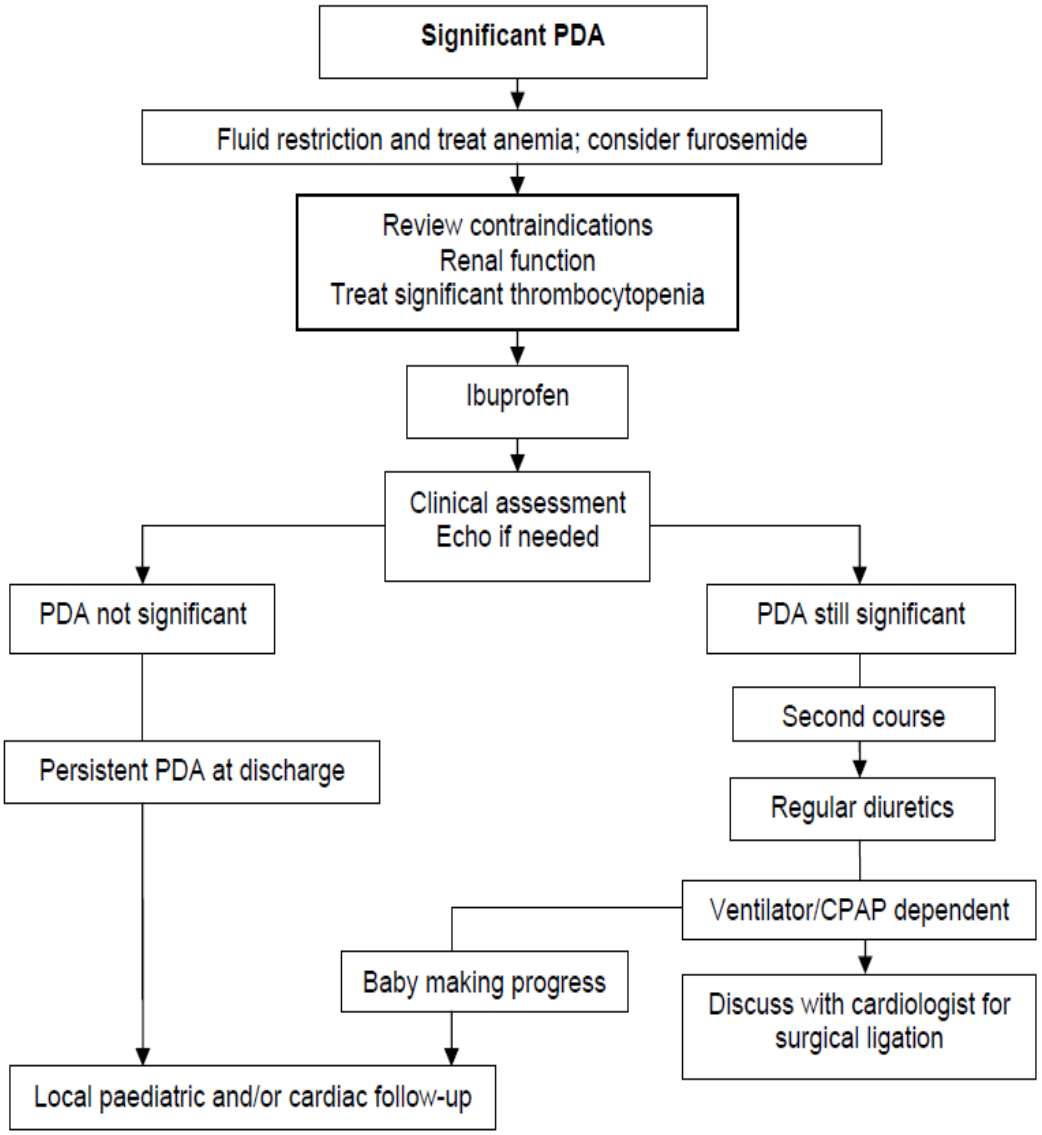
References:

1- Benitz WE and Committee on Fetus and Newborn. Patent Ductus Arteriosus in Preterm Infants. *Pediatrics*. 2016;137(1):e20153730

2- Geneva Foundation for Medical Education and Research, *Obstetrics and Gynecology Guidelines: Patent ductus arteriosus*, https://www.gfmer.ch/Guidelines/Neonatology/Patent_ductus_arteriosus.htm.

3- Doyle T. et al., *Management of Patent Ductus Arteriosus in Term Infants, Children, and Adults*, UpToDate, Jan 12, 2018, https://www.uptodate.com/contents/management-of-patent-ductus-arteriosus-in-term-infants-children-and-adults.

Medical treatment of persistent PDA <34 weeks' gestation



From: Neonatal Clinical Guidelines, 2017-2019, NHS.

Supraventricular Tachycardia

Introduction

Supraventricular tachycardia is the most common pathological tachycardia in newborns; can be new presentation or commenced in fetal life.

Recognition and assessment

- Sustained, accelerated non-sinus rhythm, regular and narrow-complex, originating above the level of the atrioventricular junction.
- Heart rate >200 bpm.
- May be 1 of 3 tachycardias:
    - Atrial
    - Atrioventricular nodal re-entry (AVNRT)
    - Atrioventricular re-entrant (AVRT), most common form
- Can be presenting feature of a congenital heart defect; do not wait to exclude this before commencing treatment.

Symptoms and signs

- Acute onset in a baby in heart failure/shock with no previous signs and symptoms.
- Fetal tachycardia during pregnancy.
- Baby with irritability, poor feeding, sweating and breathlessness for hours/days before presentation.
- SVT can cause reduced cardiac output due to reduced diastolic filling time.
- Many babies tolerate SVT well, however if tachycardia is sustained for >6 hours, signs of congestive heart failure may develop, with irritability, tachypnea and pallor.

Causes

- No known cause in majority of babies.
- Idiopathic SVT is more common in neonates than older children.
- Wolf-Parkinson-White pre-excitation, only becomes visible after conversion to sinus rhythm.
- Congenital heart defect, including Ebstein's and TGA.

Triggers

- Co-existing infections e.g. LRTI

Examination

- Heart rate >200 bpm.
- Capillary refill.
- Blood pressure.
- Respiratory rate, may be normal/abnormal depending on:

- Signs of heart failure.
- Co-existing respiratory conditions.
- Infections.

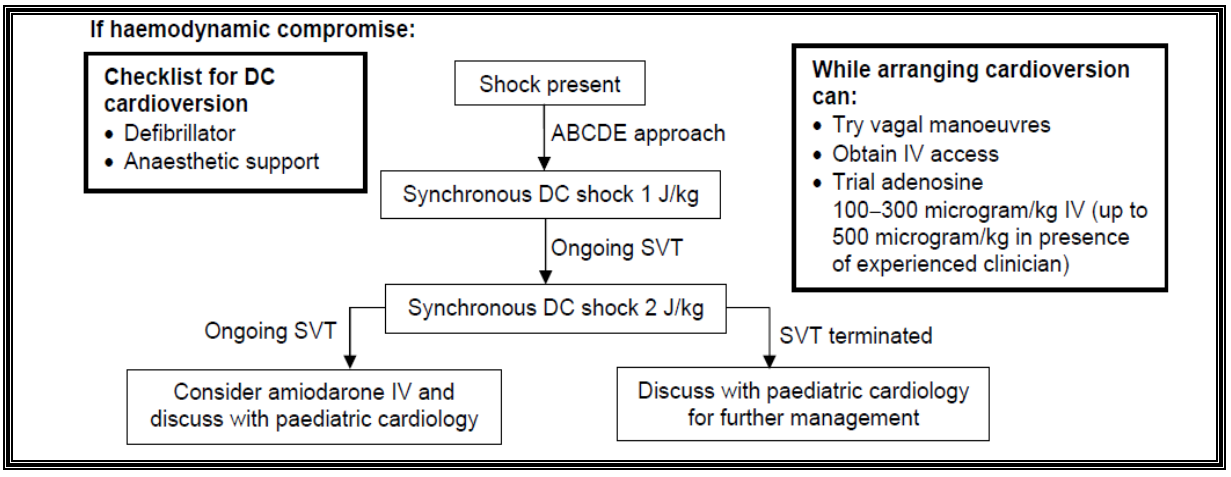
- SpO2 may be normal, low, or of poor signal in hemodynamic compromise.
- Cardiovascular and respiratory examination; may be normal aside from fast heart rate.
- Examine baby for other reasons of tachycardia, including pain and environmental factors e.g. pyrexia, (particularly in premature baby in incubator).

Investigations

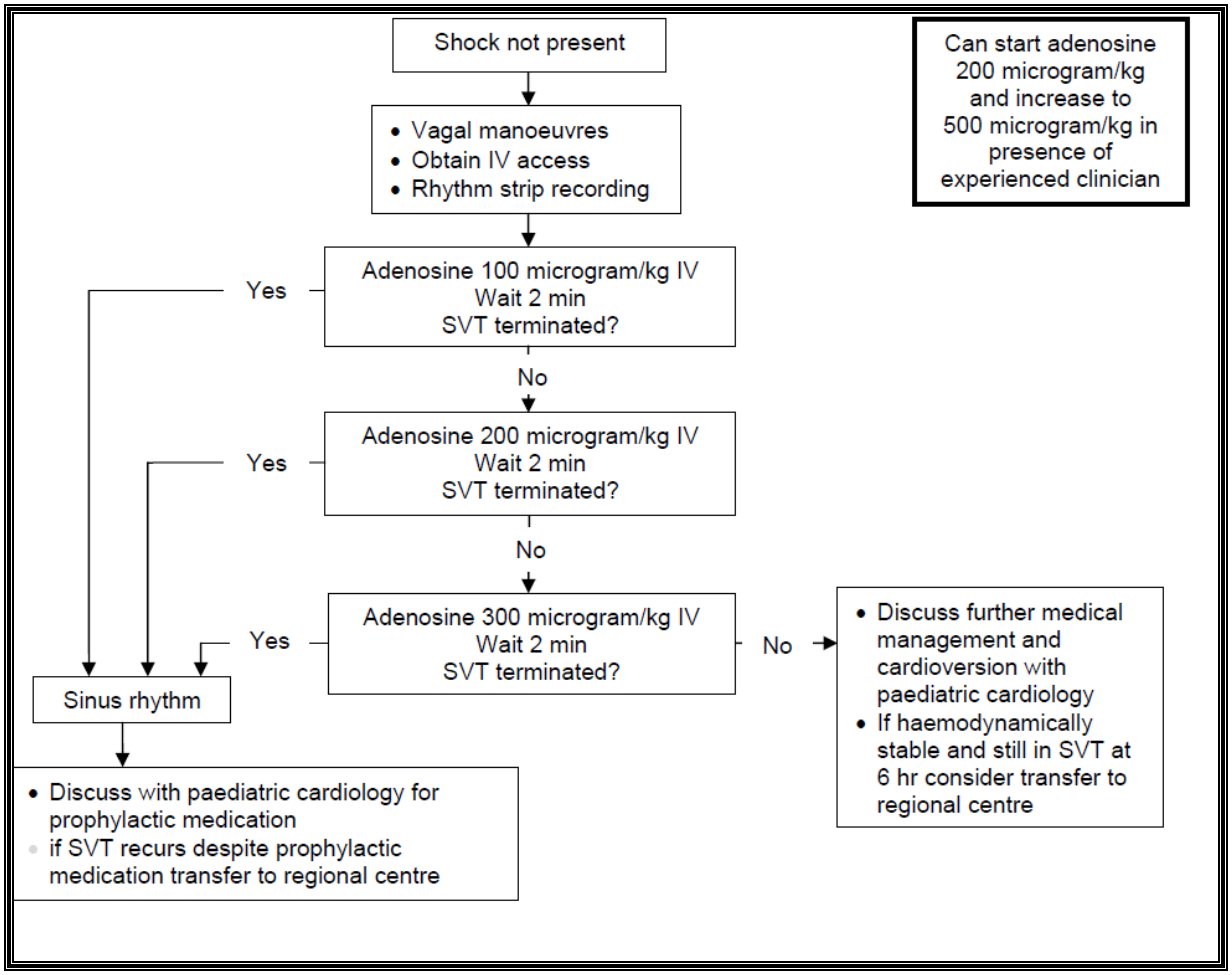
- 12-lead ECG to confirm SVT diagnosis in hemodynamically stable cases.
- If baby hemodynamically unstable, or if ECG not available, defibrillator can record and print rhythm strips from 3 different leads.
  - Once SVT terminated, perform repeat ECG to assist with identification of pre-excitation and any other underlying rhythm abnormality.
- Blood gas for acid-base balance.
- Electrolytes, ionized calcium.
- Echocardiogram to assess structural anatomy and cardiac function.

Management

If hemodynamic compromise:



If no hemodynamic compromise:



Additional information

Adenosine

- Give via cannula into large vein in upper limb, followed by rapid sodium chloride 0.9% flush; very short half-life of 10-30 sec, must get to the heart as quickly as possible.
- Acts by slowing conduction time through the atrioventricular (AV) node.
- Intraosseous access ineffective due to time taken for venous return.
- Use 3-way lines; 1 syringe for adenosine and 1 for sodium chloride 0.9% flush.
- Never test cannula by aspirating blood into syringe with adenosine before injection; will lead to breakdown of adenosine.
- Keep defibrillator nearby. Capture and print rhythm while adenosine given via defibrillator rhythm strip or ECG recording.
- Starting dose 100 micrograms/kg; repeat after 2 min; if no effect increase to maximum dose of 300 micrograms/kg.
- If experienced clinician present, maximum dose 500 micrograms/kg.

Vagal maneuvers

- Cold stimulation of the trigeminal nerve (afferent branches) instigates stimulation of the vagal nerve (efferent branches); slows AV node conduction.
    - Wrap bag of ice in towel and apply to baby's face. or

    - Wrap baby in towel and immerse entire head in ice-cold water for 5 sec.
- Unilateral carotid massage not recommended; difficult to perform in neonates and has limited effect.

DC cardioversion

- Applies direct current of electricity to the heart, synchronized to R wave of QRS complex on ECG.
- Reduces risk of inducing ventricular fibrillation.
- Synchronized shock starting at 1 J/kg; if no response increase to 2 J/kg.

Chemical cardioversion:

Discuss with pediatric cardiology if:

- Hemodynamically unstable and unresponsive to adenosine IV or DC cardioversion.
- Hemodynamically stable and unresponsive to adenosine IV.

Prophylactic medication

- When SVT has terminated, it is vital to commence medication to prevent further episodes.
- Choice of prophylactic medication based on:
    - Previous history of SVT (including in fetal life),
    - Assessment of ECG, both in SVT and once terminated,
    - Cardiac function. Discuss with pediatric cardiology center and send ECG/echocardiogram for review

Follow-Up

- Any episode of SVT, follow-up with pediatrician with expertise in cardiology/pediatric cardiologist.
- Baseline echocardiogram in outpatient clinic (if not already done).
- Holter monitor.

References:

1- Salerno JC, Seslar SP. Supraventricular Tachycardia, *Arch Pediatr Adolesc Med*. 2009;163(3):268-274.
2- St. George-Hyslop S, Morton C, Daley E, Neonatal and Pediatric Guidelines for Arrhythmia Management: What the Neonatal and Pediatric Critical Care Nurse Needs to Know, Canada: Pediatric Cardiac Intensive Care Society, 2014, https://www.pcics.org/wp-content/uploads/2014/12/Neo_Pedia_Guidelines_Arrhythmia.pdf.
3- Malekian A et. al, Evaluation and Management of Neonatal Supraventricular Tachycardia, *Journal of Comprehensive Pediatrics*. 2016 August;7(3):e35982.

PART V: Gastrointestinal Problems

Total Parenteral Nutrition:

- Total Parenteral Nutrition (TPN) is an effective way of maintaining nutrition in infants who cannot be fed or who will be slow establishing enteral feeds in the first days of life. Preterm infants have low calorific reserves (<4 days in infants <1000g) and maintaining nutrition is an essential part of intensive care.
- TPN improved survival by 40% in neonates of 28-30 weeks gestation with respiratory distress syndrome (RDS). TPN is also associated with shorter hospital stay. Full nutrition requirements can be safely started on the first day of life.
- The risks of TPN include line infections, metabolic disturbances and cholestatic jaundice and these risks need to be balanced against the benefits. As the benefits require TPN to be used for at least 7 days, TPN should not be used unless the infant is unlikely to be on full enteral feeds by day 7.
- TPN is also important in maintaining nutrition in infants with necrotizing enterocolitis and infants with short bowel syndrome, where enteral feeding is harmful or not tolerated.
- Components of TPN:

Calories	Goal: 80-90 kcal/kg/day to term and 90-100 kcal/kg/day to VLBW and 100-110 to ELBW. A minimal of 70 kcal/kg/day (goal 90-120 kcal/kg/d)/
Carbohydrates (40-50% of total calories) Dextrose: 3.4 kcal/gm	Peripheral PN: D 5-12.5% Central PN: up to D 25% Start 6-8 mg/kg/min in preterm (3-4 mg/kg/min in full term), and increase over 2-7 days by 0.5-1 mg/kg/min each day up to 9-12 mg/kg/min (13-17 gm/day with a maximum of 18 gm/day). ELBW infants usually need 8-10 mg/kg/min (if total fluid requirement >120 cc/kg/day, use D 5% to avoid hyperglycemia). Provide glucose to maintain blood sugar >40 mg/dl and < 150-200 mg/dl
PROTEIN (7-16%of total calories) PROTEIN: 4 kcal/gm	Should be started as soon as possible on the 1st day of life in sick infants, preterm and VLBW infants. Type: aminosol 10% is the currently available solution. Start by 3 gm/kg/d on day 1 and increase to 3.5 g/kg on day 2, then advance to a max of 4gm/kg/day
Fat (40-50% of total calories) Fat: 9 kcal/gm	Type: intralipid 20% is the preferred preparation; Start within 24 hours of birth. Dose: start by 1 gm/kg/day and increase by 0.5-1.0 gm/kg/day as tolerated up to a max of 4 gm/kg/day. Infuse over 24 hours (don't exceed 0.12 gm/kg/hour). Monitor TG: level (should be <200mg/dl and <150gm/dl in jaundice). Stop infusion when exceeding these levels. No need to stop lipids in septic neonates**,** monitor TG level.
Electrolytes	Sodium and chloride are usually not necessary till day 3 unless needed (according to frequent measurement of Serum Na, Cl): give 2-4 meq/kg/day of NaCl after initial dieresis. Potassium: should not be started until renal function is clearly

	established (good UOP) especially in ELBW: give 2-3 meq/kg/day. Calcium: give 60-80 mg/kg/day of elemental calcium (6.5-8.6 cc/kg/day of calcium gluconate 10%).
Vitamins and trace elements	IV multivitamin solution and trace elements as below

Solivito N (FK) (Water soluble)	1/10th vial per kg provides per kg/day:	
	Thiamine (B1) 0.32 mg, Riboflavin (B2) 0.36 mg, Nicotinic acid 4.0 mg, Vitamin B6 0.4 mg, Pantothenic acid 1.5 mg	Biotin 6.0 micrograms, Folic acid 0.04 mg, Vitamin B12 0.5 micrograms, Vitamin C 10.0 mg
Vitlipid N Infant (FK) (Fat soluble)	4 ml/kg (to a maximum daily dose of 10 ml) is added to the lipid solution.	
	Infants <2.5 kg will receive 4 ml/kg, providing per kg per day: Vitamin A 276 micrograms (920 iu), Vitamin D 4.0 micrograms (160 iu), Vitamin E 2.56 mg (2.8 iu), Vitamin K 80 micrograms	Infants >2.5 kg will receive 10 ml daily, providing a total daily intake of: Vitamin A 690 micrograms (2300 iu), Vitamin D 10 micrograms (400 iu), Vitamin E 6.4 mg (7 iu), Vitamin K 200 micrograms
Trace minerals	Peditrace 1 ml/kg/day provides a full range of trace minerals and electrolytes (Zinc, Copper, Manganese, Selenium, Fluoride, Iodine, chloride). Magnesium sulphate is added routinely at 0.3 mmol/kg/d. If serum calcium level is low, need to ensure magnesium levels are adequate.	

Suggested monitoring schedule for neonates receiving TPN

Measurement	Frequency of measurement
Weight	Daily (if condition allows)
Length, H.C	Weekly
Intake and Output	Daily
Glucose	2-4 hours after IV running, then 2-3 times/day in the first week, then daily
Week 1	Daily U+E/LFT/Bone Profile
Subsequent weeks:	U+E 2-3/week,
	Weekly LFT/Bone/Triglycerides/Magnesium
Monthly:	Selenium/Copper/Zinc/Manganese/Carnitine
Ammonia	(If on high protein)
TG	1-2 weekly

Reference:

Gaza Neonatal Network, *Gaza Neonatal Network Protocols*, Updated 2014.

Feeding Protocol

Aim

The aim of this guideline is to provide a standardized approach to feeding in preterm infants.

Background

- The goal of nutrition is to achieve optimal growth.
- Following a standardized approach by having guidelines for enteral feeding in preterm neonates and thereby reducing variation may reduce risk of NEC.

Risk Groups

- This guideline uses a risk factor approach. Increasing prematurity, growth restriction and abnormal dopplers are risk factors for NEC.

Phases of nutritional support

- There are four phases of nutritional support of premature infants, these are
- 1. Phase 1: Parenteral nutrition + Gut priming
- 2. Phase 2: Transition feeding: Enteral phased in, parenteral out
- 3. Phase 3: Full Enteral (late)
- 4. Phase 4: Post-discharge

Commencing feeds

- There is a limitation of evidence regarding the timing of initiation of any feed.
- Units with prolonged periods of enteral fasting have been shown to have the lowest rates of necrotizing enterocolitis. However, prolonged periods of parenteral nutrition has disadvantages with increased rates of catheter acquired infection and cholestasis.
- Infants receiving inotropes for hypotension may be at increased risk of reduced gut perfusion; therefore feeds should be avoided in this situation.
- Use of umbilical catheters is not a contraindication to feeding.
- Use the patient's actual weight when calculating nutrient requirements, If actual weight is lower than the birth weight, then birth weight should be used.

GIT priming (Trophic feeding):

- Start priming feeds on day 1 or 2 and start with low volume, e.g., 10 cc/kg/day.
- Withholding and delaying of priming feeds increase risk of NEC and is associated with longer days of TPN infusion

Feeding route:

- Most infants <35 weeks gestation will require orogastric or nasogastric tube feeding.
- No evidence to suggest an advantage of continuous feeding over bolus feeding.
- Continuous feeding (rather than bolus feeding) may be useful in infants with gut resection, severe respiratory problems & high output stomas.

- Naso-jejunal feeding not recommended but can be considered for preterm infants with very severe GOR. When used, continuous feeding must be used.

Advancing feeds

- It is suggested that increments to be limited to 20 mL/kg/day in infants considered at highest risk, but allowing up to 30 mL/kg day in those infants of lesser risk.
- Feeding advancement in VLBW:
    - Start priming feeds on day 1 or 2.
    - Start with low volume, e.g., 10 cc/kg/day.
    - Monitor gastric residuals.
    - If feeds tolerated then increase feeds slowly in frequency and/or size as residuals subside.
    - Do not hold feedings because of occasional large residuals in a well-baby (see below).
    - Pay attention to passage of meconium.
- Feeds can be increased if:
    - Gastric aspirates <25% of volume given since last residual check.
    - No bilious aspirate.
    - No significant vomiting (>50% of feed).
    - No significant abdominal distension.
- Stop feeds if:
    - GA >50% of volume given since last replacement of residual.
    - Dark bile stained aspirate.
    - Suspected or confirmed NEC
    - If inotropes are being used to maintain a normal blood pressure.
    - Exchange transfusion in last 24 hours.

Action with the gastric residuals

- Aspirate NG tube every 4-6 hours dependent on cares.
- Bile:
    - Dark bilious? If so then NPO, check NG position, clinical exam and assessment the position of NGT in case of inadvertent advancement past the pylorus. AXR should be ordered if any doubt.
    - Light bile stained? Acceptable if volume aspirated OK.
- Volume:
    - Less than 1.5 mL or less than 25% of volume given since last replacement of residual?
        - Replace entire amount and continue with feeds. Increment feeds if due.
    - Volume 25-50% of volume given since last replacement of residual?
        - If well and no clinical evidence of NEC, replace the hourly volume due only without increments of feeds till GRV has been below 25% in two consecutive occasions.
        - Consider glycerin tip if no stools passed in last 24 hours and no abdominal tenderness.
    - Volume >50% of volume given since last replacement of residual?

- Empty the stomach, put NBM for at least 4 hours and clinically assess for NEC.
- Consider withholding feeds for 12-24 hours even if clinical assessment is normal if there has been recent feed intolerance.
- Recommence feeds at 0.5-1 mL/hour for 6 hours, then 50% of previously attained feeds for 6 hours then back to previously attained feed rate.
- No further increments should be attempted for a further 24 hours.
- If either abdominal distension or large aspirates present in absence of no opened bowels for 24 hours then glycerin tip rectally can be given.

Type of milk:

- AAP recommends that All preterm infants should receive human milk (breast milk). Human milk should be fortified, with protein, minerals, and vitamins to ensure optimal nutrient intake for infants weighing <1500 g at birth. Accordingly the following is the list of available milk for preterms:
    - **Breast milk (BM) is the best – expressed**.
    - Fortification of breast milk needed in preterm, i.e., multi-nutrient fortifiers as preterm breast milk is different composition and may not be enough to sustain growth.
    - Preterm formula – adapted to mimic breast milk.
    - 'Special' feeds – e.g., pre-digested formula for surgical neonates, additives to add calories, etc.

References:

1. Gaza Neonatal Network, *Feeding the Preterm Babies*, January 2015.
2. Patole SK, de Klerk N. Impact of Standardized Feeding Regimens on Incidence of Neonatal Necrotizing Enterocolitis: A Systematic Review and Meta-Analysis of Observational Studies. *Arch Dis Child Fetal Neonatal Ed*. 2005 Mar;90(2):F147-51. Review.
3. Pietz J, Achanti B, Lilien L et al. Prevention of Necrotizing Enterocolitis in Preterm Infants: A 20-Year Experience. *Pediatrics*. 2007 Jan;119(1):e164-70. Epub 2006 Dec 4.
4. Patole S, McGlone L, Muller R. Virtual Elimination of Necrotizing Enterocolitis for 5 Years – Reasons? *Med Hypotheses*. 2003 Nov-Dec;61(5-6):617-22.
5. Hospital for Sick Children, *Neonatal Guidelines*, 2016.

Breast Milk Fortification

- **Breast milk fortification is considered for:**
  - <1500 g (birth weight) or below 34 weeks gestation who are receiving breast milk.
  - >1500 g (birth weight) when weight gain is less than 15 g/kg/day and if weight is falling off centile chart after day 14.
  - With consistent serum urea levels <2 mmol/l and >2 weeks old.
  - Only when baby has had EBM for 2 weeks. and is receiving full enteral feeds, i.e. the maximum tolerated – aim for minimum of 180 ml/kg/day EBM.
- **Caution about use of fortifiers:**
  - Family history of cow's milk protein allergy – use hypoallergenic formula powder instead.
  - When using potassium acid phosphate supplements.
  - Babies with NEC – if NEC suspected do not use fortifier due to fortifier increasing osmolarity of BM. If baby is recovering from NEC, use fortifier with great caution for same reason.
  - Dexamethasone therapy – unless plasma urea and amino acid levels are within acceptable range.
- **How to use fortifiers:**
  - Use freshly EBM when possible and fortify minimum amount of EBM as close as possible to baby's feed time as the fortifier may alter the composition of the EBM.
  - Do not make up more fortified milk than is required as storage reduces the effectiveness of some anti-infective components of EBM and may lead to increased osmolality.
  - Check the expiry date of the fortifier before use.
  - Fortify at half-strength for first 24 hours (i.e., half a sachet of fortifier to 50 ml EBM); increase to full-strength as tolerated. One sachet provides 2.1 g of fortifier. Smaller volumes of fortifier must be weighed on medical weighing scales.
  - Shake breastmilk gently to distribute fortifier.
  - Discard any unused open sachets of fortifier.
- **When to stop breast milk fortifiers:**
  - Infant must be sustaining adequate growth, has an adequate breast milk intake and must have blood values within normal limits (Schanler 2005).
  - If baby receiving >50% of feed requirement as formula milk, fortifier is not necessary (Jones & King 2005).

Preterm nutritional requirements include:

Energy requirement, protein requirement, protein to energy ratio, long chain polyunsaturated fat, prebiotics and probiotics, minerals and vitamins.

Energy requirements:

- Preterm infants: 110-135 kcal/kg/day.
- Term infants 96-120 kcal/kg/day (range for term infants depends on method of feeding).
- IUGR babies do not necessarily have higher requirements than their appropriately grown counterparts.

Recommended protein supply for preterm infants:

- Infant body weight 1-1.8kg:3.5-4g/kg/day
- Infant body weight <1kg:4-4.5g/kg/day
- There is no benefit to feeding >4.5g/kg/day

Protein to energy ratio must be considered for all preterms:

- Infant body weight 1-1.8 kg: 3.2-3.6 g/100 kcal (12.8-14.4%).
- Infant body weight <1 kg: 3.6-4.1 g/100 kcal (14.4-16.4%).

Vitamin A	400-1000 µg RE/kg/day
Vitamin D	20-25 µg/day, difficult to achieve (Aim to provide 10 µg/day vitamin D)
Iron	1-3mg/kg/day at two to six weeks of age (two to four weeks in ELBW infants)
Folic acid	35-100 µg/kg/day
Sodium	69-115 mg/kg/day (monitor serum/urine sodium)
Calcium	120-140 mg/kg/day, calcium to phosphorus ratio between 1.5 and 2
Phosphorus	60-90 mg/kg/day

Monitoring: How to ensure adequate nutrition?

- Monitor protein intakes.
- Measure weight three times a week: Tue/Thu/Sun.
- Plot birth weight on admission and weekly weights thereafter on centile charts.
- Measure & plot length weekly (Tue) until 40 weeks post-conceptional age and then every two weeks until discharge.
- Measure and plot head circumference weekly: Tuesday.
- Lab tests: Weekly monitoring of serum Na, K, phosphorus, calcium, urea and creatinine, CRP, Hb as well as urinary sodium, required for nutritional assessment.

References:

1- Schanler et al, *Breast Milk Feeding and Fortification for Premature Infants*, UpToDate, 2018.
2- University of Iowa Children's Hospital, *Guidelines for the Use of Human Milk Fortifier in the Neonatal Intensive Care Unit*, 2011.

Guideline for initiation and advancement of enteral feeding:

Weight	Initiation of Feeds	Rate of Increase	Volume of Increase (ml/kg/day)	Days to Full Feeds
500-599 g	1 ml q 6 h x 96 hours			500 g = 17 days 599 g = 19 days
	0.5 ml q 2 h x 24 hours			
		Starting day 6: 0.5 ml q 24 h	10-12 ml/kg/day	
600-749 g	1 ml q 4 h x 72 hours			600 g = 14 days 749 g = 16 days
	1 ml q 2 h x 24 hours		8-10 ml/kg/day	
		Day 5-10: 0.5 ml q 24 h	8-10 ml/kg/day	
		Starting Day 11: 1 ml q 24 h	16-20 ml/kg/day	
750-999 g	1 ml q 4 h x 72 hours			750 g = 13 days 999 g = 16 days
	1 ml q 2 h x 24 hours		6-8 ml/kg/day	
		Starting day 5: 1 ml q 24 h	12-16 ml/kg/day	
1000-1299 g	1 ml q 2 h x 72 hours			1000 g = 9 days 1299 g = 11 days
		Starting day 4: 1 ml q 12 h	18-24 ml/kg/day	
1300-1499 g	2 ml q 2 h x 24 hours			1300 g = 7 days 1499 g = 10 days
		Starting day 2: 1 ml q 12 h	16-18 ml/kg/day	
1500-1749 g	3 ml q 3 h x 24 hours			1500 g = 6 days 1749 g = 7 days
		Starting day 2: 2 ml q 9 h (every 3rd feed)	24-28 ml/kg/day	
1750-1999 g	4 ml q 3 h x 24 hours			1750 g = 5 days 1999 g = 6 days
		Starting day 2: 1 ml q 3 h	32-36 ml/kg/day	
2000-2499 g	5 ml q 3 h x 24 hours			2000 g = 3 days 2499 g = 4 days
		Starting day 2: 2 ml q 3 h	51-64 ml/kg/day	
>2500 g	6 ml q 3 h x 24 hours			2.5 kg = 3 days
		Starting day 2: 3 ml q 3 h	~70 ml/kg/day	

Necrotizing Enterocolitis (NEC)

Definitions

- Acute inflammatory disease in newborn intestine characterized by hemorrhagic necrosis, which may lead to perforation and destruction of the gut.
- Clinical presentation usually comprises triad of abdominal distension, gastrointestinal bleeding and pneumatosis intestinalis (air in bowel wall on abdominal X-ray).
- Necrotizing Enterocolitis (NEC) is when sections of the bowel tissue die and is among the most common and devastating gastrointestinal (GI) emergency in neonates and can present late in tiny babies.
- As "Early" or 'suspected' NEC is difficult to diagnose, if in doubt treat early and conservatively (nil by mouth and broad spectrum antibiotics).
- NEC is predominantly a disease of the very low birth weight infant and is most common in babies < 1000 g or those that are both preterm and growth restricted.
- In general, the age of onset is inversely proportional to gestation; therefore smaller babies present later.
- The mortality rate of NEC is 20-40% with the highest rate amongst those that require surgery.
- Note: Spontaneous perforation in preterm infants probably represents a different disease entity with a different pathogenesis. The more premature the infant, the later the disease occurs after birth.
- Diagnostic criteria using Bell's staging or Vermont-Oxford criteria both have similar shortcomings since severe NEC can develop without meeting the advance criteria.

Modified Bell's criteria

Stage 1: Suspected NEC: clinical signs suggestive but X-ray non-diagnostic.

Stage 2: Definite NEC: mild to moderately ill – abdominal X-ray demonstrates pneumatosis intestinalis.

Stage 3: Advanced NEC: severely ill, bowel intact or perforated.

Diagnosis and treatment of NEC

A. Suspected NEC in a clinically stable infant should be investigated and treated as NEC.
B. Suspected NEC in an unwell/unstable infant OR confirmed NEC in a clinically stable infant should be resuscitated, stabilized, investigated, monitored and treated for 5-10 days. Consider discussion with surgical colleagues +/- early transfer in cases not responding to medical management.
C. Confirmed NEC in a sick/clinically deteriorating infant requires urgent resuscitation and stabilization, close monitoring of clinical, hematological and biochemical status; urgent discussion with surgical and neonatal colleagues and transport team.

Clinical tips:

- Early symptoms may be non-specific: Increased episodes of bradycardia, apnea and desaturations; temperature instability, tachycardia, lethargy. mild abdominal distension, feed intolerance, e.g., large bilious or large bloody aspirates, vomiting.
- Classic NEC in a preterm (usually after 10 days of age):
    1- Feed intolerance.
    2- Abdominal distension (may be shiny +/- periumbilical erythema), tenderness.
    3- Bloody stools.
- Symptoms and signs may progress rapidly, often within hours: Increased crying; abdominal discoloration; visible loops, absent bowel sounds, intestinal perforation; systemic hypotension, acidosis, DIC plus signs of generalized peritonitis, marked tenderness and distension of abdomen, right lower quadrant mass.

Investigations:

1. **Blood:** Monitoring of white cells, differentials (neutropenia), platelet counts (sudden decreases suggest disease progression) + inflammatory markers; blood cultures; coagulation screen; blood gases; sugar, electrolytes and lactate.
2. **Abdominal radiograph** (AP +/- left lateral decubitus) +/- radiological opinion. Findings:
    - **Early imaging signs:** Dilated loops of bowel; paucity of gas; gas-filled loops of bowel unaltered on repeated examinations (fixed loops).
    - **More advance imaging signs:** Pneumatosis intestinalis (submucosal bubbly or cystic appearance and/or subserosal linear or curvilinear appearance); portal venous gas; pneumoperitoneum.

Diagnosis, Signs and Symptoms, Severity	**Treatment Strategy**
Suspected/unconfirmed NEC Abdominal distension (no radiographic evidence) Unexpected onset of feeding intolerance Unwell; increased bradycardia episodes; raised inflammatory markers; decreasing neutrophil & platelets; blood in stools	Close observation for worsening signs and abdominal distension and feeding intolerance; Consideration of bowel decompression and brief stopping of feeds; AXR; monitor white cells, differentials, platelet counts; blood cultures & antibiotics.
Definitive medical NEC Unwell; abdominal distension with pneumatosis intestinalis, portal venous gas, or both; fixed dilated loops of intestines and ileus patterns; decreasing platelet & neutrophil counts; lactate acidosis	Bowel decompression and stop enteral feeds for 5-10 days, parenteral nutrition. Close monitoring of white cells' differentials and platelet counts; blood cultures and IV antibiotics for 5-10 days; monitor AXR.
Failure of medical management (after 3-4 days) e.g. persistent ileus pattern, abdominal distension, AXR showing absence of bowel gas-consider elective discussion with surgical team	
Surgical NEC Free intraperitoneal air on top of above clinical picture; shock/ deteriorating clinical condition and biochemical status, e.g., abnormal electrolytes	Urgent surgical referral: exploratory laparotomy +/- resection. Placement of drain.

Treatment of NEC

1. Management depends on clinical presentation and severity as detailed in Table 1.
2. Medical intervention includes: abdominal decompression, bowel rest, parenteral nutrition, supportive care and antibiotics.
3. Nil by mouth – bowel rest, depending on degree of suspicion, severity of symptoms/signs may be a brief stopping of enteral feeds, e.g., 24-48 hours (for unconfirmed NEC) or 5-10 days. Refer to refeeding after NEC below.
4. IV fluid/total parenteral nutrition (TPN) at ≤ 150 cc/kg (3rd space loss).
5. Fluid resuscitation in shocked babies (10 mL/kg normal saline)
6. Strict fluid balance, monitor urine output, consider catheterization.
7. Nasogastric tube on free drainage.
8. Start broad spectrum intravenous antibiotics – including anaerobic and gram negative cover. The antibiotics used may change from one unit to another and there is inadequate evidence to suggest specific regimen.
9. Analgesia and pain management.
10. Intensive care monitoring.
11. Appropriate resuscitation.
12. Ventilatory support. Also, consider ventilation for infants on CPAP to avoid further abdominal distension.
13. Surgery (25% to 50% of cases) – Early discussion with surgical team regarding on-going management, urgency of surgical assessment / intervention and the need for transfer – e.g., when not responding to/failure of medical management, where perforation/stricture is suspected.

Monitoring treatment

- Observe general condition closely and review at least 12-hourly.
- Daily:
    - Acid-base.
    - Fluid balance (twice daily if condition unstable).
    - electrolytes (twice daily if condition unstable).
    - FBC and coagulation (twice daily if condition unstable).
    - repeat X-ray daily or twice daily until condition stable. Discuss with consultant/surgeons.

Long-term management

- Advise parents about signs of bowel obstruction.
- Medical +/- surgical follow-up after discharge.
- Contrast studies if clinically indicated for strictures.
- Appropriate developmental follow-u

Re-feeding after NEC

- In a clinically stable infant with unconfirmed NEC, consider restarting feeding after 5 days of nil by mouth.
- In definitive NEC, consider restarting feeding after 10 days of nil by mouth.
- Rate of feed increment no more than 30 ml/kg/day (refer to feeding guideline).
- Use EBM or donor breast milk; if these unavailable, consider elemental formula, e.g., Pepti Junior.
- After resolution of clinical and radiological features in medically managed NEC, if feeds cannot be established, i.e., recurrent/large aspirates with abdominal distension, etc. plus dilated loops on plain AXR, surgical opinion should be sought to exclude a post-NEC stricture.

Prevention

Factors conferring a predisposition to NEC include genetic factors and several immature characteristics of the fetal intestine, including altered microbiota, inadequate intestinal barrier function, and an excessive inflammatory response. Because of the fulminating nature of NEC, preventive approaches are extremely important:

1. Rapid increases in feeding increases the likelihood of NEC.
2. Complete withholding of feeds lead to prolonged use of parenteral nutrition, intestinal atrophy, increased permeability and inflammation, and late onset sepsis..
3. Exclusive use of human milk enterally may lower the incidence of NEC..
4. Recommendation: early initiation of minimal enteral feeds of expressed human milk avoiding rapid increments: refer to Feeding guideline.
5. Prolonged empirical use of intravenous antibiotics increases the incidence of NEC.
6. Enteral supplementation of probiotics reduces incidence of severe NEC and mortality. Prebiotics enhance the proliferation of endogenous flora such as bifidobacteria and appear to alter the consistency and frequency of stools, but their efficacy in prevention of NEC is unclear.
7. Antenatal corticosteroids.
8. Early intervention (nil orally) for suspected NEC.
9. Infection control practices may limit the size of disease clusters

References:

1- Gaza Neonatal Network, *Necrotizing Enterocolitis (NEC) in Neonates*, February 2015.
2- Neu J, Walker WA. Necrotizing Enterocolitis. *N Engl J Med* 2011;364:255-64.
3- Tarnow-Mordi WO, Wilkinson D et al., Probiotic Reduce All-Cause Mortality in Necrotizing Enterocolitis: It is Time to Change Practice. *Pediatrics* 2010;125:1068-70.

4- Taeusch HW, Ballard RA. *Avery's Diseases of the Newborn*, 7th Ed. W.B. Saunders Company: Philadelphia, 1998.
5- Morgan J, Young L, McGuire W, *Slowly Advancing Milk Feeds does not Reduce the Risk of Necrotizing Enterocolitis in Very Low Birth Weight Infants*, Cocharane Summaries, 2012.

Liver Dysfunction in Neonates

Definitions:

- Cholestasis: conjugated hyperbilirubinemia ≥ 2 mg /dL and/or ≥20% of total bilirubin.
- Acute liver failure with raised transaminase and coagulopathy unresponsive to vitamin K.

Causes:

Biliary tract disorders	Neonatal hepatitis	Metabolic
• Extra-hepatic biliary atresia • Bile duct stricture • Choledochal cyst • Alagille syndrome • Non-syndromic bile duct paucity	Isolated • Associated with: ◦ parenteral nutrition ◦ maternal diabetes ◦ hydrops fetalis ◦ trisomy 21	• α_1-antitrypsin deficiency • Cystic fibrosis • Galactosaemia • Dubin-Johnson syndrome • Bile acid disorder • Haemochromatosis
Infection	**Endocrine**	**Toxins/injury**
• Cytomegalovirus • Toxoplasmosis • Sepsis	• Hypopituitarism • Hypothyroidism	• Parenteral nutrition • Multifactorial preterm • Haemolytic disease • Hypoxia

Symptoms and signs

- Pale or acholic stools.
- Prolonged jaundice (defined as visible jaundice at day 14 in term and day 21 or older in preterm babies).
- Bleeding, including intraventricular hemorrhage from vitamin K deficiency.
- Green jaundice on any day of life.
- Acute collapse with liver failure.
- Failure to thrive.
- Family history is important.

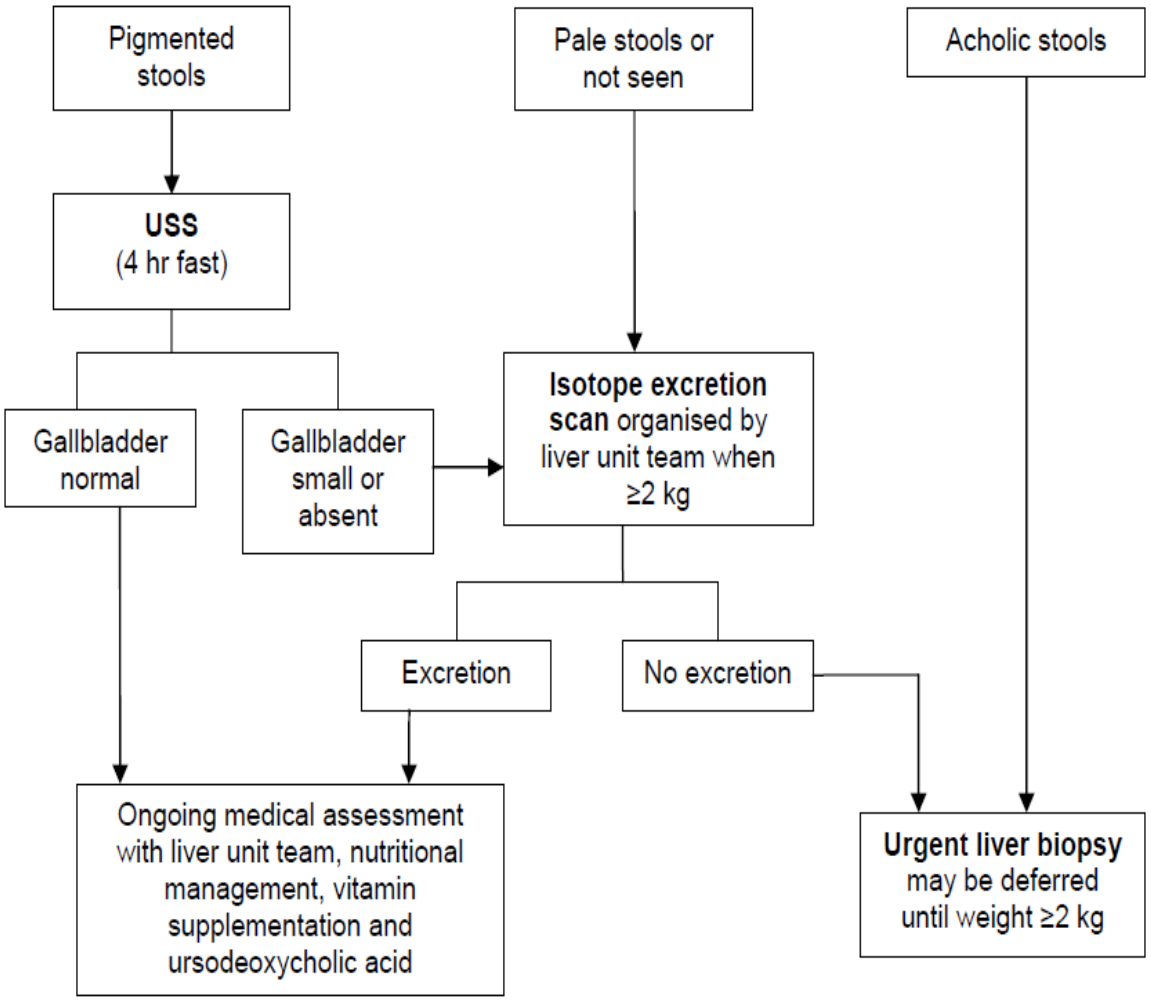
Investigations:

- Coagulation screen.
- Transaminases, bilirubin (total and conjugated), albumin, gamma GT, and alkaline phosphates.
- Galactosemia and tyrosinemia screen (reducing substances and urine organic acids).
- T4 and TSH and 8 am cortisol.
- Abdominal ultrasound scan, after 4 hour fast if possible, to include liver and gallbladder examination.
- If clinical suspicion is high, toxoplasma serology, CMV IgM or PCR or urine PCR for CMV, syphilis serology, viral PCR from swabs of any vesicles for herpes simplex, hepatitis E serology.
- If metabolic disorder is suspected, plasma lactate, plasma and urine amino acids, and urine organic acids.
- Consult pediatric GI if possible.

Treatment:

- According to cause, ADEK vitamins, Ursolit, MCT based formulas, referral to GI consultant.

Flow diagram: from NHS Neonatal Protocols, 2017-2019



Reference:

Bedside Clinical Guidelines Partnership, Neonatal Guidelines 2017-19, Staffordshire, Shropshire and Black Country Neonatal Operational Delivery Network and Southern West Midlands Neonatal Operational Delivery Network.

PART VI: Hematology

Blood Group Incompatibility

Postnatal monitoring

Babies at risk

Those with mothers with known blood group antibodies including:

- D (Rhesus), c, C, s, E, e, Duffy
- Kell: causes bone marrow suppression in addition to hemolysis

Management of babies at risk of hemolysis

Antenatally: prepare a plan based on antibody titers, middle cerebral artery Dopplers and evidence of hydrops

- In severely affected cases, order blood in advance for exchange transfusion.
- Send cord blood urgently for: Hb, blood group, direct Coombs' test (DCT) and bilirubin.
- In all babies who have had an in-utero blood transfusion (IUT), send cord blood also for a Kleihauer test.
- If pale with abnormal cardiorespiratory signs (e.g. tachycardia), admit to neonatal unit (NICU).
    - If cord bloods not available, check baby's blood immediately for bilirubin, Hb and DCT.
    - Monitor serum bilirubin, usually at 6-hourly intervals until level is both stable/falling and 2 consecutive values are >50 micromol/L below the treatment threshold.
    - Plot bilirubin values on gestational age-specific charts.
    - Decide whether baby needs phototherapy or exchange transfusion as determined by the gestational age-specific charts.
- If baby has negative DCT and had no IUT, no further action required; baby is not affected.

Phototherapy

- Refer to jaundice guideline table and treatment charts.
- Prophylactic phototherapy (e.g. from birth) is not beneficial.
- DO NOT subtract the direct/conjugated bilirubin value from the total.
- Administer phototherapy (see Jaundice guideline).
- Check bilirubin 6 hours after onset of phototherapy and at least 6-hourly until level is both stable/falling and 2 consecutive values of >50 micromol/L below treatment threshold.

Intravenous immunoglobulin (IVIG)

- Always discuss indications with consultant.
- See guideline of hyperbilirubinemia.

Exchange transfusion

- Always discuss indications with consultant.
- See Exchange transfusion guideline.

Before discharge

- Check discharge Hb, bilirubin and review need for folic acid.

Follow-up and treatment of late anemia

Babies with weakly positive DCT:

- If baby did not require treatment for jaundice, do not give folic acid and no follow-up is needed.
- If baby required treatment for jaundice, follow guidance below.

All babies with hemolytic anemia:

- Arrange Hb check and review at age 2 weeks.
- Dependent on rate of fall of Hb from discharge Hb, frequency of Hb checks planned (may need to be as frequent as weekly).
- For babies who had intrauterine Tx, IVIG or exchange transfusion, follow up with Hb check every 2 weeks initially, and until age 3 months; thereafter arrange developmental follow-up (see below).
- For all other babies who had Coombs' tests strongly positive, review with Hb check at 2 and 6 weeks; once Hb stable, discharge from follow-up and discontinue folic acid if this has been prescribed.

Indication for top-up transfusion for late anemia:

- Symptomatic anemia
- Hb <7.5 g/dL

Ongoing neuro-developmental follow-up and hearing test

Arrange for any baby:

- With definite red cell anomalies.
- Who has undergone an exchange transfusion.
- Who has had an IUT.
- Who required IVIG.
- With serum bilirubin at or above exchange transfusion threshold.

References:

1- Bennardello F et al, Recommendations for the Prevention and Treatment of Hemolytic Disease of the Fetus and Newborn, *Blood Transfus*. 2015 Jan; 13(1): 109–134.
2- White J et al, *Guideline for Blood Grouping and Red Cell Antibody Testing in Pregnancy*. British Committee for Standards in Hematology, 2016.
3- UCSF Children's Hospital, *Hemolytic Disease of the Newborn: Intensive Care Nursery House Staff Manual*, https://www.ucsfbenioffchildrens.org/pdf/manuals/42_Hemol.pdf.

Coagulopathy in Newborns

- Clotting abnormalities are commonly seen on the neonatal intensive care unit.
- The aim of this guideline is to advise on the initial management and investigation of the neonate with coagulation abnormalities.

Clotting screen

- PT- prothrombin time
    - This assesses the function of factors II, V, VII and X- which includes the vitamin K dependent factors,
    - Prolonged in vitamin K deficiency, warfarin usage, and fibrinogen deficiency.

- APTT- activated partial thromboplastin time.
    - This measures the activity of factors II, V, VIII, IX, X, XI and XII.
    - It is also abnormal in fibrinogen deficiency.

- TT- Thrombin time
    - This tests for fibrinogen deficiency/dysfunction, such as in disseminated intravascular coagulopathy (DIC).
    - Prolonged with heparin.

Reference ranges

- Coagulation problems are common in preterm infants.
- There remains a scarcity of data on the acceptable normal ranges.
- It is known that the components of the coagulation system vary widely from adult ranges across different gestations; for example fetal fibrinogen is known to be more active.

Corrected Gestational Age	**Age**	**PT (s)**	**APTT (s)**	**Fibrinogen (g/l)**
23-27		14.4 – 36.7	40.5 – 158.5	0.7 – 4.8
28 – 34		13.9 – 20.6	30 – 57	0.87 – 4.7
34 - 36	1 day	10.6 -16.2	27.5-79.4	1.5-3.7
	5 days	10-15.3	26.9-74.1	1.6-4.2
	30 days	10-13.6	26.9-62.5	1.5-4.1
Temp	1 day	11.6-14.4	26.8-48.7	2.3-3.4
	5 days	10.9-13.9	34.0-51.2	2.4-3.9
	30 days	10.6-13.1	33-47.8	2.2-3.2

Clotting abnormalities in term infants

- A specific bleeding disorder should be suspected in infants with bleeding in healthy term or late preterm infants,

- Oozing from umbilical stump,
- Bleeding following capillary heel prick sampling, or attempts at cannulation,
- Excessive cephalohematoma
- Unexplained intracranial hemorrhage.
- A family history may be helpful; however 1/3 of infants with severe hemophilia have no previous family history.

- Expert hematology advice may be required for further investigation and treatment.
- Although rare, a congenital bleeding disorder must be considered (and appropriate tests requested before blood product support) in a bleeding infant or with an unexplained severe coagulopathy. The infant should not be discharged until the results are available.
- For mild conditions, testing may be required at a later date as definitive diagnosis may not be possible until the hemostatic system has matured.

Clotting Abnormality	**PT alone**	**APTT alone**	**TT alone**	**PT and APTT**	**PT. ASPTT. TT**	**All Normal**
Factor abnormality	Factor VII def	Factor VIII IX, XI, XLL def	Low fibrinogen	Factor II, V, X def	Fibrinogen deficiency	XIII def
Diagnosis	Vitamin K def	Hemophilia A or B Von Willebrand disease	Heparin contamination	Liver disease	DIC	Platelet defects
	Warfarin	Heparin			Severe liver disease Heparin	

Clotting abnormalities in preterm infants

- There is no evidence to support the routine testing of coagulation in preterm infants, or literature to suggest which infants should be tested.
- It would be reasonable to perform a coagulation profile in:
    - Infants at high risk of abnormalities e.g. those who may have a consumptive coagulopathy (DIC, sepsis especially gram negative infections, NEC),
    - Who have suffered a significant hemorrhage (e.g. severe bruising, pulmonary hemorrhage, grade 4 IVH).
    - Those undergoing surgical procedures such as laparotomy.
- It should be noted that the wide ranges for “normal” clotting times quoted for preterm infants overlap with values that could occur in neonates with congenital bleeding disorders e.g. hemophilia.
- The possibility of a bleeding disorder should therefore still be considered if there is a family history or if there is bleeding symptoms even if the clotting screen is normal.
- Specific factor assays may be required which should be discussed with a hematologist.
- There is no evidence for routine “screening” coagulation profiles or prophylactic administration of FFP.

Treatment

- Empirical blood product support may be indicated if there is bleeding or the clotting times are significantly prolonged (more than 1.5 times the mean normal range) and the infant is considered to be at higher risk of bleeding, e.g., bruised, septic, has suffered a recent hemorrhage (e.g., significant IVH or pulmonary hemorrhage) or is to undergo an invasive procedure.
- When interpreting coagulation results, take into account heparin contamination as this will falsely prolong APTT and in some cases PT.

Suggested treatment threshold / action

	Fibrinogen g/L	PT (s)	APTT (s)
>28/40 gestation	< 0.7	21	113
28-34/40 gestation	< 0.9	20	80
34-37/40 birth	<1.0	20	80
34-37/40 day 5	<1.0	19	76
34-37 day 30	<1/0	18	67
Term (birth)	<1.0	20	64
Term day 5	<1.0	19	64
Term day 30	<1.0	18	61
Action-bleeding/high risk of hemorrhage	Cryoprecipitate	Vitamin K+- FFP	FFP
Evidence strength/category	4D	3C	3C

FFP- Fresh Frozen Plasma

- This is a blood product containing fibrinogen, factors II, VII, VIII IX, X, XII, XIII.
- There is evidence that routine use of FFP for fluid boluses/blood pressure support for prophylaxis of IVH does not offer benefit in the short or long term and therefore cannot be recommended.
- The dose of FFP is 10-20 ml/kg delivered over 30 minutes.

Cryoprecipitate:

- This is precipitate that forms following the thawing of FFP.
- It contains a high concentration of factor VIII, von Willebrand factor, fibrinogen factor XIII and fibronectin.
- Cryoprecipitate is often used for infants with low fibrinogen due to DIC,
- However there is no neonatal evidence to support this use.
- The dose used is 5-10ml/kg infused over 30 minutes.

Specific factor concentrates

- Factor VIII, IX and VWF containing
    - For severe hemophilia or type 2 VWD

- Should be referred to tertiary centers.
- Must be discussed with a consultant pediatric hematologist.

Specific coagulopathies

Vitamin K deficiency

- This is a common acquired cause of coagulopathy which can result in vitamin K deficiency bleeding (VKDB).
- It occurs due to low placental transfer of vitamin K, low bacterial colonization of the gut leading to low endogenous supply, and low intake of vitamin K due to the low quantities in breast milk.
- There are 3 subtypes:
  - Early VKDB
    - This presents within the first 24 hours with serious bleeding as intracranial bleeding, in infants of mothers on vitamin K inhibitors such as anticoagulants, anticonvulsants and anti-tuberculosis drugs.
  - Classical
    - Occurs between days 1 and 7 with GI bleeding and intracranial hemorrhage.
    - Often these infants have not received vitamin K at birth. The incidence of classical VKDB is 0.01-1.5% without vitamin K prophylaxis.
  - Late
    - This occurs between 2 and 12 weeks of age.
    - The majority of these infants present with intracranial hemorrhage. The incidence of late VKDB is 4-10 per 100,000 births.
- Investigation
  - Initially PT will be prolonged, however in more severe forms; the APTT will also be increased.
- Treatment
  - Urgent vitamin K is the treatment of choice given by slow intravenous injection.
  - Unless venous access cannot be established in which case this can be given subcutaneously..
  - The intramuscular route should not be used when there is a coagulopathy.
  - In infants who are bleeding, FFP should be given in addition to Vitamin K.
  - In the presence of life-threatening hemorrhage or intracranial hemorrhage, the use of Prothrombin Complex Concentrate should be discussed with a hematologist.
- It is recommended that all infants receive 1 mg vitamin K in the first 6 hours after birth to prevent VKDB.
- Infants receiving this orally require a further dose to prevent the late form.

Disseminated Intravascular Coagulation (DIC)

- This is the most common form of coagulopathy seen on the neonatal unit.
- It results from activation of the coagulation cascade leading to consumption of coagulation factors and subsequent hemorrhage.

- Diagnosis is made in infants with a prolonged PT, APTT, reduced fibrinogen, and thrombocytopenia and raised D-dimers.
    - Note, not all parameters may be abnormal especially in early DIC.
- Treatment
    - Supportive
        - The mainstay of treatment is reversing the underlying condition- this is commonly sepsis or NEC, hypoxia, etc.
    - Blood products
        - Beyond supportive care there are no clear guidelines on the optimal management of neonatal DIC.
        - Blood product support may be indicated if there is bleeding or the infant is at risk of bleeding from an invasive procedure and the clotting times are significantly prolonged.
        - Those more than 1.5 times the mean normal range would usually trigger empirical therapy.
        - Mild DIC usually does not warrant blood product support.
    - Platelets
        - Thrombocytopenia should be treated as per guideline, aiming for a platelet count of 30-50 $x10^9$/l.
    - FFP- 10-20 ml/kg of FFP can be given to improve coagulation tests by about 30%.
    - Cryoprecipitate 5-10 ml/kg – this can be used for infants with low fibrinogen levels; however this practice is extrapolated from adult literature as there are no trials of this in newborns.

References:

1- UCSF Children's Hospital, *Neonatal Coagulation Disorders: Intensive Care Nursery House Staff Manual*, https://www.ucsfbenioffchildrens.org/pdf/manuals/40_Bleeding.pdf
2- Auckland District Health Board, *Newborn Services Clinical Guideline*, NZ, 2018 Update.
3- Wong W, Glader B, *Disseminated Intravascular Coagulation in Infants and Children*, UpToDate, 2018, https://www.uptodate.com/contents/disseminated-intravascular-coagulation-in-infants-and-children/print.

Polycythemia in Newborn

Definition: Central hematocrit > 65% (venous sample to confirm).

Causes:

A. Falsely elevated Hct: heel stick sample.

B. Dehydration. Weight loss and decreased urine output are sensitive indicators of dehydration.
C. True polycythemia

1- Placental transfusion occurs with delayed cord clamping, twin-twin transfusion, feto-maternal transfusion, or perinatal asphyxia.
2- Iatrogenic polycythemia: too much blood was transfused.
3- Intrauterine hypoxia may be caused by placental insufficiency. It may be seen in postmature or small for gestational age infants, preeclampsia/eclampsia, and infants of diabetic mothers as well.
4- Maternal use of the drug propranolol, maternal smoking and severe maternal heart disease.
5- Chromosomal abnormalities as trisomy 21.
6- Idiopathic.

Clinical presentation:

Many infants with polycythemia are asymptomatic. Symptoms and signs of polycythemia include respiratory distress, tachypnea, hypoglycemia, lethargy, irritability, apnea, seizures, jitteriness, vomiting, weak sucking reflex, poor feeding, and cyanosis.

Treatment:

1- Obtain CBC, glucose monitoring, sodium, BUN, calcium, bilirubin.
2- Symptomatic infant: Consider partial exchange transfusion.
3- Asymptomatic infant:
   - ✓ HCT 65 to 75%, start IV hydration, monitor for symptoms and keep checking HCT every 12 hours.
   - ✓ HCT >75 to 80%, then partial exchange transfusions is needed.
4- To calculate the volume of Plasmanate that must be exchanged, use the following formula:
   Volume exchanged = Weight (kg) X 80 X (HCT of patient – desired HCT) / HCT of patient
   (Blood volume = 80 mL/kg), desired HCT is 60% always, take out blood and transfuse normal saline:

References:

1- Auckland District Health Board, *Newborn Services Clinical Guideline*, NZ, 2018 Update.
2- Hansen AR, *Cloherty and Stark's Manual of Neonatal Care*, 8th edition, 2017.

Neonatal Thrombocytopenia

Introduction

- Normal platelet count for neonates is 150–400 x 10 9/L. Population–based studies on cord blood suggest 2% of term infants have a platelet count < 150, and 0.2% have platelets < 50.
- Thrombocytopenia (e.g. platelets <100) should be investigated and may be a symptom of underlying disease.
- The commonest cause of a falsely low platelet count is a clot in the sample. Repeat if in doubt, especially if capillary sample or difficult peripheral venepuncture.
- The natural history of thrombocytopenia in sick infants is very consistent. Platelets fall by day 2 of life in 75% of affected babies, and usually reach their nadir around day 4. By day 10, the platelet count has recovered to normal in 90% of cases.
  - In an otherwise well term infant, the commonest cause of thrombocytopenia is alloimmune. In a preterm or systemically unwell baby, the commonest cause is sepsis.

Causes:

Timing	Most common etiology	Less common etiology
Early-Onset Neonatal (<72 hours)	Placental insufficiency Perinatal asphyxia DIC Alloimmune (NAIT) Autoimmune	Congenital infection (e.g. CMV, toxoplasma, rubella) Thrombosis (e.g. aortic, renal vein) Bone marrow replacement (e.g. congenital leukemia) Metabolic disease (e.g. propionic and methylmalonic acidemia) Congenital/inherited
Late-Onset Neonatal	Late-onset sepsis NEC	Congenital infection (e.g. CMV, toxoplasma, rubella) Autoimmune Kasabach-Merritt Phenomenon

Treatment:

Platelet count ($x10^9$)	Indications for transfusion
<20	1. All neonates
<30	1. Neonates <1000 g and <7 days 2. Clinically unstable (e.g. fluctuating BP) 3. Previous major bleeding (e.g. Grade 3-4 IVH, pulmonary hemorrhage) 4. Current minor bleeding 5. Concurrent coagulopathy 6. Requiring surgery or exchange transfusion 7. NAIT
<50	1. Major Hemorrhage

Practice points

a. Consider clinical risk factors in addition to absolute platelet count:

    1. Timing of onset (early versus late),
    2. Primary origin (maternal, placental or neonatal/fetal),
    3. Individual risk for bleeding (gestational age, postnatal age, NEC/sepsis, surgery, signs of bleeding).

b. In a clinically stable, term neonate without NAIT, signs of infection or pre-existing IVH the threshold for transfusion of $<20 \times 10^9$/l seems safe.

c. Persistent unexplained thrombocytopenia should be investigated for uncommon causes.

d. For platelet transfusion dose, see the Blood Product Guideline.

Reference:

Auckland District Health Board, *Newborn Services Clinical Guideline*, NZ, 2018 Update.

Blood Transfusion in NICU

Common causes of neonatal anemia

1. Preterm delivery before establishment of normal red cell and iron stores in last trimester.
2. Blood loss for Laboratory testing.
3. Expansion of blood volume with growth.
4. Physiological cessation of red cell synthesis in the first 6 weeks after birth.

Although these factors combine to result in the 'normal' fall in hemoglobin concentration in the first 6-9 weeks after birth, this is accompanied by improved oxygen unloading capacity as 2,3-DPG levels rise, so that tissue oxygen delivery may improve despite reduced oxygen carrying capacity. Thus the possible benefits of transfusion need to be balanced against the known (and unknown) risks for each individual baby.

Indications for transfusion

1. Shock due to blood loss. If severe see the Massive transfusion protocol. (Term baby estimated total blood volume is 80ml/kg and extremely preterm baby is 100ml/kg).
2. Exchange transfusion for severe hemolytic anemia – See neonatal jaundice protocol.
3. Anemia of prematurity - transfusion thresholds.

Table 1: Hemoglobin concentration, g/dL (hematocrit, %)

Respiratory Support		No Respiratory Support
<7 days	11 (35)	10 (30)
8-14 days	10 (30)	9 (25)
>15 days	9 (25)	7 (23)

These thresholds are for guidance only and should be individualized considering the following factors:

Severity of respiratory disease (and other condition)

1. Any symptoms that might relate to anemia e.g. increasing apneas.
2. The reticulocyte count (marker of RBC production).
3. Any evidence of on-going blood loss or hemolysis (e.g. a rhesus baby who'd been managed with intra-uterine transfusions).
4. Possible or proven sepsis.
5. Baby to have surgery – It remains uncertain what the optimal preoperative hemoglobin should be for neonates undergoing major surgery.
6. Stable growing babies > 6 weeks old: Transfuse only if hematocrit <23 **and** symptomatic.

Irradiated components are required for:

1. Infants with known or suspected immunodeficiency disorders.
2. Infants who have received intrauterine transfusions.
3. Infants transfused with directed donations (from family relatives).
4. Exchange transfusion where the requirement to irradiate will not unduly delay transfusion.

Volume to Transfuse:

1. In general a dose of 15 ml/kg can be expected to raise the hemoglobin concentration by about 20g/L.
2. Small babies (<1,500 g) in the first week of life: 10- 15 ml/kg over 2 hours.
3. Larger babies and older babies: 15-20 ml/kg over 2 hours to maximize hemoglobin rise while minimizing numbers of transfusions required.
4. There is no indication for routine furosemide. If there is risk for fluid overload consider giving 1 mg/kg at the start of the transfusion

Transfusion reactions

Type of reaction	Symptoms and signs
Febrile	1. Pyrexia, rigors.
Circulatory overload	1. Increase in blood pressure, heart rate and respirations. 2. Pulmonary edema, dyspnea, increase in urinary output
Allergic	1. Urticaria, facial edema, dyspnea, hypotension 2. TRALI (transfusion associated lung injury)
Hemolytic	1. Collapse with hypotension. 2. Shock, pyrexia, rigors, hemoglobinuria, hemoglobinemia, oliguria, later uremia.
Infected blood	1. Pyrexia, profound collapse and shock, pallor, dyspnea, low blood pressure, rapid pulse.

Pre-Administration Checklist

1. The unit of blood/plasma must be checked by a Registered Nurse with a current IV certificate and checked by a RN or Enrolled Nurse, Registered Obstetric Nurse with current IV certificate

2. Informed consent must be obtained unless the situation is life threatening. Consent is documented on the Agreement for Treatment (CR0111) form and signed by parent. However verbal consent by a parent is acceptable provided it is documented in baby's chart, until written consent can be obtained.

3. Check maternal antibody status and baby's blood group if known.

4. Baby's identity – the baby's identification band is checked against front sheet of clinical records.

5. Swinging label is checked with baby identity and component issue form.
6. Swinging label is checked with label on bag for donation number, donation group, expiry date and/or collection date to determine age of blood. **MUST BE LESS THAN 35 DAYS OLD.** To limit donor exposure, dedicated units may be available for small babies who will require up to eight transfusions in the first four weeks of life.
7. Check blood is leukodepleted and CMV negative.
8. The unit of blood/plasma/platelets is checked for abnormalities (visual inspection).
9. Check prescription order and amount to be given (blood transfusion/IV fluid balance chart).
10. If administering blood via a luered cannula, check patency of luer prior to ordering blood.
11. Administration of each pediatric pack should take no longer than 2 hours – no exceptions. If the amount of blood required must be given over 3 hours, a further pack of blood will need to be obtained from blood bank.
12. If a Guthrie card (NBST) has not yet been taken, ensure this is done prior to the first RBC transfusion.

References:

1- Auckland District Health Board, *Newborn Services Clinical Guideline*, NZ, 2018 Update,
2- Sunnybrook Hospital, *NICU Guidelines*, Toronto, 2015.

PART VII: Infectious Diseases

Late Onset Neonatal Infections (after 72 Hours of Age)

- The majority of late onset infections are hospital acquired.
- Prevention of these infections is the first line of management.
- The incidence in Palestine needs to be estimated and varies from unit to another.
- This high infection rate is due to a combination of factors – a susceptible host (preterm infant), and exposure to high risk interventions (prolonged hospital admission, indwelling central lines, handing by multiple personnel, exposure to prolonged courses of antibiotics).

Risk factors

- Risk of infection is inversely related to gestational age and birth weight, and directly related to severity of illness at birth, reflecting need for invasive interventions e.g. prolonged ventilation, central venous access and parenteral nutrition.
- Delayed introduction of enteral feeds is associated with higher infection rates.
- Increased risk of sepsis after gut surgery especially if enteral feeds slow to establish e.g. post-gastroschisis or necrotizing enterocolitis (NEC) with stoma

Signs and symptoms of sepsis in infants:

- The signs and symptoms of sepsis in infants are varied and subtle.
- Not all of those listed below will definitely be due to infection, and do not necessarily mean that investigations must be performed, equally some infants will have an infection without any of these signs however they should be used as triggers for a further clinical assessment of the infant.

General Pyrexia; *Temperature instability* (non-environmental), e.g. need for increase in incubator temperature.	**CNS** "Quiet" (usually identified by parents), change in cry/weak cry; irritability; seizures,
Respiratory Respiratory distress/grunting; apneas; desaturations (a change in the previous pattern); increased ventilatory requirements/need for CPAP or intubation.	**Cardiovascular** Tachycardia; bradycardias (a change from the previous pattern); hypotension; poor peripheral perfusion/mottling ; increased metabolic acidosis/lactic acidosis.
Metabolic Hyperglycemia; hypoglycemia. Jaundice.	**Renal** Poor urine output (usually secondary to hypotension/poor perfusion).
GI Poor feeding/weak suck; Vomiting; Poor feed tolerance e.g., increased aspirates; bilious aspirates/vomiting; loose stools.	**Hematological** White cells – increase or decrease, especially neutrophils; thrombocytopenia; coagulopathy

Causes (organisms):

Late onset sepsis in babies who were not admitted to NICU, still GBS, E.coli, listeria should be considered.

In NICU patients those who develop sepsis after 72 hours, The most common are Coagulase negative Staphylococcus (most common cause of line sepsis), Staph Aureus and Gram negative bacilli (Klebsiella, E Coli & Enterobacter Cloacae.

Suspected late onset (>72hrs) sepsis

A. Full Septic work up.

- Blood culture peripheral & lines if present.
- LP (Required for **all** babies).
- Urine (SPA, or catheter).
- Wound swabs, ET secretions (if ventilated); consider stool for virology (*consider case by case*).

B. Babies admitted from community – Ampicillin plus Gentamicin. If meningitis is suspected or LP postponed give ampicillin plus Cefotaxime.

C. All other babies: according to the microbiome in the hospital and the common organism in the unit. Vancomycin and amikacin should be good empiric treatment in general. But where there is higher incidence of gram negative organism or baby is very sick, piperacillin/tazobact or Meropenem should be started with amikacin.

D. In units where CRE is present, colistin to be considered.

E. In those with positive cultures take new control cultures and reassess inflammatory markers after 48 hours.

F. Stop antibiotics according to the following:

- Baby is well, cultures are negative and normal labs → in 36-48 hours.
- Baby is well, cultures are negative but high inflammatory markers → 5-7 days.
- Gram negative sepsis → 14 days after negative control culture.
- Gram negative meningitis → 21 days after negative control CSF culture but if there was abscess or ventriculitis at brain imaging, duration should be 4-6 weeks.
- Gram positive sepsis → 7-10 days are usually enough.
- Gram positive meningitis → 10-14 days after negative control CSF culture.

If baby is not improving or deteriorating, consider upgrading antibiotics after taking new cultures and consider fungal sepsis (adding fluconazole or amphotericin).

What about the baby not getting better?

For infants failing to improve after 24-48 hours, consider the following:

1. Persistent line infection? – Re-culture or change lines with adequate period free of lines.
2. Fungal infection? – Especially in presence of thrombocytopenia.
3. Another focus? E.g., bone, liver abscess, endocarditis.
4. Consider ultrasound screening of above sites.
5. Consider viral screen.
6. Consider immune defect.
7. Is the baby on the correct treatment (with therapeutic drug levels?)
8. Discuss with microbiology.
9. May be appropriate to change antibiotic therapy to meropenem, vancomycin and fluconazole.

Meningitis

Meningitis is diagnosed if a lumbar puncture has any of the following: positive gram stain or positive culture or more than 22 white blood cells/L.

1. Infants with suspected meningitis should have their antibiotics changed to Cefotaxime and ampicillin/amoxicillin pending CSF culture results, ***unless microbiological surveillance data reveal local bacteria and/or resistance patterns indicating the need for different antibiotics***. Consider also the risk of herpes encephalitis and the need for aciclovir.
2. Meningitis is diagnosed if a lumbar puncture has any of the following:
   - Positive Gram stain.
   - Positive culture.
   - More than 22 white blood cells/L.

   If < 22 cells/microliter, still consider bacterial meningitis if other symptoms and signs, e.g., seizures until final results from cultures, etc.
3. Meningitis due to a Gram-positive infection shown by CSF Gram stain, continue treatment with intravenous ampicillin/ amoxicillin and Cefotaxime while awaiting the CSF culture result and seek expert microbiological advice.
4. Meningitis due to a Gram-negative infection either by CSF Gram stain or culture, stop ampicillin/amoxicillin and give at least 14 days of treatment with Cefotaxime alone or alternative antibiotics based on microbiology advice.
5. Meningitis due group B streptococcus in CSF culture treated with 5 days of gentamicin ***and*** 14 days of benzyl penicillin. Penicillin is the treatment of choice. In cases of GBS meningitis, use high doses of penicillin (450,000-500,000 U/kg/day) or ampicillin (150-200 mg/kg/day for sepsis, 300–400 mg/kg/day for meningitis).

6. Positive for listeria from CSF culture or blood culture, consider stopping Cefotaxime and treating with ampicillin/amoxicillin and gentamicin for 21 days. Gentamicin continued until the patient improves (usually 7 to 14 days) or, in poor responders, for up to three weeks if there are no signs of nephrotoxicity or ototoxicity.

7. If positive for a Gram-positive bacterium other than group B streptococcus or listeria form the cerebrospinal fluid culture, seek expert microbiological advice on management.

8. Other organism: Treatment of other organisms should be guided by microbiology advice.

9. Suspected meningitis (organism not known, i.e. negative CSF culture): If clinical or CSF findings are suggestive of meningitis, babies should complete 14 days of antibiotics, e.g., Meropenem, amoxicillin and topical antifungals. Treat meningitis for 14 days.

Central line infection

- With Coagulase negative staphylococcus – 5 days vancomycin and topical antifungals after line removal.
- Other organisms – follow microbiology advice.

Confirmed Staph aureus infections:

Use Cloxacillin (culture positive Staph Aureus sepsis should be treated for three weeks. Actively exclude the possibility of osteomyelitis and septic arthritis which will require antibiotic treatment for six weeks).

UTI

- Treatment of confirmed UTI should be based on susceptibility results.
- UTI prophylaxis: trimethoprim is first line. Discuss with consultant microbiologist and neonatologist if known trimethoprim resistance.

References;

1- Gaza Neonatal Network, *Late-Onset Sepsis*, May 2014.
2- Polin RA, Committee on Fetus and Newborn. Management of Neonates with Suspected or Proven Early-Onset Bacterial Sepsis. *Pediatrics* 2012; 129:1006.
3- Nizet V, Klein JO. Bacterial Sepsis and Meningitis. In: Remington JS et al (Ed), *Infectious Diseases of the Fetus and Newborn Infant*, 7th ed., Elsevier Saunders, Philadelphia 2010.
4- NICU Women's Hospital Hamad Medical Corporation, *Clinical Guidelines: Use of Antibiotics in NICU*. Approved by: HMC Corporate Antibiotic Committee, April 30th, 2012.
5- Pilling E., *North Trent Neonatal Network Clinical Guideline: Management of Late Onset Infection on the Neonatal Unit*, February 2012.

Maternal Varicella

The aim of this protocol is to provide guidance on the diagnosis and management of Varicella Zoster virus in the newborn.

- Varicella-zoster virus (VZV) is the human herpesvirus that causes primary varicella infection, known as chickenpox.
- Latent VZV infection can reactivate as herpes zoster also called shingles.
- Varicella pneumonia is the most common cause of mortality,
- The incubation period for varicella typically is between 10 and 21 days, although the administration of varicella-zoster immune globulin (VZIG) or intravenous immune globulin (IVIG) can extend the incubation period up to 28 days,
- Patients with varicella are considered contagious from 1 to 2 days preceding the development of the rash until all lesions have crusted over.
- The preferred method for the diagnosis of VZV is polymerase chain reaction or direct fluorescent antibody testing of vesicular swabs or scrapings.

There are 2 separate presentations depending on timing of infection:

- Fetal varicella syndrome (FVS): maternal chickenpox infection before 20 weeks' gestation.
- Neonatal varicella: maternal infection in perinatal period or close contact with chickenpox or shingles in first 7 days after birth.

Fetal varicella syndrome FVS

Approximately 25% to 36% of women infected during pregnancy will transmit VZV to their fetuses, but fewer than 2% of maternal infections result in FVS.

- Symptoms and signs
    - Neurological abnormalities (e.g., mental retardation, microcephaly, hydrocephalus, seizures, Horner's syndrome).
    - Limb hypoplasia.
    - Scarring of skin in a dermatomal distribution.
    - Cortical atrophy, microcephaly, bowel and bladder sphincter dysfunction, vocal cord paralysis.
    - Chorioretinitis, cataracts and microphthalmia.
    - Intra-uterine growth restriction.
- Investigations
    - Maternal
        - If no history of chickenpox, check maternal VZ IgG at time of contact.
        - If mother develops chickenpox rash, send swab from base of vesicle in viral transport media for varicella zoster PCR.
    - Neonatal
        - ≤7 days VZ IgM (can be done on cord blood), or
        - >7 days VZ IgG (even if VZ IgM negative at birth).

        - Persistence of VZV IgG beyond seven months of age.
        - If vesicles present send swab from base of vesicle in viral transport media for varicella zoster PCR.
- Management
    - Management is supportive and requires long-term multidisciplinary follow-up.
    - Varicella zoster immunoglobulin (VZIG) or aciclovir have no role in the management.

Neonatal varicella (NV)

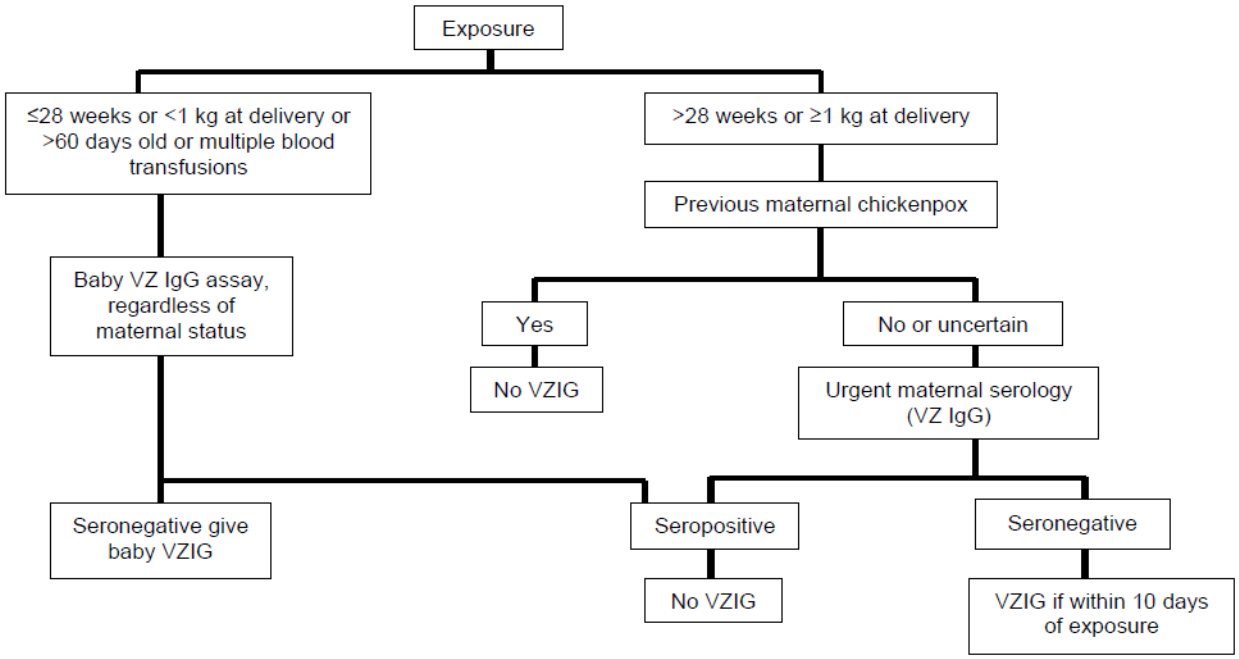
- NV is a serious illness with high mortality (approximately 30%).
- Most commonly occurs in babies born to mothers with chickenpox or close contact with chickenpox or zoster within 7 days of birth.
- Management of exposure to chickenpox/zoster.
    - Requires VZIG.
- Management of baby born to mother who develops chickenpox rash (but not zoster) within 7 days before birth, or 7 days after birth:
    - Give VZIG 250 mg (1 vial approximately 1.7 mL) IM (not IV).
    - Up to date, 125 units (1 vial) intramuscularly for neonates weighing >2.1 kg to 10 kg and 62.5 units (0.5 vial) for children weighing ≤2 kg.
    - Antenatal chickenpox: give as soon as possible after delivery (must be within 72 hour).
    - Postnatal chickenpox: give as soon as possible and within 10 days after initial exposure.
    - Consider giving in different sites in small babies.
    - Can be given without antibody testing of baby.
    - Of no benefit once neonatal chickenpox has developed.
    - Not needed for babies born after 7 days of appearance of maternal chickenpox, or where mother has zoster; these babies should have transplacental antibodies.
    - May not prevent NV, but can make the illness milder
    - If VZIG not available or IM injection contraindicated, give 0.2 g/kg IVIG (less effective).
- Management of baby exposed to chickenpox after birth from non-maternal source (see Decision pathway for VZV contact):
    - Significant exposure: household, face-to-face for 5 min, in same room for >15 min.
    - A case of chickenpox or disseminated zoster is infectious from 48 hours before onset of rash until crusting of lesions.
    - Give VZIG in the following cases of postnatal exposure to varicella:
        - Varicella antibody-negative babies (determined by testing mother for varicella antibodies) exposed to chickenpox or herpes zoster from any other contact other than mother, in first 7 days of life.
        - VZ antibody-negative babies of any age, exposed to chickenpox or herpes zoster while still requiring intensive or prolonged special care nursing.
        - For babies exposed postnatally, regardless of maternal chickenpox history, who:

- weighed <1 kg at birth, or
- Were ≤28 weeks' gestation at birth, or
- Are >60 days old, or
- Have had repeated blood sampling with replacement by packed cell infusions, perform VZ IgG assay and, if negative, give VZIG (because they are at risk of not having received or retained sufficient maternal VZ IgG).

Symptoms and signs of NV

- Mild: vesicular rash.
- Severe: pneumonitis, pulmonary necrosis, fulminant hepatitis.
    - Mortality 30% without VZIG.

Decision pathway for VZV contact



Treatment

- Aciclovir.
- Indications:
    - Babies with signs and symptoms of NV.
    - If high risk (e.g. premature) and mother develops chickenpox 4 days before to 2 days after delivery.
    - Chickenpox in baby:
        - Currently treated with corticosteroids.
        - Born prematurely.
        - Immunocompromised.
- Dosage:
    - 20 mg/kg IV (over 1 hour) 8-hourly, diluted to 5 mg/mL.
    - For renal impairment, refer to Neonatal Formulary.
    - Treat for ≥7 days; up to 21 days if severe.

Subsequent management

Where:

- On postnatal ward, unless baby requires neonatal intensive care support:
    - Isolate mother and baby together in separate room until 5 days after onset of rash and all lesions crusted over.
    - If baby already exposed, breastfeeding can continue, but explain to mother possible risk of transmission.

Staff:

- Exposed staff with no history of chickenpox, VZ vaccination or of unknown VZ IgG status to have VZ IgG measured by occupational health.
    - If VZ IgG negative,
        - Immunize with varicella vaccine.
        - Remove from clinical duties during days 7–21 following exposure.
        - If in high-risk group for complications (immunocompromised), offer VZIG.

Monitoring treatment

- Aciclovir:
    - Ensure good hydration.
    - Stop once clinical improvement occurs, or when all lesions crusted.

Discharge and follow-up

Maternal infection:

- After baby has had VZIG, discharge.
- Advise mother to seek medical help if baby develops chickenpox, preferably via an open-access policy where available.

Fetal infection:

- Diagnosed with positive VZ IgM or positive VZV PCR.
- Ophthalmic examination.
- Cranial ultrasound.
- Developmental follow up.

References:

1- Institute of Obstetricians and Gynecologists, Royal College of Physicians of Ireland and the Clinical Strategy and Programmes Division, Health Service Executive, *Clinical Practice Guideline, Chickenpox in Pregnancy*, Nov 2015.
2- Lamont R, Sobel J, Carrington D, Mazaki-Tovi S, Kusanovic J, Vaisbuch E, Romero R. Varicella-Zoster Virus (Chickenpox) Infection in Pregnancy. *BJOG* 2011;118:1155–1162.
3- Cobelli Kett J., Perinatal Varicella, *Pediatrics in Review*, January 2013, Vol 34 / Issue 1.

RSV Prophylaxis for Prevention of Bronchiolitis

- Palivizumab was licensed in June 1998 by the Food and Drug Administration for the reduction of serious lower respiratory tract infection caused by respiratory syncytial virus (RSV) in children at increased risk of severe disease.
- For qualifying infants: 5 doses given, a dose beginning in November and continuation for a total of 5 monthly doses will provide protection for most infants through April.
- If prophylaxis is initiated in October, the fifth and final dose should be administered in February, which will provide protection for most infants through March.
- If prophylaxis is initiated in December, the fifth and final dose should be administered in April, which will provide protection for most infants through May.

Summary of guidance

- In the first year of life, palivizumab prophylaxis is recommended for infants born before 29 weeks, 0 days' gestation.
    - Palivizumab prophylaxis is not recommended for otherwise healthy infants born at or after 29 weeks, 0 days' gestation.
- In the first year of life, palivizumab prophylaxis is recommended for preterm infants with CLD of prematurity, defined as birth at <32 weeks, 0 days' gestation and a requirement for >21% oxygen for at least 28 days after birth.
- Clinicians may administer palivizumab prophylaxis in the first year of life to certain infants with hemodynamically significant heart disease.
- Clinicians may administer up to a maximum of 5 monthly doses of palivizumab (15 mg/kg per dose) during the RSV season to infants who qualify for prophylaxis in the first year of life.
    - Qualifying infants born during the RSV season may require fewer doses. For example, infants born in January would receive their last dose in March.
- Palivizumab prophylaxis is not recommended in the second year of life except for children who required at least 28 days of supplemental oxygen after birth and who continue to require medical intervention (supplemental oxygen, chronic corticosteroid, or diuretic therapy).
- Monthly prophylaxis should be discontinued in any child who experiences a breakthrough RSV hospitalization.
- Children with pulmonary abnormality or neuromuscular disease that impairs the ability to clear secretions from the upper airways may be considered for prophylaxis in the first year of life.

- Children younger than 24 months who will be profoundly immunocompromised during the RSV season may be considered for prophylaxis.
- Insufficient data are available to recommend palivizumab prophylaxis for children with cystic fibrosis or Down syndrome.
- Palivizumab prophylaxis is not recommended for prevention of health care-associated RSV disease.

References:

1- AAP, RSV Recommendations Unchanged after Review of New Data, *AAP News*, October 19, 2017.
2- Committee on Infectious Diseases and Bronchiolitis Guidelines Committee, Updated Guidance for Palivizumab Prophylaxis among Infants and Young Children at Increased Risk of Hospitalization for Respiratory Syncytial Virus Infection, *Pediatrics*, August 2014, Vol 134 / Issue 2.

Infection Control and Prevention

Purpose and intent:

To provide a process to reduce the risk of cross-contamination between patients in neonatal areas.

Practice outcome:

Decrease the incidence of nosocomial infections in vulnerable newborns.

Guidelines:

Key factors:

- Hand hygiene
- Personal protective equipment
- Cleaning and sterilization
- Visitors
- Environment
- Screenings
- Isolation precautions

Adhere to the "4 Moments for Hand Hygiene":

- Before initial patient / patient environment contact
- Before aseptic / clean procedures
- After body fluid exposure risk
- After patient / patient environment contact

Staff and Visitors:

- Upon entering the Neonatal Intensive Care Unit, follow the instructions.
- Instruct all visitors in appropriate hand hygiene and infection prevention measures.
- Remove all rings, watches and other jewelry on hands and wrists before performing hand hygiene and handling of neonatal patients.
- Keep natural nails clean with the nail not showing past the end of the finger, with any nail polish fresh and in good condition and no artificial nails or nail enhancements.
- Keep arms bare to the elbows during direct patient care.

Central lines and indwelling catheters:

- Wear clean gloves for all handling of invasive devices such as peripheral IVs, chest tubes, etc., that are indwelling.
- Management of central lines is done according to the Neonatal Guideline "Central Venous Access Device Management in Neonates".

- Discontinue invasive devices including chest tubes, drains and urinary catheters as early as possible to diminish the infection risk.
- Provide skin antisepsis prior to invasive procedures using the appropriate antiseptic options.
- For umbilical catheter insertions prevent potential chemical burns by using care to cleanse the umbilical cord only and not the abdominal skin.

Isolation of infected baby:

- Cover gowns or another appropriate barrier must be worn if:
    - An infant is on isolation technique.
    - A staff member will be holding an infant in close contact and then will move on to hold a second infant with close contact.
    - A patient care activity is likely to generate splashed or sprays of anybody fluid.

Environment:

- Gather all clean supplies with clean hands and assemble them on a clean surface.
- Use medication bedside bins for medications only.
- Clean bins daily and when visibly soiled.
- Any papers or lines or bedding of the baby are part of his own environment and hand hygiene measures should be followed when touching these.

Cleaning and disinfection:

- Use hospital approved disinfectant to clean contaminated surfaces and objects.
- Clean surface with hospital approved disinfectant before and after infant feeding preparation.
- Wipe patient bedside area at the start of every shift and as often as necessary.
    - This includes bedside table or cart, counter tops, monitor, ventilators, IV pump control pads and any computer keyboard that are in the area. Clean incubators / infant warmers according to a schedule and additionally as required.
- When cleaning an incubator or warmer, remove and scrub all detachable parts. If the incubator has a fan, clean and disinfect it according to the manufacturer's instructions. Maintain the air filter as recommended by the manufacturer. Replace mattresses when the surface covering is broken. Clean and disinfect portholes, cuffs and sleeves frequently.

Infection spread from staff and visitors:

- Staff members who have cold sores (herpetic lesions) do not work with newborns until the lesion is crusted and dry.
- Visitors who have been identified as having an infection can visit only after consultation with the Infection Prevention and Control department and the attending neonatologist.
- Families who wish to bring toys in to the hospital are encouraged to bring in toys that are easily cleaned. Plush toys are sent home with the family to be laundered weekly and when visibly soiled or contaminated.

- Keep plush toys away from direct contact with patients who have invasive lines.

References:

1- Hospital for Sick Children, *Neonatal Guidelines*, Toronto, 2015.

2- Winnipeg Health Authority, *Acute Care Manual, Infection Control and Prevention*, Canada, 2018.

PART VIII: Neurology

Cranial Ultrasonography

Purpose

- To detect brain injury in at-risk babies in order to provide appropriate medical management.
- To detect lesions associated with long-term adverse neuro-developmental outcome.

ROUTINE SCANNING PROTOCOL FOR PRETERM BABIES

- Scan preterm babies according to the following minimum regimen
- Scan babies of ≥33 weeks' gestation only if clinically indicated

Gestation					
<30 weeks	0–3 days		6–10 days	14–16 days	36 weeks CGA or at discharge
30–32 weeks		3–7 days			36 weeks CGA or at discharge

Additional scans

- If routine scans show a significant abnormality, discuss serial scanning with consultant.
- **If intraventricular (grade 2+) or intraparenchymal hemorrhage:** follow-up at least weekly until stable (more frequently if unstable posthemorrhagic hydrocephalus and clinically indicated.
- Perform additional scans as clinically indicated or following a significant clinical event:
    - Necrotizing enterocolitis
    - Major collapse
    - Repeated severe episodes of apnea and bradycardia
    - Unexplained sharp fall in hemoglobin
    - Change in neurological status
    - Abnormal head growth
    - Pre and post-operatively

Follow-up

If scan is abnormal at 6 weeks, discuss the need for further imaging with consultant.

Indications for scanning term/near term babies

- Neonatal encephalopathy/ischemic brain injury
- Neonatal seizures
- Multiple congenital abnormalities (except trisomy 21)
- Unexplained poor feeding at term

- Unexplained hypoglycemia, looking for pituitary and midline structures
- Meningitis, congenital viral infection
- Metabolic disorders
- Suspected brain malformations
- Consider further imaging e.g. MRI scan or, if ultrasound abnormal, CT scan of brain
- Significant maternal alcohol intake during pregnancy.

Scan reporting

- Appropriately trained staff must interpret cranial ultrasound scans.

Intraventricular hemorrhage

- None
- Localized IVH without dilatation (germinal matrix hemorrhage, subependymal hemorrhage)
- IVH with ventricular dilatation
- Large IVH with parenchymal infarction

Ventricular size

- Normal
- Enlarged (measure and plot ventricular index)

Parenchymal lesions

- None
- Periventricular flare
- Cystic lesions
    - Single large porencephalic cyst
    - Multiple cysts (cystic periventricular leukomalacia)

Documentation

- Documentation is extremely important. Archive digital copies of scans for future review – each image must contain patient identifiers.
- Record following information on investigation chart:
    - Date scan requested
    - Date scan carried out
    - Record ultrasound result (or file a written report) in baby's notes.
    - Record a plan for performing future scans.
- Record in notes any discussion with parents, especially of abnormal scans.
- Include results of all scans in discharge summary, even if normal.
- If eligible baby transferred to another hospital before scanning, communicate need for scan in transfer summary.

Cranial U/S has poor sensitivity in detection of the following (ask CT/MRI): cerebral edema, subdural and subgaleal hemorrhage, after HIE, white matter injury in preterm babies.

References;

1. Hansen AR, *Cloherty and Stark's Manual of Neonatal Care*, 8th edition, 2017.
2. Gleason CA, Devaskar SU (Ed.), *Avery's Diseases of the Newborn*, 9th edition, 2012.
3. Gomella TL et al., *Neonatology: Management, Procedures, On-Call Problems, Diseases and Drugs*, 7th edition, 2013,
4. Auckland District Health Board, *Newborn Services Clinical Guideline*, NZ, 2018 Update.
5. Bedside Clinical Guidelines Partnership, *Neonatal Guidelines 2017-19*, Staffordshire, Shropshire and Black Country Neonatal Operational Delivery Network and Southern West Midlands Neonatal Operational Delivery Network.

Hypoxic Ischemic Encephalopathy (HIE)

Definition:

Hypoxic-ischemic encephalopathy (HIE) is a type of neonatal encephalopathy caused by systemic hypoxemia and/or reduced cerebral blood flow resulting from an acute peripartum or intrapartum event. It is a condition which can cause significant mortality and long-term morbidity. HIE can be a clinical consequence of perinatal, birth and/or neonatal asphyxia.

Risk factors:

- History of non-reassuring cardiotocography (CTG)
- Fetal heart rate abnormalities during labor
- Low Apgar score
- Acidotic umbilical arterial or venous gas
- Need for prolonged resuscitation

Diagnostic Criteria:

The American College of Obstetricians and Gynecologists (ACOG) developed a consensus statement regarding the criteria needed to define an intrapartum hypoxic-ischemic insult that is severe enough to cause a neonatal encephalopathy that subsequently leads to cerebral palsy.

Markers of acute hypoxia-ischemia – **Neonatal encephalopathy** (SEIZURE, STUPOR, COMA, HYPOTONIA) is most likely due to acute hypoxia-ischemia when one or more of the following conditions are present **(Essential criteria)**

1. Metabolic acidosis (pH<7, or base deficit ≥12 mmol/L in fetal, cord or within 60 minutes of life.
2. Apgar score 0-3 for longer than 5 minutes or Apgar score of <5 at 5 minutes and 10 minute.
3. Acute brain injury seen on brain MRI or magnetic resonance spectroscopy (MRS) consistent with hypoxia-ischemia (limited use in our settings, as it is usually done late after 72 hours for prognostic purposes).
4. Presence of multisystem organ failure consistent with hypoxic-ischemic encephalopathy
5. Exclusion of other identifiable etiologies, such as trauma, coagulation disorders, infectious conditions, or genetic disorders.

The cornerstone of all statements is the presence of severe metabolic acidosis (pH < 7.0 and base deficit ≥ 12 mmol/L) at birth in a newborn exhibiting early signs of moderate or severe encephalopathy.

Severity staging of HIE: (modified from Sarant-1976)

Signs	**Stage I (Mild)**	**Stage II (Moderate)**	**Stage III (Severe)**
LOC	Hyper alert	Lethargic	Stuporous, coma
Muscle tone	Normal	Hypotonic	Flaccid
Posture	Normal	Flexion	Decerebrate
DTR/clonus	Hyperactive	Hyperactive	Absent
Myoclonus	Present	Present	Absent
Moro reflex	Strong	Weak	Absent
Pupils	Mydriasis	Miosis	Unequal, poor light reflex
Seizures	None	Common	Decerebration
EEG	Normal	Low voltage changing to seizure activity	Burst suppression to isoelectric
Duration	<24-48 hours	Resolve within 5 days	Days to weeks

From: Hansen AR, *Cloherty and Stark's Manual of Neonatal Care*, 8th edition, 2017, pp. 796-797.

Investigations (Some tests may not be available locally)**:**

Day one		**Subsequent days**
1st line on admission	**2nd line same day**	
Blood glucose Blood cultures Coagulation (PT / APPT / TT / Fibrinogen) Arterial blood gas Lactate FBC / film / platelets Hb / PCV U&Es and LFTs CRP	Magnesium Troponin I (peaks 6-12 hours post insult) Congenital infection screen Maternal Kleihauer if anemic or history of APH ***To exclude other causes of neonatal encephalopathy consider***: Lumbar puncture/Metabolic screen including ammonia, amino acids/Urine for amino and organic acids, ketones, reducing substances/Genetic investigations.	Daily FBC Coagulation Renal function LFTs

Imaging:

Head ultrasound soon after admission to rule out intracranial hemorrhage as it may contraindicate cooling therapy, at 24-48 hours you may see signs of brain edema.

In general head ultrasound has little prognostic utility but relative increase of end diastolic blood flow velocity compared to peak systolic blood flow velocity (Resistive Index<0.55) in anterior cerebral artery predicts poor outcome.

DW MRI at day 5 of life or just after rewarming is a good indicators for future outcome.

Management of HIE:

- Optimal management is prevention through recognition of risk factors and appropriate timely intervention. However, many cases of perinatal asphyxia are unanticipated and unpreventable.
- The clinical management of infants with HIE is a combination of therapeutic hypothermia (where appropriate) and supportive management, dependent on the extent of organ compromise. Each baby's management should be individualized, with close monitoring of cardiorespiratory status and early identification and treatment of multi- organ system complications where appropriate.
- If the baby meets the criteria for cooling discuss as soon as possible with the consultant on call
- This discussion includes: selection of patients who need cooling and initiation of passive cooling pending transfer to the treatment center and the steps that should be undertaken to ensure that cooling is safely initiated and maintained.

Eligibility criteria for therapeutic hypothermia (Refer to Cooling guidelines)**:**

The following criteria will be used as a guide when choosing to provide neonatal hypothermia.

Inclusion Criteria:

A. **Infants ≥ 35 completed weeks gestation admitted to the NICU with at least one of the following:**
    (1) Apgar score of ≤ 5 at 10 minutes after birth
    (2) Continued need for resuscitation, including endotracheal or mask ventilation, at 10 minutes after birth
    (3) Acidosis within 60 minutes of birth (defined as any occurrence of umbilical cord, arterial or capillary pH < 7.00)
    (4) Base Deficit ≥ 16 mmol/L in umbilical cord or any blood sample (arterial, venous or capillary) within 60 minutes of birth.
    (5) Infants that meet criteria A will be assessed for whether they meet the neurological abnormality entry criteria

B. **Moderate to severe encephalopathy** (Seizure, hypotonia, coma)
C. **Timing:** Initiation of this therapy should begin within 3-6 hours of birth. New data suggest that cooling before 12 hours of age may have benefits.

Passive cooling:

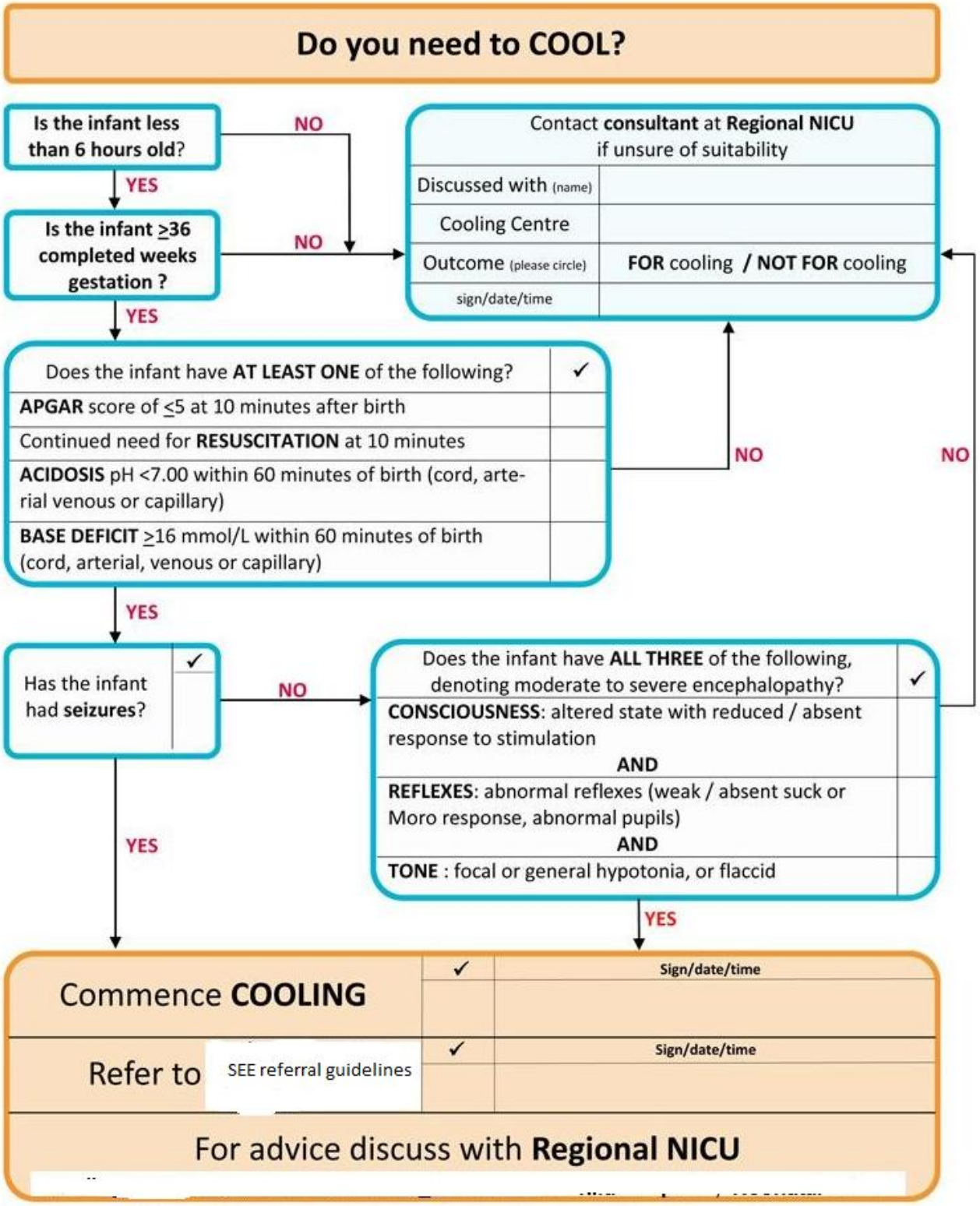
- For all infants born outside of the Cooling Centers, passive cooling should only be commenced after discussion with treatment center and continued until the infant is transferred.
- Care is taken to not overheat the infant prior to cooling
- Turn off radiant heat source and allow to cool passively- turn off incubator and open doors

- Umbilical venous and arterial lines should be inserted as venous access may not be easy to establish once the infant is cooled and frequent blood samples +/- invasive BP monitoring may be required
- Insert approved rectal probe to 3 cm
- Turn off radiant heat source and allow to cool passively
- Cooling (core temperature between 33.0 and 34.0°C) normally continues for a period of 72 hours before careful rewarming. Infants with severe PPHN may require warming earlier.
- Infants are nil by mouth during their initial stabilization and assessment. Consideration of starting trophic feeds (20ml/kg/day) during active cooling is at the discretion of the consultant and may depend on the availability of EBM.
- Infants do not need to be routinely intubated and ventilated during therapeutic cooling. This should be assessed on an individual case basis.
- Cold is a noxious stimulus. During cooling, patients may be kept comfortable on a morphine infusion of lowest possible dose (5mic per kg per hour, titrate as needed.
- Monitor rectal temperature continuously aiming for a rectal temperature of 33.5°C (range 33-34°C – **do not** allow it to drop below this). Record rectal temperature every 15 minutes. ***Please ensure you use a low reading thermometer***.
- **Continuous monitoring of HR, Respiration, BP, is advisable during cooling.** Obtain central access (UVC/UAC).
- Perform cranial ultrasound (CUSS) to investigate for any other major structural causes of encephalopathy. Discuss any unexpected findings with consultant.

Active cooling (Criticool device):

- Assemble the criticool system according to device manual available in your unit.
- Set temperature at 33.5°C;
- Cooling for 72 hours.
- Intensive care monitoring during cooling;
- Whole panel of blood work (CBC, electrolytes, calcium, kidney function, liver function, coagulation, blood gases, lactate) every 12 hours;
- Gradual rewarming of 0.2 to 0.5°C per hour till you reach 36.5°C;
- Brain MRI (DWMRI) to be performed after rewarming (3-5 days of age);
- Continuous EEG monitoring or aEEG (CFM) during and after cooling;
- Manage seizures accordingly;
- General management of the infant is provided according to the routine clinical practice guidelines and protocols such as:
    - respiratory support,
    - cardiovascular support,
    - management of seizures,
    - infection,
    - fluid and electrolyte balance.

Identification and selection of patients for cooling flowchart * ∞



***CONSENT –** Verbal parental assent should be sought for cooling treatment which requires transfer to the cooling center and parents may be given a copy. Details of all discussion with parents about their infant's treatment with cooling should be documented in the infant's notes.

References:

1. AAP and ACOG Task Force. *Guidelines for Hypoxic Ischemic Encephalopathy*, Updated 2014.
2. Gaza Neonatal Network, *Hypoxic Ischemic Encephalopathy*, July 2014.
3. Yvonne Wu, MD, MPH: Clinical features, diagnosis, and treatment of neonatal encephalopathy, UpToDate 2013
4. National Institute for Health and Clinical Excellence. IPG347. Therapeutic hypothermia with intracorporeal temperature monitoring for hypoxic perinatal brain injury. file://publications.nice.org.uk/therapeutic-hypothermia-with-intracorporeal-temperature-monitoring- for-hypoxic-perinatal-brain-ipg347 (Accessed on November 29, 2011).
5. Perlman JM, Wyllie J, Kattwinkel J, et al. Neonatal resuscitation: 2010 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science with Treatment Recommendations. Pediatrics 2010; 126:e1319.
6. Yorkshire Neonatal Network HIE guideline
7. North Trent HIE Neonatal Network Guideline

Intraventricular Hemorrhage (IVH):

Introduction:

IVH, the most common type of neonatal intracranial hemorrhage, occurs mainly in preterm infants ≤32 weeks of gestation.

The incidence ranges from 13-65% in different centers, decreases with advancing gestational age and is influenced by certain perinatal risk factors (see below).

Pathogenesis is related to:

(1) Intra-vascular factors:

- Impaired cerebral autoregulation.
- Fluctuating cerebral blood flow (related to fluctuating arterial blood pressure).
- ↑ Cerebral blood flow (e.g., due to hypercarbia, excess volume expansion).
- ↑ Cerebral venous pressure (e.g., with pneumothorax, asphyxial heart failure).
- Hypotension and reperfusion.
- Coagulation abnormalities.

(2) Vascular factors:

- Germinal matrix, a highly vascular structure with poor capillary support, is present 50% of ventricular area or distends ventricle).
- Intra-parenchymal echodensity (IPE) represents periventricular hemorrhagic infarction and is often referred to as Grade IV IVH.

Severity and grading of IVH by head ultrasound:

The following grading system is used:

- Grade I – Bleeding is confined to the GM.
- Grade II – GMH and IVH occupies between 10 to 50 percent of the lateral ventricle volume.
- Grade III – GMH and IVH occupies more than 50 percent of the lateral ventricle volume and is associated with acute ventricular distension.

Prevention of IVH

Prevention of IVH is primary goal of management and important factors are:

Perinatal:

- Prevention of prematurity.
- Improved perinatal management, including:

- Maternal transport of women in preterm labor to regional center.
- Antenatal glucocorticoids: accelerate lung maturation and decrease IVH.
- Optimal obstetrical management

Postnatal:

- Skilled resuscitation to avoid hypoxia and hypercarbia.
- Circulatory support to avoid hypotension and fluctuating arterial blood pressure.
- Correction of coagulation abnormalities.

Management:

Other than early diagnosis and careful supportive care (including correction of coagulopathies, circulatory and respiratory support), there is no therapy for IVH. Consider consultation with Neurology for all IVH cases except Grade I and mild Grade II. For progressive ventricular dilatation (post-hemorrhagic hydrocephalus), the essential point is early recognition. Head circumference does not increase until after there has been considerable ventricular dilatation. Therefore, do serial head U/S examinations in infants with IVH ≥grade II. Some cases of ventricular dilatation will respond to serial lumbar punctures and/or acetazolamide (carbonic anhydrase inhibitor) or other diuretics (to decrease CSF production). Persistent, progressive ventricular dilatation requires a ventricular reservoir or ventriculo-peritoneal shunt by a neurosurgeon.

General measures include the following:

- Maintenance of arterial perfusion to avoid hypotension or hypertension and preserve cerebral blood flow without significant perturbations.
- Adequate oxygenation and ventilation with specific avoidance of hypocarbia, hypercarbia, and acidosis.
- Provision of appropriate fluid, metabolic, and nutritional support.
- Seizures should be treated to avoid any associated impairment of cerebral oxygenation and cerebral perfusion, or elevations of systemic blood pressure.
- Detection of posthemorrhagic ventricular dilatation (PHVD), which is the major complication of severe IVH.

References:

1. Hansen AR, *Cloherty and Stark's Manual of Neonatal Care*, 8th edition, 2017.
2. Gleason CA, Devaskar SU (Ed.), *Avery's Diseases of the Newborn*, 9th edition, 2012.
3. Gomella TL et al., *Neonatology: Management, Procedures, On-Call Problems, Diseases and Drugs*, 7th edition, 2013.
4. Auckland District Health Board, *Newborn Services Clinical Guideline*, NZ, 2018 Update.
5. Bedside Clinical Guidelines Partnership, *Neonatal Guidelines 2017-19*, Staffordshire, Shropshire and Black Country Neonatal Operational Delivery Network and Southern West Midlands Neonatal Operational Delivery Network.

Neonatal Seizures

The incidence of neonatal seizures in term infants is 0.7-2.8 per 1000 live births and is higher in the preterm population. In term infants hypoxic-ischemic encephalopathy is the most common cause, but other causes include intracranial hemorrhage, infection, metabolic abnormalities, CNS malformations and drug withdrawal.

Types of seizures

The clinical manifestations of neonatal seizures differ from those in older children. Five major varieties are described:

1- Subtle,
2- Generalized tonic,
3- Multifocal clonic,
4- Focal clonic, and
5- Myoclonic.

Jitteriness is not a seizure but is frequently confused with one and may be a sign of cerebral irritation.

History, examination, and investigation

- It is important to obtain a careful perinatal history and perform a physical examination.
- Hypoglycemia or meningitis should be recognized and treated promptly.
- Investigation should include:
    1- Blood glucose.
    2- FBC and PCV,
    3- Blood gas.
    4- Sodium, potassium, magnesium, calcium and phosphate.
    5- Further investigation including lumbar puncture, cerebral ultrasound, metabolic screen and CT or MRI will depend on the individual case.
    6- Neuroimaging:
        - Cranial ultrasound scans recommended for all babies with seizures to exclude intracranial hemorrhage
        - Magnetic Resonance Imaging (MRI) to evaluate the cause of seizures in preterm babies and to provide the definitive diagnosis in term babies
    7- Neurophysiology
        - EEG is the only way to identify electrographic seizures and to monitor response to therapy

Indication for treatment

- Untreated seizures may continue for extended periods of time, interfere with ventilation or precipitate cardiovascular collapse.

- Cardio-respiratory compromise may impair cerebral vascular autoregulation and predispose to secondary brain injury.
- In general if seizure duration >3 min or frequency or >3 per hour treatment is required.
- Ensure that ventilation and perfusion are adequate and any hypoglycemia is corrected.
- Drugs should be given intravenously to achieve a rapid onset of action and predictable blood levels.

Usual sequence of therapy

1	**<u>Phenobarbitone</u> 20 mg/kg loading dose (slow IV infusion over 30 mins)** - If the initial 20 mg/kg dose is ineffective, additional doses of 5-10 mg/Kg can be administered until either seizures have ceased or a total dose of 40 mg/Kg has been given.
2	**<u>Phenytoin</u> 20 mg/kg (slow IV infusion over 30 mins, i.e. < 1 mg/kg/min)** - Cardiac rate and rhythm should be monitored during the infusion.
3	**Livetricetam (keppra) 20-60 mg/kg/day** - Infuse over 1 hour in a 5% solution made up in 5% dextrose.
OR	**Clonazepam 100-200 micrograms/kg (intravenously over 30 seconds)** - And if control not achieved then Clonazepam intravenous infusion 10-30 micrograms/kg/hour.
OR	**<u>Midazolam</u> 0.05 to 0.15 mg/kg as a slow push over 5 minutes** - Can be repeated 2-4 hourly as required or given as a continuous infusion (10-60 micrograms/kg/hour).

Convert to maintenance therapy when seizures controlled (usually not >48 hours infusion).

N.B. If there are recurrent seizures with no obvious cause consider pyridoxine dependency.

A therapeutic trial of pyridoxine IV 50 -100 mg may be helpful (this may be considered during EEG).

EEG

It is not necessary to defer therapy until an EEG can be obtained. However, EEG may assist in confirming that subtle phenomena are seizures or to determine if a paralyzed infant is having seizures.

The interictal EEG may be useful in estimating prognosis particularly in HIE.

Maintenance therapy

- Phenobarbitone 3-6 mg/kg/day. IV, IM, or oral.
- Phenytoin 3-8 mg/kg/day IV only (oral absorption is erratic).
- Maintenance therapy should begin 12 hours after the loading dose and is given divided q 12 hours.
- Drug levels are important when these drugs are used for maintenance.
- Slow elimination rates in asphyxiated infants, secondary to hepatic and/or renal involvement, may lead to drug accumulation.
- Also maintenance administration of phenytoin is difficult because of its nonlinear kinetics and rapid decrease in elimination rates in the first weeks of life.

Duration of therapy

- Optimal duration of therapy depends principally on the likelihood of recurrence of seizures.
- Following HIE there is a low risk of seizure recurrence after early withdrawal of anticonvulsant in the neonatal period.
- Hence, it is usual to discontinue the anticonvulsant prior to discharge.
- However, infants with prolonged or difficult seizures and those who continue to show abnormality on EEG may benefit from continuing treatment (usually monotherapy with phenobarbitone).
- The neurodevelopmental outcome depends on the cause of seizures. Major cerebral malformations have a poor prognosis whilst the outcome from HIE, infection, and metabolic abnormalities will be variable. It is important that all infants with neonatal seizures receive adequate follow up.

References:

1. Queensland Maternity and Neonatal Clinical Guidelines Program. *Neonatal Seizure Guideline No.MN10.10-V2-R15*. Queensland Health. 2010. Available from: http://www.health.qld.gov.au/qcg.
2. Hospital for Sick children, *Neonatal Guidelines*, Toronto, 2105.

Congenital Hypotonia

Congenital hypotonia is a relatively common diagnosis in the newborn period. It is defined as a subjective decrease of resistance to passive range of motion in a newborn and can be due to a defect at any level of the nervous system.

Causes include (but are not limited to):

Central (most common)	1. Hypoxic ischemic encephalopathy 2. Intracranial hemorrhage 3. Cerebral malformations 4. Chromosomal abnormalities (e.g. Trisomy 21, Prader-Willi syndrome) 5. Congenital infections (TORCH) 6. Acquired infections 7. Peroxisomal disorders 8. Drug effects (e.g. benzodiazepines)
Spinal cord	1. Birth trauma (especially Breech delivery) 2. Syringomyelia
Anterior Horn Cell	1. Spinal Muscular Atrophy 2. Pompe's disease (acid maltase deficiency)
Neuromuscular junction	1. Myasthenia gravis (transient/ congenital) 2. Infantile botulism
Muscle	1. Muscular dystrophies (including congenital myotonic dystrophy) 2. Congenital myopathies (e.g. central core disease)
Peripheral nerves	1. Hereditary motor and sensory neuropathies
Metabolic myopathies	1. Acid maltase deficiency 2. Carnitine deficiency 3. Cytochrome-*c*-oxidase deficiency

The first goal in diagnosing the source of neonatal hypotonia is to ascertain if it is central (upper motor neuron) or peripheral (lower motor neuron). Central causes are the most common. This delineation will determine the investigations most likely to yield a diagnosis.

History

1. Any significant family history – affected parents or siblings, consanguinity, stillbirths, childhood deaths.
2. Maternal disease – diabetes, epilepsy, myotonic dystrophy (may not be recognized).
3. Pregnancy and delivery history – drug or teratogen exposure.
4. Decreased fetal movements.
5. Abnormal presentation.
6. Polyhydramnios/ oligohydramnios.

7. Apgar scores.
8. Resuscitation requirements.
9. Cord gases.
10. History since delivery:
    1. Respiratory effort.
    2. Ability to feed.
    3. Level of alertness.
    4. Level of spontaneous activity.
    5. Character of cry.

Physical examination

A detailed physical examination should be performed, assessing muscle tone, any asymmetry, the infant's strength, deep tendon reflexes (DTR), and any dysmorphic or unusual features.

Central	***Anterior Horn Cell***	***Nerve***	***Neuromuscular Junction***	***Muscle***
Normal strength	Generalized weakness	Weakness, distal>proximal	Weakness, face/ eyes/ bulbar	Weakness, proximal > distal, face, EOM
Normal / increased DTRs +	Decreased/ absent DTRs	Decreased/ absent DTRs	Normal DTRs	Decreased DTRs
+/- seizures	Fasciculations	+/- Fasciculations	No fasciculations	
+/- dysmorphic features, reduced alertness	Often described as alert		+/- arthrogryposis	+/- contractures

+ At times babies with profound central hypotonia may have absent DTR, therefore absent DTR at least in the first few days of life would not rule out a central cause for the hypotonia.

* Note that the presence of profound weakness as well as hypotonia suggests a disorder of the lower motor neuron. A sign of this may be a weak cry. Weakness is uncommon in central hypotonia except in the acute stages.

Arthrogryposis (the fixation of joints at birth) may be associated with neonatal hypotonia, more commonly with lower motor neuron unit or multisystem abnormalities.

Additional clues which may direct to a specific diagnosis:

1. Hepatosplenomegaly – storage disorders, congenital infections
2. Renal cysts, high forehead, wide fontanelles – Zellweger's syndrome
3. Hepatomegaly, retinitis pigmentosa – neonatal adrenoleukodystrophy
4. Congenital cataracts, glaucoma – oculocerebrorenal (Lowe) syndrome
5. Abnormal odor – metabolic disorders
6. Hypopigmentation, undescended testes – Prader Willi

Examination of the mother is also important in suspected cases of congenital myotonic dystrophy or myasthenia gravis.

Most studies have found that central causes account for 60-80% of cases and that the diagnosis can usually be made by a careful history and examination. However, there may be a mixed picture. Infants with a peripheral cause for their hypotonia may be at increased risk for problems during labor, delivery and resuscitation and develop hypoxic ischemic encephalopathy.

Investigations

Further investigation needs to be guided by history and examination.

1. If the infant is hypotonic but has a degree of strength, a central cause is most likely and investigations should be directed toward this.
2. If the infant is hypotonic and weak a peripheral cause is possible and an early review the neurology service is warranted.

Reference;

Auckland District Health Board, *Newborn Services Clinical Guideline*, NZ, 2018 Update.

PART IX: Fluids and Electrolytes and Metabolic Disorders

IV Fluids Principles

Principles

- Postnatal physiological weight loss is approximately 5–10% in first week of life
- Preterm babies have more total body water and may lose 10–15% of their weight in first week of life.
- Postnatal diuresis is delayed in respiratory distress syndrome (RDS) and in babies who had significant intrapartum stress.
- Preterm babies have limited capacity to excrete sodium in first 48 hours.
- Sodium chloride 0.9% contributes a significant chloride (Cl-) load which can exacerbate metabolic acidosis.
- Liberal sodium and water intake before onset of natural diuresis is associated with increased incidence of patent ductus arteriosus (PDA), necrotizing enterocolitis (NEC) and chronic lung disease (CLD).
- After diuresis, a positive sodium balance is necessary for tissue growth.
- Preterm babies, especially if born <29 weeks' gestation, lose excessive sodium through immature kidneys.
- Babies <28 weeks have significant transepidermal water loss (TEW).

Monitoring

Weight

- On admission.
- Daily for intensive care babies: twice daily if fluid balance is a problem.
- Use in-line scales if available.

Serum sodium

- Daily for intensive care babies.
- If electrolyte problems or ≤26 weeks, measure twice daily.
- Admission electrolytes reflect maternal status: need not be acted upon but help to interpret trends.
- Serum urea not useful in monitoring fluid balance: reflects nutritional status and nitrogen load.

Serum creatinine

- Reflects renal function over longer term.
- Trend is most useful.
- Tends to rise over first 2–3 days.
- Gradually falls over subsequent weeks.
- Absence of postnatal drop is significant.

Urine output

- Review 8-hourly for intensive care babies.
- 2–4 mL/kg/hour normal hydration.
- <1 mL/kg/hour requires investigation except in first 24 hours of life.

- >6–7 mL/kg/hour suggests impaired concentrating ability or excess fluids.

Normal requirements

Humidification

- If <29 weeks, humidify incubator to 60-80%.
- If ventilated or on CPAP ventilator, set humidifier at 38°C

Normal fluid volume requirements:

Day	Pre-term	Full-term
1	80 ml/kg/day	60 ml/kg/day
2	100 ml/kg/day	80 ml/kg/day
NO ADDED ELECTROLYTES IN THE 1ST 48 HOURS*		
3#	120 ml/kg/day	100 ml/kg/day
After 48 hours, add potassium (1-2 mEq/kg**) and sodium (2-3 mEq/kg/d)		
4	150 ml/kg/day	120 ml/kg/day
5	150 ml/kg/day	150 ml/kg/day

* Add calcium in the first 24 hours ONLY for ELBW infants.

** Start K supplements only after UOP has been established, usually by 3rd day of life to 1-2 mEq/kg/d and increase over 1-2 days to 2-3 mEq/kg/d

manage fluids by increments or decrements of 20-40 cc/kg/day after 3rd day of life depending on weight changes and Na values as following:

- Fluids should be increased if:
  - ✓ Weight loss is >1-2% in term and >2-3 % in preterm infants.
  - ✓ UOP is low.
  - ✓ Serum Na is rising.

- Fluids should be decreased if:
  - ✓ Weight is not falling appropriately (physiologic decrease).
  - ✓ Serum Na is decreasing.

Type of fluid

- Glucose 10% is the first choice in full-term & pre-term, use D 5% if birth weight <1000 g & has glucose intolerance.

Modify fluid rate in:

- Radiant warmer (open system): add 50%.
- Phototherapy: controversial in full-term, may be needed in LBW to add 10-20ml/kg/day.
- Hyperthermia: increase by 30%.

- GIT losses (ex: pyloric stenosis): replace losses by NaCl 0.9% and add K if good urine output.
- Other ongoing losses: replace 1 mL by 1 mL; choice of fluid depends on electrolyte content of the body fluid.
- Birth asphyxia (see protocol): Restrict total fluids to 40 mL/kg/day for first 48 hours. Liberalization will then depend upon clinical progress.
- Oliguric AKI (see AKI protocol) – Restrict input to insensible losses plus previous 6 hours urine output, to be replaced over following 6 hours. Fluid balance must be re-calculated every 6 hours.
- Fluid overload: The diagnosis is based on weight gain, edema, and often hyponatremia management is usually effected by 10% to 20% decrements of total daily fluid intake, while carefully monitoring clinically and laboratory.

References:

1. Hansen AR, *Cloherty and Stark's Manual of Neonatal Care*, 8th edition, 2017.
2. Gleason CA, Devaskar SU (Ed.), *Avery's Diseases of the Newborn*, 9th edition, 2012.
3. Gomella TL et al., *Neonatology: Management, Procedures, On-Call Problems, Diseases and Drugs*, 7th edition, 2013,
4. Auckland District Health Board, *Newborn Services Clinical Guideline*, NZ, 2018 Update.
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Hyperglycemia in the Newborn

Definition

Defined as blood glucose level of more than 145 mg/dl (Hansen AR, *Cloherty and Stark's Manual of Neonatal Care*, 8th edition, 2017, page 321).

Causes of hyperglycemia

- Iatrogenic,
- Extremely low birth weight <1000 gm,
- Stress e.g. infection,
- Side-effect of medication e.g. glucocorticoid therapy,
- Hypoxia,
- Neonatal diabetes.

Complications of hyperglycemia

- Associated with periventricular hemorrhage, retinopathy of prematurity and death.
- Undernutrition leading to faltering growth.
- Osmotic diuresis leading to dehydration.
- Exacerbation of hypoxic ischemic brain injury.

Management of hyperglycemia

The first step is to investigate and treat underlying pathology as infection.

1. Reduce dextrose intake: For babies in the first 72 hours of life, or who are receiving a large volume of intravenous fluids, consider changing 10% dextrose to 5% dextrose (at GIR of 4 mg per kg per minute).

   NB. Hypotonic fluids with glucose concentration less than DW 5% should be avoided.

   Begin TPN as soon as possible as some aminoacids may promote insulin secretion.

2. Insulin:
   Criteria for insulin use: Persistent blood glucose concentration ≥ 250 mg/dl despite minimal glucose infusion rate.

   Boluses of 0.05 -0.1 unit per kg of short acting insulin Q 4-6 hours may be used initially as needed.

Management of insulin infusion

1. Administer in same line as intravenous fluids, so if there are any interruptions, both are interrupted together.

2. Starting dose usually 0.05 units/kg/hour, then adjusted according to requirements by increase of 0.01 unit/kg/hour if glucose is >180mg/dl.
3. **Do not** include insulin in the total daily fluid intake - it should be titrated on top of the prescribed fluid intake.
4. Monitor the blood glucose concentration Q 1 hour till you have stable blood glucose readings then you can space, if glucose decreases to <145 mg/dl, wean insulin by 0.01 unit rate and continue hourly monitoring.
5. If develops hypoglycemia, stop insulin infusion immediately and administer DW 10%.
6. Aim for a blood glucose concentration between 145-180 mg/dl while on insulin infusion.
7. Once the blood glucose concentration is stable within the target range, wean insulin dose at least daily, more often if tolerated.

References

1. Alsweiler JM, Harding JE, Bloomfield FH. Tight Glycemic Control with Insulin in Hyperglycemic Preterm Babies: A Randomized Controlled Trial. *Pediatrics*. 2012;129(4):639-47.
2. Hansen AR, *Cloherty and Stark's Manual of Neonatal Care*, 8th edition, 2017.

Sodium Imbalances

Management of hyponatremia

- Normal Range: 135-145 mEq/L
- Definition of hyponatremia: serum sodium < 130mEq/L

Causes

- Excessive free water
  - Reflection of maternal electrolyte status in first 24 hours.
  - Failure to excrete fetal extracellular fluid will lead to edema without weight gain.
  - Water overload: diagnose clinically by edema and weight gain.
  - Excessive IV fluids.
  - Inappropriate secretion of ADH in babies following major cerebral insults, or with severe lung disease.
  - Treatment with indomethacin or ibuprofen.
- Excessive losses
  - Prematurity (most common cause after age 48 hours).
  - Adrenal insufficiency.
  - GI losses.
  - Diuretic therapy (older babies).
  - Inherited renal tubular disorders.
- Inadequate intake
  - Preterm breast fed babies aged >7 days.

Management:

Management depends on the cause

1- Emergency measures (hyponatremic seizures):
- Give NaCl 3%* (1 cc = 0.5 mEq) 4-6 mL/kg IV push over 15 min.
  * To prepare NaCl 3%, add 1 ml NaCl 23.4% to 9 ml NaCl 0.9%.

2- If serum Na < 120 mEq/L REGARDLESS the cause, it is recommended to use NaCl 3% to correct Na deficit using the below formula over 4- 6 hours.

Total Na deficit = (125 – measured Na) X B.W (kg) X 0.6

Note: In asymptomatic hyponatremia with serum Na > 120 mEq/L, hypertonic infusions are NOT indicated.

3- Correct sodium deficit using the above formula

Give only 2/3 the amount over 24 hours with added maintenance of sodium (3 mEq/kg) and the remaining 1/3 over the next 24 hours.

Follow-up serum Na every 4-6 hours till correction

4- Excessive IV fluids and failure to excrete fetal ECF. Management of the cause:
- Reduce fluid intake to 75% of expected

Inappropriate ADH

Clinical features
- Weight gain, edema, poor urine output.
- Serum osmolality low (<275 mOsm/kg) with urine not maximally dilute (osmolality >100 mOsm/kg).

Management
- Reduce fluid intake to 75% of expected.
- Consider sodium infusion only if serum sodium <120 mmol/L.

Acute renal failure

Management
- Reduce intake to match insensible losses + urine output.
- Seek advice from middle grade doctor/consultant.

Excessive renal sodium losses

Management
- If possible, stop medication (diuretics, caffeine) that causes excess losses.
- Check urinary electrolytes.
- Calculate fractional excretion of sodium (FE Na+ %):
  - FE Na+ = [(urine Na x plasma creatinine)/(urine creatinine x plasma Na)] × 100
  - Normally <1% but in sick preterm babies can be up to 10%.
  - Affected by sodium intake: increased intake leads to increased fractional clearance.
  - If >1%, give sodium supplements.
- Calculate sodium deficit
  - = (135 – plasma sodium) x 0.6 x weight in kg
- Replace over 24 hours unless sodium <120 mmol/L or symptomatic (apnea, fits, irritability).
- Initial treatment should bring serum sodium up to about 125 mmol/L.
- Use sodium chloride 30% (5 mmol/mL) diluted in maintenance fluids. Ensure bag is mixed well before administration.

Management of hypernatremia

Definition:
Serum sodium > 145 mEq/L

Mild: 146–149 mmol/L
Moderate: 150–160 mmol/L
Severe: >160 mmol/L

Most common cause is failure to establish adequate oral intake while attempting breastfeeding.

Hypernatremia does not reflect total body sodium (may be normal, high or low depending on the cause).

Neonates with chronic hypernatremia often do not demonstrate overt signs of intravascular volume depletion and dehydration until late in the course of the condition.

Management:

Assess fluid status, based on clinical and laboratory criteria

Mild hypernatremia (Manage in postnatal ward/at home):

- Put baby to the breast and encourage mother to express breast milk (EBM).
- Top up baby with EBM/formula milk 100 mL/kg/day by cup or syringe.
- Check U&E and calcium after 12 hours.
- Monitor blood glucose as per Hypoglycemia guideline.
- Aim to establish breastfeeding and reduce top-up once sufficient EBM.
- Admit to the neonatal unit and give IV fluid if:
    - Oral feeds not tolerated.
    - Baby unwell.
    - Repeat U&E shows worsening hypernatremia, moderate or severe hypernatremia.
    - Associated hypocalcemia.

Moderate to severe hypernatremia:

- Emergency phase (if signs of shock): 1st priority is to restore intravascular volume with isotonic fluid (normal saline is preferred) – give 20 cc/kg over 20 min and repeat as needed.
- Rehydration phase: replace fluid deficit and the maintenance needs plus ongoing losses:
    - Administer fluid at a constant rate over time for correction.
    - Typical rate: 1.25-1.5 times maintenance (1.25-1.5 x maintenance fluid).
    - Example: weight 2 kg, day 5 of life: fluid required = 1.5 x 2 x 150= 450 mL
    - Refer to fluid management guideline according to weight and postnatal age.
    - Feeding to be considered in calculation of maintenance fluid.
    - For proper adjustment of sodium level, keep NPO for 24 hours if serum Na >175 mEq/L.

- Follow serum Na ***after shock*** therapy then ***every 2-4 hours*** till desired rate of decline of serum Na then ***every 4-6 hours*** till serum Na < 150 mEq/L.
- Goal of drop of serum sodium is **12 mEq/L/day (<0.5 mEq/L/hour)**.
- Increase the rate if slow drop of serum Na.
- Decrease the rate if rapid drop of serum Na.
- The only indication for rapid correction of hypernatremia (reducing serum Na by 1 mEq/L/hour or 24 mEq/L/day) without risk of brain edema is acute hypernatremia due to accidental sodium loading.

- Choose appropriate type of fluids (suggested by Avery according to serum sodium):
    - Na < 165 mEq/L: pediatric dextrose/saline (D4.3%-0.18 NS) (31 mEq/L) or
    - Na > 165 mE/L: use D 5%-NS* (154 mEq/L).
    - If this solution is not available, prepare by adding 15.5 mL NaCl 23.4% to 500 mL pediatric dextrose/saline (this equals (62+ 15.5) x 2 = 155 mEq).
    - If sodium drop is higher than desired, add hypertonic saline to IV fluid to keep Na concentration of the solution 10-15 mEq/L less than serum Na.
    - Example: serum sodium 180, sodium concentration of fluid should be 165-170 mEq (Add 21-22 mL NaCl 23.4% to each 500 mL NS).
    - Once serum Na, UOP and renal function are normalized, give standard IV or oral fluids according to the patient condition with monitoring of serum Na for additional 24 hours.

Emergency management of seizures (usually due to rapid correction):

- Give NaCl 3% as 4-6 cc/kg IV push over 15 minutes.

Symptomatic management

- Hypernatremia is usually associated with hyperglycemia and hypocalcemia.
    - Hypocalcemia should be corrected.
    - It is NOT recommended to give insulin for hyperglycemia.
- Treat any underlying cause;

References:

1. Hansen AR, *Cloherty and Stark's Manual of Neonatal Care*, 8th edition, 2017.
2. Gleason CA, Devaskar SU (Ed.), *Avery's Diseases of the Newborn*, 9th edition, 2012.
3. Gomella TL et al., *Neonatology: Management, Procedures, On-Call Problems, Diseases and Drugs*, 7th edition, 2013,
4. Auckland District Health Board, *Newborn Services Clinical Guideline*, NZ, 2018 Update.
5. Bedside Clinical Guidelines Partnership, *Neonatal Guidelines 2017-19*, Staffordshire, Shropshire and Black Country Neonatal Operational Delivery Network and Southern West Midlands Neonatal Operational Delivery Network.

Potassium Imbalances

Management of hyperkalemia

Definition:

- Serum K > 6.0 mEq/L in a non-hemolyzed specimen (normal 3.5-5.5 mEq/L).
- Babies often tolerate concentrations up to 7.5–8.0 mmol/L without ECG changes.

Symptoms and signs

- Cardiac arrest
- ECG abnormalities (see below):
    - Tall peaked T waves
    - Widened QRS complex
    - Sine waves (widened QRS complex merging with T wave)
    - Prolonged PR interval, bradycardia, absent P wave

Causes

- Renal failure: secondary to hypoxic ischemic encephalopathy, sepsis and hypotension, or structural abnormalities
- Cellular injury with potassium release, e.g. large intraventricular hemorrhage, hemolysis.
- Very-low-birth-weight babies without renal failure (non-oliguric hyperkalemia) in first 12–48 hours
- Excess +K in IV solutions
- Endocrine (congenital adrenal hyperplasia)

Management:

- ***Serum potassium >6.0 mmol/L (stable with normal ECG)***
    - 1st confirm potassium level through a STAT serum sample.
    - Stop all K+ IV solutions, oral supplements and potassium-sparing diuretics.
    - Institute continuous ECG monitoring.

- ***Serum potassium >7.0 mmol/L without ECG changes***
    - As above.
    - If available, give salbutamol 4 microgram/kg IV in glucose 10% over 5–10 min: effect evident within 30 min but sustained benefit may require repeat infusion after at least 2 hours.
    - If IV access difficult/IV salbutamol is unavailable, give nebulized salbutamol 2.5-5 mg/dose as a single dose and repeat if necessary until serum K < 5.0 mEq/L (max. 12 doses).
    - Give furosemide (controversial): 1 mg/kg IV in infants with adequate renal function.

- If serum potassium still >7.0 mmol/L, give soluble insulin; start regular insulin 0.05 U/kg with 2 ml/kg D10% then IVI of insulin 0.1-0.2 U/kg/hour, diluted in D10% 2 ml/kg/hour. Repeat insulin infusion as necessary until K+ <7.0 mmol/L.
- Monitor blood glucose every 15 min for first 2 hours during and after infusion.

- ***Serum potassium>7.5 mmol/L with ECG changes***
  - As above, but first institute emergency measures below:
    - Give 10% calcium gluconate 100-200 mg/kg over 5-10 min (1-2 ml/kg) over 5–10 min.
    - Flush line with sodium chloride 0.9% or preferably use a different line.
    - Give IV sodium bicarbonate (1-2 mEq/kg over 10-30 min). This is effective even in babies who are not acidotic (2 mL of sodium bicarbonate 4.2% = 1 mmol).

- ***Further treatments: discuss with consultant***
  - A cation-exchange resin, such as kayexalate (1g/kg/6h orally or 500 mg/kg rectally, with removal by colonic irrigation 8-12 hourly, repeat every 12 hours. Dose can be doubled at least once to 1 g/kg in severe hyperkalemia). Useful for sustained reduction in serum potassium but takes many hours to act and is best avoided in sick preterms who are at risk of necrotizing enterocolitis.
  - If severe hyperkalemia persists despite above measures in term babies with otherwise good prognosis, contact renal team for consideration of dialysis.
  - Exchange transfusion using fresh blood or washed red blood cells is another strategy for sustained and reliable reduction in serum K+ concentration.

- ***Subsequent management***
  - Recheck serum K+ 4–6 hourly; when arrhythmias present with renal failure, monitor hourly.
  - Monitor urine output and maintain good fluid balance.
  - If urine output <1 mL/kg/hour, unless baby volume depleted, give furosemide 1 mg/kg IV until volume corrected.
  - Treat any underlying cause (e.g. renal failure).

Management of hypokalemia

- Normal range: 3.5 – 5.9 mEq/L.
- Definition: serum K < 3.5 mEq/L.
- Hypokalemia is rarely symptomatic until serum K < 2.5 mEq/L.
- Slowly replace K either IV or orally (AVOID rapid K administration).

Symptoms and signs

- Muscle weakness and paralysis
- ECG changes
  - Increased amplitude and width of P wave
  - Prolongation of PR interval

    - T wave flattening and inversion
    - ST depression
    - Prominent U waves (best seen in precordial leads)
    - Apparent long QT interval due to fusion of T and U waves
- Arrhythmias (premature atrial and ventricular beats, sinus bradycardia, paroxysmal atrial or junctional tachycardia, atrioventricular block, and ventricular tachycardia or fibrillation)

Causes

- Low intake/K+ concentration in IV fluids.
- Alkalosis (approximately 0.4 mmol/L fall in K+ for every 0.1 unit rise in pH).
- Insulin administration.
- Salbutamol administration (high dose, nebulizer/IV).
- Diarrhea (Note: K+ content of lower GI losses is >upper GI losses).
- Renal losses – diuretics, bicarbonate administration or renal tubular acidosis, Bartter syndrome.
- Increased mineralocorticoid activity – as in hypovolemia, 11- beta-hydroxylase deficiency, (rarer form of congenital adrenal hyperplasia; presents with virilization, hypertension, and hypokalemia), primary hyperaldosteronism.

Immediate management

- Rule out metabolic alkalosis (causes potassium shift) and discontinue medications that lowers potassium (if possible).
- Give additional supplements: 3-4 mEq/kg/day.
- Treat underlying pathology.

Symptomatic babies

- Give the available IV K+ supplementation..
- Potassium chloride is the usual choice for supplementation.
- Must be diluted at least 50-fold with sodium chloride 0.9% or a mixture of sodium chloride 0.9% in glucose prior to administration.
- Maximal peripheral concentration 40 mmol/L (1 mmol in 25 mL).
- Maximal central concentration 150-200 mEq/L.
- Rate 0.2 mmol/kg/hour (Maximal IV infusion rate: 1 mEq/kg/hour (24 mEq/kg/day) with EEG monitoring when infusion rate > 0.5 mEq/kg/hour).
- Recheck potassium at 2–4 hours and assess continuing need for infusion.

Asymptomatic babies

- Potassium replacement given according to how baby is being fed.
- Orally fed babies:

    - Oral supplementation should be given e.g. potassium chloride 1 mmol/kg – 12 hourly dose – increased/titrated according to response.
- Babies on intravenous fluids:
    - Potassium chloride 3–5 mmol/kg/day, depending on electrolyte levels, may be added to intravenous fluid.
- Babies receiving parenteral nutrition:
    - Increase K+ concentration in the PN to 3–5 mmol/kg/day.
    - If modified PN not available, run K+ infusion 3–5 mmol/kg/day to run alongside current PN.

Subsequent management

- Monitor potassium levels according to clinical need.
- Well babies receiving oral K+, check level 1–2 weekly.
- Babies on IV fluids or PN with mild hypokalemia (potassium 3-3.5 mmol/L), check daily.
- Check more frequently in significant hypokalemia (serum level <3 mmol/L), symptomatic hypokalemia or if concentrations of potassium >5 mmol/kg/day are being given.
- Once plasma/serum potassium level is normal, continue potassium supplementation for a further week if baby is orally fed to allow replenishment of total body potassium (intracellular) stores, or reduce potassium down to 2 mmol/kg/day if baby is on IV fluids/TPN.
- Re-check the potassium level following this to ensure hypokalemia does not recur.

References:

1. Hansen AR, *Cloherty and Stark's Manual of Neonatal Care*, 8th edition, 2017.
2. Gleason CA, Devaskar SU (Ed.), *Avery's Diseases of the Newborn*, 9th edition, 2012.
3. Gomella TL et al., *Neonatology: Management, Procedures, On-Call Problems, Diseases and Drugs*, 7th edition, 2013,
4. Auckland District Health Board, *Newborn Services Clinical Guideline*, NZ, 2018 Update.
5. Bedside Clinical Guidelines Partnership, *Neonatal Guidelines 2017-19*, Staffordshire, Shropshire and Black Country Neonatal Operational Delivery Network and Southern West Midlands Neonatal Operational Delivery Network.

Approach to Newborn with Suspected Metabolic Disorder

Inborn errors of metabolism (IEM) comprise a group of disorders, in which a single gene defect causes a clinically significant block in a metabolic pathway resulting either in accumulation of substrate behind the block or deficiency of the product. All IEMs are genetically transmitted, typically in an autosomal recessive or X-linked recessive fashion.

Always when metabolic disease is suspected, try to consult a metabolic disease specialist and consider referral to tertiary unit where metabolic and genetic service is available.

Clinical findings suggestive of an IEM include:

- History of consanguinity, mental retardation, or SIDS.
- Symptom onset with institution of feedings or formula change (symptom free interval after birth, then symptoms start hours to days after initiation of feeds).
- History of growth disturbances, lethargy, recurrent emesis, poor feeding, rashes, seizures, hiccoughs, apnea, tachypnea.
- Physical findings: tachypnea, apnea, lethargy, hypertonicity, hypotonicity, hepatosplenomegaly, ambiguous genitalia, jaundice, dysmorphic or coarse facial features, rashes or patchy hypopigmentation, ocular findings (cataracts, lens dislocation or pigmentary retinopathy), intracranial hemorrhage, unusual odors.
- Laboratory findings:

- Metabolic acidosis with increased anion gap.
- Hyperammonemia.
- Hypoglycemia, ketosis or ketonuria, direct hyperbilirubinemia.
- Lactic acidosis, high lactate/pyruvate ratio.
- Non-glucose-reducing substances in urine, elevated liver function tests including PT and PTT, neutropenia and thrombocytopenia.

Initial approach:

- Rule out non-metabolic causes of symptoms, such as infection or asphyxia, at the same time obtain samples for metabolic screen as mentioned below: lab assessment).
- Obtain consult from metabolic service.

Laboratory assessment prior to therapy

- Blood glucose, newborn screen card, CBC with differential, platelets, blood gas, electrolytes for anion gap.
- Liver function tests, total and direct bilirubin, PT, PTT, uric acid..
- Blood ammonia, lactate should be collected without a tourniquet, kept on ice and analyzed immediately.
- Urine: color, odor, pH, glucose, ketones, reducing substances (positive for galactosemia, fructose intolerance, tyrosinemia and others).

- Save samples for plasma amino acids and urine organic acids (best time during decompensation or according to metabolic specialist recommendation).
- CSF: glycine (for nonketotic hyperglycinemia), lactate, pyruvate if appropriate. These flow charts are guides to the differential diagnosis of hyperammonemia.

NB: Not all inborn errors of metabolism will present with acidosis, hyperammonemia, or hypoglycemia. Neurological signs (e.g., seizures, obtundation) may be the predominant feature in several IEMs (e.g., nonketotic hyperglycinemia, molybdenum cofactor deficiency, peroxisomal disorders).

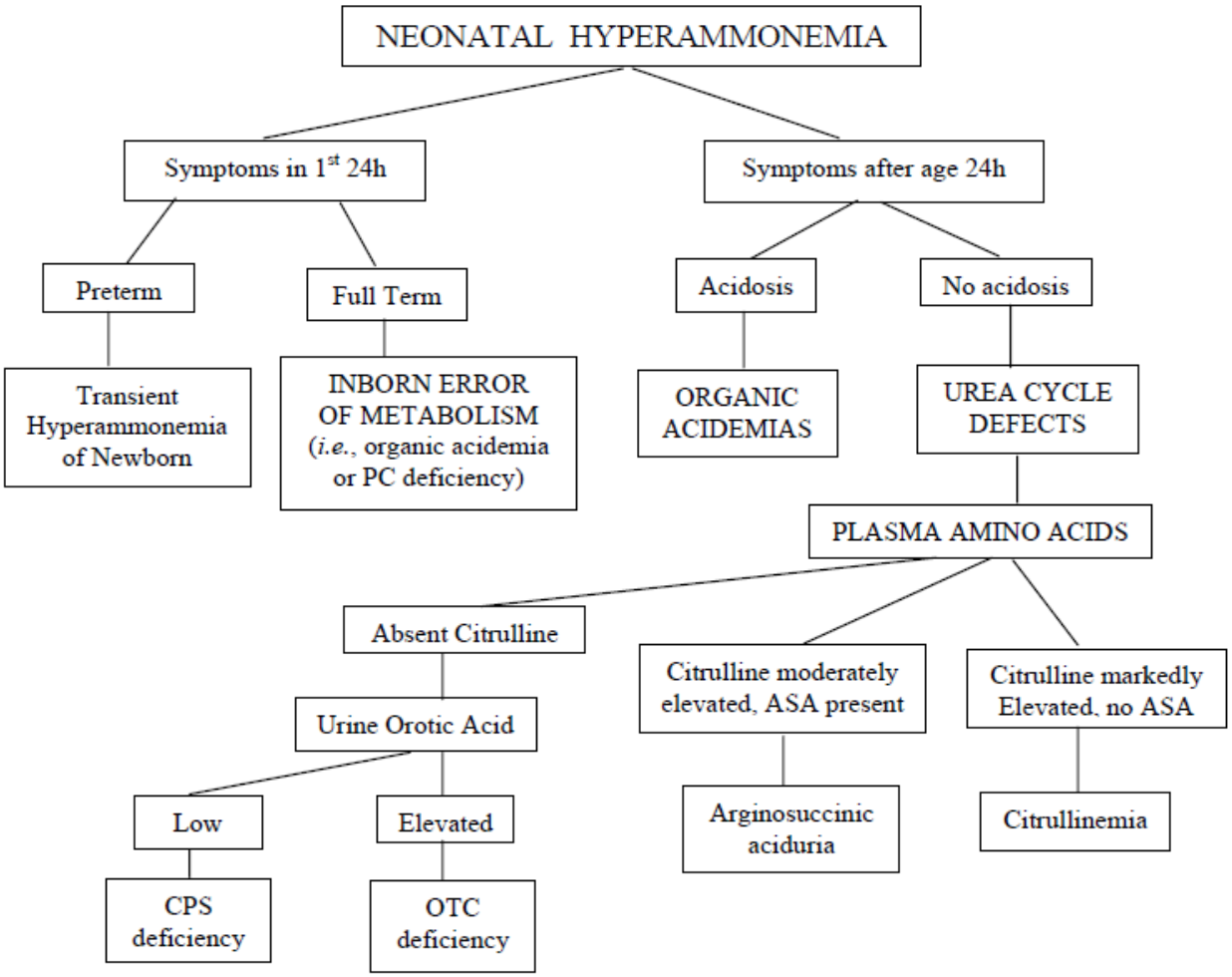

Figure 1. Flow chart for differential diagnosis of hyperammonemia. (ASA, arginosuccinic acid; CPS, carbamyl phosphate synthetase; OTC, ornithine transcarbamylase; PC, pyruvate carboxylase). Chart is adapted from Burton BK: Pediatrics 102: E69, 1998.

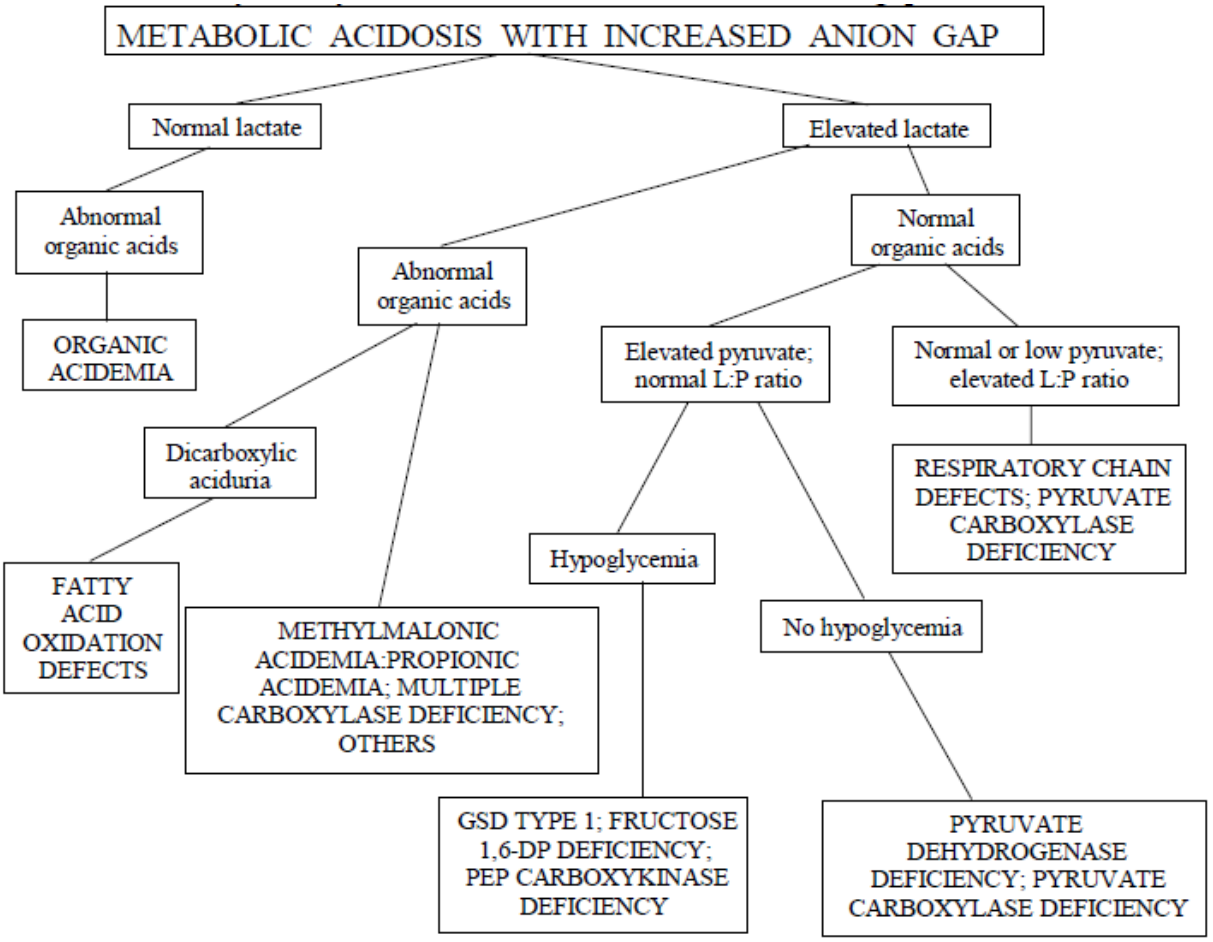

Figure 2. Flowchart for evaluation of metabolic acidosis in the young infant.
(Fructose-1,6-DP, fructose-1,6-diphosphatase; GSD, glycogen storage disease; L:P ratio, lactate to pyruvate ratio)
Chart is adapted from Burton BK: Pediatrics 102: E69, 1998.

Treatment:

Every baby with suspected metabolic disorder should be managed with the following steps, along with consultation with a metabolic specialist:

- Hydration /nutrition/acid-base management:
  - ✓ Rehydrate infant and stop all oral intake to eliminate protein, galactose and fructose.
  - ✓ Provide calories with IV glucose at 8-10 mg/kg/min (even if insulin is required to keep the blood glucose level normal).
  - ✓ Give IV lipids only after ruling out a primary or secondary fatty acid oxidation defect.
  - ✓ Withhold all protein for 48 to 72 hours, while the patient is acutely ill, and until an aminoacidopathy, organic aciduria or urea cycle defect has been excluded.

- ✓ Special enteral formulas and parenteral amino acid solutions are available for many disorders.
- ✓ Treat significant acidosis (pH<7.2 or base deficit > 12) with NaHCO3 drip.
- ✓ Treatment of hyperammonemia is **urgent**. The severity of neurological impairment in infants with urea cycle defects depends upon the duration of the hyperammonemic coma.
- ✓ Treatment of coexisting/precipitating factors (e.g., infection, thrombocytopenia).
- ✓ Cofactor replacement: Certain enzyme deficiencies are vitamin-responsive, so they can be started early after consultation and recommendation of the metabolic disease specialist, examples:
    - The vitamin-responsive form of propionic acidemia, holocarboxylase synthetase deficiency, and biotinidase deficiency: biotin (5 mg daily, oral or parenteral).
    - Vitamin-responsive methylmalonic acidemia: Vitamin B12 (1 mg daily, IM).
    - Vitamin-responsive maple syrup urine disease: thiamine (50 mg daily, oral).
- ✓ It is important to make a specific diagnosis, even in a dying child, to help parents understand what happened and to provide information that might affect future reproductive planning.
- ✓ If an autopsy is not permitted, request consent for pre-mortem or immediately postmortem specimens.
- ✓ Blood should be centrifuged and the plasma should be frozen.
- ✓ Urine and spinal fluid should be refrigerated.

References:

1. Hansen AR, *Cloherty and Stark's Manual of Neonatal Care*, 8th edition, 2017.
2. USCF Children's Hospital, *Neonatal Guidelines*, Updated 2004
3. Kliegman R, Stanton, B, St. Geme J, Schor N (eds.), Nelson Textbook of Pediatrics, 20th edition, 2016.

Acute Kidney Injury

(Previously referred to as acute renal failure)

Definition

- Sudden impairment in kidney function, that results in the retention of nitrogenous waste products (e.g., urea) and alters the regulation of extracellular fluid volume, electrolytes, and acid-base homeostasis.
- In neonates, serum Creatinine cut-point used to define AKI is **1.5 mg/dL** or greater**, independent** of day of life and **regardless** of urine output.
- AKI may be **anuric** (self-explanatory), **oliguric** (urine volume less than 0.5-1 mL/kg/h) or **non-oliguric** (adequate but poor quality urine output), depending upon the severity of the reduction in GFR and the degree of tubular reabsorption.
- AKI may be pre-renal (85%), renal (11%), or post-renal (3%).

N.B.: **Neonatal chronic kidney disease** is diagnosed when sustained derangements of glomerular filtration or tubular function occur with minimal to no resolution over time (evidence of kidney damage for more than 3 months).

Table 1: Acute kidney injury classification

Stage	Serum creatinine (SCr*)	Urine output
0	• No change **or** • Rise of <26 mmol/L	>0.5 mL/kg/hr
1	• Rise >26 mmol/L in 48 hr **or** • Rise >1.5–1.9 x reference SCr in 7 days	<0.5 mL/kg/hr for 6–12 hr
2	• Rise 2.0–2.9 x reference SCr range in 7 days	<0.5 mL/kg/hr for >12 hr
3	• Rise >3 x reference SCr in 7 days **or** • SCr value >220 mmol/L **or** • Receipt of dialysis	<0.3 mL/kg/hr for >24 hours or anuria for >12 hours

***SCr – lowest previous SCr value**

Evaluation

- Take history of:
  - Oligo-/polyhydramnios.
  - Risk factors: prematurity, HIE, RDS, sepsis, umbilical artery catheterization, drugs.
  - Volume depletion, urine output, urine stream.
  - Family history of renal disease.
- Measure blood pressure.
- Examine for: signs of dehydration, dysmorphic features, edema, renal masses, and palpable bladder.
- Laboratory:

1. Urea, creatinine* & serum electrolytes: each 8 hours.
   * Creatinine before 48 hours postpartum is misleading.
2. Blood gases each 4-8 hours.
3. Glucose each 4 hours.
4. Ca, Ph, Mg, albumin, uric acid.
5. CBC CRP, blood culture.
6. Urinalysis, urine culture, and a spot urine sample for sodium, creatinine, and osmolality can help to differentiate the cause (see table), urine dipstick for protein, casts, blood.

- Imaging studies:
  - ✓ A renal and bladder ultrasound.
  - ✓ Abdominal X-ray if UAC in place.
  - ✓ Doppler ultrasound.
  - ✓ Voiding cystourethrogram (VCUG).
  - ✓ Scintigraphy can be used to demonstrate renal structure and function (DTPA, DMSA. MAG3).

DIAGNOSTIC INDICES

Indices	Pre-renal	Intrinsic
Urine osmolality	>400	<400
Urine analysis	Normal	>5 RBCs
Urine sodium mmol/L	31 +/- 19	63 +/- 35
Urine protein/creatinine ratio	29 +/- 16	10 +/- 4
Fractional excretion of Na	<2.5	>2.5
Renal failure index	<3	>3

Management of AKI

Prevention:

- Monitor blood urea, serum creatinine and electrolytes in neonates at risk for renal impairment (ex.: sepsis, HIE).
- Ensure adequate fluid balance especially in preterm babies.
- Early treatment of hypovolemia.
- Relief of obstruction.
- Avoid nephrotoxic drugs if possible, discontinue if AKI.

Treatment:

1. Insert urine Catheter to R/O lower urinary tract obstruction and to monitor UOP.
2. Monitor: weight/12 hours, BP/12 hours or more frequent if abnormal, cardiac monitor (for arrhythmia).
3. Fluid challenge with 10 to 20 mL/kg of isotonic fluids (usually normal saline) over 30 minutes should be given to all infants with oligo-anuria* with close observation to vital signs and urine output.

* Avoid fluid challenges if suspected urinary outlet obstruction or signs of fluid overload**.

****** Tachypnea, edema, excessive weight gain, raised blood pressure, Gallop rhythm, hepatomegaly.

- A positive response, which indicates a prerenal cause, is an increase in urine output to ≥1 mL/kg per hour.
- In infants who respond, the urine output should be maintained by adequate fluid maintenance and replacement that takes into account ongoing urinary and insensible losses, and allows for other losses.
- The fluid challenge should be repeated in infants who do not respond to the initial infusion and do not have clinical signs of fluid overload.
- Absence of a response to a repeated challenge generally indicates intrinsic renal failure which necessitates fluid restriction to estimated insensible water losses plus the urine output.

4. Drug therapy:

- Few data are available to support the use of low-dose dopamine, or diuretics for the treatment or prevention of AKI.
- Loop diuretics: use high dose furosemide: (2-5 mg/kg/dose over 5-10 minutes up to 4 times daily – do not exceed 0. 5 mg/kg/minute) if oliguria present, then 0.5–1 mg/kg every 6 hours in term babies, every 12 hours in preterm ≥32 weeks and every 24 hours if postmenstrual age under 31 weeks.
    - Contraindicated in anuria.
    - An initial diuretic response can be seen in 2–5 min after intravenous administration of the drug, with peak effect within 30 min where there is normal renal function.
    - Continuous IV infusion (0.05-0.40 mg/kg/hour- titrate to effect): continuous doses may be superior to larger intermittent doses: dilute with normal saline as 1-2 mg/ml.
    - In AKI there is no role for the use of continuous infusion unless there is good urine output after the initial bolus dose of furosemide.
- ACE-I in children with ischemic AKI should be avoided**.**

5. Management of metabolic disorders

- Can usually be managed by attention to electrolyte intake during the initial course of AKI with frequent evaluation and specific therapies.
- Metabolic acidosis:
    - ✓ Replacement with bicarbonate is indicated in infants with AKI if pH <7.20.
    - ✓ **In infants with severe respiratory failure, large doses of bicarbonate should be avoided**.
    - ✓ If bicarbonate therapy is to be given in preterm infants, it should be administered as a **slow infusion over 30 minutes** due to its significant adverse effects.

6. Nutritional support:

    - Commonly parenteral nutrition, feeds, or both will need to be concentrated to avoid excessive fluid gain.
    - A minimum of 100 kcal/kg per day is needed.
    - Infants who are able to take enteral feedings should be given a formula that has a low renal solute load and low phosphate content (**breast milk is ideal**).

7. Careful assessment of medication dosing:

    - Consultation with pharmacists and a nephrologist familiar with drug dosing in renal failure is invaluable according to GFR*.
      * GFR (mL/min/1.73 m^2) = K x L (cm) / P cr (mg/dl)
      K = 0.33 in preterm, 0.45 in full term infants

8. Dialysis (peritoneal dialysis is preferred on hemodialysis).

    - Indications to initiate dialysis include:
    - Severe electrolyte abnormalities that are not correctable with medical interventions: severe acidosis (serum bicarbonate <12 mEq/L), hyperkalemia ≥8 mEq/L, hyponatremia ≤120 mEq/L.
    - Volume overload with heart failure, pulmonary edema.
    - Adequate nutrition cannot be maintained because of persistent oliguria or anuria.

Prognosis

- Outcome dependent on cause and extent of renal damage.
- Vast majority of cases of renal failure will recover if the underlying cause is addressed and supportive management provided to maintain fluid and electrolyte balance until recovery takes place, normally over 24–48 hours.

Reference:

Bedside Clinical Guidelines Partnership, *Neonatal Guidelines 2017-19*, Staffordshire, Shropshire and Black Country Neonatal Operational Delivery Network and Southern West Midlands Neonatal Operational Delivery Network.

PART X: Common Surgical Problems

Esophageal Atresia

Definition

Congenital anomaly with blind ending esophagus which may be associated with a fistula between the abnormal esophagus and the trachea.

Diagnosis

- Suspect antenatally if scans show polyhydramnios +/- absent stomach bubble.
- Refer to fetal medicine specialist.
- Plan appropriate place of delivery.
- Parents should meet pediatric surgeon antenatally.
- Most cases present shortly after birth. Suspect if:
    - History of polyhydramnios +/- absent stomach bubble.
    - Frothing at mouth.
    - Respiratory symptoms on feeding.
    - Difficulty in passing nasogastric tube (NGT).
    - Anorectal malformation.

Delivery

- If diagnosis suspected antenatally, avoid:
    - Any positive pressure ventilation [including mask ventilation, HFNC, CPAP and endotracheal tube (ETT)]; pouch distension may lead to respiratory compromise and/or aspiration via a distal pouch fistula
- If intubation indicated, ETT tip as close to carina as possible to minimize gas flow through a fistula. Ventilatory pressures should be as low as possible.
- If any significant respiratory compromise, instigate a time critical transfer to surgical unit.

Confirmation of diagnosis

- Experienced operator to place radio-opaque 8 Fr NGT. Typically resistance is felt 10–12 cm from nostril in term baby.
- Do not use force (may lead to esophageal perforation).
- AP X-ray of whole chest and abdomen.
- Diagnosis confirmed if NGT curled in upper esophagus.
- Gastric air bubble/bowel gas confirms presence of fistula between trachea and distal esophagus.
- Do not attempt a contrast esophagogram.

Management on NICU

- If respiratory support required or abdominal distension, contact surgical unit and transfer team immediately (time critical transfer).
- Nurse 30° head-up with head turned to side to facilitate drainage of secretions.
- Pass 10 Fr Replogle tube into esophageal pouch.
- If Replogle tube unavailable, place 10 Fr NGT into pouch, aspirating every 15 min.

- An NGT cannot be placed on suction so needs regular, intermittent aspiration.
- Insert until resistance is met, then withdraw by 1 cm.
- Tape securely to face. Usually 10–12 cm at nostril in a term baby.
- Attach tapered end of tube to continuous suction.
- Baby should be relaxed and pink with no respiratory distress or secretions in the mouth.
- Keep nil-by-mouth.
- Flush Replogle tube with sodium chloride 0.9% 0.5 mL via the sidearm every 15 min.
- If using an enteral tube to drain saliva, aspirate every 15 min, more frequently if visible oral secretions or respiratory difficulty evident.
- If no movement of secretions in Replogle tube after flushing with sodium chloride 0.9% 0.5 mL via the sidearm, change tube.

Fluids and medication

- Commence maintenance IV fluids.
- Give vitamin K IM.
- Start broad spectrum antibiotics IV.
- Examine baby for other associated abnormalities (e.g. cardiac murmur, anorectal abnormalities).
- Discuss baby's condition and treatment plan with parents and ensure they have seen baby before transfer.
- Contact surgical center to arrange transfer as soon as possible.
- Inform surgical unit staff when baby is ready for transfer. Have available: name, gestational age, weight, ventilatory and oxygen requirements (if applicable) and mother's name and ward.

Blocked tube

- Suspect if:
    - No continuous flow of secretions along tube.
    - Visible oral secretions.
    - Baby in distress.
- Clear airway with high-flow oropharyngeal suction.
- Increase low-flow suction and flush Replogle tube with air, observing flow of saliva along tube.
- If patency not restored, replace with new Replogle tube and return low-flow suction to previous level.
- If Replogle tube replaced, alternate nostrils to avoid long-term stretching of nares.

References:

1. Gomella TL et al., *Neonatology: Management, Procedures, On-Call Problems, Diseases and Drugs*, 7th edition, 2013.
2. Hansen AR, *Cloherty and Stark's Manual of Neonatal Care*, 8th edition, 2017.
3. SickKids Hospital, *NICU Protocol*, 2015.

Omphalocele

Definition

Omphalocele is a midline defect of the anterior abdominal wall that results in the herniation of abdominal contents into a membrane-covered sac. Herniated abdominal contents include variable amounts of intestine, often parts of the liver and occasionally other organs. The defect may be centered in the upper, mid or lower abdomen and the size and location of the defect have important implications for management. Unlike gastroschisis, omphalocele is associated with genetic abnormalities and other congenital anomalies. These include Trisomy 13, Trisomy 18, Beckwith-Weidman syndrome, and congenital heart defects.

Diagnosis

- Majority of cases diagnosed on antenatal ultrasound scan.

Pre-delivery

- Omphalocele is a surgical emergency; delivery should be planned in a hospital with an appropriate level III unit.
- Antenatal and postnatal care must be carefully planned. Communication between groups of professionals and the parents is essential.
- Before delivery case to be discussed with pediatric surgery team.

Delivery

- Take a size 8 Fr nasogastric tube (NGT) and a bag (often labelled as a bowel bag).
- Babies become cold very quickly and experience fluid loss from the exposed bowel. Perform the following as rapidly as possible:
    - Clamp cord with plastic clamp (not artery forceps) placed approximately 5 cm from baby's abdomen, checking cord clamp is securely fastened. If in doubt, apply second plastic cord clamp adjacent to the first.
    - Dry upper part of baby quickly.
    - Initiate resuscitation as required. Avoid prolonged mask ventilation, if resuscitation prolonged, intubate.
    - Pass NGT.
    - Empty baby's stomach by aspirating NGT with a 10 or 20 mL syringe.
    - Place tube on free drainage by connecting to a bile bag.
    - If stomach protruding through defect, ensure it is decompressed.
    - If stomach cannot be decompressed, call surgical registrar for further advice. Failure to decompress the stomach can cause pressure on the bowel mesentery resulting in bowel ischemia.
    - Assess color and alignment of bowel.
    - Using sterile gloves handle the bowel carefully to ensure it is not twisted or kinked and there is no traction on the mesentery.

- Check perfusion of bowel. If vascular compromise suspected, inform surgical team immediately.
- Alternatively, cover and support intestines with cling film from upper chest to lower abdomen, holding intestines in central position.
- Ensure intestines are visible.

In NICU

- Monitor perfusion and alignment of bowel at least every 15 min.
- Insert IV cannula, avoid potential long line veins.
- Avoid umbilical lines.
- Intravenous fluids are commenced at 90mL/kg/day.
- Aspirate NGT again and record volume. Replace NG losses mL-for-mL with sodium chloride 0.9% + 10 mmol potassium chloride/500 mL IV.
- Monitor central perfusion. Give further fluid boluses as required to maintain a normal CRT <2 secs. Babies with omphalocele have a high fluid requirement until the herniated bowel is replaced in the abdomen.
- Start IV antibiotics (ampicillin, gentamicin AND metronidazole).
- Discuss baby's condition and treatment plan with parents and ensure they have seen baby before transfer.

Awaiting transfer to surgical unit

- Continue to assess bowel perfusion and alignment every 15 min.
- Reassess baby's fluid requirements hourly. If fluid boluses required, give sodium chloride 0.9% 10 mL/kg IV.
- Leave NGT on free drainage.

Transfer to surgical unit

- Inform surgical unit that transfer is underway.
- Place baby in transport incubator, taking care to transfer bowel and mesentery in a supported, non-kinked position. Keep stomach empty.

Post-operative management

Position

- Nurse the infant in a supine position. If the closure is only partial, herniated bowel/liver will need to be supported when the infant needs to change position to prevent pressure sores.
- The use of a nest to support the supine position with a gel head pillow to ensure no pressure points occur.
- Two nurses or one nurse and parent can support the infant and the defect during turning and re-positioning.

Pain management

- Pain scores are recorded every 2 hours in the immediate post-operative 24 hours.
- Then every 4 hours for the next 48 hours and continue as long as analgesia is being used.
- Adjust analgesia according to pain assessment scores.

Feeding Infants with congenital abdominal defects

- Typically infants with congenital wall abnormalities have significant morbidity associated with difficulties in commencing and progressing enteral feeds. The delay in the establishment of enteral feeds contributes to lengthy requirements for central venous access, dependence on total parenteral nutrition (TPN), small bowel bacterial overgrowth, increased risk of sepsis and TPN related cholestasis resulting in a prolonged length of hospital stay, sometimes months.
- It is recommended that minimal enteral feeds (1ml 4 hourly of breast milk) should be commenced as soon as available.
- Further grading up of feeds will be guided by the neonatologist in consultation with the surgeon.
- The exact timing is still being researched, but evidence shows that for every day that enteral feeding is delayed, the attainment of full feeds is delayed.

Gastroschisis

Definition

Gastroschisis is the herniation of abdominal contents through an abdominal wall defect, usually to the right of umbilicus. Abdominal contents that are herniated through the abdominal wall include variable amounts of intestines and occasionally parts of other abdominal organs. These organs have no covering membrane or sac. Gastroschisis may be associated with small bowel atresia. This should be regarded as a surgical emergency.

Diagnosis

- Majority of cases diagnosed on antenatal ultrasound scan.

Pre-delivery

- Gastroschisis is a surgical emergency, delivery should be planned in a hospital with an appropriate level III unit.
- Antenatal and postnatal care must be carefully planned. Communication between groups of professionals and the parents is essential.
- Before delivery case to be discussed with pediatric surgery team.

Delivery

- Take a size 8 Fr nasogastric tube (NGT) and a gastroschisis bag (often labelled as a bowel bag).
- Babies become cold very quickly and experience fluid loss from the exposed bowel. Perform the following as rapidly as possible:
    - Clamp cord with plastic clamp (not artery forceps) placed approximately 5 cm from baby's abdomen, checking cord clamp is securely fastened. If in doubt, apply second plastic cord clamp adjacent to the first.
    - Dry upper part of baby quickly.
    - Initiate resuscitation as required. Avoid prolonged mask ventilation, if resuscitation prolonged, intubate.
    - Pass NGT.
    - Empty baby's stomach by aspirating NGT with a 10 or 20 mL syringe.
    - Place tube on free drainage by connecting to a bile bag.
    - If stomach protruding through defect, ensure it is decompressed.
    - If stomach cannot be decompressed, call surgical registrar for further advice. Failure to decompress the stomach can cause pressure on the bowel mesentery resulting in bowel ischemia.
    - Assess color and alignment of bowel.
    - Using sterile gloves, handle the bowel carefully to ensure it is not twisted or kinked and there is no traction on the mesentery.

- Place baby onto the same side as the defect (usually right) and support bowel on a folded nappy placed slightly under baby.
- Check perfusion of bowel. If vascular compromise suspected, inform surgical team immediately.
- Place baby's legs and trunk into gastroschisis bag, feet first, and pull draw-string under baby's arms, so both arms are outside of the bag.
- Alternatively, cover and support intestines with cling film from upper chest to lower abdomen, holding intestines in central position.
- Ensure intestines are visible.

In NICU

- Monitor perfusion and alignment of bowel at least every 15 min.
- Insert IV cannula, avoid potential long line veins.
- Avoid umbilical lines.
- Intravenous fluids are commenced at 90 mL/kg/day.
- Aspirate NGT again and record volume. Replace NG losses mL-for-mL with sodium chloride 0.9% + 10 mmol potassium chloride/500 mL IV.
- Monitor central perfusion. Give further fluid boluses as required to maintain a normal CRT <2 secs. Babies with gastroschisis have a high fluid requirement until the herniated bowel is replaced in the abdomen.
- Start IV antibiotics (ampicillin, gentamicin AND metronidazole).
- Discuss baby's condition and treatment plan with parents and ensure they have seen baby before transfer.

Awaiting transfer to surgical unit

- Continue to assess bowel perfusion and alignment every 15 min.
- Reassess baby's fluid requirements hourly. If fluid boluses required, give sodium chloride 0.9% 10 mL/kg IV.
- Leave NGT on free drainage.

Transfer to surgical unit

- Inform surgical unit that transfer is underway.
- Place baby in transport incubator, taking care to transfer bowel and mesentery in a supported, non-kinked position. Keep stomach empty.
- Place baby on side of defect and support bowel on a folded nappy just slightly under baby. Check bowel perfusion immediately and at least every 15 min.

Post-operative management

Position

- Nurse the infant in a supine position. If the closure is only partial, herniated bowel/liver will need to be supported when the infant needs to change position to prevent pressure sores.

- The use of a nest to support the supine position with a gel head pillow to ensure no pressure points occur.
- Two nurses or one nurse and parent can support the infant and the defect during turning and re-positioning.

Pain management

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- Further grading up of feeds will be guided by the neonatologist in consultation with the surgeon.
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References:

1. Gomella TL et al., *Neonatology: Management, Procedures, On-Call Problems, Diseases and Drugs*, 7th edition, 2013.
2. Hansen AR, *Cloherty and Stark's Manual of Neonatal Care*, 8th edition, 2017.
3. SickKids Hospital, *NICU Protocol*, 2015.

Myelomeningocele (MMC)

Definition

- Defect of the backbone and spinal cord
- MMC is the most serious type of spina bifida; spinal cord and meninges push out and create a sac in baby's back.
- Associated with significant damage to spinal cord.
- Can leave nervous system vulnerable to life-threatening infection.

Management

Antenatal diagnosis

- Refer to neurosurgery team.

Post-delivery – Neonatal management in local unit:

- Systemic management: as per local unit guideline.
- First line antibiotics: as per local unit guideline.
- Give vitamin K.
- Nurse prone/lateral, irrespective of gestation and ventilator status.
- Baseline cranial ultrasound.
- Occipital frontal circumference (OFC) daily before transfer.

Specific MMC management

- Open MMC
  - Surgical closure recommended in first 24-48 hours.
  - Transfer to appropriate surgical unit ≤24 hours (providing condition stable).
  - If flap closure required, neurosurgeon to refer to plastic surgeon.
- Closed MMC
  - Treat as elective surgery.
- Protect exposed meninges until surgical closure performed. Immediately after delivery, cover lesion with non-adherent silicone dressing, followed by sodium chloride soaked gauze..
- Do not place gauze in direct contact with exposed meninges. Can cause tearing and leaking of CSF as gauze dries out and sticks to meninges.
- If evidence of hydrocephalus, cerebral spinal fluid (CSF) diversion will be considered at time of closure.
- Avoid contact with products containing latex; high risk (25-65%) of developing latex sensitization and allergy.
- Document daily on centile chart:
  - Head circumference.
  - Weight.

- Document pre-operative administration of vitamin K and completed screening tests on neonatal checklist.

Pre-operative investigations and management

- Protect lesion from soiling and contamination.
- Nurse baby prone/lateral.
- Apply minimal tape to skin due to sensitivity to tapes, and to prevent epidermal stripping.
- Bloods for:
  - FBC
  - U&Es
  - Clotting
  - Group and save
- Ultrasound of renal system.
- MRI of head and spine at earliest opportunity as baseline (if possible pre-operatively, but do not delay surgery for imaging).
- Consider clinical photography before and after repair.
- Obtain consent at time of consenting for surgery.

Discharge

- Provide parents with wound care advice.
- Advise first bath 7-10 days post-operatively (unless advised otherwise).
- Neurosurgical CNS to provide information regarding shunt malfunction.
  - If no shunt present, ensure parents made aware of signs and symptoms of hydrocephalus.
- Liaise with health visiting team to:
  - Ensure safe infant sleeping/SIDS guidelines taught.
- Arrange follow-up appointments:
  - Neurosurgery ward clinic: 1 week post-discharge.
  - Named consultant clinic: ≤6-8 weeks post-discharge.
  - Urology/urodynamics: book before discharge (including ultrasound appointment).
- Provide parents with contact details of neurosurgical CNS:
  - CNS to provide copy of SHINE charity booklet, with additional team names completed.

References:

1. Gomella TL et al., *Neonatology: Management, Procedures, On-Call Problems, Diseases and Drugs*, 7th edition, 2013.
2. Hansen AR, *Cloherty and Stark's Manual of Neonatal Care*, 8th edition, 2017.
3. SickKids Hospital, *NICU Protocol*, 2015.

Inguinal Hernia

Introduction

- Incidence: 0.5–1% in term babies and 5–10% in premature babies.
- Right-sided in 50% of cases, left-sided in 10% and both sides in 40%.
- Most cases can be managed with elective surgery at time of discharge from NICU.
- Manage incarcerated hernia as a surgical emergency.

Clinical features

- Visible swelling or bulge in inguino-scrotal region in boys, inguino-labial region in girls.
- May be constant or intermittent, becoming more prominent with crying or straining.

Simple inguinal hernia

- Often painless, but many babies happier after repair.
- Oxygen requirements may fall after repair.

Incarcerated inguinal hernia

- Generally presents with a tender firm mass in the inguinal canal or scrotum.
- Baby may be fussy, unwilling to feed and crying inconsolably.
- Overlying skin may be edematous, erythematous and discolored.
- May be associated abdominal distension, with/without bilious vomiting.
- Arrange emergency surgical referral.

Management and referral

Reducible inguinal hernia

- If asymptomatic, refer by letter to surgeon. Include likely date of discharge and parents' contact details.
- Inform parents of the risk of hernia becoming incarcerated; if baby develops a tense, painful swelling and is in obvious pain, parents should seek immediate medical advice; if swelling not reduced ≤2 hours, serious complications may arise.

Incarcerated inguinal hernia

- Stabilize baby.
- Administer analgesia (morphine IV), then gently try to reduce hernia.
- If fully reduced, arrange elective inguinal herniotomy before discharge. Refer to pediatric surgical team, for elective review.
- If not reducible:
    - Inform Neonatologist and surgical team.

- Keep child nil-by-mouth.
- Insert large bore nasogastric tube (NGT), empty stomach and leave on free drainage.
- Obtain IV access and send blood for FBC and U&E.
- Start maintenance IV fluids.
- Aspirate NGT 4-hourly in addition to free drainage and replace aspirate volume, mL-for-mL with sodium chloride 0.9% with 10 mmol potassium chloride in 500 mL IV. Leave NGT on free drainage.
- If hernia remains irreducible, refer urgently for surgical assessment.

References:

1. Gomella TL et al., *Neonatology: Management, Procedures, On-Call Problems, Diseases and Drugs*, 7th edition, 2013.
2. Hansen AR, *Cloherty and Stark's Manual of Neonatal Care*, 8th edition, 2017.
3. SickKids Hospital. *NICU Protocol*, 2015.

SECTION D: Nursing Protocols

Introducing IV Access

A. Indications

Administration of IV medications, fluids, or parenteral nutrition when utilization of the gastrointestinal tract is not possible.

B. Preparation

1. Avoid areas adjacent to superficial skin loss or infection.
2. Avoid vessels across joints, because immobilization is more difficult.
3. Take care to differentiate veins from arteries.
    a. Palpate for arterial pulsation.
    b. Note effect of vessel occlusion.
        i. Limb vessel: Arteries collapse, veins fill.
        ii. Scalp vessel: Arteries fill from below, veins fill from above.
    c. Note color of blood obtained (arterial blood is bright red; venous blood is darker).
4. If limb requires warming prior to procedure, use a heel warmer.
5. Cut scalp hair using small scissors to allow for stabilization of the IV (do not shave the area).
6. Apply tourniquet correctly:
    a. Minimize time applied.
    b. Avoid use in areas with compromised circulation.
    c. Avoid use for scalp vessels.
7. When using scalp veins, avoid sites outside the hairline.
8. Consider using protective skin preparation in small premature infants to prevent skin trauma upon removal of tape or dressing.
9. Limit to two to three placement attempts per person.
10. Comfort measures: Pacifier, swaddling, oral sucrose.
11. Assemble equipment. Do not remove cannula cover or Butterfly cover from needle.
12. Check IV solution for sediment or contaminant If sediment is observed, notify Charge nurse, and return solution to Pharmacy.
13. Prime all IV tubing. Use aseptic technique.
    a. Date and time.

b. Label IV pump with tape if pump for another line is in use. (UAC Peripheral arterial line).

14. Cut clear tape strips.
15. Prepare as for minor procedure, Ensure that neutral thermal environment is maintained. It is often necessary to transfer small infants to a radiant warmer for peripheral IV placement to avoid cold stress.
16. Maintain ambient oxygen concentration that is required by infant.
17. Have a second person available to assist in holding the infant as needed during the procedure.
18. WASH HANDS thoroughly.
    a. Donning of gloves is recommended to insert needle.

C. Equipment

Sterile

1. Povidone-iodine swabs or 70% alcohol swabs,
2. Appropriate needle (minimum 24 gauge for blood transfusion) a. 21- to 24-gauge IV catheter (preferably shielded),
3. Connection for cannula (i.e., T connector) 4. 2- × 2-inch gauze squares,
4. Isotonic saline in 3-mL syringe,

Nonsterile

1. Tourniquet.
2. Procedure light.
3. Materials for restraint.
4. Transilluminator.
5. Warm compress to warm limb if necessary (heel warmer).
6. Appropriate-sized arm board.
7. Cotton balls.
8. Scissors.
9. Adhesive tape, transparent tape (Tegaderm), use the minimum amount necessary on fragile premature skin.

D. Procedure

1. Use transillumination to visualize vessel if needed.

2. Select vessel for cannulation. It is recommended to begin with more distal sites and progress proximally if needed.
3. Apply tourniquet if anatomic site indicates.
    a. Place as close to venipuncture site as possible, not tight.
4. Prepare skin area with antiseptic. Allow to dry at least 30 seconds.
5. Select straight segment of vein or confluence of two tributaries.
6. Grasp catheter between thumb and first finger. For winged Angiocaths, grasp plastic wings.
7. Anchor vein with index finger of free hand and stretch skin overlying it. This maneuver may also be used to produce distention of scalp veins.
8. Hold needle parallel to vessel, in direction of blood flow.
9. Introduce needle through skin a few millimeters distal to point of entry into vessel.
10. Introduce needle gently into vessel until blood appears in hub of needle or in cannula upon withdrawal of stylet.
11. Remove stylet.
12. Advance cannula as far as possible.
13. Remove tourniquet.
14. Connect T connecter and syringe, and infuse small amount of saline gently to confirm intravascular position.
15. Anchor needle or cannula as shown in. Attach IV tubing and secure to skin.
16. If an arm board is necessary for securing site, place the affected extremity in an anatomically correct position before taping. Consider placing cotton or a 2- × 2-inch gauze square beneath the hub of T connector to prevent a pressure injury.
17. Label date & time IV started on pump.
18. DOCUMENT IN NURSE'S NOTES: time IV. started, by whom, site, size and type of needle, IV. solution, rate and patient's response. Also document who has attempted to start iv and the # of attempts by each person.

E. Post-procedure care

1. Look for blanching of skin over vessel when fluid is infused (arterial spasm).
2. Be alert for signs of phlebitis or infiltration.
    a. Inspect site hourly.
    b. Discontinue IV immediately at any sign of local inflammation or cannula malfunction.

3. Arrange tape dressing at IV site to allow adequate inspection or use transparent sterile dressing over site of skin entry.
4. Maintain an accurate intake and output record.
5. Weigh the infant daily.

F. Complications

1. Hematoma:. Hematomas can often be managed with gentle manual pressure.
2. Phlebitis.
3. Infiltration of subcutaneous tissue with IV.
4. Infection.
5. Embolization of clot with forcible flushing.
6. Accidental injection or infusion into artery, with arteriospasm and possible tissue necrosis.
7. Burn from antiseptic for premature babies –use suitable sterilizer for those <30 weeks or less than 1250 gm as diluted chlorhexidine or saline.
8. Air embolus.
9. Ischemia or gangrene of lower extremity, complicating infusion into saphenous vein.

References:

1. Mahiri GM, Jayashree P, *Atlas of Procedures in Neonatology*, 5th ed., 2013, Philadelphia, New York.
2. Bedside Clinical Guidelines Partnership, *Neonatal Guidelines 2015–17*, Staffordshire, Shropshire & Black Country Newborn and Maternity Network Southern West Midlands Maternity and Newborn Network.

Arterial Puncture/Sampling

A. Indications

1. Sampling for arterial blood gas determination.
2. Sampling for routine laboratory test when venous and capillary sampling are not suitable or unobtainable.
3. To obtain a large quantity of blood.

B. Special preparation and consideration for neonates

a. Selection of arterial site:

1. Peripheral site preferred.
2. Radial artery preferred if ulnar collateral intact.
3. Posterior tibial artery satisfactory.
4. Brachial artery should never be used for sampling.

b. Perform arterial sampling only when venous or capillary sampling is inappropriate or unobtainable.

c. Use smallest possible (23- to 27-gauge) needle to minimize trauma to vessel and to prevent hematoma formation.

C. Equipment

1. Sterile gloves.
2. Sterile needle.
    a. A 23- to 25-gauge venipuncture needle, preferably a safety-engineered needle.
    b. A butterfly needle with extension tubing is often easier to use.
3. Appropriate antiseptic solution.
4. Gauze pads.
5. Oral sucrose solution (24% to 25%).

D. Procedure

1. Clean the site with povidone–iodine and alcohol.
2. Position needle for arterial puncture against direction of blood flow.
    a. Keep angle of entry shallow for superficial vessels at 15 to 30 degrees.
    b. Penetrate the skin first slightly proximal to the best point of pulsation, and then puncture artery to minimize trauma to vessel.
    c. Apply gentle suction on syringe as soon as blood flow is observed.

d. If no blood flow is obtained or blood flow ceases, adjust depth of penetration or the angle of the needle. If resistance is encountered, withdraw needle cautiously until blood returns. Be patient and gentle—artery may spasm when needle is introduced, or with multiple attempts.

e. Use fresh needle and repeat skin preparation if withdrawal from skin is necessary.

3. Check distal circulation after puncture:

    a. Arterial pulse.

    b. Capillary refill time.

    c. Color and temperature.

4. Take action to reverse arteriospasm, if necessary:

    a. Warm contralateral extremity (reflex vasodilation).

    b. Maintain neutral thermal environment for affected extremity (i.e., keep heat lamps off area).

    c. Maintain limb in horizontal position.

    d. Correct hypotension or hypovolemia if present.

E. Complications

1. Distal ischemia from arteriospasm, thrombosis, or embolism.
2. Infection (rare).

    a. Osteomyelitis.

    b. Infected hip joint after femoral puncture.

3. Hemorrhage or hematoma.
4. Nerve damage:

    a. Median nerve (brachial artery puncture).

    b. Posterior tibial nerve.

c. Femoral nerve.

5. Extensor tendon sheath injury, resulting in “false cortical thumb”.
6. Pseudo-aneurysm following brachial artery puncture.

References:

1. Mahiri GM, Jayashree P, *Atlas of Procedures in Neonatology*, 5th ed., 2013, Philadelphia, New York.
2. Bedside Clinical Guidelines Partnership, *Neonatal Guidelines 2015–17,* Staffordshire, Shropshire & Black Country Newborn and Maternity Network Southern West Midlands Maternity and Newborn Network.

Arterial Line Sampling

A. Indications

1. Blood gas analysis.
2. Biochemical/and hematological investigations.

B. Special preparation and consideration for neonates

1. Record SpO2 and TcCO2 at time of taking blood to allow comparison with blood gas if performed.

2. Wash hands and put on gloves.

3. Place paper towel beneath 3-way tap collection port (maintain asepsis by non-touch technique rather than sterile gloves and towel).

4. Ensure 3-way tap closed to port hole.

C. Equipment

1. Gloves.
2. Paper towel.
3. Alcohol swabs x 2.
4. Syringes:
    - 2 mL syringe (A) for clearing line.
    - 2 mL syringe (B) for other blood samples as necessary.
    - 1 mL syringe (C) pre-heparinized for blood gas analysis.
    - 2 mL syringe (D) containing 0.5–1 mL of sodium chloride 0.9%.
5. Appropriate blood sample bottles and request forms.

D. Procedure

1. Remove Luer lock cap, clean with alcohol swab and allow to dry, or prepare bioconnector.

2. Connect 2 mL syringe (A).

3. Turn 3-way tap so it is closed to infusion and open to syringe and arterial catheter.

4. Withdraw 2 mL blood slowly. It must clear the dead space.

5. If bioconnector not being used, turn 3-way tap so it is closed to arterial catheter to prevent blood loss from baby.

6. Reattach syringe. Clear the connection of air.

7. Then flush with small amount slowly to clear blood from the line.

8. Record amount of blood removed and volume of flush on baby's daily fluid record.

E. Post procedure care

1. Ensure all connections tight and 3-way tap turned off to syringe port to prevent hemorrhage.

2. If sampling from umbilical arterial catheter (UAC), ensure lower limbs are pink and well perfused on completion of procedure.

3. If sampling from peripheral arterial line, check color and perfusion of line site and limb housing arterial line.

4. Ensure line patency by recommencing infusion pump.

5. Before leaving baby, ensure arterial wave form present and all alarms set.

F. Complication

1. Hemorrhage: Luer locks tight and 3-way taps appropriately adjusted.

2. Infection: Maintain sterile technique during sampling to reduce risk of infection.

3. Arterial spasm: Limb appears blanched. Stop procedure and allow time for recovery. Warming of opposite limb can elicit reflex vasodilatation.

4. Thrombosis or embolism: Sodium chloride 0.9% each time sample taken. If catheter not sampling, clot formation may be in progress. Request urgent middle grade review of arterial line for a prompt decision about removal.

5. In accuracy of blood gas results:

    a. Analyze sample immediately. After blood is withdrawn from an artery, it continues to consume oxygen.

    b. Excess heparin in syringe can result in a falsely low pH and PaCO2. Remove excess heparin from syringe before obtaining sample.

    c. Do not use if air bubbles in sample: take fresh specimen.

Heel Stick Capillary Blood Sampling

A. Indications

1. Capillary blood gas sampling.

2. Routine laboratory analysis (standard hematology, chemistries, toxicology/drug levels) requiring a limited amount of blood in which minimal cell lysis does not alter results.

3. Newborn metabolic screen.

B. Equipment

1. Gloves.

2. Heel-warming device or a warm towel. The warmer should be applied for 5 minutes and then removed prior to heel stick.

3. Antiseptic (Betadine/saline or alcohol swab).

4. Pad or other means of protecting bed linens.

5. Heel-lancing device. Use appropriate size for infant. Spring-loaded needle-puncture devices designed for adult glucose testing are not appropriate for infants.

6. Specimen collector as appropriate:

   a. Serum separators.

   b. Hematology tubes.

   c. Capillary blood gas tube.

   d. Newborn metabolic screen filter paper.

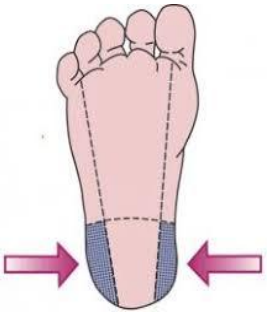
7. Capillary tubes for blood transfer to lab tubes, if appropriate.

8. Small adhesive bandage or gauze wrap.

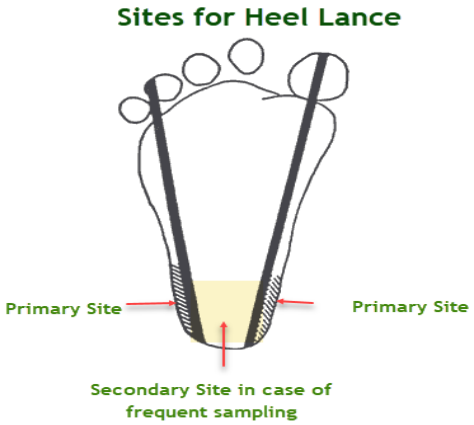
C. Procedure

1. Identify site; the preferred areas for capillary heel testing are the outer aspects of the heel (fig.1).

Fig. 1. Appropriate sites for capillary heel stick sampling are along the sides



a. Vary sites to prevent bruising and skin damage.



2. Apply heel warmer or warm towel for 5 minutes. Remove just before procedure.

3. Provide comfort measures: Facilitated tucking/ swaddling and concentrated sucrose solution results in less measurable pain and faster resolution of discomfort in the infant following the procedure.

4. Wash hands and put gloves on.

5. Cleanse site with antiseptic followed with saline wipe or alcohol wipe.

6. Place automated lancing device in appropriate position. Apply pressure along the calf with counter-pressure by the thumb. Do not squeeze the heel.

7. Place automated device/stick on site and activate.

8. Wipe away first drop of blood with gauze or clean wipe.

9. Using capillary action, fill blood gas tube, holding tube horizontally.

10. Release pressure, allowing capillaries to refill.

11. Guide blood drops into tube or collect with capillary tube for transfer to laboratory tube.

12. If blood stops flowing, wipe site to remove clot with alcohol swab, gauze, or clean wipe; ensure time for capillary refill; and then reapply pressure to leg. If blood does not flow, choose another site and repeat procedure or consider venipuncture.

13. When samples have been collected, apply pressure to puncture site and wrap with gauze or apply adhesive bandage.

Important tips:

1. Collect blood gas sample first, then hematology samples, and then chemistry / toxicology samples.

2. Ensure that blood gas samples are free of air bubbles.

3. Flick side of hematology microtube during collection process to activate anticoagulant and prevent clotting.

4. Newborn metabolic screen: See Specific collection guidelines (Guthrie card screening).

D. Complications

1. Pain – comfort measure as mentioned above.

2. Infection.

3. Tissue loss and scarring.

4. Calcified nodules – select a new site for each puncture.

5. Bruising can occur easily in the preterm neonates and is avoided by not using excessive or prolonged.

References:

1. Mahiri GM, Jayashree P, *Atlas of Procedures in Neonatology*, 5th ed., 2013, Philadelphia, New York.
2. Bedside Clinical Guidelines Partnership, *Neonatal Guidelines 2015–17*, Staffordshire, Shropshire & Black Country Newborn and Maternity Network Southern West Midlands Maternity and Newborn Network.

Extravasation Injury

Definition

Inadvertent infiltration of IV administered solutions into subcutaneous tissue.

Background

1. Approximately 4% of babies develop skin necrosis as a result of extravasation of an IV infusion.

2. A small proportion of these babies develop long-term cosmetic or functional compromise.

3. Extravasation may be due to:

a. Cannula piercing the vessel wall.
b. Distal venous occlusion causing backpressure and increased vascular permeability.

4. Centrally placed catheters may cause extravasation as often as peripheral cannula.

Clinical presentation

- Fussiness, crying, or withdrawal of the limb.
- Blistering and discoloration of skin.
- Staging of extravasations is recommended.

Tabl.1 describes one that is commonly used:

Table 1: Grading of extravasation injuries

Grade 1	**Grade 2**	**Grade 3**	**Grade 4**
- IV device flushes with difficulty - Pain at infusion site - No swelling or redness	- Pain at infusion site - Mild swelling - Redness - No skin blanching - Normal distal capillary refill and pulsation	- Pain at infusion site - Marked swelling - Skin blanching - Cool blanched area - Normal distal capillary refill and pulsation	- Pain at infusion site - Very marked swelling - Skin blanching - Cool blanched area - Reduced capillary refill - Arterial occlusion - Blistering skin /necrosis

Investigations

- No specific investigations required. However, if wound appears infected:
  - Wound swab.
  - FBC.
  - CRP.
  - Blood culture.
  - Start appropriate antibiotics.

Acute management

- Depends on degree (see table 2).

- Most extravasation injuries are of Grades 1 and 2 and do not require extensive intervention.
- Grade 3 and 4 injuries have a greater potential for skin necrosis, compartment syndrome and need for future plastic surgery, depending on type of solution extravasated.

Table2: Management		
Grade 1 and 2	**Grade 3**	**Grade 4**
- Stop infusion immediately - Remove cannula and splints/tapes - Elevate limb	- Stop infusion immediately - Remove constricting tapes - Leave cannula in situ until review by doctor/ANNP - Withdraw as much of the drug/fluid as possible via the cannula - Consider irrigation of affected area - Elevate limb - Inform tissue viability nurse	- Stop infusion immediately - Remove constricting tapes - Leave cannula in situ until review by doctor/ANNP - Withdraw as much of the drug/fluid as possible via the cannula using a 1-mL syringe. - Photograph lesion – provided no delay in further treatment - Consider use of hyaluronidase or a specific antidote. The use of hyaluronidase may obviate the need for the multiple puncture or saline washout techniques described below. - Elevate limb - Inform tissue viability nurse / registrar / consultant
* **Multiple-puncture technique**: In infants who develop tense swelling of the site, multiple punctures of the edematous area using a blood-drawing stylet (and strict aseptic technique) has been used to allow free drainage of the infiltrating solution, decrease the swelling, and prevent necrosis. The area is then dressed with saline soaks to aid drainage. * **Saline flush out**: A technique of saline flushing of the subcutaneous tissue. After cleaning and infiltrating the area with 1% lidocaine, 500 to 1,000 units of hyaluronidase is injected subcutaneously. Four small stab incisions are then made in the tissue plane with a scalpel blade at the periphery of the area. Saline is injected through a blunt cannula inserted subcutaneously through one of the puncture sites and flushed through the other puncture sites, massaging the fluid toward the incisions to facilitate removal of the extravasated material.		

Certain antidote that you may use for extravasation fluid (see table 3)

Table 3	
Extravasation fluid or medication	**Antidote use**
calcium, parenteral alimentation fluids, antibiotics, sodium bicarbonate, etc.	Hyaluronidase
Dopamine	Topical nitroglycerine
vasopressors such as dopamine and epinephrine,	Phentolamine

Further assessment

- Following irrigation treatment, review all injuries within 24 hours of extravasation occurring.
- Irrigation of major grades of extravasation has been used to prevent extensive skin loss and need for plastic surgery and skin grafting. However, the evidence for the use of irrigation in preventing long-term injury is limited.

Documentation

- Document extent and management of the injury in medical record**.**

Follow-up and review

- Determined by grade of extravasation.
- Neonatal medical staff review minor grades after 24 hours.
- Neonatal/plastic surgery staff/tissue viability nurse review Grades 3 and 4 within 24 hours to assess degree of tissue damage and outcome of irrigation procedure if performed.

Other considerations

1**.** *Family-centered care***:** inform parents of extravasation injury and management plan**.**
2. Infection control: observe standard infection control procedures.
3. Complete an incident report for Grade 3 and 4 extravasations**.**

References:

1. Mahiri GM, Jayashree P, *Atlas of Procedures in Neonatology*, 5th ed., 2013, Philadelphia, New York.
2. Bedside Clinical Guidelines Partnership, *Neonatal Guidelines 2015–17,* Staffordshire, Shropshire & Black Country Newborn and Maternity Network Southern West Midlands Maternity and Newborn Network.

Central Line Procedures (Umbilical Venous Line, Umbilical Arterial Line and PICC Line)

I- UAC and UVC

Equipment:

- Sterile trolley cleaned with alcohol wipe and allowed to dry.
- Sterile gown and gloves.
- Umbilical catheterization sterile instruments pack.
- Additional large sterile drapes/sterile pack and gauze.
- Cord tie (Mersilk).
- Silk suture with curved needle x2.
- Umbilical arterial catheter size 3.5-4Fg.
- Umbilical venous catheter 4Fg double lumen – 5Fg single lumen.
- 0.9% saline ampoules.
- Fixation steristrips and mefix tape.

Calculate insertion lengths:

UAC = 3 x weight + 9cm + stump
or diagonally umbilicus to shoulder length + 1cm + stump

UVC = 1.5 x weight + 5.5cm+ stump
Emergency UVC access 5cm with flashback of blood from vessel

Technique:

- Use sterile technique. Wash hands, put on sterile gown and gloves, open sterile packs.
- Prime catheter and 3-way tap with saline, leaving syringe attached throughout the procedure.
- Lift cord using sterile gauze (or ask assistant using cord clamp/forceps) clean the umbilical stump and 3-4cms of surrounding skin with 0.05% chlorhexidine solution. Ensure no cleaning solution tracks to underside of baby. Allow to dry.
- Apply sterile, waterproof drapes to area.
- Place suture around base of cord and tie loosely to prevent excess bleeding from vessel when cut.
- Holding the cord between medium forceps cut the cord cleanly using the lower edge of the forceps as a guide, cut firmly and cleanly away from you, leaving a 1-2cm stump.
- Inspect vessels and identify the arteries, smaller and thicker walled, inferior to the single vein, often standing prominent from the cut cord.
- Apply 2 forceps to opposite edges of the cord to stabilize the stump and expose the vessels. Avoid over-handling the cord.

Umbilical Lines position Guidance

UVC Optimal position	T8 – T9
Acceptable with caution	T10 – L1 (greater risk of extravasation)
Not acceptable	Above T8 in heart, diversion into liver

UAC Optimal position	T6-9
Acceptable with caution	T10-11 Or low at L3 -4
Not acceptable	T12-L2 as mesenteric and renal arteries or any diversion into leg

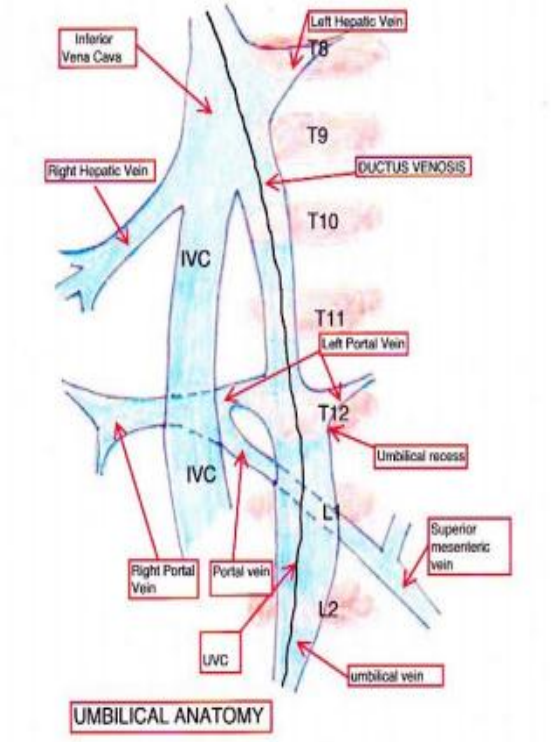
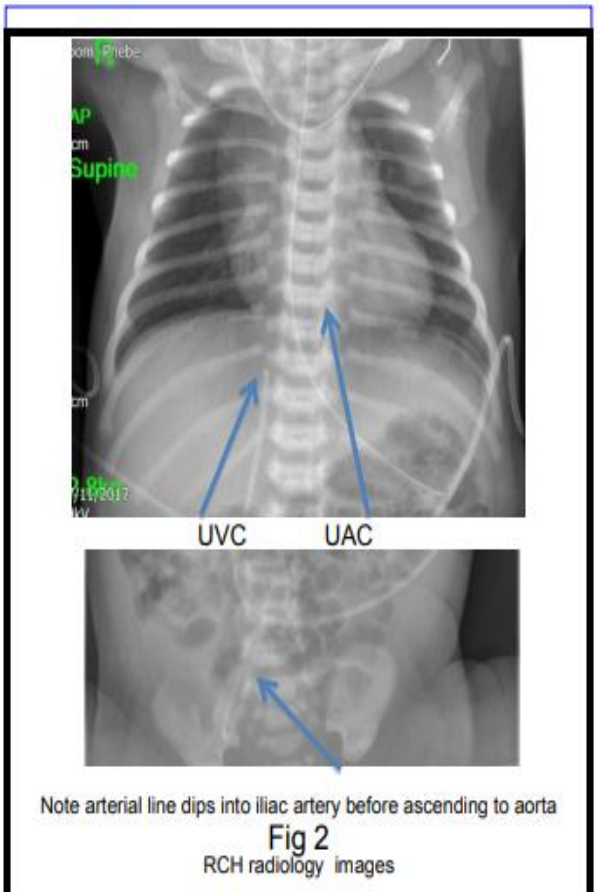


Fig.1. [4] (Drawn from post-mortem venogram image by J Clegg, RCH) **Umbilical vein anatomy:**



Note arterial line dips into iliac artery before ascending to aorta

Fig 2
RCH radiology images

- Using a fine dilator or fine forceps gently ease the vessel open and cannulate the vessel with the UAC towards the lower body (gentle upward traction of the cord may help) Apply gentle, steady pressure to insert the catheter to the required length. Some resistance may be felt at the umbilical ring and Do not apply excess force as this often results in a false passage outside the vessel.
- Aspirate to ensure a 'flashback' of arterial blood with pulsation of blood/saline present. A blood gas can be used to confirm arterial blood has been obtained.

- Insert the Umbilical Venous Catheter into the vein. Traction of the cord towards the lower abdomen may be helpful as the vessel lies superiorly to the cord. Insert to the desired length and ensure the line samples and flushes.
- To confirm the position of lines do 2 views of X-ray, and repeat X-rays after any manipulation of the line.

Nursing care for UAC

- For setup and maintenance of arterial pressure transducer see transducer application.
- Keep catheter free of blood to prevent clot formation:
    - Flush catheter with 0.5 ml of flush solution slowly over at least 5 seconds each time blood sample is drawn.
    - Infuse IV solution continuously through catheter between samples to prevent retrograde flow.
    - Note amounts of blood removed and IV fluid flush solution infused, and add to fluid-balance record**.**
- Watch for indications of clot formation.
    - Decrease in amplitude of pulse pressure on blood pressure tracing.
    - Difficulty withdrawing blood samples.
- Take appropriate action if clot forms.
    - Do not attempt to flush clot forcibly.
    - Remove catheter. Replace only if critical line.
- Avoid enteral feeding with catheter in situ if possible. Increased risk of mesenteric thromboembolism has been documented.

Documentation

Document who, when, and why the UAC was applied. Record the infant's reaction prior to, during and after the procedure. Record any complications occurred related to the application of the UAC.

II- Peripherally Inserted Central Catheter (PICC)

Definition

Peripherally inserted central catheter (PICC) is a thin, soft, long catheter that is inserted into a vein in a child arm, leg, or neck.

The tip of the catheter is positioned in a large vein.

Purpose

The goal is to spare veins from these frequent needle sticks, it can also spare veins and blood vessels from the irritating effect of iv medication, can be used in hospital sitting, nursing facilities, or at home and can stay in place for weeks or months, if needed.

Responsibility

1- Doctor.

2- Radiologist.
3- Trained nurse.

Contraindication

1- Small diameter of arm vein.
2- Femoral access necessary because of mediastinal syndrome.
3- Particular conditions of the arm (infection, paresis, presence of devices).
4- Severe renal impairment.

Equipment

1- Catheter with deferent size.
2- Sterile set.
3- Heparinized normal saline.
4- Syringes.
5- Three ways.
6- Tagaderm for fixation.

Procedure

1- Examine the child and find the appropriate vein.
2- Make the measurement to decide the length of catheter insertion:
   - The upper arm: from the site of insertion till the sternum.
   - The lower extremities: from the site of insertion till the diaphragm margins.
3- Fill the catheter with heparinized saline.
4- Clean the site of insertion with polidine.
5- Maintain a sterile field.
6- Insert the catheter at the length you measured.
7- Fix the catheter temporarily and obtain chest x-ray.
8- Finally, fix the catheter if in position.

Complications

1- Discomfort during procedure.
2- Bleeding at the site of insertion.
3- Accidental puncture of the artery at the site of insertion.
4- Thromboses.
5- Phlebitis.
6- Sepsis.
7- Cellulites.
8- Pain.
9- Line blockage or breakage.
10- Line extravasations.
11- Catheter tip migration.
12- Air embolus.
13- Pericardial effusion.
14- Pleural effusion.
15- Cardiac tamponade.

Nursing alert

1- Mild oozing of blood from the insertion site may occur for up to 24 hours. If oozing occurs, the initial dressing should be changed when it subsides. If oozing of blood is a problem, a small piece of thrombin foam can be applied over the insertion site and under the dressing for the first 24 hours after insertion.
2- The catheter site dressing should be replaced when it becomes damp, soiled, or loose. Transparent dressings should be changed every 7 days except in those patients in whom the risk of dislodging the catheter outweighs the benefit of changing the dressing.

Nursing care

1- Keep catheter free of blood to prevent clot formation:
   - Flush catheter with 0.5 ml of flush solution slowly over at least 5 seconds each time IV solution changed.
2- Watch for indications of clot formation or phlebitis.
   - Take appropriate action if clot forms.
   - Do not attempt to flush clot forcibly.
   - Remove catheter. Replace only if critical line.

References:

Mahiri GM, Jayashree P, *Atlas of Procedures in Neonatology*, 5th ed., 2013, Philadelphia, New York.

Preparation for Endotracheal Intubation

Purpose:
Placement of an oral or nasal endotracheal tube for:

a. Pulmonary diseases, e.g., Surfactant deficiency.
b. Airway management, e.g., Post-surgical infant.
c. Central causes, e.g., apnea.
d. Abnormalities of muscles of respiration, e.g., myotonic dystrophy.
e. Miscellaneous causes of respiratory failure, e.g., sepsis.

Definition:
A tube that is inserted at the mouth (endotracheal tube) to permit mechanical ventilation and to facilitate secretion removal.

Responsibility:

- Licensed nurse.
- Physician.

Equipment:

- ETI that suits the size of the babies tube diameter for patient weight**:**

Weight	Tube size
< 1250 g	2.5 mm
1250-3000 g	3.0 mm
> 3000 g	3.5 mm

- Oxygen source (oxygen set, flow meter, and oxygen tube).
- Suction apparatus.
- Suction tube (with a diameter half of that of the EIT).
- Cardio respiratory monitor.
- Oxygenation monitor (optional), e.g. pulse oximetry.
- Bag and mask ventilation.
- Stethoscope.
- Gloves.
- Scissors.
- Magill forceps (optional for nasotracheal intubation).
- Pediatric laryngoscope with straight blade.
  - Miller blade no. 0 for babies less than 3 kg.
  - Miller blade no. I for babies more than 3 kg.
- Adhesive tape: 8 to 10 cm lengths of 1/2 inch width tape with half the length split and one 10 to 15 cm length unsplit.
- Resuscitation equipment (appropriate size mask / suction catheter).
- Gauze (wet and dry) to clean around the mouth and nose for better adhesion of tape.

Activity:

A. ***Key points***

1- ETT intubation is at least a two-person procedure and can be performed by medical and nursing staff deemed competent in this procedure.

2- If a prolonged period of hypoxia or bradycardia occurs during an attempt at intubation, the procedure should be stopped and the infant given bag and mask resuscitation until stabilized. Depending on the level of experience, no more than two attempts should be made to intubate before handing over to a more experienced staff member.

3- Sedation prior to intubation may be considered in infants >34weeks.

4- Rapid sequence pre-medication may be delivered as below:

   1- IV Morphine 0.1 mg/kg
   2- IV Atropine 20 mcg/kg
   3- IV Suxamethonium 1-2 mg/kg

   Suxamethonium should not be used if there is a suggestion of upper airway obstruction that may prevent intubation.

B. ***Insertion of an oral ETT***

1- Select tube size and if using an introducer, insert it to the end of the tube and bend it slightly. This aids in providing traction for the tube to allow easy passage. Ensure it does not protrusion out of the end, may cause trauma or perforation.

2- Position the infant supine with the head in a neutral position. Gently tilt the infant's head into a sniffing position. Over-extension of the neck will lift the pharynx out of view and collapse the trachea.

3- Pass the laryngoscope blade gently along the right side of the mouth, pull the tongue and the epiglottis forward by exerting traction perpendicular to the blade of the laryngoscope. Care should be taken not to tilt the blade upward.

4- Slide the laryngoscope blade back until the epiglottis and vocal cords come into view.

5- Insert the ETT, pass through the cords, advancing no further when the entire black strip has passed through the cords or to the shoulder of a Coles tube.

6- Ensure the ETT is advanced to the correct depth only and no further avoiding hyperinflation of the right lung and collapse of the left lung.

7- Assess chest wall movement.

8- Connect the infant to the ventilator ensuring stability of the ETT.

C. ***Strapping of an ETT***

1- Apply hydrocolloid tape to both cheeks.

2- Apply the first trouser leg tape to the right cheek.

3- Place the upper leg across the top of the lip.

4- The lower leg is placed directly on the tube and it is wrapped around the tube in a spiral fashion.

5- The second trouser leg tape is applied to the left cheek, and the lower leg is placed across the lower lip.

6- The upper leg is placed directly on the tube and it is wrapped around the tube in a spiral fashion.

Shortening the dead space on the ETT

Shortening the dead space on the endotracheal tube optimizes ventilation. This is at least a 2 person procedure. Medical staff should be aware that the procedure is under way.

Procedure

1- Do not shorten the ETT until you have ascertained that it is in at the correct depth, i.e. in case it needs to be advanced. Leave a minimum of 5cm from the nares or mouth.
2- Ensure the infant is stable, settled and restrained if necessary.
3- If suction device is in place, make sure the catheter is completely clear of the interior of the ETT or that the device has been disconnected from the ventilator circuit.
4- Cutting the ETT on a slight angle makes it easier to reintroduce the ETT connector afterwards.
5- For ease of measuring when suctioning, make sure the 'cm' markings are visible at the cut end of the ETT.

Documentation:

1- Document the pain response of the baby (according to pain scale).
2- Document ETT size, length, level of fixation, date of insertion, staff signature involved in the procedure.
3- Document the procedure and any complication in nurses' observational sheet.

References:

Mahiri GM, Jayashree P, *Atlas of Procedures in Neonatology*, 5th ed., 2013, Philadelphia, New York.

Care of Mechanically Ventilated Baby

Purpose

1- To help the patient maintain patent airway**.**
2- To help the patient maintain adequate respiratory function**.**
3- To maintain good tissue oxygenation.

Definition

a. Mechanical ventilator is a machine that generates a controlled flow of gas into a patient's airways. Oxygen and air are received from cylinders or wall outlets, the gas is pressure reduced and blended according to the prescribed inspired oxygen tension (FiO2), accumulated in a receptacle within the machine, and delivered to the patient using one of many available modes of ventilation:

b. Conventional Ventilation / IMV

1- Controlled ventilation according to a predetermined pattern (pressure and flow) and frequency.
2- Time-controlled/pressure limited ventilation.
3- Mandatory ventilation ignores patient's spontaneous RR.
4- Tidal volume is determined by the pressure pattern (pressures set).

c. Synchronized Intermittent Mandatory Ventilation (SIMV)

1- Combines spontaneous breathing with synchronized ventilation.
2- Support is provided for the rate set by the operator, not for the breaths the infant takes in between the ventilator strokes.
3- No pressure support for the patient's breath.
4- Useful for weaning bigger infants from the ventilator.
5- If the patient is apneic, the ventilator cuts in at the set rate.

d. Synchronized Intermittent Positive Pressure Ventilation (SIPPV)

1- Ventilation strokes are synchronized with spontaneous breathing: a stroke begins when a spontaneous inspiration is detected and ends after the IT (giving pressure support).
2- The patient determines the respiratory rate.
3- If the patient becomes apneic, the ventilator cuts in at the rate determined by the IT & ET, the same as IPPV.
4- Patient has time to breathe out.
5- Can be combined with VG and VIVE.

Responsibility

1- Licensed trained nurse,
2- Physician

Equipment

1- Ventilator machine.

2- Respiratory set.
3- Oxygen and air source
4- Humidifier base and chamber.
5- Electric supply

Procedure:

1- Flow sensor issues:

1- If the flow sensor is removed for surfactant administration or any other reason, then ventilator will automatically revert to the conventional pressure limited time cycled mode of ventilation and will utilize the preset pressure limit as the PIP. Thus when the sensor is removed, the PIP will potentially be set at 15-20 percent higher than the pressure that is actually needed to provide the required VT and the baby will receive unnecessarily high VT and potential volutrauma.

2- If the flow sensor becomes dirty, it may incorrectly read tidal volume, and provide widely variable pressures to reach target volumes. If flow Vs. time waveform appears noisy, and secretions are cleared from tubing/circuitry, consider replacing flow sensor.

2- Alarms:

1- Low minute volume alarm:

1. Do a blood gas analysis. If there is respiratory acidosis, check for appropriate respiratory rate and VT and make adjustments if necessary.
2. Consider increasing the rates or set tidal volume.
3. If gases are good and ventilation settings are appropriate, then consider resetting the minute volume limits but do not exceed 50% of the desired range (e.g. minimum 0.1 L/kg/min and max 0.45 L/kg/min).

2- High minute volume alarm

1. Set VT may be too low so that you are not providing adequate alveolar volume and the infant has to breathe very quickly – adjust VT up.
2. There may be water in the line causing the ventilator to trigger at times when the infant is not taking a breath. This situation can lead to gas trapping. Clear the water from the circuit and observe.
3. If excess triggering is not due to either of the above, discuss a small increase (0.3) in the trigger sensitivity with your consultant (do not exceed a trigger sensitivity of 1.3).

3- Low tidal volume

1- Look for obstruction.

2- See if there is air leak more than 60 percent. If so, review tube position & orientation, discuss about changing the Tube to a bigger one or consider taking baby off volume guarantee.

3- Check that appropriate amount of flow is delivered to ensure that pressure achieves plateau within first 33-50% of inspiratory period. Increase flow if necessary to achieve this goal.

4- Check that inspiratory time is not set to an inappropriate low value (review duration of inspiration on flow Vs. time graph).

5- Limitations at very low volumes – the ventilator cannot accurately deliver volumes of less than 2 mL.

Documentation

Document any action done on the nurse's notes and flow sheet.

Suction

General Observations

1- Auscultate the infant's chest prior to suctioning to evaluate the need for suctioning. Suctioning an endotracheal tube is not a routine procedure, and should only be performed on an identified basis. Infant's in the acute phase of hyaline membrane disease produce little or no mucous unless infection is present.
2- Do not suction the endotracheal tube within 1-6 hours of surfactant instillation, as this will remove surfactant, & therefore decrease the effectiveness of surfactant. Only suction if clinically indicated.

In-line ("closed") suction system

1- The in-line ET adaptor will be placed on the ETT by the RRT following intubation. The depth required for suctioning of ETT will be determined by the RRT based on placement of ET adaptor.
2- The in-line suction catheter is changed q 24 hours by the bedside nurse.

Risks associated with endotracheal suctioning

1- Hypoxia – lung volume and alveolar volume are reduced by suctioning; induced atelectasis, resulting in arterial oxygen desaturation.
2- Increased cerebral blood flow velocity and intracranial pressure.
3- Bradycardia, dysrhythmias.
4- Altered pulmonary function.
5- Destruction of mucociliary transport.
6- Trauma – mucosal ulceration & hemorrhage (Necrotizing tracheobronchitis). Studies show suctioning as a contributing factor when the catheter comes in contact with mucosal tissue. This damage leads to granulation tissue, bronchial obstruction, lobar emphysema & atelectasis.
7- Perforation, pneumothorax & pneumomediastinum. Passing the catheter until resistance is met, usually locates the catheter at the anterior boarder of the right lower lobe. Perforation may occur, leading to pneumothorax & pneumomediastinum.
8- Infection

Equipment:

Wall suction (60-80 cmH2O)

- Sterile water
- Sterile gloves
- Sterile disposable specimen container
- Sterile 0.9% NaCl
- Sterile suction catheter*

  * If baby is being suctioned with the "open" suction system

Procedure

1- Frequency of suction depends on infant’s clinical status and physician’s guidance.

2- Usually not regular or routine and performed as needed when baby shows signs of ETT obstruction or excessive secretions
3- No suction should be performed for those given surfactant within the past 6 hours.
4- Try to maintain sterility during the procedure with sterile gloves and keep suction catheter sterile.
5- Never use a pressure of more than 60-80.
6- If fresh blood comes out the suction catheter, high likelihood that iatrogenic injury or pulmonary hemorrhage has started so instill saline and do Positive pressure ventilation.
7- During the procedure you may need to increase FiO2 by 10% and keep the baby swaddled to prevent hypoxia and keep him/her comfortable.
8- Closed loop suction is currently preferred if available.

References:

Mahiri GM, Jayashree P, *Atlas of Procedures in Neonatology*, 5th ed., 2013, Philadelphia, New York.

Preparation for Chest Tube and Care of Chest Drains

Purpose

- To remove air or fluid from the pleural space or to allow lung re-expansion following surgery.

Definition

- The process of inserting a tube in the chest cavity for the purpose of air removal.

Responsibility

- Licensed nurse.
- Physician.

Equipment

- This is a sterile aseptic procedure.
- Skin preparation as per protocol.
- Lignocaine 0.5% / 1 ml syringe / 25g needle.
- Scalpel.
- Argyle chest drain catheter or Pigtail catheter with trochar or introducer (A size 16Fg cannula attached to a short extension can be used instead of a chest drain on small infants at the request of the consultant.)
- Leukostrips / Tegaderm (optional).
- Suture and needle.
- Underwater seal drainage unit (both sites) / Heimlich valve (if applicable).
- Sterile water.
- Low pressure suction unit attached to panel at 3-5 cm H2O.
- Non-toothed chest drain clamp (1 per drain).

Procedure

1. Consider appropriate sedation/analgesia/local anesthesia before commencing.
2. Assemble drainage unit.
3. Position the infant supine and supported.
4. Prepare the skin (care with <27weeks).
5. Placement in most cases should be in the 4th intercostal space in the mid-axillary line. Avoid the nipple.
6. Infiltrate the area before making the incision.
7. Insert ICC directing it anteriorly or posteriorly as indicated.

8. Connect drain to tubing ensuring the water level is correct, the drainage system is ‘on’ and the suction is on (if applicable) or drain connected to Heimlich valve, if applicable.

9. If drain for pleural effusion – send specimen for analysis.

10. Secure the ICC with a suture and/or Leukostrips/Tegaderm as applicable.

11. Secure the tubing and drainage unit to prevent dragging and accidental removal.

12. CXR for catheter placement and resolution of pneumothorax /pleural effusion.

13. Observe ICC, tubing and drainage device for effectiveness i.e. bubbling, swinging and drainage. Maintain correct water level and suction pressure if in use. Heimlich valves may need dressing/container for drainage. Label if more than one.

14. Observe insertion site for bleeding / exudates.

15. Drainage unit / tubing should not be routinely changed, leave until full or removed.

16. Clamping is only necessary when changing unit or raising it above head height. It should be clamped for the least time possible.

Documentation

Document any action done on the nurses note sheet.

Blood Gas Monitoring

Procedure	Rational
1. After insertion of an arterial line or once the infant is stable on the ventilator.	To assure function of line, to assure that ventilation parameters are appropriate and to correlate CO_2 monitoring device with blood gas.
2. If an infant experiences a significant clinical deterioration &/or multiple ventilator changes.	Infants who have clinically deteriorated may not be maintaining adequate ventilation.
3. If the infant's blood gas is significantly out of range, there will be a consultation with the inter-professional neonatal care team; appropriate action will be taken and documented and a gas should be repeated.	Timely assessment, follow-up and intervention are key to the safety and stability of the infants in our care. Usually repeat in <30 minutes.
4. Every 24- 48 hours for a stable ventilated infant	Monitoring of ventilation without excessive blood sampling is the goal within the NICU. This includes attempting to co-ordinate blood gases and other blood sampling.
5. PRN post extubation.	If infant is not exhibiting any signs of respiratory distress, a blood gas may be unnecessary
6. PRN if infant is stable on.	If infant is not exhibiting any signs of respiratory distress, a blood gas may be unnecessary.

Respiratory Care: Respiratory Assessment and Monitoring of Sick Newborn

Purpose

- To monitor the activity of the breath of the patient.
- To detect the respiratory rate, and any episode of apnea.

Definition

The process of monitoring the breath activity, and trend breathing over time.

Responsibility:

- All physicians.
- Licensed nurse.

Equipment:

- Cardiopulmonary monitor and electrodes.

Activity:

- Monitor infant's respirations for:
  - Alert I NICU = Q 2 hrs.
  - Alert IMCU II = Q 3 hrs.
- Respirations can be taken by observation or on the monitor.
- Sometimes the cardio-pulmonary (CP) monitor does not give an accurate reading of the respiratory rate.
- Respiratory rate should be taken by observation at least once a shift.
- Rating of apnea:
  - Periodic apnea: absence of breathing 5-10 seconds followed by periods of ventilation 10-15 sec.
  - Apnea: the cessation of respiratory air flow and/or respiratory movement for 20 seconds or longer.
  - Record and report any kind or apneic response and if associated with bradycardia or color change.
  - Infants need stimulation for breathing if apnea was longer than 20 seconds.
  - Report and record if respiratory rate above 60 breaths/minute.
- By observation:
  - Place the infant in supine or side-lying position.
  - Count the respirations by observing chest and abdomen movements for one minute.
  - Record respiration rate on the daily nursing charting sheet.

- By CP Monitor:
  - Apply CP monitor if not applied to the baby and make sure the electrodes are connected well to the infant.
  - Read respiratory rate from the screen.

Low Flow Nasal Cannula Oxygen Therapy

Definition

Refers to administering oxygen by a plastic tube ended with too small prongs which fit to the infant nostrils. It is the nurse and doctor responsibility.

Purpose

To provide supplemental oxygen to infants with a stable ongoing oxygen requirement not needing ventilation

Equipment

- Low flow oxygen meter
- Appropriate size nasal prongs
- Skin protection tape / tape to secure prongs to face

Activity

- Apply skin protection to face.
- Connect nasal prongs to oxygen supply and dial up required flow on meter.
- Place nasal cannula on to infants face ensuring the cannula is pointing downward to follow the natural curve of the nostrils.
- Maintain SaO2 as per protocol.
- Check and document flow hourly and at any time the infant deteriorates.

High Flow Nasal Cannula

Definition

Delivery of humidified, heated and blended oxygen/air at flow rates between 1-8 L/min via nasal cannula.

Indications

- Treating or preventing apnea of prematurity
- Respiratory support for babies with:
  - Respiratory distress syndrome (RDS) – first-line or post extubation
  - Chronic lung disease
  - Meconium aspiration
  - Pulmonary edema

    - Pulmonary hypoplasia
    - Pneumonia
- Babies slow to wean off nasal CPAP
- Babies with nasal trauma from nasal CPAP

Setting and flow rate

- Set operating temperature at 36-38ºC.
- Start at flow rate of 4-6 L/min (flow rates >6 L/min in babies <1 kg discuss with on-call consultant).
- Use up to 8 L/min in babies >1 kg, unless baby requires FiO2 >0.4 or has CO2 retention, acidosis or apnea, in which case consider alternative support.
- Ensure there is leak around the prongs.

Monitoring

- Continually:
    - Heart rate
    - Respiratory rate
    - SpO2
- If on supplemental oxygen or on clinical grounds – blood gases.
- Prescribe supplemental oxygen on drug chart

Contraindications

- Upper airway abnormalities
- Ventilatory failure
- Severe cardiovascular instability
- Frequent apneas (despite caffeine in preterms)

Weaning flow rates (only if FiO2 <30% for the past 24 hours)

- If FiO2 >0.3, it may not be possible to wean flow rate.
- Attempt to reduce by 1.0 L/min 24-hrly.
- Attempt to stop (if baby is on 21% FiO2 then does not require nasal prong for low flow oxygen).

References:

1- Bedside Clinical Guidelines Partnership, *Neonatal Guidelines 2017-19*, Staffordshire, Shropshire and Black Country Neonatal Operational Delivery Network and Southern West Midlands Neonatal Operational Delivery Network.
2- Auckland District Health Board, *Newborn Services Clinical Guideline*, NZ, 2018 Update.

Cooling Therapy for HIE – Nursing Perspectives

Procedure

A. Preparation prior to initiation of whole body cooling:

1. Nurse all infants on an 'open radiant warmer bed' (even if non-ventilated) during the intervention period (i.e. first 4 days of life) or Caleo incubator with the lid off.
2. Place an arterial catheter (peripheral arterial or umbilical) if possible to monitor blood pressure and for investigative purposes.
3. Obtain an electrocardiogram (12-lead) at the earliest possible time (if possible before initiating hypothermia or otherwise when it is feasible) and repeat as required.
4. Obtain blood for CBC, blood gas, electrolytes (Na, Ca, K, Cl), lactate, PT, PTT, glucose, AST, ALT and creatinine prior to starting hypothermia protocol.
5. Turn off the overhead radiant warmer.
6. Feed the specialized rectal infant servo control probe per rectum to the 5 cm mark and secured to the infant's inner thigh.
    a. Mark the distance by a pen on the probe to monitor its location within the infant and monitor its location hourly.
    b. It is important that the probe is at least inserted 5 cm to accurately measure the infant's core temperature (the probe is specifically designed for this purpose and should not cause any mucosal trauma). This probe can be marked with permanent marker and marking should be checked hourly.
    c. Leave the probe in for the intervention period (usually first 4 days of life).
    d. Do not remove probe for cleaning as it is not required.
7. Connect the rectal probe via connecting cable to HP module.
8. The rectal temperature will be displayed on the HP monitor.
9. The rectal thermometers are disposable while the connector is reusable.
10. Place a skin probe on the infant's abdomen to monitor skin temperature.
11. Record rectal temperature in the temperature section, with R besides it to distinguish between Rectal and Axilla on the Nursing flow sheet. Set the temperature regulation on skin control regulated from the rectal probe.
12. Remove any heating pad/blanket from under the infant.
13. Remove any head cover if present.
14. Nurse the infant naked. If possible the patient should be nursed without a diaper.

B. Achieving hypothermia:

1. Aim for a rectal temperature of 33-34°C within one hour of starting hypothermia.
2. By just turning off the radiant warmer, the infant may start dropping his/her rectal temperature and you may not need any additional intervention to achieve target temperature.
3. Active cooling with gloves containing cool water will only be required if the temperature is >35.5°C.
4. If needed, place gloves containing cool water and wrapped in light linen beside the infant's abdomen to achieve hypothermia.
5. Start with 4 gloves and to avoid overshooting, once the temperature drops below 34.5°C, reduce to two gloves.

C. Management of the infant when receiving whole body cooling:

1. During the intervention period, parents may touch their infant and hold his/her hands. However, in order to avoid wide fluctuations in the temperature, don't permit extensive skin-to-skin contact during the intervention period.
2. Provide all other medical and nursing care as per current practice unless otherwise specified. This includes nursing observational charting, recording of information such as neurological status, i.e. level of consciousness, responsiveness, presence or absence of seizures, jitteriness, incidence and frequency of seizures, administration of anticonvulsants, investigations as recommended by the team and supporting parents going through this difficult time.
3. If the infant is ventilated, maintain humidifier at usual temperature.
4. Consider to initiate morphine via bolus 0.05-0.1 mg/kg followed by a continuous infusion of 10 mcg/kg/hour. If hypotension occurs and is requiring inotropic support, consider the use of Fentanyl 1 mcg/kg bolus followed by a continuous infusion of 1 mcg/kg/hour. If infant appears uncomfortable, or in pain, adjust pain management strategies appropriately.
5. Per-rectal medications can be administered if the infant is "NPO". Having the rectal thermometer probe is not a contraindication to P/R administration of medications.
6. If the infant requires muscle relaxants, they are not contraindicated while receiving hypothermia.
7. If the infant is persistently hypoxemic (SaO2 < 80% for >2 continuous hours) or persistently hypotensive (mean arterial blood pressure 4 hours) when receiving hypothermia, please consult staff neonatologist on call to consider terminating hypothermia.
8. Attach Cerebral Function Monitor (CFM) throughout the stay if available.
9. Check stool/meconium for occult blood. Asphyxiated infants can have occult blood in the stool due to intestinal ischemia and not necessarily due to rectal probe.

10. The infant will feel cold and look dusky, however, if the infant is saturating well that means he/she is not hypoxemic.

11. The heart rate will reduce to range of 90-140 bpm. Please set low heart rate alarm at 75 bpm and call physician/NP if it is persistently below this level or the rhythm is abnormal.

D. Rewarming of infant after 72 hours

1. After 72 hours of hypothermia, rewarm the infant gradually by 0.5-1°C per hour.
2. Increase the set point of the environmental temperature (via radiant warmer) by 0.5°C, with a goal of rewarming the infant at a rate not faster than 1°C per hour.
3. Continue this until the axillary temperature reaches approximately 36.80 C and rectal temperature is approximately 37°C.
4. It may take up to 6 hours for rewarming the infant to normal temperature range.
5. Remove the rectal probe after 6 hours of rewarming if the temperature has returned to normal range. Manage the infant's temperature in routine way from this point onwards.
6. Set the alarm limits for heart rate, temperature etc. back to normal range.

E. Investigations while receiving hypothermia

- Obtain the following investigations before the start of hypothermia and repeat at 24, 48 and 72 hours of age: CBC, arterial blood gas, lactate, PT, PTT, AST, ALT, creatinine, glucose, electrolytes, and calcium.
- Obtain and repeat a 12-lead electrocardiogram as required.
- Attach Cerebral Function Monitor (CFM) throughout the stay if the monitor is available.

References:

1- Palestinian Ministry of Health, *Neonatal Care Procedural Manual for Hospitals*, 2010.
2- Auckland District Health Board, *Newborn Services Clinical Guideline*, NZ, 2018 Update.

Neonatal Skin Care

General Skin Care

Assessment

1- Assess skin once each shift for redness, dryness, flaking, scaling, rashes, lesions, excoriation, or breakdown.

2- Consider using a validated skin assessment tool such as the Neonatal Skin Condition Score *(Lund and Osborne, 2004*).

The Neonatal Skin Condition Score			
Skin condition	1	2	3
Dryness	= Normal, no sign of dry skin	= Dry skin, visible scaling	= Very dry skin, cracking/fissures
Erythema	= No evidence of erythema	= Visible erythema <50% body surface	= Visible erythema >50% body surface
Breakdown	= None evident	= Small localized areas	= Extensive
Note: Perfect score = 3; worst score = 9.			

3- Identify those infants at increased risk for skin breakdown:

- Gestational age <32 weeks
- Edema
- Use of paralytic agents and vasopressors
- Multiple tubes and lines
- Numerous monitors
- Surgical wounds
- Ostomies
- Technologies that limit movement: high ventilation, extracorporeal membrane oxygenator

4- Evaluate and report abnormal skin findings and analyze for possible causation. Intervene according to interpretation of findings or physician order.

Bathing

Initial Bath

1- Assess for stable temperature a minimum of 4 hours before first bath.

2- Use cleansing agents with neutral pH or minimum dyes or perfume, in water.

3- Do not completely remove vernix caeosa.

4- Bathing of preterm infant (<32 weeks of gestation) performed with sterile water alone. Also Sterile water is to be used for all baths in the Level III setting, or if the infant has non-intact skin.

5- Any infant who has an unstable respiratory and/or cardiovascular status should not be bathed unless it is medically indicated i.e. HIV exposed baby, or Hepatitis B.

Routine

1- Decrease frequency of baths (every 2^{nd} or 3^{rd} day). Assess the infant's ability to tolerate the stress of the bath. Infants are to be bathed based on an individual basis, and to be assessed before the procedure. No infant is to be bathed routinely.

2- Use cleanser or soaps no more than two times a week.

3- Avoid rubbing skin during bathing or drying.

4- Immerse stable infants fully (except head) in an appropriate-sized tub.

5- Use swaddled immersion bathing technique: slow unwrapping after gently lowering into water for sensitive, but stable, infants needing assistance with motor system reactivity.

6- Ventilated infants do not require a full bath; they may have body fluids removed by gently removing the excess body fluids.

7- After the bath, re-evaluate the baby's temperature, cardiovascular and respiratory status. Document the infant's tolerance of the procedure during the bath.

Cord care

A- Immediate

1- Clean cord and surrounding skin surface as needed with cleanser used for initial or routine bathing and rinse thoroughly or cleanse with sterile water.

2- Clean umbilical cord with warm water and cotton wool and keep dry.

B- Ongoing

1- Keep cord area clean and dry. If cord becomes soiled with urine or stool, cleanse area with water.

2- Educate staff and families about normal mechanism of cord healing.

3- Teach parents or care-givers to keep area clean and dry, avoid contamination with urine and stool, keep nappy folded away from area and wash hands before handling baby's umbilical cord area,

Emollients

Follow hospital protocol or consider the following:

- Apply emollient as needed for dry, flaking skin.
- Use only emollients without perfumes, preservatives, or dyes.

Adhesives

- Decrease use as much as possible.
- Use transparent semipermeable adhesive dressings to secure intravenous lines, catheters, and central lines.
- Use hydrogel electrodes.
- Consider using pectin or hydrocolloid barriers beneath adhesives to protect skin.
- Secure pulse oximeter probe or electrodes with elasticized dressing material (carefully avoid restricting blood flow).
- Do not use adhesive remover, solvents, and bonding agents.
- Avoid removing adhesives for at least 24 hours after application.
- Use water, mineral oil, or petrolatum to facilitate adhesive removal.
- Remove adhesives or skin barriers slowly, supporting the skin underneath with one hand and gently peeling away from the skin with the other hand.

Antiseptic Agents

- Apply before invasive procedures.
- Evaluate the risks and benefits of any antiseptic agent.
- Chlorhexidine gluconate (diluted to 2% in term babies) and 10% povidone-iodine have both been shown to reduce skin bacterial counts in newborns.
- Avoid use of alcohol.

Transepidermal water loss

1- Minimize transepidermal water loss and heat loss in small preterm infants (<30 weeks of gestation) by measuring ambient humidity during first weeks of life and considering an increase in humidity to **70%** for the first week of life by using one or more of the following options or hospital guidelines:

- Transparent dressings
- Servo-controlled humidifying incubator
- Supplemental conductive heat sources such as heated mattresses

- Polyethylene coverings (but avoid having plastic wraps in contact with skin surfaces for long periods)

2- Provide supplemental humidity:

- 70% during the first week of life.
- 60% during the second week of life.
- 50% during the third week of life and until discontinued.
- Discontinue humidity when the baby reaches 32 weeks post-conceptual age or sooner if the baby is dressed and bundled.

Skin breakdown

Prevention

- Decrease pressure from externally applied forces using water, air, or gel mattresses; sheepskin; or cotton bedding.
- Provide adequate nutrition, including protein, fat, and zinc.
- Apply transparent adhesive dressings to protect arms, elbows, and knees from friction injury.
- Use tracheostomy and gastrostomy dressings for drainage and relief of pressure from tracheostomy or gastrostomy tube (Hydrasorb or Lyofoam).
- Use emollient in the diaper area (groin and thighs) to reduce urine irritation.

Treating skin breakdown

1- Irrigate wound every 4 to 6 hours with warm half-strength normal saline using a 30-ml or larger syringe and 20-gauge Teflon catheter.
2- Culture wound and treat if signs of infection are present (e.g., excessive redness, swelling, pain on touch, heat, or resistance to healing).
3- Use petrolatum-based ointments for uninfected wounds. Apply hydrogel with or without antibacterial or antifungal ointments (as ordered) for infected wounds (may need to moisten before removal).
4- Use hydrocolloid for deep, uninfected wounds (leave in place for 5 to 7 days) or as an ostomy barrier and to improve appliance adhesion; warm barrier in hand for several minutes to soften before applying to skin.
5- Avoid use of antiseptic solutions for wound cleansing (used for intact skin only).

Other skin care concerns

Use of substances on skin

1- Evaluate all substances that come in contact with infant's skin.

2- Before using any topical agent, analyze components of preparation and:

• Use sparingly and only when necessary.

• Confine use to smallest possible area.

3- Whenever possible and appropriate, wash off with water.

4- Monitor infant carefully for signs of toxicity and systemic effects.

Use of fluid therapy and hemodynamic

2- Monitoring: Be certain fingers or toes are visible whenever extremity is used for intravenous or arterial line.

3- Secure catheter with transparent dressing or tape to promote easy visualization of site.

4- Assess site hourly for signs of ischemia, infiltration, and inadequate perfusion (check capillary refill).

5- Avoid use of restraints (e.g., arm boards); if used, check that they are secured safely and not restricting circulation or movement (check for pressure areas).

6- Use commercial intravenous protector (e.g., I.V. House) with minimum tape.

FIG. 23-17 I.V. House used to protect the intravenous site.

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7- Change oximeter probe sites every 4-6 hours or more often only if evidence of skin irritation. Observe the sites closely for burns and abrasions.

8- When using transcutaneous monitors use the lowest heat setting possible and rotate sites every 3-4 hours. Apply two fixation rings and alternate between them to avoid having to remove them as often. Assess skin integrity within the ring before application and change to a new site if skin has been compromised.

Diaper dermatitis

Brief background

Diaper dermatitis is caused by prolonged and repetitive contact with an irritant (e.g., urine, feces, soaps, detergents, ointments, friction). Although the irritant in the majority of cases is urine and feces, a combination of factors contribute to irritation (Fig. 11-3).

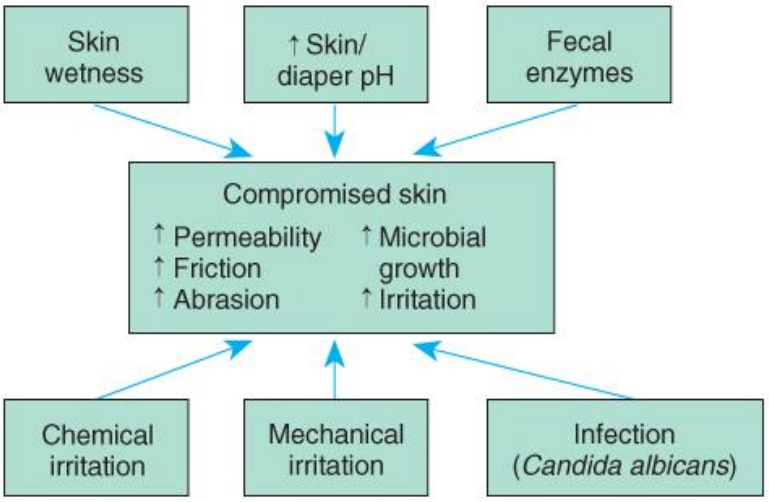

FIG. 11-3 Principal factors involved in development of diaper dermatitis.

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Clinical presentation

- The eruption of diaper dermatitis is manifested primarily on convex surfaces or in folds. The lesions represent a variety of types and configurations.
- Eruptions involving the skin in most intimate contact with the diaper (e.g., the convex surfaces of buttocks, inner thighs, mons pubis, scrotum.)
- Perianal involvement is usually the result of chemical irritation from feces, especially diarrheal stools.
- Candida albicans infection produces perianal inflammation and a maculopapular rash with satellite lesions that may cross the inguinal fold.

Types of diaper dermatitis	
Type 1	Epidermis intact and no candidal infection present
Type 2	Epidermis intact and candidal infection present
Type 3	Epidermis not intact and no candidal infection present
Type 4	Epidermis not intact and candidal infection present

Therapeutic management

1- Keep skin dry.
- Use superabsorbent disposable diapers to reduce skin wetness.
- Change diapers as soon as soiled, especially with stool, whenever possible.
- Expose healthy or only slightly irritated skin to air, not heat, to dry completely.

2- Apply ointment, such as zinc oxide or petrolatum, to protect skin, especially if skin is very red or has moist, open areas.

- Avoid removing skin barrier cream with each diaper change; remove waste material and reapply skin barrier cream.
- To completely remove ointment, especially zinc oxide, use mineral oil; do not wash vigorously.

3- Avoid over-washing the skin, especially with perfumed soaps or commercial wipes, which may be irritating.

- May use a moisturizer or non-soap cleanser, such as cold cream or Cetaphil, to wipe urine from skin.
- Gently wipe stool from skin using a soft cloth and warm water.
- Use disposable diaper wipes that are detergent- and alcohol-free.
- Avoid the use of powders such as talcum.
- Encourage breastfeeding through infancy.
- Identify concomitant candida albicans infection and treat with low potency antifungal cream and include clotrimazole, miconazole, ketoconazole, and nystatin ointment.

4- For inflammations that do not respond to these interventions, topical glucocorticoid preparations are sometimes required. If steroids are prescribed, their use is limited to low-potency preparations, such as a 0.5% or 1% hydrocortisone cream.

5- If the dermatitis is both fungal and a contact irritant dermatitis, it may be necessary to layer the ointment with the antifungal preparation:

(1) Mycostatin powder is used,

(2) Followed by an application of alcohol free skin protectant to seal the powder onto the skin surface.

(3) A generous application of a skin barrier cream is then done, such as zinc oxide or pectin paste.

References;

1- Wong, D.L., *Whaley & Wong's Nursing Care of Infants and Children*, 10th edition, 2015, Mosby, St. Louis.

2- Gardner S et al. *Merenstein and Gardner's Handbook of Neonatal Intensive Care*. 8th ed., 2015, St. Louis, London, Syelrey: Mosby.

3- Association of Women's Health, *Obstetric and Neonatal Nurses: Evidence-Based Clinical Practice Guideline: Neonatal Skin Care*, ed. 3, Washington, DC, 2013.

Thermoregulation and Neutral Thermal Environment

Neutral thermal temperature:

The body temperature at which an individual baby's oxygen consumption is minimized. Thus a minimal amount of the baby's energy is expended for heat maintenance, and energy is conserved for other basic functions and for growth.

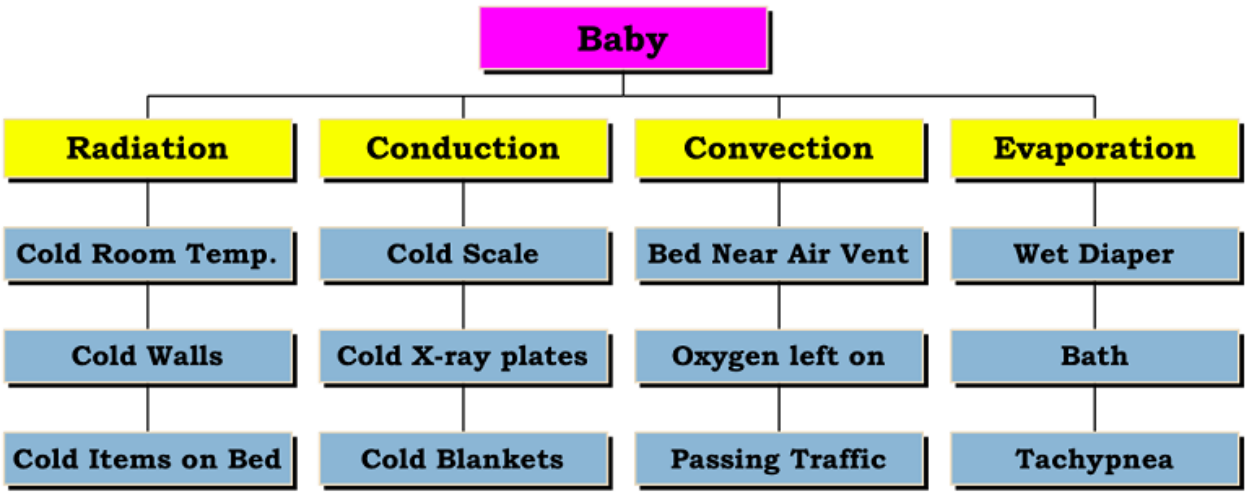
Why are preterm infant, high risk newborn and LBW at greater risk for thermoregulation problems?

- ↓Brown Adipose Tissue
- ↑Body surface area
- ↓Subcutaneous fat
- ↓Glycogen stores
- ↑Body water content

Methods of measuring temperature

- Rectal thermistors are thin, flexible probes that must be inserted at least 5 cm to obtain an accurate reading.
- In critically ill infants, the skin temperature is usually routinely monitored in addition to axillary temperature readings. A skin probe is secured to the right upper quadrant of the abdomen. The temperature probe should not be placed under the axillary or any other position except as recommended by the manufacturer.
- Only abdominal skin temperature has been shown to be an effective monitor of neutral thermal environment.
- Axillary temperatures provide readings as accurate as rectal and core temperature methods. Axillary temperatures should be maintained at 36.5°C to 37.5°C in term and 36.3°C and 36.9° C in preterm.

Possible sources of heat loss



Consequences of hypothermia or cold stress

1- Respiratory distress, hypoxemia, apnea
2- Pulmonary hemorrhage
3- Hypoglycemia
4- Hyperbilirubinemia
5- Acidosis
6- Bradycardia

Rewarming the hypothermic infant

- Always be prepared to intervene.
- Rewarm slowly (0.5˚C per hour).
- Monitor closely (vital signs every 15-30 min).
    - Core temp
    - Skin temp will be higher than axillary
    - Blood pressure: Rewarming may lead to vasodilation – hypotension
    - Heart rate and rhythm : Bradycardia & arrhythmias common with hypothermia
    - Respiratory rate and effort: apnea, distress
    - SPO2 and blood glucose

Guidelines for rewarming

- Incubator better controlled than warmer.
- Set temp 1-1.5˚C above core temp.
- Assess infant temp every 15-30 minutes.
- As infants core temp reaches set temp and infant is not showing signs of deterioration, increase set temp again.
- Continue process until temp within normal range.

Strategies to prevent heat loss/cold stress

- Two broad categories of interventions foster thermal neutrality: blocking avenues of heat loss (see table below), and providing external heat and environmental support to maintain temperature within the normal range of 36.5° to 37.5° C.

Method of heat loss	Strategies to prevent heat loss
Convective heat loss	• Providing warm ambient air temperature • Placing infants less than 1500 grams in incubators • Keeping portholes of the incubator closed • Warming all inspired oxygen • On open warmers, keeping sides up and covering infant if possible • Using Infant Servo Temperature Control
Radiant heat loss	• Avoiding placement of incubators, warming tables and bassinets near cold windows, walls, air conditioners, etc.. • Placing a knit hat on the infant's head • Wrapping tiny babies in saran or "bubble" wrap • ↑ environmental temperature
Conductive heat loss	• Placing a warm diaper or blanket between the neonate and cold surfaces • Placing infant on pre-warmed table at time of delivery • Using sports gel pack • Warming all objects that come in contact with the neonate • Admitting infant to a pre-warmed mattress • Skin to skin contact
Evaporative heat loss	• Keeping the neonate and his/her environment dry. • Drying the baby immediately after delivery. • Placing preterm or SGA infant in occlusive wrap or polyethylene bag at delivery esp. for babies born at 26 to 30 weeks • Delay bath until temperature is stable

- The air temperature in newborn care areas should be kept at 23.8° to 26.1° C, and humidity should be kept at 30% to 60%.
- Raising the delivery room temperature to 24° to 26° C, as recommended by the WHO, decreases cold stress in preterm infants less than or equal to 32 weeks of gestation.

Fig. A: Research-based algorithm for weaning from servo control to air control mode in an incubator

(Reference: Gardner S et al. *Merenstein and Gardner's Handbook of Neonatal Intensive Care*. 8th ed., 2015, St. Louis, London, Syelrey: Mosby)

Criteria for Weaning to Air Control

1. Infant is medically stable and in a condition that permits weaning.
2. Infant requires minimal heat output from servo control set at 36.5° to 37° C.
3. Infant is gaining weight adequately: 15 to 20 g/kg/day, based on gestational age and chronologic age.

↓

1. Determine infant's age and weight.
2. Determine appropriate incubator temperature range (see Table below).

↓

Remove the temperature probe and heat-reflecting disk using soap and water or mineral oil.

↓

Obtain the infant's axillary temperature to establish a baseline temperature. Temperature should be at least 36.5° C.

↓

Switch the heat from servo-control to air control on the incubator and set the incubator control temperature (see Table below).

↓

1. Obtain the infant's axillary temperature every 30 minutes to 1 hour.
2. Increase or decrease the temperature of the air control no more than 0.5 degree per 30 minutes or 1 degree per hour to maintain the infant's temperature.

Birthweight and Incubator Temperature Range

Table 1: Neutral Thermal Environment For Infants Day 1 – 5 of Life				
Age	**1000 - 1200g** +/- 0.5°C	**1201 - 1500g** +/- 0.5°C	**1501 - 2500g** +/- 1.0°C	**>2500g and >36wk**
0 - 12 Hours	35.0	34.0	33.3	32.8
12 - 24 Hours	34.5	33.8	32.8	32.4
24 - 96 Hours	34.5	33.5	32.3	32.0

Table 2: Neutral Thermal Environment For Infants > 5 Days Of Age			
Age	**<1500g**	**1501 - 2500g**	**>2500g and >36wk**
5 - 14 Days	33.5	32.1	32.0
2 - 3 Weeks	33.1	31.7	30.0
3 - 4 Weeks	32.6	31.4	
4 - 5 Weeks	32.0	30.9	
5 - 6 Weeks	31.4	30.4	

Note: Within each range, the younger the infant and/or the lower the infant's weight, the higher the temperature required.

Reference of figures: Ringer SA, Care Concepts: Thermoregulation in the Newborn, Part ll. *Neo Reviews*, 2013:14 ;e221.

Fig. B: Research-based algorithm for servo-controlled weaning from an incubator to an open crib

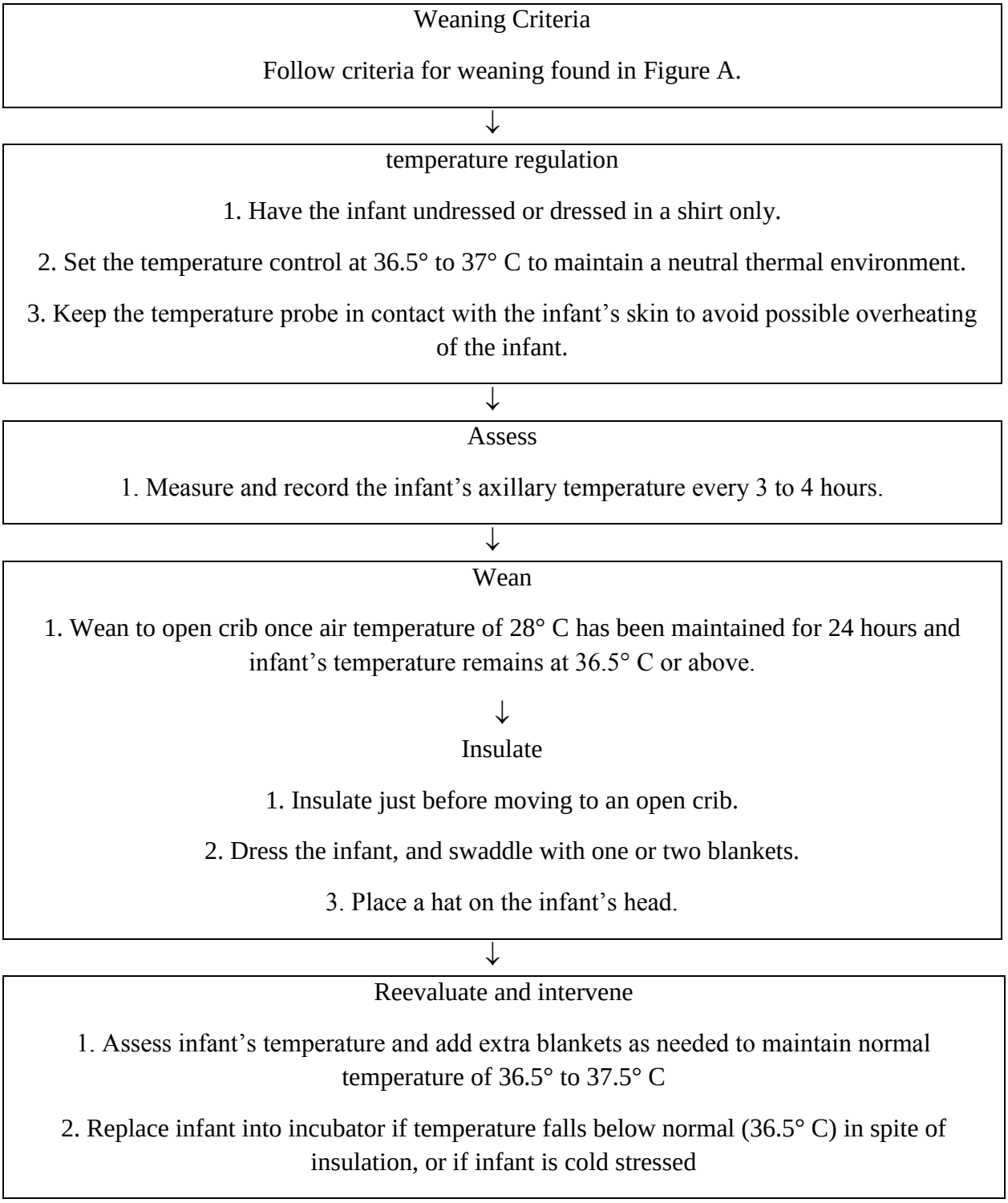
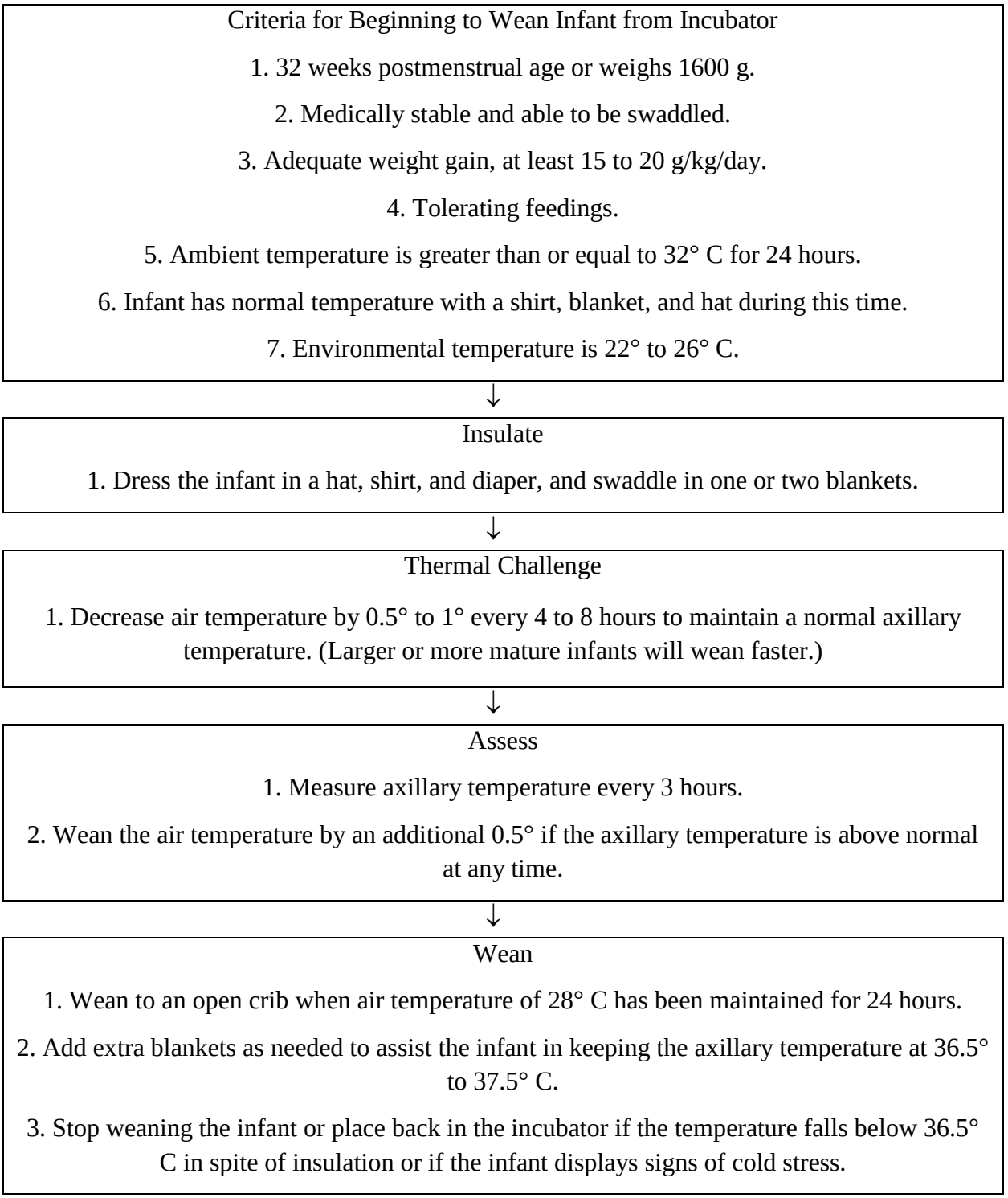


Fig. C: Research-based algorithm for air mode/manual weaning from an incubator



Incubator Humidity

- It is recommended that infants < 27 weeks gestation be commenced in an incubator humidity of 80%. However this should be assessed according to skin integrity, gestational age, CGA and the set temperature requirement of the incubator.
- Weaning of humidity should be alternated with weaning of the incubator temperature until a level is reached that maintains a PA temperature within the target range.
- Weaning of humidity should be commenced during the first week of life when the infant is able to maintain a per axilla temperature within the target range. Weaning should commence at 5% intervals over the period of a week to around 50% at the end of the first week of life.
- During the second week of life, the humidity can be reduced to 40% and thereafter ceased if the incubator is at or less than 32 degrees. Some infants may require humidity until 2- 3 weeks of age however this should be discussed with a senior nurse.

Suggested Values For Balance Of Humidity And Incubator Temperature	
Incubator Temperature	**Humidity %**
38	80
37	70
36	60
35	50
34	40

Reference:

King Edward Memorial Hospital, *Neonatology Guidelines*, Western Australia North Metropolitan Health Service, Updated 2015.

Early Preparation for Expected Admission of Premature or Sick Newborn

I- Admission nurse is responsible for checking the resuscitation equipment / admission set-up prior to admitting an infant:

1- A warmer or pre-warmed incubator**.**
2- Ventilator / nasal CPAP, oxygen set, suction set.
3- Stethoscope, ambubag and tail. Appropriate mask.
4- Cardiopulmonary monitoring: Invasive/ Non-invasive blood pressure, SPO2.
5- CVP.
6- Thermometer.
7- Reweighed disposable nappy and equipment for urinalysis.
8- Hat.
9- Scales / Measuring tape.
10- Admission paperwork / name bands.
11- 2 - 3 syringe pumps +/- infusion pump with prescribed IV fluid d/w 10%.
12- Equipment for peripheral and/or central access.
13- Equipment for septic work up: blood culture bottle, sterile gauze & needles, syringes, plain tube, edeta tube, ESR, sterile gloves, L.P set.
14- OGT with baby set in plastic basket.
15- Intubation equipment: laryngoscope with blades size 00, 0, 1 according to baby weight, ETT of different sizes 2.5, 3, 3.5, and 4 according to weight.

II- It is the responsibility of person taking over the care of the infant to check the following:

1- Obtain a detailed history of the birth and relevant pre/perinatal events.
2- Ascertain if there is a need to isolate the infant.
3- Check the infant's identification and sex.
4- Check whether the infant has voided or passed meconium since birth.
5- Cord clamp in place, no ooze and skin intact.
6- Administration of Vitamin K and/or Hepatitis B immunization if not given in labor room.
7- Administration of other medications.
8- The mother's hepatitis status.

Procedure

1- On admission, weigh the infant to provide a baseline on which to calculate fluids/feeds/drug doses. Keep the infant attached to the ventilator if their condition warrants.
2- Place the infant on a pre-warmed radiant warmer or incubator.
3- If practical, complete head circumference and length – may be done later if condition warrants. If there is excessive molding or caput, the Head Circumference should be repeated when this has resolved.

4- Record and monitor baseline observations: pulse, B/P, respiration, rectal temperature, O_2 saturation.
5- If ventilated (respiratory management), chest x-ray/abdomen x-ray for ETT/line placement and further management.
6- Routine bloods sampling.
7- Use appropriate positioning aids to enhance physiological stability, promote energy conservation and to reduce physiological and behavioral stress.
8- Initially weigh all nappies to assess urine output and obtain urine for ward urinalysis.
9- If there is a suspicion of sepsis, a septic screen should be performed.
10- Administer prescribed medications after obtaining specimens for laboratory investigations.
11- Administer Vitamin K and Hepatitis B according to protocol.
12- Commence fluids or feeds as early as possible, preferably within 2 hours of birth.
13- Respiratory compromised infants should only be fed enterally if their condition allows.
14- Check plasma glucose level (Dextro stick) after 2 hours of intravenous fluids, or pre 2nd feed if feeds are enteral.
15- At 6-8 hours of age, check biochemistry if on IV fluids if requested. May need further microbiology or hematology investigations dependent on condition.
16- OGT is inserted prior to chest x-ray.
17- IV therapy as prescribed.
18- When stabilized:
    1- The preterm infant should be transferred into an incubator.
    2- If there is excessive amounts of bodily fluids (meconium or blood) minimally cleanse with a cloth whilst under the warmer.
    3- Use appropriate positioning aids to enhance physiological stability, promote energy conservation and reduce physiological and behavioral stress.

When the parents visit, make sure that they are welcomed, shown the layout of the unit and understand NICU hand washing and visiting guidelines

References;

1- Wowden, V.R. and Greenberg, C.S, *Pediatric Nursing Procedures*, 3rd edition, 2013, L.W.W: Philadelphia.
2- Wong, D.L., *Whaley & Wong's Nursing Care of Infants and Children*, 10th edition, 2015, Mosby, St. Louis.
3- Makassed Islamic Charitable Hospital, *Neonatal Protocol and Procedure*, 2014.

Prevention of IVH – Nursing Perspectives

1. Position with head in midline and head of bed slightly elevated.
2. Avoid tight encircling phototherapy masks.
3. Avoid rapid fluid infusions for volume expansion.
    a. Know normal blood pressure (BP) value for infants weight and age.
    b. Suggest dopamine therapy to maintain BP if infant isn't hypovolemic.
4. Administration of hyperosmolar solutions such as sodium bicarbonate slowly.
5. Monitor BP diligently. Note fluctuating pattern in arterial pressure tracing in high-risk ventilated infants and inform physician.
6. Maintain temperature within neutral thermal range.
7. Suction only as needed.
8. Monitor closely for signs of pneumothorax such as :- Increased mean BP especially increases in diastole BP (early), Increased heart rate, changes in breath sounds which may or may not be appreciated, decreased PaO2, Increased PaO2, Shift in cardiac point of maximum impulse, and Hypotension and bradycardia (late).
9. Avoid interventions that cause crying.
    a. Consider long-tern methods of achieving venous access to avoid frequent venipunctures.
    b. Critically evaluate all manipulations and handling.
    c. Use analgesics for stressful procedures.
10. Maintain blood gas values within a normal range.
    a. Use continuous noninvasive monitoring of oxygenation.
    b. Adjust FiO2, as needed, to maintain TcPO2 or pulse oximeter within desired range. Adjustment of supplemental oxygen (particularly lowering FiO2) must be done slowly to avoid the flip-flop phenomenon.
    c. Maintain a partial pressure of carbon dioxide (PC02) greater than 30 mmHg, keep peak inspiratory pressures (PIP) less than 30 cm H20 and keep the mean airway pressure (MAP) less than 12.5 cm H20.
11. Avoid intervention that cause hypoxia.
12. Benzyl alcohol, a common preservative in bacteriostatic water, heparin sodium, and some saline flushes, should not be used to flush IV catheters or to dilute or reconstitute medications. Nurses must read labels carefully to detect the presence of preservatives in any medication administered to an infant.

13. Practice minimum handling of infants at high risk to avoid fluctuations in cerebral blood flow. Keep lighting and noise levels low and handle the infant as little as possible.
14. Keep the baby's hips and legs lower than his or her head during diaper changes to avoid increasing intracranial pressure.

References;

1- Wong, D.L., *Whaley & Wong's Nursing Care of Infants and Children*, 10th edition, 2015, Mosby, St. Louis.
2- Verklan T, Walden M, *Core Curriculum for Neonatal Intensive Care Nursing*, 5th ed.. 2014, Philadelphia: Saunders.

Common Medication Infusions

NB; The medication should be prescribed by doctors in detail (dose, amount of fluid to be diluted in, type of fluid and rate of infusion) – must double check by doctor and nurse

Dopamine

Presentation:

Ampoule: 200 mg / 5mL

Action & indication:

Inotropic agent that increases cardiac output and renal perfusion.

Dose:

2 to 20 microgram / kg / min
Begin at 3 microgram / kg / min and titrate dose according to response.

Compatibility:

- NS, D5W, D10W, D5NS, LR..
- Dopamine is stated to be incompatible with iron salts, oxidizing agents, sodium bicarbonate, and other alkaline solutions (e.g. Aminophylline, phenobarbital).

Preparation:

- Use solution prepared in Pharmacy if available**.**
- Withdraw 30 mg of dopamine per kg of baby's weight (0.75 mL/kg) and dilute to 50 mL with appropriate infusion fluid.
  This will give the following infusion rates:
  - 0.5 mL / hour = 5 microgram / kg / minute
  - 1 mL / hour = 10 microgram / kg / minute
  - 1.5 mL / hour = 15 microgram / kg / minute
- If a different concentration is required, refer to the Calculation of Drug Infusion table.

Administration:

- Continuous IV infusion only.
- The concentration used is dependent on the patient dosage and fluid requirement.
- Concentration greater than 3.2 mg/ml must be given via central line.
- Dopamine is administered by intravenous infusion into a large vein using an infusion pump or other infusion control device.
- Adjust the rate of infusion every 30 mins to desired response.

- Do not bolus other drugs via Dopamine infusion.
- If no central IV access is available the maximum concentration for infusion through a peripheral vein is 1.6 mg/ml.

Adverse effects:

- Ectopic beats, bradycardia, tachycardia, vasoconstriction, excessive diuresis.
- Hypertension.
- Extravasation can cause tissue necrosis.

Notes:

- Avoid extravasation.
- Blood pressure must be continuously monitored during infusion**.**
- Store the intact vials at controlled room temperature 15°C to 30°C.
- Protect from excessive heat and from freezing.
- Stability of diluted solutions 24 hours at Controlled room temperature 15°C to 30°C.
- The drug is inactivated in alkaline solution.
- Phenytoin when given together with Dopamine may cause severe hypotension and bradycardia.

Antidote:

Phentolamine, an alpha-adrenergic blocker, may be useful in an overdose situation that does not respond to discontinuation of dopamine.

Dobutamine

Presentation:

Vial: 250 mg/20mL
Vial: 250 mg powder for reconstitution (Aspen)

Action & indication:

Inotropic agent used to increase cardiac output. Cardiovascular shock.

Dose:

- Maximum dose: 20 microgram / kg / min
- Initially 5 microgram / kg / min.
- Adjust according to response to 2 to 15 microgram / kg / min

Compatibility:

- D5W, D10W, LR, NS

- Incompatible with Sodium bicarbonate or any other strongly alkaline solution.

Preparation:

- Use solution prepared in Pharmacy if available.
    - Dobutamine is supplied either as solution or powder
- To reconstitute powder:
    - Add 18 mL Water for Injections to vial. Dissolve powder. Withdraw solution and further dilute to 20 mL = 250 mg/20mL.
    - Withdraw 30 mg of dobutamine per kg of baby's weight (2.4 mL/kg) and dilute to 50 mL with appropriate infusion fluid.
    - This will give the following infusion rate:
        - 0.5 mL / hour = 5 microgram / kg / min
        - 1 mL / hour = 10 microgram / kg / min
        - 1.5 mL / hour = 15 microgram / kg / min
    - If a different concentration is required, refer to the Calculation of Drug Infusion table.

Administration:

- Continuous IV infusion via using syringe pump.
- Administer into central or large peripheral vein.

Adverse effects:

- Tachycardia
- Dysrhythmias
- Hypertension

Notes:

- Avoid extravasation.
- Blood pressure must be continuously monitored during infusion**.**
- Store intact vial at controlled room temperature 15°C to 30°C,
- Prepared infusions may be stored at ref. and infused within 24 hrs.
- The solution should be clear and no more than faintly pink in color. Pink coloring of solution does not affect potency.
- Do not freeze; freezing cause crystallization.
- When diluted in D5W may exhibit a pink color, which will increase with time. This color change caused by a slight oxidation of the drug, but there is no significant loss of potency.

Fentanyl

Presentation:

- Syringe: 20 microg/2mL.
- Ampoule: 100 microg/2mL.

Description:

Analgesic, Opioid

Indications:

- Elective endotracheal intubation.
- Analgesia.

Dose:

Elective endotracheal intubation

- IV Bolus:
  - 2 microg/kg over 3 minutes

Analgesia:

- IV Bolus:
  - 1 microg/kg over 3 minutes every 2 to 4 hours as required.
- IV Continuous Infusion:
  - 1 to 4 microg/kg/hour

Adverse effect:

- **Common:** Laryngospasm, bradycardia, chest wall rigidity (responds to Naloxone) and urinary retention (with continuous infusion).
- **Serious:** Respiratory depression, opioid withdrawal symptoms in neonates treated for greater than 5 days via continuous infusion.

Monitoring:

Respiratory and cardiovascular status, urine output.

Compatibility:

- D5, NS, DW10

- Fentanyl citrate is stated to be physically incompatible with phenytoin, pentobarbital, and thiopental.

Preparation:

- Bolus:
  - Use prefilled syringes if available.
  - Dilution:
    - Take 50 microg (1mL) of fentanyl from an ampoule and make up to 5 mL with a compatible fluid.
    - Concentration is 10 microg/mL fentanyl
- IV Infusion:
  - Use Fentanyl 100 microg/2 mL ampoules to prepare.
  - Withdraw 50 microg (1 mL) of fentanyl per kg of baby's weight and dilute to 50 mL with a compatible fluid.
  - 1 mL/hour = 1 microg/kg/hour

Administration:

- **IV Bolus:** Slow push over 3 minutes, then a slow flush for residual medication in the tubing.
- **IV Continuous Infusion:** Administer as a continuous infusion via syringe pump.

Notes:

- Store the intact vial at controlled room temperature 15°C to 30°C.
- Protect from light.
- Stability of premixed solution:
  - 24 hours at controlled room temperature 15°C to 30°C,
  - 48 hours at ref.
- Too-rapid bolus administration may result in apnea or chest wall rigidity and respiratory paralysis.

Antidote:

Effects can be reversed by Naloxone (10mcg/kg).

Morphine Sulphate

Presentation :

- Syringe: 1 mg/mL (1,000 microgram/mL).
- Mixture: 1 mg/mL (as hydrochloride).

Action & indication:

- Opioid analgesic.
- Sedative to assist ventilation.
- Management of opioid dependent infants with Neonatal Abstinence Syndrome.

Dose:

Dose must be ordered in micrograms.

- Intermittent dose: 100-200 microgram/kg/dose 4-6 hourly
- Infusion dose: 10-20 microgram/kg/hour (doses up to 40 mic per kg can be used with caution).

Compatibility:

- NS, D5W

Preparation:

- Use solution prepared in Pharmacy if available.
    - Syringe contains 1000 microgram in 1mL = 100 microgram in 0.1 mL
- Infusion dilution:
    - Dilute 500 microgram (0.5 mL) per kg of baby's weight to 50 mL with appropriate infusion fluid.
    - Infuse at 1 mL/hour = 10 microgram/kg/hour.
    - Example: To prepare an infusion solution for a 780g baby: Take 500 microgram (0.5 mL) x 0.78 = 390 microgram (0.39 mL) and dilute to 50 mL with appropriate infusion solution. Infuse at 1 mL/hour = 10 microgram/kg/hour.
- Dilution for intermittent doses only if required for infants < 1 kg:
    - Dilute1000 microgram to 10 mL = 100 microgram in 1 mL

Administration:

IV. It may be given undiluted or diluted with compatible IV fluid.

Adverse effects:

- Hypotension.

- CNS depression, respiratory depression.
- Monitor respiratory and cardiovascular status.

Notes:

- Store at controlled room temperature 15°C to 30°C.
- Protect from light.
- The preferred route for administration is IV (IM rout not recommended).
- Monitor for respiratory depression.
- Prepared infusions may be stored at ref. for 24 hours.
- Antidote: Naloxone**.**
- If baby has been on a morphine infusion for at least one week, wean morphine dose slowly.

Alprostadil (Prostaglandin E1)

Presentation:

Ampoule: 500 microgram/mL (refrigerated).

Action & Indication:

- Promotes dilatation of all arterioles.
- Used to maintain patency of ductus arteriosus in neonates with congenital heart defects dependent on ductal shunting for oxygenation and perfusion until corrective surgery can be performed. (Cyanotic heart disease, duct dependent lesions).

Contraindication:

Total anomalous pulmonary venous return.

Dose:

- Starting Dose:
    - 10 to 50 nanograms/kg/minute.
    - If effective within 30 minutes, contact cardiologist for review of dose.
- Maintenance Dose:
    - 2.5 to 10 nanograms/kg/minute.
    - Aim for the lowest dose that maintains ductal patency.

Monitoring:

- Neonates receiving alprostadil for more than 120 hours, or maintained on high doses, should be closely monitored for evidence of antral hyperplasia, gastric outlet obstruction and cortical hyperostosis (e.g., widening fontanelles).
- Aim for improving oxygen saturation, palpable femoral pulses and resolving acidosis.

Adverse effect

- **Common**:
    - Flushing, bradycardia, tachycardia, hypotension, fever, hypoglycemia.
- **Serious:**
    - May cause apnea in infants, especially in the first hour of infusion (consider intubation and ventilation)
    - Prolonged use in high doses may cause gastric outlet obstruction.
    - Increased risk of hemorrhage.

Administration

IV Infusion: Continuous Infusion. If volume infused is less than 0.5 mL/hour, then it must be run in conjunction with glucose 5% or sodium chloride 0.9% infusion.

Compatibility:

- D5W, D10W, NS

Preparation:

- ***Low concentration: 10 nanograms/kg/minute***
- **First dilution**
    - Draw up 1 mL (500 microgram) of alprostadil and make up to 10 mL with compatible fluid.
- **Second dilution**
    - From the 1st solution, withdraw 0.6 mL/kg body weight (30 microgram/kg) and dilute to 50 mL with compatible fluid.
    - Final volume is 50 mL.
    - This will give the following infusion rate: 1 mL/hour = 10 nanograms/kg/minute.
- ***High concentration: 50 nanograms/kg/minute***
- **First dilution**
    - Draw up 1mL (500 microgram) of alprostadil and make up to 10 mL with compatible fluid.
- **Second dilution**
    - From the 1st solution, withdraw 2.4 mL/kg body weight (120 microgram/kg) and dilute to 50 mL with compatible fluid.
    - Final volume is 50 mL.
    - This will give the following infusion rate: 1.25 mL/hour = 50 nanograms/kg/minute.
    - The infusion solution may be further diluted if required.

Notes :

- Maximum effectiveness within 96 hours of birth.
- Check compatibility if infusing with other medications or IV solutions.

- Store the intact vial at ref.
- Discontinue infusion immediately if apnea or bradycardia occurs.
- If undiluted alprostadil sterile solution comes in direct contact with a plastic container, plasticizers are leached from the side walls. the solution may turn hazy and the appearance of the container may change; this appears to be a concentration dependent phenomenon.
- To minimize the possibility of haze formation, alprostadil sterile solution should be added directly to the intravenous infusion solution, avoiding contact with the walls of plastic containers.
- Prepare fresh infusion solution every 24 hours.

References:

1- *NeoFax* 2011.
2- Royal Women's Hospital, *Neonatal Pharmacopoeia*, 2nd ed., 2005, Melbourne.
3- National Institute for Health and Care Excellence (NICE), *British National Formulary for Children*, 2013.
4- Jones PD, *Pediatric Pharmacopoeia*, 13th edition, 2002, Melbourne: Women's and Children's Health,
5- Taketomo CK, *Pediatric and Neonatal Dosage Handbook*, 21st edition, 2014-2015, Lexi-Comp, Hudson, Ohio.
6- Lacy CF, Armstrong LL, Goldman MP, Lance LL, *Drug Information Handbook 2008-2009*, 17th edition, 2009, Lexi-Comp.
7- Kizior R, Hodgson B, *Nursing Drug Handbook 2016*, 1st Edition, 2015, Saunders.

Tips to Avoid Medications Errors

General Principles:

1. All staff administering medications to neonates are responsible for checking the 6 rights of medication safety:
    - RIGHT MEDICATION
    - RIGHT PATIENT
    - RIGHT DOSE
    - RIGHT ROUTE
    - RIGHT TIME
    - RIGHT DOCUMENTATION
2. Don't allow yourself to be rushed, even in emergency situations.
3. If you are not happy to check and administer a drug – say so and don't do it.
4. Never administer a drug unless you are sure of what you are giving.
5. Be aware of local and national policies and guidelines.
6. Never trust someone else's calculations, even if that someone is senior to you.
7. Always calculate the dose yourself – you are responsible and accountable for your own actions.

Medication procedure:

1. All medications prescribed for an infant will be ordered in weight per kilogram of body weight and not by fluid volume, e.g. micrograms, milligrams, grams not milliliters.
2. All medications prescribed for an infant will have the frequency ordered in hours or using accepted abbreviations listed in this policy, such as 6 hourly or quid.
3. Only standard abbreviations listed in this policy may be used on a medication chart. The exception being daily which must be written in full.
4. The prescribed dose should be able to be accurately measured.
5. The first dose ordered should be commenced within 5 to 30 minutes and the time of the next dose organized to fall on the time closest to the treatment regimen. Medication times are listed on the medication chart.
6. When ceasing a medication, a diagonal line must be drawn from the hour of cessation to the top line for that particular medications.
7. When changing dosage or frequency, the order must be ceased and entirely rewritten.
8. Each medication chart will have a printed label on the front of the chart showing the neonates:
    - Name.
    - Date of birth.
    - Unit number.

9. Every medication ordered must be legibly printed in black ink and contain the following information:
   - Generic name of the medication
   - Dose
   - Date prescribed
   - Frequency of administration and times entered
   - Route of administration
   - Indication for use
   - Printed name, designation and legible signature of the prescribing
   - Date of ceasing/changing dosage.
10. Medication Protocols Manual will be provided which will contain the following information:
   - Generic names of medications
   - Dosage regimens
   - Dilution regimens
   - Preferred route/s of administration and/or method of administration
   - Contraindications
   - Side effects
   - Compatibility.
11. Any medication that is not listed in the Medications Protocols Manual must be noted and a protocol developed.
12. Any medication prescribed outside the protocols must be checked by a pharmacist and or a consultant and countersigned in the medication chart.
13. Medications prescribed in an approved research trial will have a protocol to follow.
14. Medications ordered verbally are not to be given to a neonate until these are written on a medication chart. The exception is in a life-threatening emergency where verbally order the medications and the dose, and in some circumstances give the dose.
15. Two nurses must still be involved in the checking. A nurse involved in the emergency must write down the medications, doses and times given.
16. After the emergency has finished, the doctor must prescribe the given medications on the medications chart and the person(s) giving and checking the medications initial the chart and document these on the neonatal observation chart and in the progress notes.
17. The staff member giving the drug will initial in the top box on the medications chart and document on the neonatal observation chart. The person checking the medication will initial the bottom box. Any staff member giving medications must print their name and designation and sign their usual initials on the back of each medication chart. Both staff members checking medications are responsible for its safe administration.
18. Where alternative routes (oral/PR) or a dose range (5-10 mg) are ordered, the route chosen and the dose given must also be documented on the medication sheet.
19. When topical medications are prescribed, the area of application must be specified.

20. All medications must be given or a slow infusion commenced as soon as possible after being drawn up. Oral medications can be left to give with a feed as long as the feed is within the next 30 minutes.
21. When drawing up and giving IV or UA medications, aseptic technique must be used at all times to ensure sterility.
22. When giving more than one medication at a time each one must be labeled with:
    - The medication
    - The route of administration
    - The initials of the staff drawing up the drug.
23. When PRN medications are given, the reason why they are given and the results obtained must be documented.
24. If a medication is not given, the reason must be documented on the medication sheet using the codes as listed on the chart.
25. Medications may be added to infusion fluids, however, a nurse must only add one additive to each burette, syringe or bag. The Protocols Manual or Pharmacy must be checked for compatibility. The exception to this is when glucose concentration is changed, a nurse may add one extra additive.
26. No medications are to be added to packs of blood and blood products or to parenteral nutrition (PN) bags.
27. Medications may be added through a sideline as close to the cannula as possible when PN is running as long as the compatibility is checked with Pharmacy. All intravenous lines must have a non-return valve in each line to prevent one fluid back flowing up another line.

List of medications which do not need to be prescribed on a medication chart

Use of these preparations will be recorded in the nursing notes and/or on the neonatal observation chart:

- Non-prescription creams and pastes for the protection of skin (nappy rash), mucosal membranes and conjunctiva. This excludes preparations containing steroids or antibiotics
- Normal saline for use with suction or as nose drops.
- Normal saline for IV bungs.

List of medications which do not need to be checked by RN

- Non-prescription creams and pastes for the protection of skin (nappy rash), mucosal membranes and conjunctiva. This excludes preparations containing steroids or antibiotics.
- Normal saline for use with IV bungs, suction or as nose drops.