METROHEALTH MEDICAL CENTER
NICU REFERENCE GUIDE

Fourth Edition, 2006

Marc Collin, M.D., Editor

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Finally, we are most thankful to the families who entrust the care of their most precious gift, their babies, to us.

FORWARD

Neonatal providers should consult first with formal neonatal textbooks and related journals carefully to become familiar with the details involved in managing such a high risk population. The Quick Reference Guide is to be utilized to help remember the major decision points in assessing, diagnosing and treating major neonatal problems. Note the information within may not apply to all situations or patients. Practitioners must use their own judgment in adapting this information to individuals. If the information contained within is insufficient, please seek further consultation. Information not referenced is considered standard practice and/or adapted from several sources listed in the reference section.

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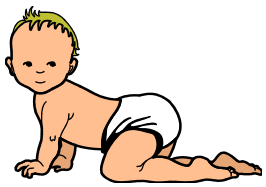


CARDIOVASCULAR

HYPOTENSION

Definition: (see below: based on BW and age)
Generally aim for MAP > 35 in term infants. Generally in infants < 1 kg do not treat unless MAP < 25. Assess perfusion, pulses, oxygenation, CVP, pulse pressure and general clinical state and needs.

Differential diagnosis
Hypovolemia due to blood or fluid loss; sepsis; cardiogenic; drugs causing vasodilation or myocardial depression; CNS depression

Treatment

- Volume replacement 10ml/kg Normal Saline over 5 - 30 minutes based on severity. (FFP, PRBC or 5% Albumin infusions may also be used).
- Inotropes (only useful if fluid status adequate)

FIGURE 2

CARDIOVASCULAR

Blood Pressure--Normal, Healthy Preterm infants within first 3-6 hours of life

(Hegyi, et al, 1994)

Weight	Systolic	Diastolic
501-750	50-62	26-36
751-1000	48-59	23-36
1001-1250	49-61	26-35
1251-1500	46-56	23-33
1501-1750	46-58	23-33
1751-2000	48-61	24-35

Maturation of Mean Arterial Pressure

(Stork, et al, 1984)

Age	<1 kg	1-1.5 kg	1.5-2.5 kg	>2.5 kg
Birth	33 ±15	39 ± 18	42 ± 20	49 ± 19
1 week	41 ± 15	47 ± 18	50 ± 20	60 ± 19
2 wks	45 ± 15	50 ± 18	53 ± 20	64 ± 19
4 wks	48 ± 15	53 ± 18	56 ± 20	68 ± 19

Quick Calculation for MAP

[(5 x kg) + 30] +/- 10 = MAP

Respiratory Rate

Generally, 40-60/minute

Heart Rate

Term: 80 - 180

Preterm: 100 – 180

CARDIOVASCULAR

HYPERTENSION

Hypertensive values

Fullterm: Systolic > 90; Preterm: Systolic > 80
Treatment is usually instituted for Systolic > 100-120 and depends on etiology.

Differential Diagnosis

Measurement error

Renal: arterial stenosis, renal vein thrombosis, embolism, presence of UAC, renin-producing tumors, polycystic kidneys, conditions which increase renin release thus leading to vasoconstriction and increased blood volume (renal ischemia, sodium depletion, decrease blood volume or blood pressure), obstructive uropathy.

Others: Increased ICP, coarctation of aorta, congenital adrenal hyperplasia, neuroblastoma, medications (e.g. steroids, theophylline, ocular phenylephrine.)

CARDIOVASCULAR

COMMON DRIP CALCULATIONS
(REFER TO DRIP TABLES)

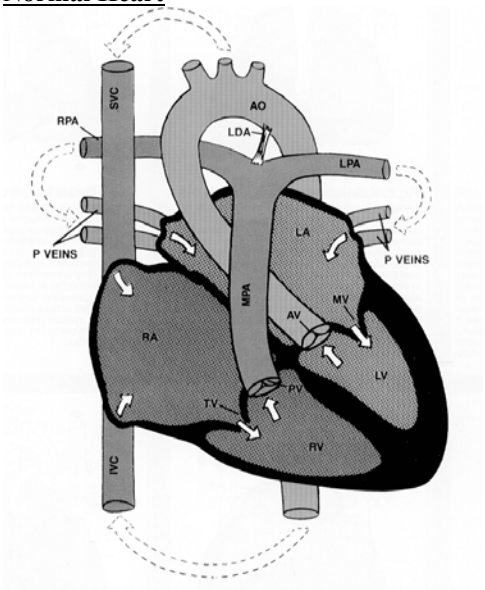
- **DOPAMINE DRIP**
(dose = 4-20 ug/Kg/min)
(Pages 116-117)

- **DOBUTAMINE DRIP**
(dose = 4-20 ug/Kg/min)
(Pages 118-119)

- **PROSTAGLANDIN DRIP**
(dose = 0.05-0.1 ug/Kg/min
(Page 120)

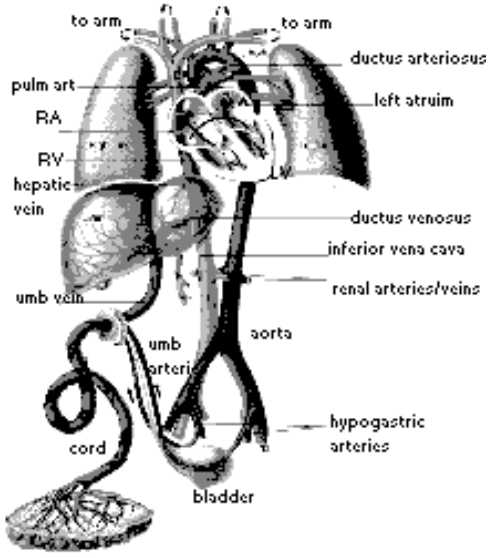
CARDIOVASCULAR

Normal Heart



CARDIOVASCULAR

Fetal Circulation



CARDIOVASCULAR

Approach to the Cyanotic Baby

Types of Cyanosis

Peripheral- confined to the skin
Central- includes lips, mucous membranes; reduced Hgb > 3 gm/dL

Causes of Central Cyanosis

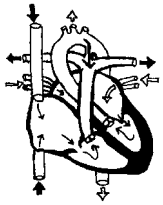
- Alveolar hypoventilation- CNS, respiratory and metabolic problems
- Right to left shunt- CHD, PDA, Pulmonary, or PPHN
- V/Q mismatch
- Diffusion interference
- Decreased Hgb affinity for oxygen

Work-up

- Maternal history: esp. meds, DM, methemoglobinemia, prenatal and delivery history, PROM.
- PE: respiratory rate, apnea, prematurity, perfusion, congenital anomalies, plethora, tone, heart sounds, and murmurs.
- CXR- note lung disease, pulmonary vascularity, heart shape and size.
- Labs- Hct, glucose, Ca, CBC/diff; consider sepsis work-up.
- ABG- hyperoxia test in 100% O2, simultaneous right radial and lower body gases.
- Echocardiogram
- Prostaglandins, if ductal-dependent cyanotic heart disease is suspected.

CARDIOVASCULAR

PDA



Increased patency:
Lack of ductal smooth muscle (prematurity)
Decreased patency:
O2 increases smooth muscle contraction
Hemodynamics:
L to R shunt due to increased SVR and decreased PVR; increased pulmonary and increased left ventricular pressure/volume lead to bilateral CHF.

Features

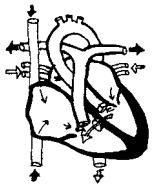
Usually evident by the end of the first week of life; bounding pulses, active precordium, murmur (80-90%, less if VLBW), CHF (cardiomegaly, increased pulmonary vasculature).

Treatment

Fluid restriction, indomethacin, ibuprofen, surgical ligation.

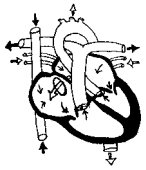
CARDIOVASCULAR

VSD



Hemodynamics
Varies with size. May spontaneously close (30-50%). L to R shunt if PVR less than SVR; increases pulmonary blood flow and decreases pulmonary compliance.
Features Depends on size. Murmur @ LLSB, may have CHF, CXR may show cardiomegaly and increased pulmonary vascular markings.

ASD



Hemodynamics
As PVR decreases, L to R shunt develops; may lead to RVH. May spontaneously close (25-50%).
Features: Varies from none to CHF, FTT; murmur at 2nd ICS; CXR - RAH, RVH, large pulmonary artery.

CARDIOVASCULAR

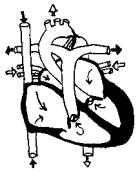
AV Canal (Endocardial cushion defect)

Hemodynamics: When PVR < SVR, L to R shunt.

Features

Varies on AV valve regurgitation, active PMI, thrill @ LLSB, murmurs vary, usually LLSB, CXR-- cardiomegaly, bilateral atrial/ventricular hypertrophy, increased pulmonary markings.

Coarctation of Aorta



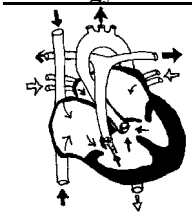
Hemodynamics

Usually at insertion site of ductus, but may be pre- or post-ductal. Pre-ductal- Systemic blood flow dependent on ductus. Pulmonary venous congestion due to obstruction.

Features: Lower extremities- weak pulses, poor perfusion, BP lower, CHF; CXR- cardiomegaly, RVH.

CARDIOVASCULAR

Tetralogy of Fallot



Anatomy: Pulmonary stenosis (RVOT obstruction), VSD, overriding aorta, RVH.

Hemodynamics

Mild: L to R shunt via VSD--leads to CHF. Moderate: may have minimal shunt if PVR and SVR are balanced; Crying causes R to L shunt. Severe: R to L shunt.

Features: Severe: hypoxemia, cyanosis. CXR: Boot shaped heart. "TET" spells after 1 mo of life: paroxysmal dyspnea and cyanosis.

Pulmonary Stenosis

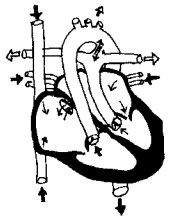
Hemodynamics

Severe: RV hypoplasia leads to R to L shunt at PFO. Pulmonary blood flow dependent on PDA (L to R). Mild: some R to L shunt at PFO and some hypoxemia until PVR decreases.

Features: Mild: loud murmur @ LUSB; Mod/Severe: less murmur, cyanosis, hepatomegaly. CXR: mild cardiomegaly with decreased pulmonary blood flow.

CARDIOVASCULAR

Transposition of the Great Vessels



Anatomy

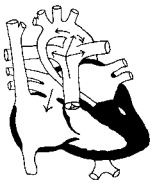
Aorta arises from RV, systemic circulation receives unoxygenated blood. PA arises from LV.

Hemodynamics

Bidirectional shunting via PFO and PDA.

Features: Cyanosis; CXR: narrow mediastinum, normal heart size, "egg on side" appearance; ECG: normal or RVH.

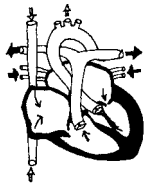
CARDIOVASCULAR
Hypoplastic Left Heart Syndrome



Anatomy: Left heart chamber usually very small; varies on degree of aortic and/or mitral atresia or hypoplasia.
Hemodynamics: Systemic circulation supplied by R to L PDA flow. PDA constriction leading to pulmonary flooding, low systemic flow, poor coronary perfusion, cardiogenic shock.
Features: Weak pulses, single S_2, gallop rhythm, CHF, shock may develop rapidly. CXR – cardiomegaly, pulmonary engorgement.

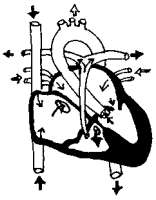
CARDIOVASCULAR

Aortic Stenosis



Hemodynamics
Varies on degree, may have some LV hypoplasia.
Features: L-sided heart failure. CXR: LAE & LVH.

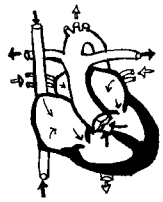
Tricuspid Atresia



Anatomy: Enlarged RA, PFO, hypoplastic RV, VSD.
Hemodynamics: Systemic venous blood returns to RA, passes through PFO to LA to LV. LV supports pulmonary blood flow through VSD or aorta to PDA.
Features: Cyanosis that worsens with PDA closure. Single S2. CXR and murmur--Non-diagnostic.

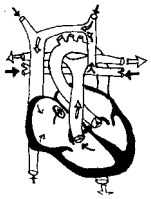
CARDIOVASCULAR

Truncus Arteriosus



Anatomy: Single large great vessel arises from both ventricles, overriding a VSD.
Hemodynamics: Increased blood flow to lungs as PVR decreases.
Features: Cyanosis, single S2, CHF; CXR - cardiomegaly and increased pulmonary markings (if no PS).

Total Anomalous Pulmonary Venous Return (TAPVR)



Anatomy: Pulmonary veins have no connection with LA- they drain into RA via a systemic venous channel. PFO required for survival.
Features: cyanosis, fixed and single S2, CHF, rales; CXR- varies.

CARDIOVASCULAR

Manifestations of CHF in Neonates

Pulmonary Venous Congestion:

Tachypnea, Rales, Dyspnea, Pulmonary edema, Hypoxemia

Systemic Venous Congestion:

Hepatomegaly, Periorbital edema

Persistent Pulmonary Hypertension of the Newborn (PPHN)

Definition

Pulmonary artery smooth muscle constriction or hyperplasia prevents adequate pulmonary blood flow and normal transition from fetal to neonatal circulation. Characterized by hypoxemia, anatomically normal heart and a right to left shunt through the PDA and/or PFO.

History:

- Cyanosis and tachypnea
- Perinatal distress or meconium staining of the amniotic fluid.
- History of marked lability in oxygenation

Physical Exam:

- Cyanosis, tachypnea, and respiratory distress.
- Loud, single S2, or harsh systolic murmur (tricuspid regurgitation).

CARDIOVASCULAR

Causes:

- Acute pulmonary vasoconstriction from acute perinatal events such as hypoxia, hypoventilation, hypothermia, hypoglycemia, or pneumonia.
- Idiopathic PPHN, with a normal CXR.
- Hypoplasia of the pulmonary vascular bed associated with congenital diaphragmatic hernia, oligohydramnios, congenital cystic adenomatoid malformation, or other space-occupying lesions.

Differential Diagnosis:

- Congenital diaphragmatic hernia
- Meconium aspiration syndrome
- Pneumonia
- Pneumothorax
- Pulmonary hypoplasia
- Pulmonary sequestration
- RDS
- Alveolar capillary dysplasia
- Surfactant protein B deficiency
- Congenital Cyanotic Heart Disease
  - Partial anomalous pulmonary venous return/TAPVR
  - Pulmonary atresia with intact ventricular septum
  - Tetralogy of Fallot with absent pulmonary valve
  - Transposition of the great vessels
  - Tricuspid atresia

CARDIOVASCULAR

Work-Up

Lab Studies

- ABG
- CBC with differential and platelets
- Serum electrolytes

Imaging Studies

- Chest X-ray
- Cardiac echocardiography
- Cranial ultrasonography to r/o IVH if considering ECMO.

Other Tests

- Pulse oximetry: preductal (right arm) and postductal (either foot) sites to assess for right-to-left shunt at the level of the ductus arteriosus.

Management

- Continuous monitoring of oxygenation, blood pressure, and perfusion.
- Sedation (narcotics, benzodiazepines). The use of neuromuscular blockade should be discouraged unless there is difficulty in oxygenating and ventilating the patient.
- Minimal stimulation.
- Endotracheal intubation and mechanical ventilation
- Ventilator settings should be adjusted to maintain normal expansion on CXR (≥ 8-9 ribs). Tidal volume and pulmonary mechanics monitoring to avoid overexpansion.
- High-frequency ventilation (in infant requiring high peak inspiratory pressures).
- Central venous catheter placement.
- Arterial catheter placement.
- Surfactant therapy (potentially helpful in infant with underlying parenchymal lung disease).

CARDIOVASCULAR

- Fluid and electrolyte management: adequate circulating blood volume is necessary to maintain right ventricular filling and cardiac output.
- Inotropic support with dopamine and/or dobutamine to maintain adequate cardiac output and systemic blood pressure while avoiding excessive volume administration.
- Maintain arterial PaO_2 level of >100 mm Hg to provide adequate oxygen delivery.
- Metabolic and respiratory acidosis need to be corrected. Maintain a normal to mildly alkalotic pH.
- **Nitric oxide inhalation: 5-20 ppm. (Administration of NO should occur under controlled conditions where NO, NO_2, and methemoglobin can be accurately monitored).**

SEE iNO PATHWAY (PAGE 137)

- Extracororal membrane oxygenation (ECMO)

CARDIOVASCULAR

ECMO Criteria

Oxygenation Index (OI)

$$OI = 100 \times \frac{\text{Mean Airway Pressure} \times \text{FiO2}}{\text{Post Ductal PaO2}}$$

OI > 40 is associated with 80% mortality without iNO or ECMO.

The Most Commonly Used Neonatal ECMO Criteria:

- $AaDO_2$ > 620 torr x 4-12 hours.
- OI > 35 - 40 x 0.5 to 6 hours.
- PaO_2: Range, 40-50 mmHg when FiO_2 = 1.0 after 6 hours of maximizing ventilatory support.
- Intractable acidosis with persistent hypotension despite inotropic support.

General Inclusion Criteria for ECMO

- GA ≥ 34 weeks or BW ≥ 2 Kg.
- No significant coagulopathy or uncontrolled bleeding complications
- No major intracranial hemorrhage
- Mechanical ventilation < 10-14 days
- No uncorrectable cardiac lesions
- No lethal congenital anomalies
- No evidence of severe irreversible brain damage

www.emedicine.com/ped/topic2530.htm

CNS

INTRACRANIAL HEMORRHAGE (ICH)

IVH (intraventricular hemorrhage) is the most common form of ICH. Incidence is about 20% in infants < 1500 grams. Incidence and severity vary inversely with gestational age. Greater than 50% occur within the first 24 hours of life, 90% by 72 hours, and 99% by 10 days of age.
Subdural hemorrhage and **subarachnoid hemorrhage** are less commonly seen.

Pathogenesis

The germinal matrix is a highly vascularized, weakly supported structure that is prone to both rupture and hypoxic-ischemic injury. Exaggerated fluctuations in cerebral blood flow as a result of a pressure-passive cerebral circulation in preterm infants appear to play a major role.

Risk factors

- Extreme prematurity
- Birth asphyxia
- Need for vigorous resuscitation
- Pneumothorax
- Sudden elevation/fluctuation in blood pressure
- Other: presence of labor, seizures, dyssynchronous ventilation, hypothermia, hypercarbia, acidosis, disturbances in hemostasis, rapid bicarbonate infusion, rapid volume infusion, PDA/PDA ligation, hypoglycemia.

CNS

Clinical presentation

Varies from asymptomatic to catastrophic depending on size, site, and rapidity of hemorrhage. Includes anemia, bulging fontanel, acidosis, apnea, bradycardia, seizures, changes in muscle tone, and/or level of consciousness.

IVH grades

I. Subependymal/germinal matrix bleed only
II. Intraventricular bleed, without ventricular enlargement
III. Intraventricular bleed, with ventricular enlargement
IV. Grade III, plus parenchymal bleed

GRADE 3-4 IVH RATES (MHMC)

GA (wks)	*incidence*
24-25	23%
26-27	12%
28-29	2%
≥ 30	< 1%

IVH Outcome (Papile, 1992)

Morbidity (major developmental handicap as compared to control group with no IVH):

Grade 4 IVH - 7 times the control group
Grade 3 IVH - 3 times the control group
Grade 1-2 IVH - same as the control group (11%)

CNS

Periventricular Leukomalacia (PVL)

- Ischemic infarct in watershed regions of white matter around lateral ventricles.
- Hyperemic phase may be seen on early ultrasound; cystic lesions usually not seen until about 30 days of age.
- Seen primarily in VLBW infants (< 1500 grams).
- High association of cystic PVL with later cerebral palsy (>90%).
- Evolution of neuropathologic changes in PVL: ischemic injury leading to coagulation necrosis leading to infiltration by cellular elements leading to appearance of macrophages leading to loss of cerebral tissue. This evolution takes up to several weeks. Ultrasound is an excellent modality to demonstrate progression from increased echogenicity to development of cystic lesions. PVL that is non-cystic is best visualized with MRI scan.

IMAGING STUDIES

All infants with birthweight ≤ 1500 gms and/or gestational age ≤ 32 weeks: **DOL # 3 , #10, # 30 and every 30 days thereafter until stable. Discontinue after Day 60 if WNL.**

Other infants or conditions as clinically indicated (e.g. HIE, unexplained anemia, or suspected CNS malformation- CT or MRI may be preferable in these disorders).

CNS

APNEA OF PREMATURITY

Definition: Cessation of breathing for more than 20 seconds with or without a decrease in the heart rate; apneas of 15-20 seconds in duration are generally considered borderline or mild apneas.

Apnea of prematurity is primarily a diagnosis of exclusion. Other etiologies for apnea should be considered first.

Differential diagnosis:

- **due to respiratory center depression (central apnea), airway obstruction (obstructive apnea), or mixed apneas (with central and obstructive components – most common).**

  CNS: IVH, seizures, trauma, neuromuscular disorders, sedation, maternal narcotic use
  ID: Sepsis, meningitis, pneumonia, NEC, temperature instability
  Metabolic: Hypoglycemia, hypocalcemia, hypermagnesemia, hypernatremia, hyponatremia, hyperkalemia, metabolic acidosis, hyperammonemia
  CVS: Shock, congenital heart disease, arrhythmia, cardiomyopathies
  Resp: RDS, pneumothorax, paralysis from spinal cord injury, chest deformities, suctioning
  Heme: Anemia, polycythemia
  GI: Abdominal distention, GE reflux

CNS

Initial Workup

History and PE
Include duration, frequency, level of consciousness, associated cardiovascular, respiratory, and neurologic symptoms, relationship to feeding (GERD), positioning (neutral positioning may decrease obstructive apnea), sleeping, stooling, handling.

Labs
CBC/diff/ platelets, glucose, electrolytes, calcium, ABG; Consider- Head ultrasound, CXR, EEG, EKG, sepsis work-up, drug levels, tox screen.

Management
Treat underlying cause. If apnea of prematurity, consider:

- Respiratory support PRN, i.e. O2, CPAP, NIMV, mechanical ventilation.
- **Caffeine (IV/PO)** – preferred medical therapy due to decreased side effects, increased dosing interval, and wider therapeutic range (v. theophylline), thus requiring fewer checks of drug levels.
  - Oral loading dose = 10 mg/kg Caffeine **BASE**; maintenance, 2.5–5 mg/kg/dose, Caffeine **BASE** once daily.
  - IV loading dose = 20 mg/kg caffeine **citrate;** maintenance, 5-10 mg/kg/dose caffeine **citrate** once daily IV over 30 minutes.
- **Theophylline** – loading dose = 4 mg/kg PO or IV infusion over 20 minutes. Maintenance = 1.5-2

mg/kg/dose every 8 hours. Give first maintenance dose 1-2 hours after loading dose.

Adjusting Theophylline doses according to drug levels: Bolus = 0.6 x kg x (desired-observed)

SEIZURES

Clinical Manifestations

Focal clonic, multifocal clonic, tonic, myoclonic, or subtle (ocular, oral-buccal-lingual, swimming, rowing, bicycling movements, apnea or autonomic signs). Due to the subtle nature of infantile seizures, it is important to examine for nystagmus when considering the possibility of seizures. Also, autonomic signs such as blood pressure alterations, heart rate changes from baseline, and hypoxemia may be noted (and may represent prominent signs in those heavily sedated or receiving pavulon).

Differential diagnosis

Jitteriness (which is stimulus sensitive, lessens while holding limbs, increases with startling, has no abnormal extra-ocular movements or associated gaze abnormalities and contains movements with low amplitude and high frequency. In addition, there is an absence of fast and slow components characteristic of a clonic seizure and jitteriness is not associated with hypertension or increased/decreased heart rate.

Familial Neonatal Seizures: onset on day 2-3 of life; appears well in interictal period; self-limited with cessation in first 6 months of life; neurodevelopmental

outcome is usually normal; autosomal dominant inheritance pattern.

Benign Neonatal Myoclonus: onset in first week of life; characterized by brief (minutes) myoclonic jerks which occur during quiet sleep and are bilateral, repetitive, and involve both upper and lower extremities; no EEG correlate; outcome is normal.

CNS: Perinatal asphyxia; intracerebral hemorrhage: subdural (birth trauma), subarachnoid, IVH; malformations.

ID: Meningitis, encephalitis, syphilis, TORCH, brain abscess.

Metabolic disturbances: hypoglycemia, hypocalcemia, hypomagnesemia, hypo/hypernatremia, pyridoxine deficiency, or amino acid disorders

Other: Drug withdrawal, toxin exposure, inherited seizure disorder.

History/PE

Family history, maternal drug history, delivery history, maternal infections, type of seizures, mental status, fontanel, scalp/skin lesions, choriamnionitis.

Initial Work-Up

Basic metabolic panel (sodium, potassium, chloride, carbon dioxide, BUN, creatinine, calcium, glucose), magnesium, blood gas, CBC, EEG, head ultrasound or CT scan or MRI). Consider sepsis work-up, toxicology screen, and work-up for metabolic disorders (urine and serum for amino acids/organic acids).

Therapy

According to signs/symptoms and etiology.
Provide 100% oxygen to every baby, initially.

CNS

Hypoglycemia: Glucose (D10W) 2 ml/kg IV bolus followed by continuous IV infusion.
Hypocalcemia: Calcium gluconate 10%, 0.5-1.0 ml/kg IV bolus (slow) (dilute 1:1 with sterile H20)
Hyponatremia: NaCl-3%, 10-12 ml/kg IV over 1 hour. (Prepare 100 ml with concentrated NaCl (23.4%): 12.8 ml + sterile water 87.2 ml.)
Hypomagnesemia: Magnesium sulfate 10%, 0.25 ml/kg IV bolus (slow) (dilute 1:1 with sterile H20)

Anticonvulsants: Phenobarbital load, 20 mg/kg, can repeat 10 mg/kg x 2. Monitor phenobarbital levels. Persistent seizures—Phenytoin load, 20 mg/kg (at 1 mg/kg/min maximum) or Ativan 0.1 mg/kg.

HYPOXIC ISCHEMIC ENCEPHALOPATHY (HIE)

Perinatal asphyxia may lead to multi-organ system dysfunction. Hypoxia/hypercapnea induces a redistribution in cardiac output which shunts blood away from less vital organs (kidneys, GI, skin, carcass) in an attempt to maintain perfusion to essential organs (brain, heart, adrenals).

There are 4 criteria essential to establishing the diagnosis of perinatal HIE:

- Severe acidosis (pH < 7.00).
- Apgar Score of 0-3 at ≥ 5 minutes.
- Neurologic dysfunction (seizures, irritability, hypotonia, stupor, coma)
- Evidence of multi-organ system dysfunction:

CNS

- Cardiac: Redistribution of cardiac output, transient myocardial dysfunction, tricuspid regurgitation, hypotension, cardiac enzyme elevation.
- CNS: Irritability, stupor, coma (see chart of Sarnat Stages, page 176).
- Pulmonary: Pulmonary hypertension, respiratory distress syndrome, aspiration syndromes.
- GI/Hepatic: Feeding intolerance, NEC, elevated LFTs, elevated GGT, elevated bilirubin, decreased clotting factors, hyperammonemia.
- Renal: Oliguria, azotemia (increased BUN/creatinine), proteinuria, hematuria, myoglobinuria.
- Hematologic: Thrombocytopenia.
- Metabolic: Hypocalcemia, hyponatremia (as a result of SIADH or renal impairment), alteration in glucose metabolism.

Predisposing Factors: Abruption, placenta previa, uterine rupture, postmaturity, prolapsed cord, nuchal cord, intrauterine fetal growth restriction, placental insufficiency, maternal hypertension, maternal hypotension, maternal hypoxia, maternal cardio-pulmonary disease.

Pathophysiology: During an hypoxic-ischemic event, cerebral circulation will be affected and cerebral blood flow becomes pressure passive. When blood flow declines during hypoxia, ATP decreases, triggering a cascade of events, resulting in the formation of free

radicals and increased extra-cellular glutamate, making cells permeable to Na^{+}, Cl^{-}, Ca^{++}, and H_2O, leading to cell death either by osmolar lysis or by the effect of cytosolic Ca^{++} on inducing enzymes such as phospholipases, proteases, and nucleases.

Neuropathologic Findings: Cerebral edema, cortical necrosis/selective neuronal necrosis, status marmoratus, PVL, porencephaly.

Diagnostic Tools in HIE: EEG, head ultrasound, CT scan, MRI, visual and auditory electrical evoked potentials.

Management

- Maintain adequate ventilation and oxygenation.
- Maintain adequate perfusion (pressors), but avoid fluid overload to help prevent/minimize cerebral edema.
- Correct acidosis.
- Maintain normal serum glucose levels.
- Treat seizures if present.

Prognosis

Stage 1: Virtually 100% have a normal neurological outcome.
Stage 2: 80% normal neurological outcome; those that were abnormal had Stage 2 for more than 7 days.
Stage 3: 50% die, 50% have major neurological sequelae (cerebral palsy, mental retardation, epilepsy, microcephaly).

CNS

Stages of Hypoxic Ischemic Encephalopathy

	Stage 1	**Stage 2**	**Stage 3**
Level of conscious-ness	hyperalert; irritable	lethargic or obtunded	stuporous; comatose
tone	WNL	mild hypotonia	flaccid
posture	mild distal flexion	strong distal flexion	intermittent decerebra-tion
stretch reflexes	overactive	overactive, disinhibited	decreased/ absent
myoclonus	present or absent	present	absent
suck	weak	weak/ absent	absent
Moro	strong	weak	absent
oculo-vestibular	normal	overactive	weak or absent
tonic neck	slight	strong	absent
autonomic function	sympathetic	parasym-pathetic	both depressed
pupils	mydriasis	miosis	not =, poor light reflex
heart rate	tachy	brady	variable
secretions	sparse	profuse	variable
GI motility	normal or decreased	increased; diarrhea	variable
seizures	none	focal or multifocal	uncommon
duration	**< 24 hours**	**2-14 days**	**hours to weeks**

Reference: Sarnat HB and Sarnat MS. Neonatal encephalopathy following fetal distress. A clinical and electroencephalographic study. Archives of Neurology 33(10):696-705, 1976.

CNS

NEWBORN CRANIAL NERVE TESTING

CN	name	test
I	Olfactory	smell
II	Optic	Vision-blink response to light & visual fixation
III	Oculomotor	Pupillary & EOMs (doll's eyes)
IV	Trochlear	EOMs -doll's eyes
VI	Abducens	EOMs -doll's eyes
V	Trigeminal	Sensory: Rooting & blink reflexes Motor: Suck & Biting
VII	Facial	Facial expressions, nasolabial folds, position/movement of mouth
VIII	Auditory	Vestibular: rotate clockwise, eyes turn in direction of rotation Auditory: startle, head turn to voice
IX	Glossopharyngeal	Tongue movement, midline uvula, gag
X	Vagus	gag, cry, autonomic
XI	Accessory	SCmuscle, head moves side to side
XII	Hypoglossal	Tongue thrusting & moving

CNS

Major Developmental Milestones
(Always use corrected age until 2 years old)

0-1 month

Auditory/Language/Visual
Reacts and Turns head to sound, prefers high-pitched sounds.
Quiets when picked up.
Sees within 8-10 inches from face, fixes on moving objects, lights, imitates facial expression.

Motor/Cognitive/Social
Head lags with pull to sit, little purpose to actions.
2/3 time sleeping.

1-2 months

Auditory/Language/Visual
Vocalizes, babbles (1-6 mo), quiets to voice.
Imitates sounds, cries for assistance.
Binocular vision (6^{+} weeks), prefers linear patterns, people, quiets to face.

Motor/Cognitive/Social
Roll supine to side-lying, lifts head 30-45° when prone, extends and kicks legs.
Attracted to new stimuli, beginning intention.
Sleeps 2-4 long periods, awake 10 hours, smiles at familiar voice, swipes objects, tears with crying.

2-3 months

Auditory/Language/Visual
Searches for sound with eyes, coos one syllable sounds, vocalizes when talked to, begins facial differentiation, begins color vision.

Motor/Cognitive/Social
Lifts head 45-60° when prone and holds for several seconds, turns prone to side, slight head lag, head bobs when sitting, kicks, plays with hands, begins reaching, purposeful activity, beginning memory.

CNS

3-4 months

Auditory/Language/Visual
Turns head to sound, smiles, squeals, coos, discovers hands, sees 15 inches, moves hands to objects.
Motor/Cognitive/Social
Sits supported, attempts to grasp, beginning perceptual abilities, discriminates, regulates patterns of eating, sleeping, takes several naps, sleeps 10 hours, laughs.

4-5 months

Auditory/Language/Visual
Utters vowel sounds, understands name, spontaneously vocalizes, smiles at mirror, looks for fallen objects.
Motor/Cognitive/Social
Transfers toy, grasps ambidextrously, no head lag, prone lifts head and chest, rolls front to back, smiles for social contact.

5-6 months

Auditory/Language/Visual
Repeats sounds, combines vowel and consonants, focuses on new objects.
Motor/Cognitive/Social
Full head control, holds bottle, supports weight on palms, rolls back to front; surprised.

6-7 months

Auditory/Language/Visual
Vocalizes pleasure/displeasure, uses tone, pitch, visually alert 50% of daytime.
Motor/Cognitive/Social
Sits unsupported with arms propped forward (tripod), wants to finger feed self, plays games (peek-a-boo), beginning separation anxiety.

CNS

7-8 months

Auditory/Language/Visual
Briefly looks for disappeared object.
Motor/Cognitive/Social
Crawls backward on abdomen, expects repetition of event, shows humor, resists.

8-9 months

Auditory/Language/Visual
Recognizes names of objects and body parts, may say mama or dada, searches for hidden object.
Motor/Cognitive/Social
Sits erect and leans forward, crawls forward and backward, stands when leaned, may pull to stand, 2-3 naps.

9-10 months

Auditory/Language/Visual
Responds to words, may utter first intentional word, repeats syllables, fears heights, finds hidden object.
Motor/Cognitive/Social
Begins thumb-finger grasp, pulls to stand, kneels, easily bored, anticipates rewards, performs.

10-12 months

Auditory/Language/Visual
Obeys commands, waves bye-bye, shakes head no, says no, says 1-2 words, points, reaches for unseen objects.
Motor/Cognitive/Social
Moves from prone to sitting, may cruise, may walk with help, preferences, moods, attempts to drink from cup.

DISCHARGE PLANNING

1. **Feeding/Nutrition**
2. **Temperature Control**
3. **Respiratory Issues**
4. **Immunizations**
5. **Newborn Screening**
6. **Hearing Screening**
7. **Ophthalmology**
8. **CNS Issues**
9. **Laboratory**
10. **Circumcision**
11. **Social Issues**
12. **Education**
13. **Follow-Up Issues**

DISCHARGE PLANNING

Feeding/Nutrition

- All oral feeds prior to discharge (exceptions: G-tube feeds or other special situations). Assess quality and quantity of feeds and be satisfied that intake is sufficient for appropriate weight gain prior to discharge. LBW infants should demonstrate consistent weight gain prior to discharge. This is not necessary for term or near-term newborns.
- WIC-eligible patients should be identified and the family encouraged to make an appointment with WIC as soon as possible after hospital discharge. This includes formula-fed and breastfed babies.
- Breastfeeding should be assessed by qualified hospital personnel, beginning shortly after delivery. Educating mother (especially first time breastfeeding mothers) on proper technique is essential. Lactation Consultant should be involved as needed.
- **Formula Preparation:**
  State of Ohio WIC recommends that all water used for formula preparation achieve a rolling boil for 1 minute until 3 months adjusted age. Well water, spring water, and distilled water are neither sterile nor fluoridated.
- **'Formula Mixing Chart' follows with special recipes (PAGE 193)**

DISCHARGE PLANNING

Enriched Human Milk

The following table shows the quantity of human milk to mix with **1 unpacked, level measuring teaspoon (2.25 g)** of NeoSure Advance or EnfaCare Lipil to arrive at the caloric densities shown. These calculations assume that human milk is approximately 20 Kcal/oz.

Approximate Caloric Density Desired	Human Milk Quantity
*24 Kcal/oz	70 mL
**27 Kcal/oz	40 mL

The following table shows the quantity of human milk to mix with **1 unpacked, level scoop (9.6 g)** of NeoSure Advance or EnfaCare Lipil to arrive at the caloric densities shown.

Approximate Caloric Density Desired	Human Milk Quantity
*22 Kcal/oz	21 oz
*24 Kcal/oz	10 oz
**27 Kcal/oz	6 oz

*This is the generally recommended recipe if enriching human milk.

****The use of hypercaloric formulas should be undertaken cautiously** as ≥27 Kcal/oz formula may not supply enough water for some infants. Hydration status should, therefore, be monitored and water supplied from other sources if necessary.

Criteria for continuing **preterm** formula (Similac Special Care Advance or Enfamil Premature Lipil) or

DISCHARGE PLANNING

fortified human milk (expressed human milk mixed with Similac Human Milk Fortifier or Enfamil Human Milk Fortifier) in preterm infants after hospital discharge:

- -Consider for infants <1 kg at birth AND <2 kg at discharge OR any preterm infant with documented nutrient deficiency (i.e. low serum phosphorus, low serum albumin, or high alkaline phosphatase).
- -Preterm formula is not usually recommended for infants >3.5 kg as the intake of Vitamin A becomes excessive.
- -State of Ohio WIC will provide 24 Kcal/oz preterm formula with a written prescription.

Criteria for continuing **transitional** formulas (age adjusted for prematurity):

- -BW <750 grams: 12 months
- -BW 750-1000 grams: 9-12 months
- -BW 1000-1500 grams: 6-9 months
- -BW 1500-2000 grams: 3-6 months
- -BW 2000-2500 grams: 1-3 months
- -BW >2500 grams: until term adjusted age

(Consider continuation beyond these guidelines if growth, adjusted for prematurity, falls below the 10th percentile.)

'Fortified' human milk (human milk with added Human Milk Fortifier powder; 1 packet to 25 ml= 24 Kcal/oz while 1 packet to 50 ml= 22 Kcal/oz) is not usually needed for more than several weeks following hospital discharge. Most preterm infants receiving human milk can be transitioned to '**enriched'** human milk (human milk supplemented with powder from

'**transitional'** formulas-i.e. NeoSure Advance and EnfaCare Lipil) or to exclusive human milk after several weeks.

- Infants requiring special formulas with special mixing instructions must have these instructions taught to the family. Discharge should not occur until the medical staff is confident that the family can properly mix the formula.
- Special instructions concerning feeding or formula preparation should be documented in the medical record and the hospital discharge summary.

RECOMMENDED VITAMIN AND MINERAL SUPPLEMENTATION FOR INFANTS:

Full term breast fed:

- 0.5 ml PO QD ADC (triple vitamin) drop beginning during the first two months of life and continuing until daily consumption of vitamin-D fortified formula or milk is 500 ml.
- iron supplement providing at least 1 mg/kg/day beginning no later than 6 months of age as either a separate iron supplement, a combined ADC and iron supplement, or adequate servings of iron-fortified infant cereals (1 oz. = 8 tablespoons dry cereal/day) and/or strained meats (one 2.5 oz. jar).

Full term formula fed:

- no supplement required if formula is a commercial product and is labeled 'iron fortified'

Preterm breast fed**:**

- *receiving fortified human milk (expressed human milk with commercial human milk fortifier added):* iron

supplement beginning no later than 2 months of age providing at least 2 mg/kg/d as either an iron-containing fortifier or as a separate iron supplement.

- *receiving enriched human milk (expressed human milk with enriched formula powder added):* 0.5 ml PO QD infant multivitamin drop with iron until 4 kg, then follow 'full term breast fed.'
- *receiving human milk without enrichment or fortification:* 1 ml PO QD infant multivitamin drop until 4 kg, then follow 'full term breast fed'

Preterm formula fed**:**

- *receiving preterm formula (Similac Special Care Advance, Enfamil Premature Lipil):* no supplement usually required if formula is a commercial product and is labeled 'iron fortified.'
- *receiving transitional formula (Similac NeoSure Advance, Enfamil EnfaCare Lipil):* 0.5 ml PO QD ADC (triple vitamin) with iron drop until 4 kg, then follow 'full term formula fed.'
- *receiving formula other than preterm or transitional (e.g. Pregestimil, Neocate):* 1 ml PO QD multivitamin with iron until 4 kg, then follow 'full term formula fed'

NOTE: A source of fluoride is recommended for infants after 6 months of age. Formula reconstituted with fluoridated water is adequate. For breastfeeding infants who do not consume any fluoridated water, a daily supplement of 0.25 mg fluoride is recommended after 6 months.

2. Temperature Control

- Infant must be able to maintain axillary temperature >36.3°C. for ≥24 hours prior to discharge. Infant

should be wearing clothes and hat and may be covered with up to two blankets.

3. Respiratory Issues

- **Pneumograms** – It is the physician's decision as to whether a pneumogram should be performed prior to discharge. An infant with apnea/bradycardia events earlier in the hospitalization may be discharged without a pneumogram after an approximately 7-day alarm-free period.
- **Home CR Monitoring** – The need for home monitoring will be determined by the attending physician, based either on clinical indicators and/or pneumogram results.
  - Infants receiving caffeine or theophylline to treat apnea of prematurity, also require home CR monitoring. Therapeutic drug levels should be documented prior to discharge.
  - The management of other disorders, such as GERD or BPD requiring home oxygen therapy, may include home monitoring as well at the attending physician's recommendation. Those with a family history of SIDS in a sibling may also be considered for home CR monitoring.
  - Teaching of CR monitor usage and trouble-shooting of potential problems, along with identification of contact persons to address potential CR monitor issues must be done prior to discharge. (A basic understanding of infant CPR and identification of resources for caregivers interested in a more detailed CPR

review must be provided to families of those being discharged on CR monitors).

– **NOTIFY CASE MANAGER TO ARRANGE FOR CR MONITOR AS SOON AS POSSIBLE SO AS NOT TO DELAY DISCHARGE.**

- **Car Seat Challenge Test –** One hour pneumogram with continuous heart rate and oxygen saturation monitoring; respiratory channel is optional.
  -Recommended prior to discharge if <37 weeks or <2 Kg at birth.
  -Test failure (apnea >15 seconds, bradycardias <80 beats/min., oxygen saturations <85%) requires repeat testing, usually 24 hours later. Continued test failure would suggest the need for car bed, avoidance of similar upright positioning at home, and parent/guardian education.
- **Oxygen** – Home oxygen therapy is an option for infants with chronic lung disease. From a practical standpoint, most infants being discharged on home oxygen should be receiving ½ liter/minute or less (as greater amounts may necessitate compressors). In addition, infants should be stable on any particular amount of oxygen for approximately 7 days prior to discharge. They should also be stable on any medications (i.e. diuretics, bronchodilators, etc.) as well.
  - Those going home on oxygen should have hematocrit and reticulocyte count checked

within one week prior to discharge. If receiving diuretics, BMP within one week prior to discharge is also recommended.

4. **Immunizations**

The AAP recommends that the first Hepatitis B vaccine (HBV) be given before hospital discharge as an important strategy to prevent disease spread. In order to encourage both a birth dose of HBV and allow the use of combination vaccines, the Vaccines for Children (VFC) program now allows **providers to give four doses of HBV.**

- Although existing data concerning the optimal timing of HBV series initiation in preterm infants is inconclusive, the AAP Red Book **(2006)** recommends initiation be delayed until the infant exceeds 2 Kg. However, as several studies suggest equivalent seroconversion rates in those <2 Kg at initiation, and in the interest of maximizing the likelihood of successfully completing the series, one may consider HBV at the time of hospital discharge for those infants still <2 Kg.
- If an infant is still in the hospital at 2 months of age, the immunizations routinely scheduled at that age should be given, including diphtheria and tetanus toxoids and acellular pertussis (DTaP), Haemophilus influenzae type B (Hib) conjugate, inactivated poliovirus (IPV) vaccine, and pneumococcal vaccine (Prevnar).
- Synagis for:

DISCHARGE PLANNING

- All infants born at ≤28 weeks gestation who are <1 year old at the start of the RSV season (usually considered to be November)
- Infants who are 29-32 weeks gestational age and are <6 months old at the start of the RSV season.
- Infants who are 33-35 weeks gestational age and are <6 months old at the start of the season with at least 2 additional risk factors (day care attendance, school age siblings, crowded living conditions, multiple births, family history of asthma, exposure to tobacco smoke or other environmental air pollutants).
- Infants with chronic lung disease, hemodynamically significant congenital heart disease or other serious conditions that compromise pulmonary or immune function.

5. <u>Newborn Screening</u>

- Obtain testing at >24 hours of age and preferably before 3 days of age. If the patient is discharged before 24 hours of age or for any other reason testing was not performed, it is the responsibility of both the hospital and the physician of record to ensure that testing be completed as soon as possible (preferably no more than 1 week of age).
- For those infants transfused prior to obtaining newborn screening, repeat testing for hemoglobin electrophoresis must be obtained at 4 months of age and for galactosemia at 3-4

days after transfusion (looking at galactose-1-phosphate levels).
(**SEE FOLLOW-UP, PAGES 207-208).**

6. Hearing Screening

- Universal Newborn Hearing Screening is mandatory in Ohio. Therefore, all babies should have hearing screening prior to discharge or arranged as outpatient visit shortly after discharge.

7. Ophthalmology

- All infants ≤ 32weeks gestation or ≤ 1500 grams birthweight must be screened beginning at 5-6 weeks of age with close follow-up (inpatient and outpatient) as per Ophthalmologist recommendations.

8. CNS Issues

- Head ultrasound is recommended if ≤32 weeks or ≤1.5 kg at birth. Periodic follow-up scans are recommended up to 30 days or up to 60 days if <1 kg (looking primarily for late PVL) or to follow a previously abnormal ultrasound. CT or MRI may better define certain CNS lesions.

9. Laboratory

- All pre-discharge and early outpatient lab testing is at the discretion of the attending physician, based on individual patient circumstances. Such testing may include:

DISCHARGE PLANNING

- Hematocrit/Reticulocyte count (ex. history of anemia or home oxygen).
- Pertinent drug levels (e.g. caffeine, theophylline, phenobarbital, dilantin)
- Basic Metabolic Panel (BMP) (Na, K, Cl, HCO_3, BUN, creatinine, calcium, glucose, anion gap) (ex. patient on diuretics).
- Chem-18 (BMP, HFP, Mg, phosphorus, uric acid, cholesterol). (ex. history of BPD/diuretics, prolonged TPN, other previously diagnosed abnormality).
- Hepatic Function Panel (HFP) (total protein, albumin, T/D bilirubin, alkaline phosphatase, ALT, AST). (ex. history of prolonged TPN, osteopenia, hepatic dysfunction).

10. Circumcision

- Newborn circumcision is an elective procedure performed at the request of parents on boys who are physiologically and clinically stable. Informed consent (ideally, obtained by the individual performing the procedure) must be obtained prior to circumcision.
- See 'Pain Management' Guidelines for analgesia recommendations (PAGES 185-186).

11. Social Issues

- *Department of Children and Family Service (DCFS)* –Infants at social or environmental risk should be identified by staff and Social Service Department. Referrals to county authorities

must be completed in a timely manner prior to hospital discharge.

- ***'Welcome Home' Program*** – State of Ohio program to be arranged for all mothers/babies.
- ***Help Me Grow*** **–** State of Ohio program for those infants/families identified as being at medical, developmental, or social risk; usually arranged through hospital's Social Service Department (Sue Macevice, 85554, 1709b; or Judy Archer, 81722, 6264b) that places a worker in the home on a regular basis to help ensure that infant/family are receiving all necessary services and referrals**.** All Lorain County patients are to be referred to Lorain County Early Intervention Services.
- *Adoption* – Social Services must be notified immediately of any newborn identified as being placed for adoption. Social Services will then represent the hospital in interactions with the agency/attorney designated by the birth mother/family.
- *Other* Social issues, such as that of the mother who is incarcerated, must be dealt with on an individual basis in conjunction with the Social Service Department.

12. Education

- Parental readiness is key. Therefore, barriers to learning by the infant's caretakers must be identified and addressed.
- Demonstrated comfort/competence with either breast or bottle-feeding; ability to mix/prepare formula.

DISCHARGE PLANNING

- Understanding of signs/symptoms of illness/lack of well being.
- Knowledge of disorders specific to their newborn.
- Discharge educational issues may include feedings, bathing, stooling, voiding, sleep cycles, sleep positioning, cord care, jaundice, car seats, circumcision care, anticipatory guidance, safety in the home, homegoing medications, and follow-up appointments. It is essential to allow sufficient time for caretakers to ask questions.
- CPR instruction should be offered to all interested caretakers, either via individual instruction or video, especially to caretakers of infants discharged on home CR monitoring. Those caretakers interested in a certified CPR program should be referred to a program in their area.
- Homegoing medications – Complete prescriptions 2-3 days prior to discharge. Must be obtained by parent and brought to NICU for teaching prior to discharge. Documentation of teaching must be included in the chart.

13. <u>Follow-up appointments/referrals</u>

1. Well-child care (WCC) - obtain name, address and phone number of infant's primary care provider (PCP). <u>Complete referral form in detail at least several days prior to scheduled discharge. NICU Secretary will then schedule WCC appointment within 2 weeks after discharge</u>

DISCHARGE PLANNING

unless otherwise specified. Document appointment time on Discharge Summary.

2. **Special Care Clinic (SCC)**-- schedule at MHMC or Lorain County Public Health Department if patient meets any of the following criteria:
   - BW ≤ 1500 grams
   - Hypoxic-ischemic encephalopathy (HIE)
   - Shock
   - Intraventricular hemorrhage (> Grade I)
   - Periventricular leukomalacia
   - Bronchopulmonary dysplasia - on home oxygen.
   - Apnea of Prematurity - on caffeine/theophylline and/or CR monitor.
   - Meningitis and/or encephalitis
   - TORCH infection
   - Small for gestational age, if extreme.
   - Per the discretion of the neonatologist or if the parents express particular concern regarding their child's developmental potential.
3. **Ophthalmology** - see Eye exam criteria and schedule outpatient appointment if infant discharged prior to first exam (< 5 weeks of age at discharge). Otherwise, follow-up appointment date per Ophthalmology Service recommendations **(see consult sheet in chart AND log book notation at NICU Secretary's desk). MUST BE PARTICULARLY CAREFUL TO SCHEDULE FIRST OUTPATIENT APPOINTMENT FOR NO**

DISCHARGE PLANNING

LATER THAN DATE SCHEDULED ON MOST RECENT CONSULT SHEET.

4. **Audiology-** as scheduled by audiologist if infant fails initial hearing screen or if initial screen not obtained prior to discharge.
5. **Consultants/Referrals-(**e.g. surgery, cardiology, neurology, neurosurgery, OT/PT, Homecare, DME, Synagis). All follow-up appointments must be pre-approved by PCP prior to discharge. Complete MetroHealth Referral Form and give to NICU Secretary who will FAX form to PCP for approval.
6. **Home Health nursing follow-up** should be strongly considered in any high-risk NICU discharge, possibly as early as 24 hours after hospital discharge.
7. **Newborn Screen** - verify that valid newborn screen has been obtained. Obtain:
   - newborn screen if not done. If infant is < 24 hrs. of age at discharge, newborn screen form should be given to family with instruction for obtaining specimen after 24 hours of age, and preferably < 1 week of age.
   - Hemoglobin electrophoresis is required for:
     - infants with BW < 1600 gms and never transfused, obtain at 6 months of age.
     - infants transfused with BW < 1600 gms, obtain at 6 months after last transfusion.
     - infants transfused with BW > 1600 gms, obtain at 4 months after last transfusion.
   - Repeat Newborn Screen or Galactose-1-phosphate level for all infants transfused prior to collection of initial Newborn Screen to

properly assess for Galactosemia. May be obtained as soon as 3-4 days after last transfusion.
NOTE: If specimen collection time is to be after discharge, PCP provider must be made aware of need for specimen via notation in discharge summary.

Documentation

1. **Discharge orders** to include feedings, monitor, medications and follow-up appointments.
2. **Discharge Summary** - complete and have Attending/Fellow review at least one day prior to discharge.
   - **a.** **Verify** - correct name, unit number, address and phone number. **PLEASE NOTE**: Babies placed for adoption MUST have adoptive family name/address/phone number. ALL identifying information of birth parent(s) MUST be deleted.
   - **b.** **Include** discharge weight, HC, length, discharge labs.
   - **c.** **Update** major problems, diagnoses and therapies according to system review by including dates for onset and dates resolved. If problem is not resolved at discharge, document follow-up plan.
   - **d.** **Include** all **significant** procedures and lab results during hospital course.
   - **e.** **Include** all appointments, WIC referrals, discharge feeding, and medications (with dosages).

HEME/BILI

Anemia

History

Family history of bleeding disorders, birth complications (perinatal blood loss, enclosed hemorrhages), gestational age (Hct tends to increase with GA) Rh, ABO or minor blood group incompatibilities, hemoglobinopathies, red cell enzyme defects, iatrogenic blood loss, evidence of acquired anemia (e.g. DIC, NEC), viral infections.

WORK-UP:

General

Hct, retic, morphology, blood type, and antibody screen, ultrasound (as indicated), urinalysis.

- Coombs and antibody screen
- Feto-maternal transfusion - Kleihauer-Betke Test
- Hemoglobin electrophoresis
- RBC enzyme deficiencies - specific enzyme assay
- Maternal TORCH infection

Management

Dependent on etiology, gestational age, illness, O2 requirement. May include transfusion, Epogen, nutritional supplementation, exchange transfusion and/or treatment of underlying disorder. **SEE TRANSFUSION GUIDELINES (PAGE 97)**

Blood smear/ Indices

- Anisocytosis- cells of different sizes
- Poikilocytosis- cells of abnormal shapes
- Microcytic- smaller than usual cells
- Hypochromic- pale cells
- Reticulocyte- young RBCs
- NRBCs- nucleated red blood cells

- Mean corpuscular volume (MCV)--RBC size (Hct x 10 /RBC count)
- Mean corpuscular Hb (MCH) weight of Hb in each RBC (Hb x 10/ RBC count)
- MCHC = volume of Hb in each RBC (Hb x 100/ Hct)

Transfusions

SEE 'ANEMIA OF PREMATURITY' TRANSFUSION GUIDELINES (PAGE 97)

weight	time of nadir	Hct
< 1 kg	4 weeks	20-26
1.5 - 2 kg	4-8 weeks	20-26
> 3 kg	8-12 weeks	30-42

Risks: Hemolytic transfusion reactions, transmission of infectious diseases, graft-vs-host response (prevented by irradiation), febrile or allergic reaction, volume overload, iron overload, metabolic (hypoglycemia, acidosis, alkalosis, hyperkalemia, hyperbilirubinemia).

Description: Use PRBCs- (Hct generally 80-90%), **MHMC uses blood that is leukocyte reduced, CMV negative, HIV negative, Hep ABC negative & irradiated. Utilizes single donor's blood per patient x 28 days.**

Limited Donor Exposure Program

- Utilizes single donor's blood per patient for up to 28 days. Infants < 750 grams BW, receive their own donor unit. Larger infants share unit with up to 2 other NICU patient recipients.

Volume

(Rate: 10ml/kg/hour unless in shock)

- **15ml/kg PRBCs over 3 hours will generally increase Hct 10-20%.**

- To calculate volume of transfusion: **ml PRBCs = kg x Blood volume* x (desired-observed Hct) / Hct of PRBCs (~80-90%)**
- *Blood volume ***estimates*** = 80ml/kg term, 100ml/kg preterm.
- Check post-transfusion hematocrit 4 hrs after completion of transfusion.
- A dose of Furosemide may be considered at the end of the transfusion in some VLBW or BPD patients.

Polycythemia

Definition - Central venous Hct > 65 mg% on two consecutive samples.

Etiologies

Enhanced fetal erythropoiesis related to:

- fetal hypoxia
- endocrine - hyperinsulinism in IDM; congenital adrenal hyperplasia
- Delayed cord clamping, twin-to-twin transfusion, maternal-fetal transfusion
- Precipitous delivery
- Genetic - Trisomies 13, 18, 21
- High altitude

Findings

Non-specific- reflect regional effects of hyperviscosity.

- **CNS** - lethargy, irritability, cerebral infarction, tremor, seizures, apnea
- **Resp** - respiratory distress, tachypnea
- **CV** - tachycardia, CHF, cardiomegaly, pulmonary hypertension.
- **GI -** poor feeding, feeding intolerance (aspirates, emesis), NEC.

- **Renal** - oliguria, renal failure, renal vein thrombosis.
- **Metabolic** - hypoglycemia
- **Heme -** hyperbilirubinemia, thrombocytopenia.

Management

- Central Hct > 70-- partial exchange transfusion to reduce Hct to ≤ 55%.
- Central Hct 65-70 & symptomatic-- partial exchange transfusion.
- Central Hct 65-70, asymptomatic-- hydration/ observation.

Partial Exchange Transfusion

Volume of exchange (ml) =
(use normal saline).

$$\frac{\text{Pt. Blood Volume} \times (\text{observed Hct} - \text{desired Hct})}{\text{observed Hct}}$$

Indirect Hyperbilirubinemia

SEE HYPERBILIRUBINEMIA GUIDELINES (PAGE 98)

Etiologies

Increased production

Blood group incompatibility, hemolytic anemias such as G6PD deficiency/ thalassemia/ spherocytosis, sepsis, TORCH, extravasation of blood (hemorrhage, hematoma), polycythemia, increased enterohepatic circulation of bilirubin (GI obstruction, ileus), IDM.

Decreased clearance

Prematurity, decreased stooling, drugs, hormones (breastfeeding), inborn errors or metabolism (i.e. Galactocemia), hypothyroidism, dehydration.

Potential Maternal/Fetal Incompatibilities

Maternal	Fetal
0	A or B
B	A or AB
A	B or AB
Rh NEG	Rh POS

Work-up

- Maternal and infant ABO/Rh, antibody, Coombs
- Total/direct bilirubin
- CBC, diff, platelets, retic, peripheral smear
- U/A for reducing substances
- Consider sepsis evaluation.
- Consider TORCH evaluation.
- If late hyperbili, consider thyroid functions.
- Follow bilirubin levels every 8-12 hours or more often if near exchange level.

Physiologic jaundice

Defined as serum bilirubin ≤ 12 mg/dL in preterm infants; ≤15 mg/dL in term infants, in first week of life.
Fullterm peaks about DOL #3
Preterm peaks about DOL #5

Management

Note: Since stools are the main route of excretion, feed the baby if possible. Generally, increase fluids 10-40ml/kg/day if treating with phototherapy depending on infant's size.

HEME/BILI

Phototherapy

In general, the phototherapy level is approximately one half the exchange level. **Exchange level = approximately 1% of BW in grams (10-12 mg/dl if < 1000 grams). May be lower if rate of rise is > 0.5mg/dl/hour.**

Double Volume Exchange Transfusion

Indications

Risk of bilirubin toxicity (Kernicterus)

Risks

Same as simple transfusion PLUS inappropriate final Hct, thrombocytopenia, coagulopathy, hypotension, arrhythmias, bradycardia, hypocalcemia, hypoglycemia, pulmonary edema, CNS hemorrhage, NEC (bowel ischemia), decreased serum drug concentrations, UAC/UVC complications, cardiac arrest.

Blood selection

1. **Type:** If Rh incompatibility: ABO compatible PRBCs; AB+ plasma; If ABO incompatibility: Group O, Rh specific PRBCs; AB+ plasma
2. **Age:** Use PRBCs as fresh as possible (< 5 days)
3. **Amount:** Double volume exchange transfusion will reduce bilirubin level approximately 50% by exchanging 87% of baby's blood.
4. **Request Hct:** 50-55%

HEME/BILI

Amount (ml) = wt. (kg) x blood volume (in ml/kg) x 2

Blood volume = 80 ml/kg (term) or 100 ml/kg (preterm)). Order enough extra blood (50ml) for tubing.

Determine rate

Single volume exchange – Infuse over 1 hour
Double volume exchange – Infuse over 2 hours

OR

Exchange 5 cc/kg/3minutes

Procedure

- NPO
- Insert UAC and UVC/large venous line. If necessary, procedure can be properly performed with single vessel access.
- Continue maintenance fluids via peripheral IV.
- Send initial bloods for Chem-18, CBC, ABG, newborn screen (if not already completed). Consider IgM, chromosomes, Hgb electrophoresis, coagulation studies **if** other co-existing problems. May also consider freezing a sample for future use.
- Continue phototherapy.
- Warm blood to body temperature via blood warmer.
- Use "automated 2 site method", i.e. infuse blood in via pump, hand withdraw blood to be discarded.
- May need Pediatric pump if rate of infusion is higher than 100 ml/hour.
- Withdraw blood from arterial line at same rate of venous transfusion, no more than 5% of blood volume at a single pass.
- Slowly agitate donor blood every 15 minutes to prevent sedimentation.

- Monitor transfusion line for possible air entry or infiltration.
- Intermittently flush arterial line to prevent clotting.
- Monitor glucose, ABGs, K^+ and calcium every hour. May need to give Ca gluconate 0.45 meq (1 ml of 10%) per dL of citrated blood (citrate-phosphate-dextrose is an added anticoagulant that binds Ca^{++} and Mg^{++}, stimulates insulin secretion, and may cause acidosis/alkalosis).
- Monitor vital signs every 10 minutes.
- Continuous EKG monitoring for evidence of hypocalcemia (prolonged QT_c interval).
- Send final blood draw for Chem-18.
- Check hematocrit, platelet count, and total bilirubin 2-4 hours after completion of double volume exchange transfusion.

Direct Hyperbilirubinemia

Differential Diagnosis

Cholestasis due to extrahepatic obstruction (biliary atresia, cysts, inspissated bile plug syndrome, gallstones), genetic and metabolic disorders (disorders of carbohydrate, lipid or protein metabolism, alpha-1-antitrypsin deficiency, hypopituitarism, CF), persistent intrahepatic cholestasis, acquired intrahepatic cholestasis due to infections such as hepatitis (A, B, C, EBV, Parvovirus), TORCH, sepsis, urinary tract infection, chromosomal anomalies, erythroblastosis fetalis, tumor of liver, delayed onset of enteral feeds, drugs or TPN > 2 weeks duration).

Diagnostic Evaluation

- Chem 18, GGT.
- CBC & differential, smear, retics, direct Coombs.

- Urinalysis (including reducing substances), examine stool color
- Consider cultures, urine CMV, Total IgM, VDRL, FTA-ABS, hepatitis panel, metabolic screen, amino acid screen, alpha-1-antitrypsin, thyroid functions, abdominal ultrasound, HIDA Scan, ammonia, sweat chloride test, newborn screening tests.
- Check maternal screens: Hepatitis BsAg, VDRL, HIV, HSV, TB
- Ask for TORCH Titers on mom.

Treatment

- Encourage enteral feeds.
- Wean from TPN, if possible; window TPN, if needed.
- Window Schedule: (See p. 59)
- Phenobarbital – 5 mg/kg/day for 5 days prior to HIDA scan.
  - Increases cytochrome p450 activity.
- Ursodeoxycholic acid (Ursodiol)
  - Decreases enterohepatic recirculation.
  - Increases bile flow.
- Remove copper and manganese from TPN.
- Choose formula with increased medium-chain triglycerides (Pregestimil, Alimentum)
- Provide fat soluble vitamin (ADEK) supplement.
- Monitor stool fats (split fats, neutral fats).

Thrombocytopenia

Definition

Platelet count <150,000/mm^3. However, platelet count > 100,000 in an otherwise asymptomatic infant without

evidence of rapid decline, requires follow-up but does not warrant an immediate work-up.

Differential Diagnosis

Decreased production of platelets or increased destruction secondary to:

- **Maternal conditions** such as drug use, infections, DIC, PIH, chronic hypertension, presence of maternally-derived anti-platelet antibodies against infant's platelets (isoimmune). Secondary to maternal ITP or SLE with antibodies formed against maternal platelets (autoimmune), or placental disorders such as thrombi or abruption. Also, Rh isoimmunization.
- **Neonatal conditions** such as sepsis, TORCH, DIC, NEC, giant hemangiomas, thrombocytopenia-absent-radius syndrome, leukemia, polycythemia, renal vein thrombosis after exchange transfusion.

Indications for treatment

- Severe thrombocytopenia-< 20K
- Moderate thrombocytopenia-<50K if symptomatic
- Consider treatment at < 70K if severely ill or pre/post-operative.

Work-Up

- CBC, differential, retic, smear, platelet count.
- Fibrinogen, fibrinogen degradation products, D-Dimer, LFTs, PT/PTT, INR.
- Maternal platelet count, maternal platelet antigen typing.
- Bacterial cultures, viral cultures, TORCH titers
- Rarely, bone marrow examination

Treatment

- Platelet transfusion
  - Random donors (vs. PLA-negative platelet donors vs. maternal platelets as needed).
  - Irradiate platelets to avoid graft vs. host disease.
  - May volume concentrate platelet unit if infant is VLBW. Process may result in some platelet destruction.
  - Rh (-) should be transfused with Rh (-) platelets to prevent sensitization.
  - CMV-negative platelets are preferred. In emergency, leukocyte-reduced platelets that have not been CMV-screened, may be considered equivalent to CMV-negative platelets.
- IVIG
- Corticosteroids

GASTROINTESTINAL

Abdominal Masses

Differential Diagnosis:

1. Renal--multicystic kidney, hydronephrosis (UPJ obstruction, posterior urethral valves), polycystic kidneys, Wilm's tumor, neurogenic bladder
2. Hepatomegaly/Splenomegaly
3. GI-obstruction, duplication, atresias
4. Calcifications--meconium peritonitis, neuroblastoma, teratoma, hepatoblastoma
5. Adrenal--hemorrhage, neuroblastoma
6. Ovarian cyst
7. Tumors-- neuroblastoma, teratoma, sarcoma

Mechanical Intestinal Obstruction

Differential Diagnosis:

1. Congenital intrinsic-- atresia, stenosis, duplication, imperforate anus, cysts, meconium ileus, webs, small left colon syndrome, Hirschsprung's disease.
2. Congenital extrinsic-- malrotation, volvulus, bands, duplications, cysts, tumors, annular pancreas, incarcerated hernia, adhesions
3. Acquired - volvulus, intussusception, thrombosis, strictures, polyps, meconium plug

Stool cultures

Salmonella**C**ampylobacter

Shigella	**C.** difficile toxin
Yersinia	**R**otavirus

GASTROINTESTINAL

NEC (Necrotizing Enterocolitis)

Stages:

I- NEC scare/suspected NEC - temperature instability, apnea, bradycardia, lethargy, increased pre-gavage residuals, mild abdominal distention, emesis, guaiac-positive stool (Stage IA) or bright-red blood from the rectum (Stage IB). X-ray normal or with intestinal dilation, mild ileus.

II- Proven NEC - X-ray shows pneumatosis intestinalis, possibly portal air, infant mildly (Stage IIA) or moderately(Stage IIB) ill: Definite abdominal tenderness, systemic toxicity including metabolic acidosis, thrombocytopenia, or ascites. Bowel sounds absent.

III- Advanced NEC - unstable vital signs with respiratory failure, peritonitis, impending (Stage IIIA) or proven (Stage IIIB) intestinal perforation. Left lateral decubitus may show free air.

Predictors of Perforation in NEC

Abdominal erythema, thrombocytopenia, I/T ratio > 0.3, leukopenia, low ANC, metabolic acidosis

GASTROINTESTINAL

Management protocol

- Obtain STAT surgical consultation.
- NPO, decompress bowel (NG tube to low intermittent suction).
- Replace NG output > 10 ml/kg/8hrs with 1/2 NS + 20 meq/l KCl.
- Labs: Blood, urine cultures; CBC with diff/plts q 8 hours until stable; ABG - maintain paO2 > 70; Keep Hct > 40, follow glucose. Consider CSF culture.
- KUB and left lateral decubitus q 6 hours until stable-check for pneumatosis, portal air, free air, fixed loops.
- Follow MAPs, consider PRBCs, FFP.
- Fluids 160-200ml/kg/day (due to third spacing).
- Consider dopamine/dobutamine if perfusion altered and sodium bicarbonate with severe acidosis.
- Broad spectrum antibiotic therapy- use a penicillin, possibly vancomycin and an aminoglycoside. Also initially cover for anaerobic bacteria for possible perforation (clindamycin). Treat for 10-14 days.

Intestinal function (problems if this portion of bowel removed)

Jejunum: loss of brush border enzymes leading to decreased CHO absorption and bacterial overgrowth, osmotic diarrhea, reduced absorption of Fe, Ca, Mg, Zn and water soluble vitamins.

Ileum: B-12 deficiency and decreased bile acid reabsorption, malabsorption of lipid and fat soluble vitamins.

GASTROINTESTINAL

Ileocecal valve: faster small intestinal emptying (dumping), bacterial overgrowth.
Colon: water and electrolyte malabsorption.

Malabsorption Due to Short Gut Syndrome

- Short term manifestation such as diarrhea, dehydration, electrolyte disturbances, acidosis, abdominal distention, perianal excoriation..
- Long term diarrhea, B12 and fat soluble vitamin deficiency, TPN associated cholestasis, FTT, central line infections, thrombosis, gallstones, renal stones.
- Normal small bowel length in newborn is approximately 200 cm. For possible survival, minimal residual small bowel length of 15 cm. with ileocecal valve or 25-30 cm. without ileocecal valve. Absence of ileocecal valve doubles the time to complete bowel adaptation.
- Initiate TPN plus small amounts of elemental (casein hydrolysate+glucose+MCT) formula (20 Kcal/oz) enterally, cautiously. Increase enteral feeds slowly as tolerated. Peds GI and Nutritionist input vital. Consider Cholestyramine PO to reduce bile acid malabsorption and TPN associated cholestasis.
- Monitor BMP, LFT, CBC, stool (pH, reducing substances, occult blood, fecal fat), plasma/red cell B12, fat soluble vitamins as appropriate. Consider GERD work-up.
- Bacterial overgrowth treated with trimethoprim-sulfamethoxazole, metronidazole, non-absorbable antibiotics.
- TPN may be needed for weeks to months.

- Future Directions: use of glutamine, soluble fibers, short-chain FA and triglycerides, peptide growth factors, bowel lengthening, small bowel/liver transplantation.

Allergic Gastroenteropathy

- Presents within first 6 months of life with variety of signs and symptoms including diarrhea, anemia, hematochezia, edema, vomiting, eczema, leukocytosis, and/or thrombocytopenia.
- Due to cow's milk and soy milk protein allergy.
- Symptoms abate rapidly when formula changed to non-cow's milk or casein hydrolysate formula (Nutramigen, Pregestimil, or Alimentum)
- Most infants able to tolerate cow's milk by one year of age.

Allergic (Eosinophilic) Colitis

- Healthy-appearing infants with rectal bleeding (1st day of life onward).
- Feeding on cow or soy protein-based formula.
- Differential diagnosis: anal fissures, swallowed maternal blood, NEC, volvulus, gastroenteritis, sepsis, intussusception, Hirschsprung's Disease.
- Diagnosis by excluding the above conditions, characteristic pathological features on rectosigmoidoscopy/rectal biopsy and appropriate response to dietary elimination of offending protein and rechallenge.
- Management: Initially NPO/IV fluids, consider CBC with differential, blood culture, coagulation profile, KUB, Upper GI, antibiotics, surgical consult, Peds

GI consult, followed by casein hydrolysate/elemental formula.

- No single lab test is diagnostic; stool eosinophils or peripheral eosinophilia may be suggestive.
- Allergic colitis resolves after infancy and most infants can tolerate regular milk by 1.5-2 years of age.

Gastroesophageal Reflux Disease (GERD) in Premature Infants

Gastroesophageal Reflux (GER) is the regurgitation of gastric contents into the esophagus or above. It is a clinical diagnosis in most patients. Forty percent of normal infants regurgitate parts of 2 or more feeds per day during the first 2 months of life. Not all that experience GER manifest symptoms, which can include weight loss, irritability, vomiting, apnea, aspiration, and failure to thrive. GER Disease (GERD) includes symptoms or complications of GER and can be common (3-10%) in preterm infant weighting < 1500 grams.

Current Tests Available to Diagnose and Evaluate GER

Conservative management should not require any of these tests.

Upper GI:

Documents anatomy (pyloric stenosis, hiatal hernia, malrotation), no reflux.

GASTROINTESTINAL

Esophageal pH Monitoring with/without Sleep Study:

- Gold Standard - 24 hours.
- Confirms acid reflux, and can be used to correlate GERD episodes in time with reported symptoms.
- Can be normal in some patients with GERD.
- Best done without drug therapy on board.
- Use formula during feedings, not apple juice, to more closely approximate usual conditions.

Milk or "scinti" Scan:

- Monitors GI function; evaluates gastric emptying
- Uses radio-labeled formula
- Shows number of episodes.

Endoscopy and Biopsy:

- Establishes presence or absence of esophagitis or eosinophilic infiltrates. Biopsy is recommended to detect microscopic changes and other causes of esophagitis

Disadvantages with Tests used to Diagnose and Evaluate (GER(D):

- Difficulty in knowing what constitutes "normal" in these infants.
- Unknown physiologic/pathologic parameters.
- Methodological differences.
- Non-prognostic - who will/won't respond or whose disease will/won't resolve.

Treatment of Gastroesophageal Reflux Disease (GERD) in Premature Infants and NICU Infants

Gastroesophageal Reflux (GER) is the regurgitation of gastric contents into the esophagus or above. It is a clinical diagnosis in most patients. Forty percent of normal infants regurgitate parts of 2 or more feeds per day during the first 2 months of life. Not all that experience GER manifest symptoms, which can include weight loss, irritability, vomiting, apnea, aspiration and failure to thrive. GER Disease (GERD) includes symptoms or complications of GER and can be common (3-10%) in preterm infants weighing < 1500 gm.

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Conservative management should not require any of these tests

Upper GI

Documents anatomy (pyloric stenosis, hiatal hernia, malrotation) not reflux

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Confirms acid reflux and can be used to correlate GERD episodes in time with reported symptoms
Can be normal in some patients with GERD
Best done without drug therapy on board
Use formula during feedings, not apple juice, to more closely approximate usual conditions

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Monitors GI function; evaluates gastric emptying
Uses radio labeled formula
Shows number of episodes

Endoscopy and Biopsy

Establishes presence or absence of esophagitis or eosinophilic infiltrates. Biopsy is recommended to detect microscopic changes and other causes of esophagitis.

Disadvantages with Tests used to Diagnose and Evaluate GER(D)

Difficulty in knowing what constitutes "normal" in these infants
Unknown physiologic/pathologic parameters
Methodological differences
Not prognostic - who will/won't respond or whose disease will/won't resolve

Draft 1 Revised 2/20/04

Legend

1. Vomiting > 1/2 feed 3-4 times daily
2. Failure to advance feeding either by inability to increase volume or discomfort in an otherwise asymptomatic patient
3. Infant positioning
   - Head of bed up
   - Prone position (monitored "tummy time" x 30 min then "back to sleep")
4. Family history of allergy to formula/food/ dairy product or other GI feeding issue
   - a. Remove human milk fortifier
   - b. Dairy free diet for Mom

   Anti-reflux formula is not appropriate for premature infants
5. Success = ability to decrease symptomatology that brought patient to use protocol initially
   AND minimal or tolerable complications to medication or intervention
   - Patients on metoclopramide should be evaluated for CNS effects
6. Acid suppression therapy can be accomplished with either H2 antagonists or proton pump inhibitors
   H2A's may have some effect on LESP, are available in injectable and oral forms
   - Famotidine (Pepcid oral suspension 40mg/5ml)- 1mg/kg/day div q12
   - Ranitidine (Zantac syrup 15mg/ml- contains 7.5% alcohol)-
     dosage in premature infants and newborns - oral/IV 1mg/kg/dose q12h, some CYP inhibition

1.Duration of medication trials 4-7 days unless otherwise indicated

2.Suggestions that drugs used in medication trials be written for a specific number of doses
for example: Metoclopramide 0.1mg Q6h x20 doses

3. All medications should be evaluated for appropriateness around day of discharge. The drug free trial (if attempting) should start at least 4-7 days prior to discharge.

Symptomatic *Regurgitating* Premature Infant

Significant vomiting[1] with one of the following
a. Multiple/ recurrent A's, B's, + D's associated with feeding
b. Failure to advance feeding[2] or discomfort with feeding
c. Failure to gain weight

Infant positioning[3]
Consider removal of caffeine/theophylline
Family history[4]- **if severe proceed to formula changes without medication trial**
Feeding intervention[5]

Metoclopramide 0.2mg/kg/dose Q6h
Evaluate 4-7 days

Fail

Add Histamine$_2$Antagonist[6]

Fail
Discontinue medications

Suspected allergy
Casein hydrolysate formula
(Almentum, Pregestimil, Nutramigen)
1-2 weeks
If successful maintain and evaluate in 2 months. **If unsuccesful try**:-

Amino acid based formula
(EleCare, Neocate)

Fail
GI consult

Succeed
Maintain x2 wks
Re-evaluate every 2 wks to either:
a. Continue - weight adjusted dose
b. Discontinue meds

Succeed[5]
a. Continue x2 wks
b. Reduce dose to 0.1-0.15mg/kg/dose

Fail
Return metoclopramide dose to 0.2mg/kg/dose
Re-evaluate every 2 wks

Succeed
Continue x2 wks
Re-evaluate every 2 wks to either:
a. Continue - weight adjusted dose
b. Discontinue meds

GENETIC SCREENING

Newborn Screening Tests

Test at ≥ 24 hours of age. If tested before 24 hours, retesting will be required.

Type	Abnormal	Action
PKU (1/16,000)	**4-6 mg/dL**	**Repeat**
	>6 mg/dL	**QM, IE**
Homocystinuria (1/210,000)	**methionine = 2 mg/dL**	**Repeat**
	Methionine >2 mg/dL	**QM, IE**
Galactosemia (1/50,000)	**No transferase activity**	**QM, IE**
Hypothyroidism (1/3500)	**T4 < 5; nl TSH**	**HS TSH & Free T4**
	T4 <5; high TSH (>30)	**As above + IE**
Sickle Cell Disease* (1/400 blacks)	**sickle or abnormal Hgb**	**Hgb electro-phoresis, referral**
Maple Syrup Urine Disease (1/200,000)	**Leucine ≥ 4 ug/dl elevations in Valine, Leucine, and Isoleucine**	**IE**

GENETIC SCREENING

Medium Chain Acyl CoA Dehydrogenase Deficiency (1/6500 – 1/17,000)	**Quantitative plasma acylcarnitine levels. Increased C_6 to C_{10} species: Prominent octanoyl - carnitine > 0.5 mM/L**	**IE**

*Screening also detects other hemoglobinopathies
QM: Quantitative measurement needed
IE: Immediate evaluation needed

PKU

- Autosomal recessive metabolic disorder
- Incidence: 1 in 16,000
- Deficiency of phenylalanine hydroxylase, on Chromosome 12.
- Results in impaired conversion of phenylalanine to tyrosine.
- Untreated - early findings: vomiting, irritability, eczema, mousy odor of urine, hypotonia, hyper-reflexia.
  - Late findings: microcephaly, seizures, mental retardation, FTT.
- Treatment: low phenylalanine diet ASAP to avoid/minimize MR.
- Offspring from maternal PKU - IUGR, microcephaly, social/behavioral problems, MR;

GENETIC SCREENING

goal is to initiate preconception low phenylalanine diet to avoid/minimize sequelae.

Homocystinuria

- Autosomal recessive metabolic disorder.
- Incidence: 1 in 210,000.
- Deficiency of cystathionine synthetase.
- Results in impaired metabolism of methionine.
- Early symptoms: oftentimes none; occasional FTT and mild developmental delay.
- Late symptoms: nearsightedness, ectopia lentis (lens dislocation), blood clotting, arachnodactyly, pes cavus (high-arched feet), pectus excavatum (sunken chest), genu valgum ('knock knees'), scoliosis, osteoporosis, seizures, psychiatric disturbances, ± MR.
- Treatment: ½ respond to high-dose Vitamin B-6 (pyridoxine), low methionine diet ASAP to prevent/minimize MR.

Galactosemia

- Autosomal recessive metabolic disorder.
- Incidence: 1 in 50,000
- Deficiency of galactose-1-phosphate uridytransferase.
- Untreated: hepatomegaly, jaundice, diarrhea, vomiting, FTT, renal failure, life-threatening E-coli infections, cataracts, MR, death.
- Treatment: dietary exclusion of lactose/galactose. Treatment will not resolve existing sequelae, but will prevent ongoing damage, making early diagnosis/treatment essential.

GENETIC SCREENING

THYROID

Follow-up of Abnormal Thyroid Screens

1. **Abnormal T4 (state screen):**
   Obtain TSH and Free-T4. If WNL, do nothing.
2. **If Free-T4 wnl & TSH elevated (3.5-9.0):**
   Repeat TSH and Free-T4 in one month. TSH should return to 0.4 - 3.59 by age of 3 - 4 1/2 months.
3. **If Free-T4 wnl & TSH > 9.1:**
   Immediate endocrine consultation.
4. **If Free-T4 < 0.7:**
   Immediate endocrine consultation.
5. **If TSH is < 0.4**
   Immediate endocrine consultation.
6. **If Free-T4 is > 2.3**
   Immediate endocrine consultation.
7. If early signs of hypothyroidism appear, screening should be repeated at first office visit with pediatrician (at 1-2 weeks of age) even if original screen was normal.

Sickle Cell Disease

- Autosomal recessive disorder of hemoglobin synthesis.
- Most commonly seen in Blacks; also seen in those with Mediterranean, Arab, and Indian backgrounds.
- Erythrocytes assume a sickle shape when oxygen tension is decreased.
- Heterozygotes (with 30-40% HbS) = 8% of African-Americans; asymptomatic under normal physiologic conditions.

GENETIC SCREENING

- Homozygotes - characterized by severe, chronic hemolytic anemia, hepatosplenomegaly, jaundice, painful sickle crises (due to occlusion of small vessels from intravascular sickling), tissue infarction, progressive organ failure.
- Not apparent at birth; anemia noted in first several months of life; increased risk of pneumococcal infections due to functional hyposplenism.

Maple Syrup Urine Disease

- Autosomal recessive genetic defect of branched-chain amino acid metabolism.
- Absence of mitochondrial enzyme complex-branched chain alpha-ketoacid dehydrogenase activity.
- May present within 2 weeks after birth
- Poor feeding, abnormal tone, vomiting, lethargy, coma, permanent neurologic damage/death.
- Hypoglycemia
- Positive urine ketones
- Screen for elevation of valine, leucine, and isoleucine
- Treatment: Diet low in branched-chain amino acids/maintain for life

GENETIC SCREENING

Medium Chain Acyl CoA Dehydrogenase Deficiency

- Autosomal recessive genetic disorder of fatty acid oxidation.
- Hypoglycemia, vomiting, seizures, lethargy, coma.
- Hepatomegaly/acute liver disease
- Metabolic encephalopathy
- Peak age of presentation: late in first year and second year of life (3-24 months)
- Treatment: no prolonged fasting (feed ≥ 4 hourly in young infants; feed ≥ 8-12 hourly in older infants/toddlers); IV glucose infusions needed if enteral intake is compromised for any reason.

Organic Acidemias

- **Isovaleric acidemia**
- **Methylmalonic acidemia**
- **Propionic acidemia**

Clinical features of the severe neonatal forms of all three:

- Hypotonia, lethargy, coma
- Disinterest in feeding, poor suck, vomiting
- RDS
- Odor of sweaty feet for IVA
- Labs: severe anion gap acidosis, ketonuria, elevated ammonia, hypoglycemia, pancytopenia

Infants showing these signs who have an abnormal screen should have the following tests: ammonia, blood gases, electrolytes, CBC, urine ketones, organic acids,

and a genetic consult. The organic acids are sent out for testing, so results will not be immediately available.

Urea Cycle Disorders

- **Citrullinemia**
- **Argininosuccinic aciduria**

Clinical features of the severe neonatal form of both are:

- Disinterest in feeding, poor suck, vomiting
- Lethargy, coma
- Labs: elevated ammonia, respiratory alkalosis

Infants showing these signs who have an abnormal screen should have the following tests: ammonia, blood gases, electrolytes, CBC, serum amino acids, urine organic/amino acids, and a genetic consult. The amino acids are sent out for testing, so results will not be immediately available.

Our Newborn Screening Nurse, Ann Ryan, is made aware of abnormal screens and follows a protocol for each test to ensure adequate follow-up. Moderate risk infants without symptoms will have a repeat newborn screen. If you have any questions, call her at X84596. Dr. Carol Crowe, Pediatric Geneticist, is also available for questions.

GENERAL NICU INFORMATION

NICU ADMISSION POLICY

All infants < 35 weeks gestation must be initially admitted to the NICU. After stability has been established, transfer to Newborn Nursery may be arranged between Services. **There is no minimum weight criteria for admission to the Newborn Nursery**.

Infection Control

a. Scrubbing/Hand-washing
   - Before entering the unit
   - Returning from delivery room
   - After lunch/break
   - **Between handling of infants and their equipment**
   - Clean stethoscope with alcohol pad between patient exams.

b. Clothing (See Hospital Policy)
   - Direct patient care: Hospital laundered scrubs or street clothes
   - No rings or wrist watches
   - Sterile procedures: sterile gown, gloves, mask/cap, protective eye wear, shoe covers.
   - **Remove L&D gowns, gloves, masks, shoe covers before re-entering NICU.**

c. NICU Cleanliness
   - No food/beverage permitted in patient care areas.
   - Keep NICU clean at all times.

d. Invasive lines
   - Insertion of peripheral IVs, PIML lines-- use Betadine and alcohol.
   - Eliminate unnecessary manipulation of UAC/UVC/CL.

GENERAL NICU INFORMATION

Visitors

Parents: 24 hours plus 24 hour phone privileges.
Grandparents: Specific hours, no phone information unless specifically permitted by parent.
Others: Must be accompanied by parent(s).
Siblings: Must be ≥ 3 years old and screened for signs of illness and prescheduled with nursing.
Visitors will be asked to leave patient bedside during MD and RN rounds to avoid HIPAA violations.

NICU Schedule

Day	AM Rounds	Conf. Mtgs.	Attending Rounds	PM Sign Out
Mon	8:00	1:00 P.M. Case Management Conf.	3:00 PM	TBA
Tues	8:00	12:00 – Physiology Block	3:00 PM	TBA
Wed	8:00		3:00 PM	TBA
Thur	8:00	2:00 – Discharge Planning Rounds		TBA
Fri	9:00	8:00 – Grand Rounds 12:00 – OB-PEDS Conf.	3:00 PM	TBA
Sat	8:30			
Sun	8:30			
Holiday	8:30			

GENERAL NICU INFORMATION

Orders

Write legibly. Date, time, and sign all orders.
Admission orders – preprinted – must be dated, timed, and signed.
Leave chart open at bedside and notify nurse that order has been written.
All respiratory orders must also be written.
All verbal/telephone orders must be signed ASAP.
TPN orders must be completed before 2:00 p.m.

Charts

Problem oriented charting recommended.
Differential diagnosis expected upon admission and with onset of new problems/complications.
Indicate whether problems are improving, without change or getting worse.
Plans expected to be problem related and include a forecast of expectations.
Document interactions with parents.
Complete green 'Summary' form at admission; update daily; give completed Summary to Newborn Office Secretary at least 1-2 days prior to discharge.

Labs

Infants with BW < 2000 gms and/or currently on TPN need Basic Metabolic Panel (BMP - Na, K, Ca, Cl, CO_2, Glu, BUN, Cr), Hepatic Function Panel (T+D Bili, AST, ALT, ALK Phos, TP, Albumin), CBC with diff, plts and retic by 2 weeks of age. Those on prolonged TPN or with previously abnormal values should be reassessed periodically (usually every 2 weeks).
Those on diuretics also require at least weekly BMP.

GENERAL NICU INFORMATION

LABWORK

See also previous page- Specimen acceptance policy,
See Procedures and See ID- Specimens for Virus

Test	Amount	Tube	Lab
CBC, diff, plt, retic	0.5ml	micro-purple	Core Lab
PT/PTT, INR, D-Dimer Fibrinogen	1.8ml	micro- blue	Core Lab
PT/PTT only	1ml	micro-blue	Core Lab
Fibrin deg products	0.5 ml	micro-blue	Core Lab
BMP*	0.5ml	micro-green	Core Lab
Hepatic**	0.5ml	micro-green	Core Lab
Total & direct bili	0.5ml or with hepatic	micro-green	Core Lab
Type, AB screen, Coombs	0.5ml	micro-purple	Blood Bank
T & CM	0.5ml	micro-purple	Blood Bank
Total IgM	0.5ml	micro-green	Core Lab
Specific IgMs	0.5ml each	micro-green	Core Lab
drug levels	0.5ml each	micro-green	Core Lab
hepatitis panel	0.5ml each	micro-green	Core Lab
triglycerid	0.5ml	micro-green	Core Lab

*BMP = sodium, potassium**,** chloride, bicarbonate, glucose, BUN, creatinine, calcium

** Hepatic = ALT, AST, total protein, albumin, T/D bilirubin, alkaline phosphatase.

GENERAL NICU INFORMATION

- Chem-18 = BMP, Hepatic plus Phos, Mg, Cholesterol, Uric Acid.

GENERAL NICU INFORMATION

LABWORK

Test	Amount	Tube	Lab
CSF (cx, cell count, total pro & gluc)	0.5ml each	sterile tube	Micro and Core Lab
NICU lytes (NA, K, ionized Ca)	0.2ml	syringe	NICU or Core Lab
ABG	0.2ml	syringe	NICU or Core Lab
CBG	fill tube	Balanced heparinized capillary	NICU or Core Lab
Hct/bili	fill tubes	2 cap tubes	Core Lab
U/A	0.5ml	plastic tube	Core Lab
urine or CSF latex	0.5ml	sterile cup	Micro
urine lytes	0.5ml	sterile cup or red plastic tube	Core Lab
urine cx	0.5ml	sterile cup or red plastic tube	Micro
blood cx	0.5ml	blood cx media	Micro
VDRL	0.5ml	micro-yellow	Serology
Serum aa's or oa's	1 ml	green on ice	Core Lab M-F
Chromo-somes	2.5ml	green	Genetics M-F

GENERAL NICU INFORMATION

MICROTAINER TUBES CHART

STOPPER COLOR	ADDITIVE	NO. OF INVERSIONS OF BLOOD TUBES	LABORATORY USE
Purple Fill to between the 250 and 500 lines	EDTA	8-10	For whole blood hematology determination. The tube must be mixed by gentle inversion immediately after collection.
Green	Sodium Heparin	8-10	For micromethod chemistry determination. Inversion of the tube assures anticoagulation .
Blue	Sodium Citrate	8-10	Must be filled up to 'fill line'.

Note: When collecting multiple specimens, follow order of draw
First - purple
Second - green
Third - blue

Specimen acceptance policy: Individuals collecting specimens must label requisition with patient name, hospital number, date and time of collection, ordering MD name and PIN number and label specimen with above minus MD name and PIN number. In addition, Blood Bank specimens require signatures on labels, micro specimens must indicate specimen source, chemistry specimens for drug testing require time last dose administered. **Failure to comply will result in rejection of the specimen.**

GENERAL NICU INFORMATION
TEMPERATURE REGULATION

Neutral Thermal Environment- (NTE)- environmental temperature where the least metabolic activity and O2 consumption is required to maintain a normal body temperature.

Mechanisms of Heat Loss

Radiation - loss from infant to another object not in direct contact with infant (isolette wall or object outside of isolette).
Conduction - direct loss from infant to a contacted surface (stethoscope, scale, non-preheated isolette).
Convection - loss from infant to air (bag and mask blowing on infant, open isolette port holes, traffic walking past radiant warmer.)
Evaporation- loss of water by evaporation from skin

Equipment

Isolette
Servocontrol (ISC) – maintains a preset body temperature by automatically adjusting environmental temperature according to infant's skin temperature probe reading. This setting is most commonly used in the VLBW infants. CAUTION must be exercised as improper placement or dislodged skin probe will potentially cause improper temperature regulation. Evaluation of the isolette temperature in conjunction with both skin probe temperature and axillary readings (see NTE charts) are necessary to determine thermal stability. Erratic or large fluctuations in isolette

temperature may indicate temperature instability in infant.

Air Control

Use for stable, LBW (1500-2500 grams) or term infants.

Radiant Warmer

Temperature maintained through the servocontrol mode. Used for term or near term infants, procedures, or very unstable preterm infants. Avoid use of Air Control setting as this increases risk of poor temperature regulation.

CAUTION: causes increased heat and water losses.

GENERAL NICU INFORMATION
NICU PARENT ORIENTATION CHECKLIST

Prior to bringing infant to NICU:

1. Brief explanation of general condition
2. Brief explanation of proposed therapies, diagnostics
3. Expected time MD/NNP will return to update parents/family on condition (should be ≤ 2 hours)
4. Expected time parents/family may first visit infant (should be ≤ 2 hours of age.)
5. Parents given option of visiting infant immediately (prior to procedures), except in urgent/emergent situations.
6. **Obtain consent for invasive procedures (ETT, UAC, UVC, PIML lines, LP) as necessary. Blood transfusion consent (or refusal) must also be signed (on back of Informed Consent Form). In an emergency, procedures may be performed without specific consent; family should be notified as soon as possible after the patient has been stabilized.**

Ongoing Parental Interactions:

1. Continuous assessment of parents' expectations
2. Acknowledgement of significant unexpected life event and corresponding grief reaction and/or stress response.
3. Explanation of general condition
4. Explanation of diagnostics/therapies
5. General prognosis, expected length of stay
6. Visitation/phone call policy
7. Explanation of role of resident/NNP, as applicable
8. Name of attending physician (written down)

GENERAL NICU INFORMATION

9. Usual sights/sounds to expect
10. Specifics to expect upon first viewing infant.
11. Reinforce benefits of human milk use, follow milk supply, and develop collaborative plan of care when mother has chosen to provide expressed milk.

GENERAL NICU INFORMATION
PRINCIPLES OF FAMILY CENTERED CARE

(Harrison, 1993)

MetroHealth Medical Center is committed to providing a Family Centered Care environment and upholding the belief that the family is both the constant in a child's life and paramount to his/her well-being.

"The family centered care approach is based on the belief that caring for children means working in partnership with families. Personnel prepared to use a family centered approach believe that all families want what is best for their children. All employees are expected to treat family members with respect, to help parents participate as integral members of the child's care team, and to support the strengths, values, and choices of families."

Parents desire:

- Open, honest communication and informed treatment choices.
- Availability of the same facts and interpretation of those facts as the professionals including: medical info, uncertainties surrounding treatments, info from parents whose children have been in similar situations, access to the chart and round discussions.
- The right to make decisions regarding aggressive treatment for their infants in situations involving high mortality/morbidity, potential suffering, and/or medical controversy.
- Information about adverse pregnancy outcomes and the opportunity to state in advance their treatment preferences if their baby is born extremely premature and/or critically ill.

GENERAL NICU INFORMATION

Parents and professionals must work together to:

- Acknowledge and alleviate the pain of infants and ensure an appropriate environment for babies in the NICU.
- Ensure the safety and efficacy of neonatal treatments.
- Develop policies and programs that promote parenting skills and encourage maximum involvement of families with their hospitalized infant.
- Promote awareness of the needs of NICU survivors, especially those with disabilities, and promote meaningful long-term follow-up and support.
- Acknowledge that critically ill newborns can be harmed by over-treatment and by under-treatment.
- Insist that our laws and treatment policies be based on compassion.
- Decrease disability through universal prenatal care.

GENERAL NICU INFORMATION
INITIAL EVALUATION/ADMISSIONS

Obtain Maternal History:

- Maternal age, gravida, para, abortions (type)
- **Maternal screens:** Blood type, antibody screen, Rubella, HBsAg, VDRL. GC, Chlamydia, HIV, GBS
- **Past Medical History**: including previous pregnancies, prematurity, living and/or deceased children, social history.
- **Significant Past Family/Genetic History**
- **Pregnancy History**: prenatal care, wt. gain, smoking, drugs (street or prescribed), alcohol, caffeine, LMP, EDC, AFP, ultrasounds, amnios, complications such as h/o preterm labor, PIH, HELLP, diabetes, IUGR, known anomalies, multiple gestation
- **Labor & Delivery History**: nonstress/stress test, reason for onset of labor, rupture of membranes (type & time), foul smelling amniotic fluid, fever, maternal wbc, fetal distress (abnormal fetal heart rate, decels, loss of variability), scalp gases, evidence of maternal bleeding (previa, abruption), maternal medications (including timing of administration in relation to delivery), intrapartum antibiotic prophylaxis, anesthesia, presentation, type of delivery (SVD, forceps, vacuum, C-section), resuscitation, Apgar scores.

GENERAL NICU INFORMATION

Labwork (as indicated):
Blood culture, CBC/diff/platelets, retic, glucose, calcium, hct/bili, blood gas, blood type and Coombs

Complete PE:

Skin: color (jaundice, cyanosis, plethora, pallor), rashes (petechiae, milia, erythema toxicum), nevus, hemangiomas, mongolian spots

HEENT: head shape and size, fontanel, caput, cephalohematoma, hair, eyebrows, eye/ear position and shape, light reflex, epicanthal folds, hypertelorism, slanting of palpebral fissures, low set or rotated ears, pre/post auricular tags or sinuses, shape and patency of nares, intactness/lesions of palate, size of tongue/jaw

Neck: clavicles, torticollis, masses (size, consistency, location).

Chest: symmetry, breath sounds, grunting, flaring, retracting

Heart: rate, rhythm, S_1, S_2 split, murmurs, clicks, pulses (quality and equality), perfusion, cap refill time.

Abdomen: soft, distention, masses, hepatosplenomegaly, kidneys, umbilical vessels (#)

Genitalia: clitoris, labia, vaginal tags, size and shape of penis, urethra, chordae, location of testes (descended, descending, non-palpable).

Extremities/Back: range of motion, # /type of digits (polydactyly, syndactyly-webbed, clinodactyly-curved, camptodactyly-bent), simian crease, nail beds, toe gaps or asymmetrical toe length, dislocation of hips, back (intact – dimples/scoliosis/ midline hair tufts.)

GENERAL NICU INFORMATION

Neuro: moves extremities, palsies, symmetry, primitive reflexes (suck, Moro, rooting, grasp, plantar, tonic neck), tone

Dubowitz /Ballard-(AGA, SGA, LGA)

Weight, Head Circumference, Length (and percentiles)

WEIGHT CONVERSION CHART

Grams	Pounds/Ounces
500	1 lb 2oz
750	1 lb 11oz
1000	2 lbs 3oz
1250	2 lbs 12oz
1500	3 lbs 5oz
1750	3 lbs 14 oz
2000	4 lbs 6oz
2500	5 lbs 8oz
3000	6 lbs 10oz
3500	7 lbs 11oz
4000	8 lbs 13oz
4500	9 lbs 15 oz

GENERAL NICU INFORMATION

Survival Rates by Gestational Age

MetroHealth NICU
Data (1997-2005)

GEST AGE	SURVIVAL(%)
24-25	69%
26-27	85%
28-29	93%
30-31	97%
≥32	99%

Survival Rates by Birthweight

MetroHealth NICU
Data (1997-2005)

WEIGHT (GMS)	% SURVIVAL
0-500	45%
501- 750	68%
751-1000	89%
1001-1250	96%
1251-1500	96%
1501-1751	99%
1751-2000	99%

(ALSO, SEE METROHEALTH NICU 'SNAPSHOT' DATA IN BACK POCKET OF BINDER.)

FLUIDS & ELECTROLYTES

FLUID GUIDELINES

NOTE: Guidelines vary with diagnosis, exam, birthweight, daily weights. Smaller babies generally require more fluid due to greater insensible water loss.

Day of Life	ml/kg/day
1	60-100
2	80-120
3	100-140
4+	150 +

DAILY ELECTROLYTE REQUIREMENTS

Day 1: Usually, no sodium or potassium given due to major shift in total body water (high in Na^+) and low urine output; Ca gluconate, 200 mg/kg/day for infants at risk for hypocalcemia (SGA, IDM, asphyxia, preterm).

Day 2 and after:

Na+, 1-3 mEq/kg/day depending on serum levels; include Na^+ in flush, UAC, HCO_3^- into calculations.

K+, 1-2 mEq/kg/day when urine output is established; acidosis increases serum K^+, alkalosis decreases serum K^+, hemolysis and IVH increase serum K^+.

Ca gluconate, 200-400 mg/kg/day, initially, depending on serum levels. **See section on parenteral nutrition.**

FLUIDS & ELECTROLYTES

CALCULATING IV ELECTROLYTES

$$\frac{\text{Desired mEq/kg/day}}{\text{ml/kg/day}} = \frac{\text{X (mEq to add)}}{\text{500 ml bag}}$$

IV GLUCOSE

Glucose is assimilated at about 6 mg/kg/min.
Day 1: 80 ml/kg/day of D10W will provide 5.5 mg/kg/min of glucose
See Hypoglycemia for calculations (PAGE 45).

ACCEPTABLE WEIGHT LOSS LIMITS

Term newborn	5-10% over 1 week
Preterm	10-15% over 12 days (approx. 2-3% per day initially)
SGA	0-8% over 12 days

Average expected time to regain birthweight is 10-22 days of life. (Smaller babies regain BW slower.)

INSENSIBLE WATER LOSSES (IWL)

Baseline approximately 40 ml/kg/day; 30% of IWL occurs through respiratory tract as moisture in expired gas while 70% is lost through the skin.

Birth weight (gm)	IWL (ml/kg/d)
750-1000	~ 100-140
1001-1250	~ 60
1251-1500	~ 50
>1500	~ 40

FLUIDS & ELECTROLYTES

*Values represent mean IWL for infants in incubators during the first week of life.

Factors affecting IWL:

prematurity - inversely proportional to GA/BW
radiant warmer + 50%
phototherapy + 50%
elevated temperatures, skin breakdown, open defects (Gastroschisis, omphalocele, neural tube defects),
respiratory distress - uncertain but significant increases in IWL.
increased inspired humidity - 30%
plastic heat shield/wrap - 30-70%

GLUCOSE IMBALANCES

HYPOGLYCEMIA

Definition:

Preterm: < 30-35; Term: < 35-40.

Risk Factors:

Prematurity, intrauterine growth retardation, asphyxia, hypothermia, sepsis, infant of diabetic mother, erythroblastosis fetalis, exposure to beta-agonist tocolytics, familial hyperinsulinism, inborn errors of metabolism.

Symptoms:

Jitteriness, tremors, irritability, lethargy, apnea, tachypnea, respiratory distress, tachycardia, hypotonia, cyanosis, high- pitched cry, seizures.

Note: May be asymptomatic despite being hypoglycemic.

FLUIDS & ELECTROLYTES

Treatment: SEE HYPOGLYCEMIA PATHWAY (PAGE 44).

Alternative Therapies for Persistent Hypoglycemia

Corticosteroids decrease peripheral glucose utilization. Hydrocortisone, 5 to 15 mg/kg/day divided q12h or Prednisone, 2 mg/kg/day orally.

Glucagon stimulates glycogenolysis; 30 mcg/kg if normal insulin level, 300 mcg/kg if increased insulin level.

Calculation (mg/kg/min):

Long Version

1. Determine grams of glucose/kg/min:
(D10W = 10gms/100ml, D12.5 = 12.5 gms/100ml)

$$\frac{\textbf{\# grams}}{\textbf{100ml}} = \frac{\textbf{X}}{\textbf{\#ml/kg/day}}$$

2. Divide by 1440 (# minutes in a day)

$$\frac{\textbf{X}}{\textbf{1440}} = \textbf{Y}$$

3. Multiply by 1000 (converts grams to mg)

Y x 1000 = mg/kg/min

Short Version

ml/kg/day x 0.69 x % glucose = mg/kg/min

(eg. % glucose of D7.5 = 0.075)

HYPERGLYCEMIA

Definition: > 160 mg/dl

Differential diagnosis: Excess intake, impaired glucose metabolism (prematurity, stress, sepsis).

FLUIDS & ELECTROLYTES

Signs: Osmotic diuresis, weight loss, glycosuria, lethargy, metabolic acidosis.
Treatment: Decrease glucose intake, consider insulin drip, 0.01 - 0.1 units/kg/hour :

Insulin drip (May IV Piggy Back with TPN, Dextrose, IL):
1. Dilute 1 ml Regular Insulin (100 units) with 93 ml NSS and 6 ml (0.3 gms) 5% Albumin-- Final concentration = 1 unit/ml. Cross multiply:

$$\frac{\text{Kg x Desired units/kg/hour}}{\text{\_\_\_ \# ml/hr to infuse}} = \frac{\text{1 unit}}{\text{1 ml}}$$

OR

1. Dilute 0.1 ml Regular Insulin (10 units) with 93.9 ml NSS and 6 ml, (0.3 gms) 5% Albumin--Final concentration = 0.1 unit/ml. Cross multiply:

$$\frac{\text{Kg x Desired units/kg/hour}}{\text{\_\_\_ \# ml/hr to infuse}} = \frac{\text{0.1 unit}}{\text{1 ml}}$$

HYPOCALCEMIA

Definition:
Total Ca < 7 mg/dl (newborns)
Ionized Ca: <1.1-1.4 mmol/L
Differential diagnosis: SGA, LGA, prematurity, inadequate intake, IDM, perinatal stress, alkalosis, diuretic therapy, excessive phosphate intake, insufficient magnesium intake, congenital hypoparathyroidism, sepsis, double volume exchange transfusion.

FLUIDS & ELECTROLYTES

Symptoms:
Jitteriness, tremors, irritability, lethargy, apnea, seizures, arrhythmias, prolonged QT (>0.40 sec.) interval.

Treatment:
Symptomatic: **100 mg/kg, 10% Ca gluconate over 1 hour.**

- Monitor for bradycardia during infusion.
- Extravasation causes skin necrosis.
- Check compatibility charts, (e.g. not compatible with bicarbonate).
- Recheck serum calcium after infusion.

Asymptomatic: Adjust maintenance intake.

HYPOKALEMIA

Definition: Serum potassium < 3.5 mEq/l.

Differential Diagnosis: Inadequate intake, abnormal losses (medications, GI losses), alkalosis, congenital adrenal hyperplasia, insulin infusion.

Symptoms: Ileus, EKG abnormalities (prolonged QT & QRS; ST depression). **Note**: hypokalemia increases digoxin toxicity.

Treatment: Increase intake, address losses or alkalosis. If K^+ < 3.0 mEq/L:

Replace IV: 1 mEq/kg over 1-2 hours, always monitor EKG

Replace PO: 1 mEq/kg/day divided qid with feeds; titrate to serum levels.

Recheck potassium level within 2-4 hours after IV replacement, or within 12-24 hours after PO replacement.

FLUIDS & ELECTROLYTES

HYPERKALEMIA

Definition: Central (non-hemolyzed) K^+ >6.0 meq/l
Differential diagnosis: Falsely elevated (hemolysis due to phlebotomy), excess intake (IVFs, PRBCs), pathologic hemolysis (IVH, hyper or hypotonic solutions, necrosis), decreased excretion (renal failure), acidosis, hypoinsulinism.
Symptoms: arrhythmias, EKG changes
Treatment: D/C IV potassium.
Treatments include Kayexalate enemas, insulin and glucose drips, and/or bicarbonate drip. Give Ca gluconate or lidocaine if ventricular arrhythmia present.

HYPONATREMIA

Definition: Serum sodium < 133 mEq/l.
Differential diagnosis: Inadequate intake, SIADH, volume overload, dehydration, hyperglycemia, drug induced (e.g. diuretics, theophylline).
Symptoms: Seizures (especially if <120), CHF, weight gain or loss, decreased or increased urine output, changes in urine osmolality.
Treatment: Depends on etiology and fluid status. For SIADH or CHF, restrict water intake. If due to diuretics or excess IV fluids, increase Na^+ intake.
Calculation for IV Na^+ replacement desired -

Na Deficit (mEq) =
kg x 0.7 x (desired Na^+ - actual Na^+)
Replace 1/2 deficit over 12 hours

HYPERNATREMIA

Definition: Serum Sodium > 146 mEq/l

FLUIDS & ELECTROLYTES

Differential diagnosis: Water deficit, water loss, sodium excess, sodium retention.
Symptoms: Dehydration, seizures.
Treatment: Decrease intake if increased, replace water deficit.
Calculation:
Water deficit is based on expected weight.

FLUIDS & ELECTROLYTES

Metabolic Acid-Base Disorders

Metabolic Acidosis: results from excessive loss of buffer or from an increase of volatile or non-volatile acid in the extracellular space.

- Anion gap: $Na^+ - (Cl^- + HCO_3^-)$
- Disorders associated with metabolic acidosis:

Increased anion gap (> 15 mEq/L)	**Normal anion gap (< 15 mEq/L)**
Acute renal failure	Renal bicarb. loss
Inborn errors of metabolism	Renal tubular necrosis
Lactic acidosis	Acetazolamide
Late metabolic acidosis	Renal dysplasia
Toxins (e.g. benzyl alcohol)	GI bicarbonate loss
	Diarrhea
	Cholestyramine
	Small-bowel drainage
	Dilutional acidosis
	TPN acidosis

Treatment:

- Should be directed at the underlying cause.
- When the arterial pH is < 7.25, correction of the bicarbonate deficit may be estimated from the following formula:

  Deficit = 0.4 x bodyweight x (desired bicarb. – actual bicarb).

- The premature infant's acid-base status can change rapidly, and frequent monitoring is warranted.

FLUIDS & ELECTROLYTES

Metabolic Alkalosis

The etiology of metabolic alkalosis can often be clarified by determining urinary chloride concentration.

Low urinary chloride (< 10 mEq/L)	High urinary chloride (> 20 mEq/L)
Diuretic therapy (late)	Bartter's syndrome w/mineralocorticoid excess.
Correction of chronic respiratory acidosis	Alkali administration
Nasogastric suction	Massive blood product transfusion
Vomiting	Diuretic therapy (early)
Secretory diarrhea	Hypokalemia

Sepsis Workups in NICU

SEE SEPSIS PATHWAY FOR ASYMPTOMATIC NEWBORNS (PAGE 139).

SEE SEPSIS PATHWAY FOR SYMPTOMATIC NEWBORNS (PAGE 140).

Calculating ANC (Absolute neutrophil count)

1. Add total number of neutrophils.
2. Divide by 100. (gives a percent)
3. Multiple by total white blood cell count (in thousands).

ANC =

$$\frac{\%\ (\text{polys} + \text{bands} + \text{metas} + \text{pros} + \text{myelos})}{100} \times \text{wbc}$$

Definition:
<1000 = mod/severe neutropenia
1000-1500 = mild neutropenia

Calculating I:T Ratio (immature: total neutrophil)

$$\frac{\text{pros} + \text{myelos} + \text{metas} + \text{bands}}{\text{above} + \text{polys}} = \text{I:T}$$

Abnormal = > 0.3

ID

CSF

Normal

wbc - (0-30)
protein (27-144 term, 50-180 preterm)
glucose (25-65) (approx 50-60% of serum glucose)

Estimating normal vs abnormal CSF wbc, if rbc present:

1. Calculate actual peripheral wbc: rbc

$$\frac{\text{peripheral wbc (in thousands)}}{\text{peripheral rbc (in millions)}} = 1{:}400\text{-}500$$

2. Compare to observed CSF wbc: rbc

$$\frac{\text{CSF wbc} + 30}{\text{CSF rbc}}$$

TORCH

Toxoplasmosis
Other
(e.g. Varicella, Syphilis, Coxsackie B, Parvovirus)
Rubella
Cytomegalovirus
Herpes Simplex Virus

Clinical Manifestations
SGA, fever, thrombocytopenia, anemia, jaundice, hepatosplenomegaly, microcephaly, intracranial calcifications, chorioretinitis, hearing deficits, rash.

General workup for Suspected TORCH
Obtain maternal serology.
Primary: Urine culture for CMV; Total IgM.
Secondary: If above positive, send Specific IgMs, eye exam, hearing screen, and brain imaging studies.

Syphilis Protocol

(See Red Book 2006 for more details)
Evaluate all newborns born to mothers with positive nontreponemal test (VDRL, RPR) confirmed by positive treponemal test (FTA) and one or more of the following characteristics:

- Syphilis untreated or inadequately treated.
- Syphilis during pregnancy treated with non-penicillin.
- Syphilis during pregnancy treated with appropriate penicillin, but no decrease in quantitative VDRL after treatment.
- Syphilis treated < 1 month prior to delivery.

- Syphilis treated, but not documented.
- Syphilis treated before pregnancy with insufficient serological follow-up.

Infant Evaluation

PE: hepatosplenomegaly, jaundice, mucocutaneous lesions, lymphadenopathy, rhinitis, IUGR, edema, pseudoparalysis.

Labs: VDRL, HIV, CBC, LFTs, UA, CSF (VDRL/total protein/cell count), CXR, long bone films, eye exam, audiology exam.

Treat If:

- Physical, laboratory, or radiographic evidence of active disease.
- Quantitative VDRL ≥ 4 times maternal titer. (Infant's blood sample, not cord blood).
- CSF VDRL positive or CSF cell count +/or total protein abnormal.
- Positive antitreponemal IgM antibody.
- Asymptomatic infant's VDRL is higher, but < 4 times maternal titer if follow-up cannot be assured.
- If test results cannot exclude disease.
- Positive placenta/umbilical cord test result, for treponemes using DFA-TP staining/dark field.

Recommended Treatment of Neonates (≤ 4 Weeks of Age) with Proven or Possible Congenital Syphilis

Clinical Status	Therapy
Proven or highly probable disease	Aqueous crystalline penicillin G, IV, 100,000 - 150,000 units/kg/day divided q. 8-12 hours.
Asymptomatic, normal CSF and radiographic examination (-). Maternal treatment: None, inadequate, undocumented, failed, or reinfected Non-Penicillin Therapy Adequate therapy but given less than 1 mo before delivery, or mother's response to treatment is not demonstrated by a fourfold decrease in titer of a nontreponemal serologic test.	Aqueous crystalline penicillin G, IV, for 10 days **Or** Clinical, serologic follow-up, and benzathine penicillin G, IM, single dose - 50,000 units/kg.

- If > 1 day of treatment missed, entire course should be restarted.

Follow-up

- VDRL at 1,2,3,6 and 12 months or until negative.
- CSF (if initially positive or suspicious) should be checked at 6 month intervals until normal or retreated.

Herpes Simplex

- In newborns, herpes simplex virus (HSV) infection can manifest as the following: (1) disseminated disease – 25%; (2) localized CNS disease – 35%; or (3) disease localized to the skin, eyes, and mouth – 40%. There may be clinical overlap among disease types.

- Disseminated infection should be considered in neonates with sepsis syndrome, negative blood culture, and severe liver dysfunction.
- The risk of HSV infection at delivery in an infant born vaginally to a mother with primary genital infection is estimated to be 33-50%. With secondary infection the risk is 0-5%.
- Diagnosis: specimens for culture should be obtained from skin vesicle, mouth or nasopharynx, eyes, urine, blood, stool or rectum, and CSF.
- Treatment: Acyclovir (20 mg/kg/dose IV q8h x 14-21 days; lower dosages recommended in preterm newborns).

Candida

Disseminated candidiasis is occuring with increasing frequency in VLBW infants. Candida albicans is the predominant species associated with maternally acquired neonatal disease while C. parapsilosis is a common species in nosocomial infection.

Risk Factors: Prematurity, ventilation > 7 days, central lines, prolonged use of antibiotics, TPN/intralipid use, maternal cerclage.

Clinical Presentation: Respiratory deterioration, feeding intolerance, temperature instability, hypotension, hyperglycemia, glucosuria, thrombocytopenia.

Complications: Meningitis in 40%, endocarditis, renal and ophthalmic fungal balls.

Therapy: Amphotericin B (0.5 mg/kg/dose once daily or 1 mg/kg/dose every other day) or liposomal amphotericin B (5 mg/kg/dose q24-48 hours if concerned about nephrotoxicity).

Group B Streptococcus

- Most common cause of neonatal sepsis and meningitis. Incidence, however, has declined considerably secondary to intrapartum antibiotic prophylactic therapy.
- Asymptomatic vaginal colonization with GBS occurs in 25-35% of pregnant women.
- Risk of transmission (colonization of infant) has been shown to range from 40–70%. Risk of septicemia estimated to be 1-2% of infants of untreated GBS positive mothers. Intrapartum antibiotic prophylaxis initiated ≥ 4 hours prior to delivery prevents mother-to-infant transmission in most cases.
- **Early onset GBS infection:** Majority of infants display symptoms within first 48 hours and about half are symptomatic at delivery. May present as pneumonia, septicemia, or meningitis (only 5-10% in early onset disease).
- **Late onset GBS infection**: Presents at 1-12 weeks. More often presents as occult bacteremia or meningitis. Osteomyelitis, septic arthritis, and cellulitis also seen.
- **Treatment: SEE SEPSIS PATHWAYS (PAGES 139, 140).**

Hepatitis B

- Clinically, may manifest as asymptomatic/anicteric infection (most common in young children), subacute illness with non-specific symptoms (anorexia, nausea, malaise), clinical hepatitis with jaundice, or fulminant fatal hepatitis.
- Chronic HBV infection with persistence of hepatitis B surface antigen (HBsAg) occurs in 70-90% of infants infected by perinatal transmission if mother is HBeAg positive, and about 5-10% if HBeAg negative.
- Pre-exposure immunization is most effective way to prevent HBV. Therefore, vaccination is recommended for all infants. **(SEE IMMUNIZATION SCHEDULE, PAGE 152).**
- Post-exposure prophylaxis can also prevent infection after HBV exposure. **(See Table from Red Book, PAGE 153).**

Human Immunodeficiency Virus (HIV)

- Mother-to-infant perinatal transmission accounts for > 90% of infant/childhood HIV infections.
- Risk of transmission to fetus is estimated to be 13-39%. Maternal Zidovudine/Retrovir (ZDV, AZT) antepartum therapy reduces perinatal transmission by about two-thirds. Hence, diagnosis of maternal HIV during pregnancy is vital.
- Postpartum transmission of HIV occurs through breastfeeding.
- PCR of DNA extracted from peripheral blood mononuclear cells is preferred test for diagnosis of HIV infection in infants. Thirty percent of ultimately

HIV-positive infants will have positive DNA PCR at < 48 hours of age, rising to 93% by 2 weeks, and virtually 100% by 1 month of age.

- Obtain first sample at < 48 hours with follow-up at 1-2 months. Any positive test should be immediately repeated for confirmation. Two separate positive tests indicate infection, while two separate negative tests exclude infection.
- Antiretroviral therapy is indicated for most HIV infected children. **Immediate consultation with a Pediatric Infectious Disease specialist is essential as appropriate therapeutic regimens change frequently.**
- Zidovudine (AZT, ZDV), 2 mg/kg/dose, PO, every 6 hours, beginning within 6-12 hours of birth and continuing for first 6 weeks.

Influenza

- "Split virus" vaccine administered at ≥ 6 months of age; dosage – 0.25 ml IM x 2 doses administered 1 month apart.
- Single dose administration for children < 9 years old fails to produce a satisfactory antibody response.

Respiratory Syncytial Virus (RSV)/Synagis

- Humanized monoclonal antibody prophylaxis to prevent respiratory syncytial virus (RSV) infection in infants at increased risk for severe disease.
- Initiated at the onset of the RSV season (November) and concluded at the end of the RSV season (April).

Synagis is approved for:

- Infants younger than 2 years of age with chronic lung disease requiring oxygen treatment in the last 6 months before start of RSV season.
- Infants born at 28 weeks of gestation or earlier benefit from prophylaxis up to 12 months of age at start of season.
- Infants born at 29-32 weeks of gestation benefit from RSV prophylaxis up to 6 months of age at start of season.
- Babies who are born between 33-35 weeks gestation if they have ≥ 2 additional risk factors, such as:
  - Chronic lung disease
  - Young siblings
  - Child care center attendance
  - Exposure to tobacco smoke
  - Congenital heart disease
- Treatment: Synagis, 15 mg/kg IM every 28-30 days throughout RSV 'season'.

Coagulase-Negative Staphylococcus (CNS)

- Coagulase-negative staphylococcus, specifically S. epidermidis, is the most common cause of nosocomial bacteremia in the NICU, accounting for > 50% of cases.
- This may be influenced, in part, by changing population in the NICU, with an increase in the proportion of extremely low birth weight (ELBW) infants.
- Foreign indwelling devices (IV, UAC, UVC, ETT, urinary catheter, VP shunt) place the ELBW infant at increased risk for S. epidermidis infections.

- In neonates, S. epidermidis bacteremia may present with apnea, bradycardia, temperature instability, abdominal distention, lethargy, or cutaneous abscesses.
- Treatment: **Vancomycin** is the mainstay of antibiotic therapy. Additional aminoglycoside coverage is indicated until culture and sensitivity results are available.

Methicillin-Resistant Staphylococcus Aureus (MRSA)

- 25% of nosocomial S. aureus infections.
- Resistant to all B-lactams and cephalosporins
- MRSA colonization can be prolonged for years.
- Requires implementation of strict infection control policy; (see NICU Nursing Policy on MRSA Colonization).
- Treatment: **Vancomycin** ± Gentamicin ± Rifampin
  - > 1500 grams: bathe in Bactistat weekly.
  - Topical treatment with Bactroban to nares/umbilicus

Obtaining Specimens for Virus and Chlamydia

- **Throat swabs--**Swab posterior pharynx with dry, sterile cotton swab. Do not touch tongue or buccal mucosa. Place swab into 2 ml of viral media. Refrigerate immediately. Do not freeze.
- **Vesicular fluids & skin scrapings--**Do not use alcohol on site of culture. Wash first with saline solution and aspirate vesicular fluid with a Tb syringe. Dilute immediately in 1-2ml of viral

media. If no fluid present, moisten cotton swab with saline and rub vigorously, place swab in viral media. Refrigerate.

- **Fecal material and rectal swabs--**Do not use collecting medium or preservative for formed stool specimens. If swab, place swab in 2-3ml of viral media. For Rotavirus, use dry rectal swab; do not break bottom of culturette or place in viral media.
- **Urine-** random sample and refrigerate immediately. Do not freeze or use culture media.
- **CSF--** Submit at least 2 ml in a screw cap tube. Refrigerate.
- **Nasopharyngeal swabs for direct FA testing--** Use wire swab, scrape vigorously enough to dislodge some cells; secretions alone are unsatisfactory. Apply contents of swab to etched slides. Air dry and send to lab. Send backup calgiswab in viral media.

Chlamydial specimens--Conjunctival scraping or swabs, cervical, urethral, rectal and NP swabs acceptable. Special chlamydial transport media must be used. Discharges are poor specimens for recovery of organism.

Infants of Mothers with Untreated Chlamydia

- Treat with oral erythromycin x 14 days
- No need to culture baby

IDM

Infant of a Diabetic Mother

Conditions associated with IDM

- Macrosomia (due to fetal hyperinsulinemia)
- Birth trauma/asphyxia (usually due to macrosomia)
- Intrauterine growth retardation (seen primarily with Class D (or beyond) diabetes due to placental insufficiency).
- Hypoglycemia (due to hyperinsulinemia)
- Hypocalcemia (decreased function of parathyroid glands)
- Hypomagnesemia (related to maternal condition)
- RDS (delayed maturation of surfactant synthesis)
- TTN (common with C-section)
- Cardiomyopathy/septal hypertrophy(increased fat and glycogen deposition)
- Persistent pulmonary hypertension
- Hyperbilirubinemia
- Polycythemia/hyperviscosity
- Renal vein thrombosis
- Congenital anomalies
    - sacral agenesis
    - small left colon syndrome

COMMUNITY RESOURCES

Visiting Nurse Association (VNA) 216-207-2131.

Help Me Grow (216-778-5554)-for Early Intervention and Follow-up (MetroHealth Social Services).

Women, Infants and Children Program (WIC) (216-778-4932)-Nutritional assistance based on income and medical need.

Healthy Start (216-987-7346)
Provides Medicaid for pregnant women and children to age 17 in families with moderate or low income.

First Call for Help (216-436-2000)
Information on services in Cuyahoga County.

Department of Children & Family Services (216-696-KIDS). Protects children who have been neglected or abused.

Domestic Violence Hotline (216-391-HELP)

Supplemental Security Income (1-800-772-1213)

Cleveland Hearing and Speech Center (216-685-5106). Call Social Services Dept. for inpatients.

Cleveland Sight Center (216-791-8118). Call Social Services Dept for inpatients.

SIADH (Syndrome of Inappropriate Antidiuretic Hormone)

Features:
Hyponatremia, low serum osmolarity, decreased urine output, high urine osmolarity, high urine sodium, weight gain, edema.

Etiology/ Differential diagnosis:
Increased ICP and/or stimulation of hypothalamic-neurohypophyseal axis (eg. HIE, meningitis); IVH and hydrocephalus, decreased BP or resistance to blood flow through the lungs can cause decreased LA filling which causes baroreceptor stimulation resulting in ADH release (right-sided heart failure, pneumothorax, BPD, hemorrhage, RDS).

Management:
- Restrict fluids to insensible losses plus urine output.
- Treat underlying cause of SIADH

Acute Renal Failure

Cause of Acute Renal Failure

A. Pre-renal Failure
   1. Systemic hypovolemia
      a. Fetal hemorrhage
      b. Neonatal hemorrhage
      c. Septic shock
      d. Necrotizing enterocolitis
      e. Dehydration
   2. Renal hypoperfusion
      a. Perinatal asphyxia

b. Congestive heart failure
c. Cardiac surgery
d. Respiratory Distress Syndrome
e. Pharmacologic
a. Indomethacin
b. Captopril

B. Obstructive Renal Failure
1. Congenital malformations
a. Imperforate prepuce
b. Urethral stricture
c. Posterior urethral valves
d. Urethral diverticulum
e. Vesicoureteral reflux
f. Ureterocele
g. Megacystis megaureter
h. Eagle-Barrett Syndrome
i. Ureteropelvic junction obstruction
2. Extrinsic compression
a. Sacrococcygeal teratoma
b. Hematocolpos
3. Intrinsic obstruction
a. Renal calculi
b. Fungus balls
4. Neurogenic bladder

C. Intrinsic Renal Failure
1. Acute tubular necrosis
2. Congenital malformations
a. Bilateral agenesis
b. Renal dysplasia
c. Polycystic kidney disease
d. Glomerular maturational arrest
3. Infection
a. Congenital

1) Syphilis
2) Toxoplasmosis

b. Pyelonephritis

4. Renal vascular
   a. Renal artery thrombosis
   b. Renal venous thrombosis
   c. Disseminated intravascular coagulation
5. Nephrotoxins
   a. Aminoglycosides
   b. Indomethacin
   c. Amphotericin B
   d. Contrast media
6. Intra-renal obstruction
   a. Uric acid nephropathy
   b. Myoglobinuria
   c. Hemoglobinuria

Management of Renal Failure

- Restrict intake to insensible water loss plus urine output in intrinsic renal failure; treat pre-renal failure with fluid challenge and/or diuretics.
- Monitor fluid balance, serum electrolytes and weight carefully.
- In early Acute Tubular Necrosis, consider a pre-renal cause. Fractional excretion of sodium will help sort this out. (See next page for calculating FENA).
  - FE $Na^+ \geq 2.5\%$ in term infants suggests renal failure.
  - FE $Na^+ < 2.5\%$ in term infants suggests pre-renal failure.
  - Fe Na^+ is high in preterm infants because of tubular immaturity.

RENAL

- Urine osmolarity > 400 mOsm/L suggests pre-renal failure; < 400 mOsm/L suggests intrinsic renal failure.

Calculating FENA (fractional excretion of sodium)

$$100 \times \frac{\text{Urine Na}}{\text{Serum Na}} \times \frac{\text{Serum Creatinine}}{\text{Urine Creatinine}}$$

Interpreting Urine Electrolytes

Calculate meq/kg/day of loss (X):

$$\frac{\text{Reported Lab Value (meq)}}{1000 \text{ mL}} = \frac{\text{X (meq/kg/day)}}{\text{*mL of u.o./kg/day}}$$

* multiply 24 hour urine output (ml/kg/hr) times 24

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COMMON PROCEDURES

Lumbar Puncture

Indications: diagnose meningitis, subarachnoid hemorrhage, drain CSF in communicating hydrocephalus

Procedure: See Pain Management Section.
Don sterile attire, prepare sterile field, and cleanse insertion area with Betadine and alcohol swab.

- Use 22 gauge, 1 ½ inch lumbar puncture needle with stylet.
- Palpate iliac crest, slide finger down to interspace, usually L4-L5.
- Insert needle, aiming toward umbilicus and advance slowly.
- Remove stylet, collect 0.5 – 1 ml CSF/tube.
- Replace stylet, remove needle, apply pressure to needle site.
- Send samples to lab as follows:

Tube #1: Microbiology (culture, gram stain, latex antigen if needed)
Tube #2: Hematology (cell count), send clearest tube
Tube #3: Chemistry (total protein/glucose)
Tube #4: Virology (if needed)

COMMON PROCEDURES

Intubation

ETT selection Guide

Weight	GA	Size ETT	Insertion Depth*
<1000 gm	< 28	2.5	6-7 cm.
1000-2000 gm	28-34	3.0	7-8 cm.
2000-3000 gm	34-38	3.5	8-9 cm.
3000-4000 gm	> 38	3.5-4.0	9-10 cm.

Blade Size: Miller '0' for < 3 kg
Miller '0' or '1' for > 3 kg
*Generally, insert 1-2 cm. below vocal cords.

Placement Confirmation:
- PediCap
- Steam in ETT
- Equal chest rise
- Auscultation – equal breath sounds
- CXR: ETT tip at or below medial head of clavicles and above carina

Medication Administration:
- See Pain Management Section
- Naloxone, Epinephrine, Atropine, and Lidocaine may be given via ETT.

COMMON PROCEDURES

Chest Tubes

Use 10F catheter if < 2 kg and 12F if > 2 kg. Use angiocaths only in extreme emergencies.

Chest tube insertion:

- See Pain Management Section
- Don sterile attire, prepare sterile field, and cleanse insertion area with Betadine and alcohol swab.
- Anterior placement for air collection
- Posterior placement for fluid collection
- Place in 4^{th}, 5^{th}, or 6^{th} intercostal space at the anterior or mid-axillary line (nipple is at 4^{th} ICS).
- Remember: nerves, arteries, and veins lie **below** the rib.
- After insertion, connect catheter to water-seal vacuum drainage system (pleur-evac system); 5-20 cm H_2O of suction used—start at lower (5-10 cm H_2O) suction and increase as necessary to resolve pneumothorax or effusion.
- Proper position must be verified by CXR.

COMMON PROCEDURES

Urine Collection

Bladder Aspiration:

- Best attempted if voiding has not occurred within the past hour.
- Must have assistance to hold legs.
- See Pain Management Section.
- Don sterile attire.
- Cleanse with Betadine, followed by alcohol swab.
- Puncture site 0.5 cm. above pubis symphysis at 90° angle to skin, advance needle 0.5-1 cm. while aspirating until urine seen in syringe. Remove needle and apply pressure to site.

Bladder Catheterization:

- Use 3.5F catheter < 1K; 5F, 1-1.8 K; 8F > 1.8 K

'Clean Catch' Urine:

- Adequate for most studies. May be utilized for urine culture if prepped with Betadine and if patient urinates shortly after placement of urine bag. Positive culture may require repeat sample if contaminant suspected.

COMMON PROCEDURES

Percutaneous Central Venous Catheterization

Indications: Anticipation of prolonged need for IV access. Catheter may be used for several weeks. Infection rates increase over time. See Pain Management Section.

Procedure: Use cephalic v., basilic v., saphenous v., or external jugular v., using premade Neo-Picc kit under sterile conditions.

Length of Insertion:
Upper extremities (superior vena cava): Measure from the insertion site, along the proposed venous pathway, to the termination of the right clavicle, and down to the 3rd intercostal space.

Lower extremities (inferior vena cava): Measure from the insertion site, along the proposed venous pathway, to the midpoint of the body, at the level of the diaphragm.

Remember: Advancement of the catheter tip into the right atrium may cause cardiac arrhythmia, or rarely, myocardial erosion with the risk of cardiac tamponade.

COMMON PROCEDURES

Confirm Placement: **Using a 5-10 ml syringe** (as smaller syringes generate excess pressure that may rupture the vessel) aspirate blood back through the catheter until blood reaches the hub. Flush gently with normal saline to prevent rupture of catheter due to high pressure. Use sterile, transparent dressing to secure line. Obtain x-ray to confirm location of catheter tip. If catheter tip is in right atrium, withdraw appropriate distance. If central location cannot be achieved, may still be used as a peripheral IV.

Complications: Infiltration, occlusion, infection, air embolism.

UAC

Indications: frequent blood gas monitoring, continuous arterial blood pressure monitoring, exchange transfusion.

Placement: Verify by X-ray.

T6-T10 (high lines, preferable)-- measure total body length (cm), divide by 3, add 1 OR measure shoulder to umbilicus (cm), add 1-2 (= cm for insertion).

L3-L4 (low lines)--Measure total body length, divide by 6, add 1 (= cm for insertion), remove the line if no improvement within 15 minutes.

To secure, use 000 silk suture.

Complications: infection, hypertension, hemorrhage, thrombosis, infarction.

UAC should be removed as soon as possible as patient's condition improves or complications are noted. **Always consider removal by 7-10 days**.

COMMON PROCEDURES

UVC

Indications: Critically ill, poor peripheral access, immediate/emergency access, CVP monitoring, exchange transfusion.

Emergency: Advance until blood return noted, use.

Placement: O.5-1.0 cm above the diaphragm (T7-8)(preferable for long term or exchange transfusion usage) --Measure total body length, divide by 6, add 1 (equals 1/2 the UAC length in cm. plus 1) OR measure xiphoid to umbilicus, add 0.5-1cm.

UVC should be removed as soon as possible after patient's condition improves or complications are noted. Always consider removal by 7-10 days.

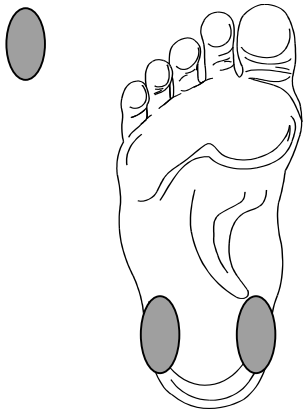
COMMON PROCEDURES

Heelsticks

Purpose: capillary blood sampling
Indications: blood gases, other labs, no more than 3 ml per draw
Procedure:

1. Wash hands thoroughly. Wear gloves
2. Positively identify patient.
3. Assemble all materials needed for the procedure
4. Place the neonate on the stomach or side, if possible, and choose the site for a heelstick.

Safe Zones :



NOTE: NEVER puncture the posterior curvature of the heel (back of the heel) as the calcaneus could be damaged.

COMMON PROCEDURES

5. Remove the Tenderfoot device from its blister pack taking care not to rest the blade slot end on any non-sterile surface.
6. Remove the safety clip. Once the safety clip is removed, DO NOT push the trigger or touch the blade slot.
7. Holding foot with the heel sticking out between your index finger and thumb, thoroughly cleanse the plantar surface of the foot with alcohol. Dry completely with sterile gauze pad.
8. Place the blade-slot surface of the device flush against the heel so that its center point is vertically aligned with the desired site.
9. Ensure that both ends of instrument have made contact with the skin; depress the trigger. Immediately remove instrument from infant's heel.
10. Wipe first blood droplet away with gauze.
11. Obtain desired amount of blood, by gently and progressively squeezing lower leg and ankle.
12. Place sterile gauze over puncture site to stop bleeding.
13. Discard contaminated materials properly.
14. Label specimen tubes correctly.

PHONE/BEEPER NUMBERS

NICU NUMBERS

NICU 85918
..... 85600
..... 1-800-221-7337
Room 1 80772
Room 2 80773
Room 3 80774
Room 4 80775
Room 5 (Isolation) 80776
Room 6 80777
Room 7 80778
Room 8 80779
Room 9 80781
Respiratory 85922
MD Conf Rm. 82528
RN Conf Rm. 85920
Doc on-call:
Fellow 84896
Intern 82640
Resident 84895
NNP 85913, 87072

Other Units

Emergency Dept. 76000
Labor & Delivery 84868
MICU 83720
OR 84367
PICU 85975
SICU 84266
2B floor 84578
2BN 84283
2CN 87601
2C floor 84360
4B 84651
4C 85743

PHONE/BEEPER NUMBERS

Labs

Blood Bank 85176
Chemistry 85101
Cytogenetics 85192
Hematology 85331
Microbiology 85174
Serology 82277
Virology 84234

Unit Managers

L&D - Kristina Jones 87287
(beep) 2811
NICU – Tracy Park 87380
(beep) 1484
NB Nursery – Ann Slogar 85493
(beep) 2688

Other Services

Case Manager (NICU)
Carol Bursley 88731
(beep) .....2529 or 216-690-3771
Code Pink Program
Monica Fundzak 85937
(beep) 1007
VNA ..... (beep) 440-207-2004
Newborn Screening
Ann Ryan (beep) 2443
Nutrition 85902
S. Groh-Wargo (beep) 2446
Pathology (Autopsy Suite) 85525
J. Sawady (beep) 2522
Pharmacy (Admin. Secy.) 83013

PHONE/BEEPER NUMBERS

NICU Inpatient 88478
Hyperal 85396
Inpatient 85297
Outpatient 87548
Clinical Specialist 83542
Laura Cummings (beep) 3779
RSV Clinic (Pat Kral) 82703
Sleep Studies
(beep) 1106
Social Services 85551
C. Ferrari (beep) 3427
Early Intervention:
Sue Macevice (beep) 1709
Special Care/Premie Clinic
Debbie Lawson 83882
(beep) 3532
X-Ray
File Room (inpatient) 82505
File Room (outpatient) 84074
Ultrasound (scheduling) 84511
Inpt. X-Ray (scheduling) 83456
Outpt. X-ray (scheduling) 84001
CT Scan 83498

PHONE/BEEPER NUMBERS

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K. Zahka 464-8410 (35397)
Judy Batke, RN (beep) 1233
ECG/Holter-Hyperspace/Muse Tab
ECHO- Hyperspace/Encounter Tab
Peds Chief Resident (beep) 1228
Peds Comp Care 85198
I. Dietz (beep) 3364
Gary Noritz (beep) 1995
A. Forster, NP (beep)..... 3223
Peds Endocrine: 88267
A. Davis (beep)..... 1651
B. Lightner, NP (beep) 2539
Peds ENT
J. Carter (beep) 690-0917
Resident (consult beep) 3152
Chief Resident (beep)..... 3174
Peds GI..... 84271
On-Call Attending 437-0804
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Peds Orthopedics Ch Res (beep).... 1813
Peds Orthopedics Jr. Res. (beep).... 1480
Peds Pulmonology 84284
D. Birnkrant (beep)..... 2402
R. Cohn (beep)..... 2030
Peds Surgery 82745
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D. Magnusen.....464-8410 (33848)
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Peds Urology:
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PAIN

GUIDELINE FOR PAIN ASSESSMENT AND MANAGEMENT IN NEONATES

1. General principles:
   A) Neonates feel pain and may respond adversely to irritating or painful environmental conditions and therapeutic interventions. NOTE: The absence of a response may indicate the infant's ability to respond has been depleted and must be carefully differentiated from a lack of pain.
   B) Neonates benefit from assessment of their reaction to adverse environmental and therapeutic stimuli coupled with efforts to reduce them or eliminate them when possible.
   C) Certain procedures are known to be painful to all neonates. **When such procedures are unavoidable, oral sugar solution, topical/local anesthetic and/or analgesia/anesthesia should be routinely provided for pre-procedural use, with procedures and post-procedural as needed.**

2. Guideline:
   A) Pain should be assessed with vital signs on a routine basis and with diagnostic/therapeutic procedures (See Pain Management Algorithm, pp. 183-4).
   B) Efforts should be made to be proactive in eliminating or decreasing the potential occurrence of pain throughout the infant's hospitalization (e.g. use of skin barriers under tape, use of adhesive products easily removed

with either water or adhesive remover product safe for infants, limb leads, etc.).

C) Pain should be assessed using N-PASS pain scale (PAGE 188) (NIPS in newborn nursery) and responded to in the following manner:
   - Scores of 1-3/10 should be responded to with comfort measures & sugar solution
   - Scores of 4-6/10 should be responded to with comfort measures, sugar solution, and analgesia.
   - Scores of 7 or above should be responded to with the above measures supplemented by opioid pharmacologic interventions.

D) Pain Management after Major Operative Procedures, consider:
   1) Fentanyl IV drip, 1-2 mcg/kg/hr (may increase by 1 mcg/kg/hr up to 5 mcg/kg/hr for pain score > 3 for 24-72 hrs. Wean by 50% every 24 hrs if on drip < 1 week or by 10-20% every 24 hours if on drip > 1 week.
   2) Morphine IV drip loading dose of 0.1 mg/kg over one hour followed by 0.01 mg/kg/hr (may increase by 0.001 mg/kg/hr up to 0.02 mg/kg/hr for pain score greater than 3 for 24-72 hrs. Wean by 50% every 24 hrs if on drip < 1 week or by 10-20% every 24 hours if on drip > 1 week.

E) Analgesia and Sedation in neonates who require ventilatory support:
   1) Administration of narcotics and sedatives to mechanically ventilated neonates should be considered on a case-by-case basis based upon pain assessment results.

2) Emergency intubations may prohibit the possibility of narcotic administration. Following intubation, narcotics should be considered based upon pain score.

PAIN MANAGEMENT ALGORITHM

Pre-procedural interventions:

- Pain Score if no baseline
- Parent Education/participation
- Individualized comfort measures
- Sucrose
- Identify ability to use topical/Sub-Q anesthetic
- Local/nerve block for circumcision
- Identify potential need of pharmacologic intervention for moderate to severe pain based on procedure or previous patient response to similar procedures.

Procedure:

- Pain score/assessment of tolerance and response
- Maintain comfort measures/sucrose
- Pharmacologic intervention for moderate to severe pain
- Monitor for adverse drug reaction

Post-procedural

- Assess for pain/agitation
- Monitor recovery/return to baseline pain score
- Maintain comfort measures
- Support recovery/consider pharmacologic intervention for moderate to severe pain
- Individualize patient plan of care to reflect interventions for future procedures

PAIN

- Circumcision and consider for immunizations:
  10-15 mg/kg acetaminophen every 6 hr for 24 hr.
- Post-Op: use medication guidelines (see pp. 185-187)
- Naloxone to reverse adverse effects.
  Dose: 0.1 – 0.2 mg/kg/IV, ET, or IM.

COMFORT MEASURES

FAMILY-CENTERED DEVELOPMENTAL CARE

- Assess parent desire to be included in procedures for comfort measures
- Individualize behavioral strategies for containment or positioning (e.g. nesting, swaddling, flexed positioning, etc) and other supportive/calming stimulation (e.g. touch, massage, rocking, talking , music, non-nutritive sucking, etc)

REDUCE NOXIOUS STIMULI

- reduce lighting , establish day/night lighting cycles
- reduce noise
- reduce smells (e.g. perfumes, alcohol, cleaners, etc.)
- cluster care and minimize handling based on individual infant response.
- Limit potentially painful procedures as much as possible.
- Regulate environmental temperature to ensure neutral thermal environment.

PAIN

ORAL

- Oral sugar solution
- Acetaminophen
- Uses:

arterial puncture	venipuncture
heel lancing	PICC
lumbar puncture	IV
eye exams	IM injection
circumcision	suprapubic tap
chest tube insertion	

TOPICAL

- EMLA greater than 37 wks
- Ela-max – newborns
- Uses:

lumbar puncture	IV
suprapubic tap	circumcision
venipuncture	IM injections
PICC	

SUBQ

- lidocaine
- Uses:

lumbar puncture
chest tube insertion
circumcision: ring block

Analgesic Medications

Acetaminophen:

Dose: 10-15 mg/kg/dose orally
Q12 hrs prn for PCA < 32weeks
Q8 hrs prn for PCA 32-36 weeks
Q6 hrs prn for PCA > 36 weeks

Fentanyl:

Dose: 1-4 mcg/kg/dose slow IV push, q 2-4 h prn or continuous infusion 0.5-1 mcg/kg/hr, titrate to response

Advantages: No histamine release

Disadvantages: Tolerance may develop rapidly following continuous infusion. Reverse chest wall rigidity with neuromuscular blocker (vecuronium, 0.1 mg/kg/dose)

Morphine:

Dose: 0.05-0.2 mg/kg/dose IV push over 5 min, q 4h prn or continuous infusion 0.01-0.02 mg/kg/hr, titrate to response

Disadvantages: Histamine release may induce hypotension.

Methadone:

Dose: 0.05-0.2 mg/kg/dose slow IV push, q 6-12h prn.

Disadvantages: Limited information on use in preterm infants, long half-life

Sugar Solutions (sucrose/dextrose):

Dose: 12.5-25%, dip pacifier or 0.5-1ml/dose, prn.

Advantages: No withdrawal

Topical (EMLA/Ela-max):

Dose: EMLA: 1gm applied for 1 hr prior to procedure.
Ela-max: 2.5gm applied for 1 hr prior to procedure.

Disadvantages: EMLA may cause methemoglobinemia.

PAIN

Sedative Medications

Lorazepam:

Dose: 0.05-0.1 mg/kg/dose slow IV push, repeat prn or continuous infusion 0.025-0.05 mg/kg/hr, titrate to response

Advantages: inactive metabolites

Disadvantages: contains benzyl alcohol and propylene glycol

Midazolam:

Dose: 0.05-0.1 mg/kg/dose IV push over 5 minutes, q 2-4 hours prn. or continuous infusion 0.05 mg/kg/hr, titrate to response.

Advantages: no propylene glycol, quick onset.

Disadvantages: contains benzyl alcohol, active metabolite, accumulation with prolonged use

Reversal Medications Do not use in situations of chemical dependence.

Flumazenil (for benzodiazepines):

Dose: 0.01 mg/kg/dose IV push over 15 seconds, repeat q1 minute prn up to a total of five doses

Naloxone (for opioids):

Dose: 0.1-0.2 mg/kg/dose rapid IV push, q 3-5 minutes prn.

PAIN

NEONATAL ABSTINENCE SYNDROME

(Finnegan, 1986)

Scoring System: For neonates exposed to opioids in utero.

Morphine Sulfate- Oral Solution

- Start when infant has a score of >8 three times or >10 twice or seizures or significant weight loss.
- Finnegan Scoring: Scores <8, treat conservatively with non-pharmacologic measures.

  Scores 8-10 0.24 mg/kg/day ÷ q3-4h
  Scores 11-13 0.28 mg/kg/day ÷ q3-4h
  Scores 14-16 0.32 mg/kg/day ÷ q3-4h
  Scores ≥ 17 0.36 mg/kg/day ÷ q3-4h
- Increase the dose by 0.04 mg/kg/dose q3-4h until the score is ≤ 4.

  Weaning may be started after the infant has maintained a score of ≤ 4 for at least 3-5 days. If the score remains ≤ 4, the dose should be decreased by 10% of the original dose every 24 hours. Discontinue oral morphine when the dose reaches ≤ 0.15 mg/kg/day

PAIN

SIGNS AND SYMPTOMS

CNS

Crying 25-50% of Interval	2
High Pitch Cry/Crying greater than 50%	3
Sleeps 2/3 of Time Interval	1
Sleeps ½ of Time Interval	2
Sleeps 1/3 of Time Interval	3
Hyperactive Moro Reflex	2
Markedly Hyperactive Moro	3
Mild Tremors – Disturbed	1
Mild Tremors – Undisturbed	3
Mod/Severe Tremors Disturbed	2
Mod/Severe Tremors Undisturbed	4
Increased Muscle Tone	2
Excoriation	1
Seizure Activity	5

METABOLIC

Sweating	1
Fever (37.8C to 28.4C)	1
Fever (greater than 38.4)	2
Respiratory Rate greater than 60/min	1
Resp.greater than 60/min. & Retractions	2
Yawning greater than 4x of Time Interval	1
Mottling	1
Nasal Stuffiness	1
Sneezing 3-4x of Time Interval	1

GASTROINTESTINAL

Poor Feeding	2
Regurgitation greater than 25% of Feed	2
Projectile Vomiting	3
Loose Stools	2
Watery Stools	3
Excessive Sucking/Mouthing	1

PAIN

NUTRITION

SEE NUTRITION PATHWAY – VLBW INFANTS (< 1500 grams) (Page 70)

SEE NUTRITION PATHWAY – LBW INFANTS (1500-2500 grams) (Page 71-72)

SEE NUTRITION PATHWAY – TERM INFANTS (Page 73)

EXPECTED GROWTH FOR INFANTS

(Ziegler al, 1976; Lubchenco, 1963; Fomon, 1982; Babson, 1970)

Weight

Preterm 24-40 wks	15 gms/kg/day
0-1 month	26-29 gms/day
1-2 months	29-35 gms/day
2-3 months	24-30 gms/day

Length (LBW infants)

Average increase in length: 0.5 -1 cm/week.

Head circumference (LBW infants)

Average increase in head circumference: 0.5-1 cm/week.

Plot values on patient's growth chart each week!

NUTRITION

PARENTERAL NUTRITION ORDERING

TPN: Reorder daily before 2:00 p.m..
IL: Order on TPN sheets. Specify dose in g/kg. Infusion time is 18 hours.
IV: Reorder every 24 hours with exact volume and additives.
NICU Standard Fluids:

- Dextrose 10% (500 ml) with 10 mEq NaCl, 7 mEq KCl, 1.5 gm Ca Gluconate.
  - These "standard" fluids are acceptable for infants of most weights and most infusion rates IF patient's electrolytes and fluid status are in the normal range.

Initiation

Newborns < 1500 gm: DOL #0-1.
Newborns > 1500 gm: When IV > 2-3 days is anticipated.
Older infants: When IV > 2-3 days is anticipated.

Dextrose

Maximum Peripheral IV concentration: 12.5%. Higher concentrations associated with phlebitis and skin sloughing.
Glucose requirements: range, 6-16 mg/kg/min; initial hepatic clearance = 6-8 mg/kg/min.

NUTRITION

Amino Acid Solution
Specialized pediatric preparations (TrophAmine©)

Intravenous Fat
20% Intralipid: 2 cal/ml; 18 hr infusion rate. Initial dose: 0.5 – 1 gm/kg/day. Maintenance dose: 1-3 gm/kg/day.
Monitoring: Triglyceride level at initiation and after changes. Best drawn during infusion so peak is known. Acceptable level is < 200 mg/dl.

Calcium/Phosphate Compatibility: Excessive amounts may form an insoluble precipitate. Follow NICU guidelines for most infants.

Ca Requirements: Needs may be as high as 1000 mg Ca gluconate/kg/day; average intake on "normal" TPN is 500-700 mg/kg/day.. NICU guidelines may be excessive for infants < 750 grams in the first week of life.

Electrolyte changes
Gradually decrease electrolytes (mEq/kg) as IV fluids are replaced by enteral feeding. Adjust chloride: acetate ratio based on acid:base balance.

Drug compatibility
Routine addition of drugs to TPN not recommended with the exception of Ranitidine (Zantac) and Iron dextran.

NUTRITION

Windowing:
Designed to provide a period off parenteral nutrition.
May prevent or decrease TPN-induced cholestasis.
Initial daily window of 1-3 hours recommended.

Parenteral Nutrition Requirements

Maintenance: 60 kcal/kg/day, 2.5 gm protein/kg/day
Growth & Positive nitrogen balance: 80-100 kcal/kg/day, 2.5-3.5 gm protein/kg/day
EFA Requirements: 0.5-1 gm IV fat/kg/day
Balance energy & protein: 150-200 non-protein calories:1 gmN; 30-40% NPC as fat.

Advisable Daily Intake (TPN)

Nutrient	pre-mature	0-12 months
fluid (cc/kg)	60-200	120-150
protein (gm/kg)	2-3.5	2-3
energy (kcal/kg)	80-100	80-120
CHO (gm/kg)	12-25	12-25
lipid (gm/kg)	0.5-3	0.5-3
Na (mEq/kg)	2-5	2-4
K (mEq/kg)	2-3	2-3
Cl (mEq/kg)	2-5	2-3
Ca (mg/kg)	50-90	40-60
PO4 (mg/kg)	35-70	30-50
Mg (mEq/kg)	0.3-0.6	0.5-1

Calories from Parenteral Solutions

Calories/ml from Dextrose (CHO: Dextrose 3.4 Kcal/gm)

D5	.17
D7.5	.26
D10	.34
D12	.41
D15	.51
D17.5	.60
D20	.68
D25	.85

Calories/ml from Common Dextrose/AA Combinations

D5% AA 0.75%	0.2
D7.5% AA 1.25%	0.3
D10% AA 1.5%	0.4
D12% AA 2%	0.49
D12% AA 2.5%	0.51
D15% AA 2.5%	0.61
D20% AA 3%	0.8
D25% AA 3%	0.97

NUTRITION

ENTERAL NUTRITION

PO feed with RR<60-70.
NG feed with RR>70 or gestational age < 34 weeks.
Special formulas (eg. PF27) must be ordered by 10 am for delivery that day.

Enteral Nutrition Requirements

Preterm: 110-130 kcal/kg/day, 3-4 gm protein/kg/day
Preterm infant with BPD or increased metabolic demands: 130-150 kcal/kg/day
RDA 0-6 months: 72-108 kcal/kg/day
RDA 6-12 months: 64-96 kcal/kg/day

Enteral Feeding Guidelines

Priming feeds: Initial feeding regimen for infants < 1250 gm, especially for smaller ELBW infants; feed 10 ml/kg/day. Usual duration is 3-7 days.

Progressive feeds:

BW	formula	frequency
< 1250g	PF24/MBM	cont or q2h
1250-1800g	PF24/MBM	q 3h
1800-2500g	NeoSure22/MBM	q 3-4h
>2500g	S20/ MBM	q 3-4h

BW	initial rate ml/kg/day	volume increase ml/kg/day	full feedings ml/kg/day
<1250g	10	10-20	150
1250-1500g	20	20	150
1500-1800g	30	30	150
1800-2500g	40	40	150-165
>2500g	50	50	150-180

Continuous feedings with MBM:
Not routinely recommended; may result in loss of 2-3 calories/oz of fat. May be used in special circumstances, such as short bowel syndrome.

NUTRITION

Iron Supplementation

Fer-in-sol: 0.6 ml = 15 mg elemental iron
Iron Dose for Preterm Infants: 2-4 mg/kg/day by 2 months of age; 4-6 mg/kg/day for iron deficiency anemia. **Also, see Anemia of Prematurity Guideline (Page 97).**

Routine Vitamin Supplementation

Order routine vitamin supplementation after tolerance of 24 hours of full enteral feeding.
LBW Infants on Premature Formula or Fortified Human Milk: 0.3 ml BID NeoVits. **(NeoVits contain 750 IU Vitamin A, 200 IU Vitamin D, 5 IU Vitamin E, and 17.5 mg Vitamin C.)**

LBW Infants on Unfortified Human Milk or a Formula Other than Premature Formula: 1.0 ml/day Multi-vitamin Drop.
Term or Near-Term Infants on Formula: no supplement needed.
Term or Near-Term Infants on Human Milk: 1.0 ml/day TriVitamin Drop.

Vitamin-Mineral Supplementation in Special Situations:

'EPO' therapy: Iron, 6 mg/kg/day. **(See Anemia of Prematurity Guideline (Page 97).**

Risk of osteopenia and/or alkaline phosphatase > 600:Calciferol, 0.05 ml/day PO (=400 IU Vitamin D)

NUTRITION

Formula Nutrients

Type	CHO	PRO	FAT
MBM	lactose	human, whey predom.	human LCT
Similac®, Enfamil®, Generic brands	lactose	cow milk, whey and casein	LCT
Prosobee®	glucose polymer (corn syrup solids)	soy	LCT
Isomil®	corn syrup, sucrose	soy	LCT
Nutramigen®	corn syrup	hydrolyzed casein and amino acids	LCT
Alimentum®	sucrose & tapioca starch	hydrolyzed casein and amino acids	LCT (67%) MCT (33%)
Pregestimil®	corn syrup, glucose & corn starch	hydrolyzed casein and amino acids	MCT (55%) LCT (45%)
Enfamil Premature®, Similac Special Care®	corn syrup & lactose	cow milk, whey predom.	LCT & MCT (50:50)

NUTRITION

Type	CHO	PRO	FAT
Enfamil EnfaCare® Similac NeoSure®	corn syrup & lactose	cow milk, whey predom.	LCT (75%) MCT (25%)
Similac Natural Care®	corn syrup & lactose	cow milk, whey predom.	LCT & MCT (50:50)
Enfamil Human Milk Fortifier®; Similac Human Milk Fortifier®	corn syrup solids	cow milk, whey predom.	LCT and/or MCT
Neocate®	corn syrup solids	amino acids	LCT (95%) MCT (5%)
EleCare®	corn syrup solids	amino acids	LCT (67%) MCT (33%)
Good Start®	lactose, malto-dextrin	whey hydroly-sate	LCT

NUTRITION

Formula: Indications, Advantages and Disadvantages

type	indication	adv	disadv
MBM	healthy term & LBW infants	digestible, absorbable, immuno-logical low cost convenient	VLBW- may have inadequate protein and Ca/phos
Enfamil®, Similac®	same, mom desires not to breast-feed	altered to approximate MBM	possible sensitivity or allergy to cow milk protein
Isomil®, Prosobee®	cow milk protein sensitive or allergic; after gastro-enteritis; galactosemia	decreased "colic" symptoms in some infants	infants allergic to cow's milk may also be allergic to soy; may not support bone mineral-ization in VLBW
Nutramigen®	sensitivity or allergy to cow's milk protein; colic and diarrhea due to milk protein allergy.	available in powder, concentrate, and ready to feed.	expensive, less available

NUTRITION

type	indication	advantage	disadvant.
Alimentum®	sensitivity to cow milk protein or other intact proteins, pancreatic insufficiency, malabsorption, short bowel, GI immaturity, cystic fibrosis, cholestasis	Available as ready to feed and powder	expensive, less available; not appropriate for sucrose intolerant; hypertonic (370 mOsm)
Pregestimil®	sensitivity to cow milk protein or other intact proteins, pancreatic insufficiency, malabsorption, short bowel, GI immaturity, cystic fibrosis, cholestasis.	long history of positive clinical experience; 320 mOsm	expensive, less available; available only as powder for home use.
Enfamil Premature®, Similac Special Care®	rapidly growing LBW or VLBW	increased caloric, protein, vitamin and mineral content	may need slow intro to increase tolerance

NUTRITION

type	indication	adv	disadv
Similac NeoSure®; Enfamil EnfaCare®	continued feeding for preterm infants after hospital discharge	increased nutrient content for catch-up growth	more expensive than standard formula
Similac Natural Care®	fortify expressed human milk for LBW; 1:1	300 mOsm when mixed 1:1; mixes easily	dilutes benefits of human milk
Enfamil Human Milk Fortifier®; Similac Human Milk Fortifier®	fortify expressed human milk for LBW; 1 packet per 25 ml.	uses more volume of mother's milk; provides 24 kcal/oz.	about 400 mOsm when mixed 1 packet per 25 ml.
Neocate®	severe allergy	non-allergenic	very expensive ; less available
EleCare®	severe allergy	non-allergenic, appropriate for infants and children	very expensive, less available
Good Start®	healthy, term	may be less expensive than other standard formulas	not hypo-allergenic; marketed directly to consumers

NUTRITION

Formula Information

Form	Kcal/ oz	Kcal/ ml	Gm Pro/ 100ml	Na mEq/ 100ml	K mEq/ 100ml
MBM (varies)	20-22	0.63-0.73	1.1	0.78	1.33
MBM:HMF (1:25)	24	0.80	2-2.3	1.55	2.90
MBM: Natural care® (1:1)	22	0.73	1.65	1.35	2.10
Enfamil Pre-mature®	24	0.80	2.4	1.39	2.13
Similac Special Care®	24	0.80	2.2	1.52	2.67
Similac Natural Care®	24	0.80	2.2	1.52	2.67
Metro PF27	27	0.90	2.5	1.65	3.05
Metro PF30	30	1.00	2.7	1.83	3.44
Enfamil®	20	0.67	1.5	0.78	1.87
Similac®	20	0.67	1.5	0.70	1.82
Isomil®	20	0.67	1.7	1.30	1.87
ProSobee®	20	0.67	2.0	1.04	2.10
Alimentum®	20	0.67	1.9	1.30	2.05
Pregestimil®	20	0.67	1.9	1.39	1.90
Nutramigen®	20	0.67	1.9	1.39	1.90
NeoSure®	22	0.73	1.9	1.07	2.71
EleCare®	20	0.67	2.0	1.32	2.58
Neocate 20®	20	0.67	2.1	1.09	2.64

NRP

CLEVELAND REGIONAL CODE PINK PROGRAM
REGIONAL PROTOCOL FOR NEONATAL RESUSCITATION

Purpose: At the time of birth, the newborn must make a transition from intrauterine to extrauterine life which involves major physiological changes including: the onset of respiration, changes in blood flow patterns, the loss of placental support and the establishment of homeostasis in a relatively cold and dry environment. This difficult process can be complicated by inherent problems of the mother or the infant leading to distress at the time of birth. The purpose of this protocol is to support the normal physiological process of adjustment to extrauterine life and to reverse or compensate for the effects of adverse maternal or neonatal problems. This support is accomplished by the provision of a patent airway and adequate ventilation, maintenance of cardiac output, correction of hypovolemia and acidosis, and avoidance of cold stress.

Policy:

1. The medical personnel in attendance at deliveries will call a Code Pink for all deliveries meeting the perinatal risk factors as adapted from the Regional Section of the Regional (Code Pink) Protocol for Neonatal Resuscitation, except those known to be intrauterine fetal deaths or decided by advance consultation with the neonatal attending/fellow, family and obstetrician to not have Code Pink called. The Code Pink team is not intended to eliminate the need for a physician in neonatal resuscitation.
2. The Code Pink Team as defined below will routinely be present for the delivery of all anticipated high risk patients. (See Risk Factors - below) In such cases the Code Pink Team will be notified using the

routine procedure, dial 81111 and provide the following information to the operator: Code Pink; location; brief statement of problem.

3. The Code Pink Team will be immediately summoned to the delivery area if a depressed infant (ineffective/absent respirations, HR<100, central cyanosis and/or minimal tone/activity) is delivered to a low risk mother. The Code Pink Team will be assembled using the **EMERGENCY** procedure, dial 81111 and provide operator with the following information: Code Pink, location and nature of emergency.
4. When an Attending or Fellow trained in neonatal resuscitation is present, he/she will assume responsibility for the resuscitation and delegate responsibility to the Code Pink Team members. When this physician is not present, the Captain of the Code Pink team will function as the team leader under the guidance of the delivering physician or anesthesiologist and in accordance with this protocol.

Code Pink Team:

1. **The Code Pink Team** consists of three, hospital-based professionals who are capable and prepared to respond to the delivery area within three minutes of a summons and perform neonatal resuscitation according to this protocol.
2. **Code Pink Team members** will have individually completed general training in the neonatal resuscitation program through NRP and specific training utilizing this Code Pink protocol (Phase I). Initial training will be supplemented by regular in-

services/updates, including participation in mock code drills.

HOSPITAL-SPECIFIC SECTION

Each hospital must tailor this section of the protocol to its individual circumstances. The items listed below, however, should be included in this section of the protocol. See Code Pink Initiation Procedure C1.1

1. The Code Pink Team members will be:
   A. AIRWAY MANAGER - dries head, suctions, administers oxygen in all forms, intubates (possible choices - Anes/Ped/Nur Anes/RT).
   B. ASSESSOR- STIMULATION/DRY BODY/CARDIAC EVAL/COMPRESSION (RN/RT/MD).
   C. RECORDER- RECORDER/MEDICATIONS - (RN, LPN).
   D. Hospitals should list other individuals who may also participate in the resuscitation on an "as needed" basis.
   E. The Code Pink Team Captain should be designated.
2. Code Pink Coordinator - Responsible for coordinating the training and scheduling of team members, the keeping of records documenting training, and audits.

   A perinatal steering committee including representatives from Obstetrics, Pediatrics, Anesthesiology, Nursing, and Respiratory Therapy to guide the necessary development, administration

and quality assurance aspects of the program is highly recommended.

3. Resuscitation Guidelines –
   Full resuscitation will be administered to any infant ≥ 500 grams regardless of gestation age and ≥ 24 weeks regardless of weight. However, ultimate determination of viability and resuscitative efforts rests with the senior member of the Code Pink Team. An order and a progress note discussing the plan is required according to Hospital Policy III-9 Guideline for the Withholding or Withdrawal of Life-Sustaining Treatment or Hospital Policy III-33 Do Not Resuscitate Policy.

   If non-viability and/or incompatibility with life due to lethal anomaly has been determined, the infant will have comfort measures provided and family needs addressed. An order and a progress note discussing the plan is required according to Hospital Policy III-9 Guideline for Withholding or Withdrawal of Life Sustaining Treatment or Hospital Policy III-33 Do Not Resuscitate Policy.

4. Training Requirements
   A. Individual Training
      1) Intensive individual training in both general resuscitation (NRP) and Code Pink (Phase I) Course should be accomplished prior to assignment to the Code Pink Team. A performance appraisal of the individual's ability to perform his/her team assignment in mock codes done with the hospital's equipment should also be satisfactory prior to

assignment to routine shifts as a regular Code Pink Team member.

2) Refresher training including mock code drills should be done on a regularly scheduled basis. Participation in a difficult resuscitation can be substituted for alternate inservices if performance feedback is given.
3) Records of individual training should be kept in the Code Pink file and in the individual personnel files of the team members.

B. Team training - shift teams should be drilled together using surprise mock codes on a regularly scheduled basis. Records of these exercises should be kept in the Code Pink file.

5. THE CODE PINK TEAM SHOULD BE PRESENT AT THE DELIVERY WHEN ANY OF THE FOLLOWING CONDITIONS IS PRESENT**.**

A. **Maternal Factors**

- History of:
  - No prenatal care: with maternal distress and/or non-reassuring fetal heart rate patterns, unknown dates
  - Substance abuse: with maternal distress and/or non-reassuring fetal heart rate patterns present
  - Toxemia/pre-eclampsia
  - Diabetic - insulin dependent.
  - Chorioamnionitis
    (Fever > 38°, increased WBC, left shift, foul-smelling fluid).
  - Abnormal vaginal bleeding.

B. **Labor and Delivery Factors**
- Non-vertex presentations delivering vaginally (breech, face or brow)
- Emergency Cesarean sections
- Cord prolapse
- Placenta previa, placental abruption
- Difficult delivery - shoulder dystocia
- General anesthesia or problems with anesthesia, (i.e. complications with high spinal)
- Delivery occurring outside Labor and Delivery area

C. **Fetal Factors**
- Abnormal FHT, baseline > 160 or < 100
- Meconium-stained amniotic fluid with evidence of non-reassuring fetal status
- Late deceleration pattern
- Persistent loss of heart rate variability
- Known anomalies
- Gestation ≤ 35 weeks
- Small-for-dates (IUGR)/large for dates (LGA)
- Multiple gestation

D. **Specific Request of Obstetrician**

E. **Hospital-Specific additional risk factors** can be added (i.e. sedation/hypnotics within 4 hours, forcep or vacuum deliveries)

6. Equipment

Based on AAP NRP guidelines

Code Boxes per Hospital guidelines.

NRP

RESUSCITATION PROTOCOL

A. **NTE**
A neutral thermal environment will be provided for all neonates through use of a radiant warmer, preferably warm, humidified oxygen, and warm blankets and hat. The infant should be brought to the resuscitation area from the delivery area by team member #2.

B. **Stimulation**
Performed by Airway Manager, who dries the head and by Team Member #2, who dries the body with a blanket or rubbing of the neonate's back. Stimulation should be brief, 10-15 seconds. If little or no response in heart rate and respiratory effort is elicited, then proceed with resuscitation.

C. **Suction**
Gently clear the airway of blood and mucous. The mouth and oropharynx are suctioned first, followed by the nares. Suctioning that includes gastric emptying is not recommended until the neonate has been stabilized. Vigorous, deep suctioning is also not recommended as both techniques can cause VAGAL stimulation and reflex bradycardia. Suctioning should be intermittent as the catheter is being withdrawn and limited to 10-15 seconds. Bulb and wall suction are available. Wall suction is to be set at medium (80-100 mm Hg). Suctioning assures an open airway; the need for suctioning should be assessed throughout the protocol.

D. **Endotracheal Suctioning Protocol** (USED ONLY WITH THE FOLLOWING: suspicion of meconium, blood, or thick mucous in the trachea, in an infant depressed at birth).

- Whenever there is any meconium or blood in the amniotic fluid the obstetrician should suction the hypopharynx and nasal passages prior to delivery of thorax with bulb or wall suction. Wall suction should be set on medium (80-100 mm Hg).
- If the newborn is crying or active at the time of delivery, proceed to the evaluation of breathing effectiveness.
- If the infant is depressed, the trachea should be intubated and suctioned with the ET tube connected to wall suction (through a meconium aspirator) at medium setting.
- The trachea should be suctioned until clear unless respiratory depression/bradycardia necessitates CPR.
- The stomach is suctioned clear of meconium with suction catheter after infant is stabilized.

E. **Oxygen** - 100% (5-10 L/min.) oxygen is used in the Delivery Room. Oxygen can be given blow-by, by bag and mask, or bag to ET tube. Oxygen by all modes will be administered by the Airway Manager.

Blow-by oxygen will be administered to any baby with spontaneous respirations who is not centrally pink by 60 seconds of age, or who shows signs of distress such as grunting, retracting or unequal expansion of the chest.

Mask CPAP is viewed as an augmented form of blow-by oxygen. **It is appropriate only if there are spontaneous respirations**. A maximum pressure of 8 cm. of water should be utilized. CPAP is utilized in an infant who remains cyanotic in spite of apparently normal respirations and blow-by oxygen. It is also used in an infant with improving respiratory status, as an intermediary step when moving from positive pressure bag and mask ventilation to blow-by oxygen.

Oxygen via bag and mask with positive pressure will be utilized if:

- Cyanosis does not improve rapidly with blow-by/CPAP
- If respiratory effort is:
  - absent
  - consists of gasping only
  - regular with a rate < 40 breaths/min. (ineffective).
- If the heart rate is < 100.

Continue ventilation with pressures required to achieve adequate chest rise and air exchange at a rate of 30-60 breaths/ minute until heart rate normalizes and color improves. If the infant's respirations become adequate, slow the rate gradually until the infant is on CPAP. If bag and mask ventilation continues for several minutes, a gastric tube should be passed and the end

port left open for air and gastric drainage release.

If the infant is transferred from the Delivery Room to the nursery, oxygen via a portable oxygen tank will be utilized.

F. **Intubation** will be the responsibility of the Airway Manager under the direction of the Team Leader. The Code Pink Team Leader will direct the Airway Manager to intubate the neonate under the following conditions:

- If adequate ventilation (determined by chest wall expansion and bilateral breath sounds) has not been established within 30 - 60 seconds with bag and mask.
- If after adequate ventilation with bag and mask for 1-2 minutes, the heart rate remains < 100 and there is no color improvement.
- If physical assessment reveals an omphalocele, gastroschisis or scaphoid abdomen with possible diaphragmatic hernia.
- To suction trachea for airway clearance.

Weight	Tube size	Blade size	Depth of Insertion
< 1 kg	2.5	0	6-7cm
1-2 kg	3.0	0	7-8 cm
2-3 kg	3.5	0	8-9 cm
3-4 kg	3.5-4.0	0-1	9-10 cm

- The ET tube is to be passed 1 cm beyond the vocal cords and rests above the carina.
- The Assessor will continuously monitor heart rate during the procedure. In a neonate who has been previously stabilized with positive

pressure ventilation, if the heart rate drops to <60-80 BPM, stop intubation efforts and provide bag and mask ventilation until the heart rate increases to ≥100. Once intubated, check for proper position of ET tube by noting depth of insertion, observing equal chest expansion, auscultating equal breath sounds, and using an end-tidal CO_2 detector. If breath sounds predominate on one side, have Airway Manager pull tube back in 0.5 cm increments until bilateral breath sounds are heard. Secure ET tube with benzoin and tape.

- Pressures and rates of ventilating should be the same as those indicated for bag and mask ventilation (above).

G. **Cardiac massage** will be initiated by Assessor any time the apical pulse is<60-80 BPM after effective ventilation for at least 30 seconds has been established. Position thumbs or 2nd and 3rd fingers over the sternum, after sliding fingers along the ribs above the xiphoid process. Compress the chest one-third of the AP diameter of the chest. Cardiac compressions are done at a ratio of 3:1 with a ventilation breath after the third compression. Support the back with your fingers if using the "thumb" method or with your free hand if using the "2nd and 3rd" finger method. Assess for a palpable pulse while performing chest compressions.

H. **Biochemical Resuscitation**
The use of drugs should be considered only if the following criteria are met:

- Adequate airway has been established, and effective bag or ET tube ventilation established.
- Heart rate remains<60-80 BPM despite adequate ventilator and compressions.

Perfusion remains inadequate

Administration:

- Drugs will be given by team member #3 via an umbilical venous catheter (see procedure for insertion) or via the ET tube.
- Drugs to be administered: (See protocol flow sheet and emergency drug sheet for appropriate timing and dosage).

I. Documentation of Code Pink Resuscitation to be recorded on the Code Pink Sheet by the Recorder during the resuscitation.

NRP

DRUG	INDICA-TIONS	DOSE/ DILUTION	SIDE EFFECTS/ PRE-CAUTIONS
Epinephrine	Restore myocardial contractility in cardiac arrest- for isoelectric EKG or persistent brady. Will increase BP	0.5 ml (1:10,000) IV/IT rapidly, IT follow with 1 ml NS	Rise in BP with CNS hemorrhage from over-dose. Tachy-arrhythmias
Normal Saline	Shock for volume expansion	10-20 ml/kg IV over 5-10 minutes	
Blood O-; 5% albumin	Shock for volume expansion	10-20 ml/kg IV over 5-10 minutes	Transfusion reaction; Transmission of infection
Sodium Bicarb, 4.2%	Metabolic acidosis which occurs in cardiac arrest	2 mEq/kg (0.5mEq/ml) IV- Give 1 mEq/kg/min	Hyper-natremia hyper-osmolarity,

NRP

DRUG	INDICA-TIONS	DOSE/ DILUTION	SIDE EFFECTS/ PRE-CAUTIONS
Neonatal Narcan (=Naloxone hydrochloride)	Narcotic depression	0.1 ml/kg of 1 mg/ml, repeat as needed	Contra - indicated if mother is suspected narcotic user (puts infant into withdrawal). Observe infant for recurrent respiratory depression as Narcan's effect may be shorter than the narcotics.
Dextrose 10%	Hypo-glycemia, blood sugar < 40	2 ml/kg IV bolus, then continuous IV D10W	Hyper - glycemia, recheck blood sugar in 20-30 minutes and q 30 min there-after until stable.

LACTATION & MATERNAL MEDICATIONS

It is essential that a determination of medication usage by the mother be completed prior to the use of her breast milk for her infant. Such 'medication' may include prescription, over-the-counter, and/or herbal products. Since breast milk may positively impact the health of newborns, the health care provider should make every attempt to use mother's milk if available. It is, therefore, important to access the best and most up-to-date resources to determine if specific medications may have an adverse effect if fed to the newborn infant. Caution must be exercised when referring to either the manufacturer's product inserts or the PDR, as this information is not necessarily accurate. In addition, the AAP reviews these medication lists only every five years.

Several good resources for this information include:

- **Medications and Mothers' Milk** by Thomas W. Hale, Ph.D., Hale Publishing, 12th Edition, 2006. (Comprehensive evaluation of 850 drugs and their usage in breastfeeding mothers.)
- **Lactation Study Center**, University of Rochester Medical Center, Dr. Ruth Lawrence; **585-275-0088.**
- **www.neonatal.ttuhsc.edu** (website from Texas Tech University School of Medicine)
- **www.motherisk.org** (website from the Hospital for Sick Children, Toronto, Canada)

LACTATION & MATERNAL MEDICATIONS

A brief list of common medications and their safety profiles follow:

L-1: Safest – Controlled studies fail to demonstrate a risk; possibility of harm is remote.
L-2: Safer – Studied in a limited number of breast feeding women without an increase in adverse effects noted; demonstrated risk is remote.
L-3: Moderately Safe – No controlled studies; risk of untoward effects is possible or controlled studies show minimal non-threatening adverse effects.

Analgesics	
Darvocet	L-2
Ibuprofen	L-1
Morphine	L-3
Nubain	L-2
Percocet	(not rated)
Toradol	L-2

Antibiotics		
Amoxicillin	L-1	
Ampicillin	L-1	
Ancef, Kefzol	L-1	
Augmentin	L-1	
Cefotetan	L-2	
Cefoxitin	L-1	
Ceftriaxone	L-2	
Clindamycin		L-3
Dicloxacillin		L-1
Flagyl	L-2	
Gentamicin	L-2	
Keflex	L-1	
Penicillin G	L-1	
Unasyn	L-1	
Vancomycin	L-1	

LACTATION & MATERNAL MEDICATIONS

Zithromax	L-2

Anticoagulants

Coumadin	L-2
Heparin	L-1
Lovenox	L-3

Anticonvulsants

Carbamazepine	L-2
Magnesium Sulfate	L-1
Phenytoin	L-2
Valproic Acid	L-2

Antidepressants

Amitriptyline	L-2
Celexa	L-3
Effexor	L-3
Lexipro	L-3
Paxil	L-2
Prozac	L-3
Tofranil	L-3
Wellbutrin	L-3
Zoloft	L-2

Antiemetics

Zofran	L-2

Antihistamines

Diphenhydramine	L-2
Sudafed	L-3

LACTATION & MATERNAL MEDICATIONS

Antihypertensives

Atenolol	L-3
Hydralazine	L-2
Hydrochlorothiazide	L-2
Labetolol	L-2
Methyldopa	L-2
Metoprolol	L-3
Nifedipine	L-2
Propranolol	L-3
Verapamil	L-2

Diuretics

Furosemide	L-3
Spironolactone	L-2

RESPIRATORY

RESPIRATORY DISTRESS SYNDROME

Differential Diagnosis

Respiratory: Upper airway obstruction (eg. choanal atresia, laryngeal web, rings, hygroma, goiter, laryngo/tracheomalacia, Pierre Robin), RDS, TTN, sepsis, pneumonia, MAS, PPHN, pneumothorax, atelectasis, pulmonary hemorrhage, pleural effusion, phrenic nerve palsy, congenital malformations (eg. TE fistula, diaphragmatic hernia, lobar emphysema, cystic adenomatoid malformation), and late processes such as BPD.

CVS: Congenital heart disease, CHF, PDA, shock

Metabolic: Any condition leading to acidosis, hypo/hyperthermia, electrolyte abnormalities, hypoglycemia

Heme: Anemia, (including anemia from acute blood loss leading to hypovolemic shock; or chronic loss leading to CHF), polycythemia

CNS: Hemorrhage, pharmacologic depression, drug withdrawal, malformations, birth asphyxia/respiratory depression

Initial Work-up

- History and physical exam
- Obtain pulse ox, blood gas, glucose, CBC, blood culture and CXR.

RESPIRATORY

Findings on CXR

Grade	Desc	Findings on CXR
I	mild	fine, granular, homogeneous, no air bronchograms
II	mild - mod	as above, plus air bronchograms
III	mod - severe	as above, plus ill-defined heart borders
IV	severe	total "white out"

Management

Supplemental Oxygen

- Nasal Cannula or Hood to maintain paO2 ≥ 55-60 and pulse ox ≥ 88-93% in VLBWs or higher in larger/more mature newborns.

Nasal CPAP

- Consider unless apneic or rapidly deteriorating. Begin at 5-6 cm H20 if paO2 < 60 and/or pCo2 ≥ 50 despite FiO2 ≥ .50
- Consider post-extubation for < 1000 gram infants

Nasal IMV

- Indicated for patients with RDS or apnea to improve the likelihood of successful extubation, especially if nasal CPAP has failed.
- Provide oxygen as needed to maintain pulse oximeter ≥ 88-93%; initiate oxygen at previous level plus 5% and titrate.
- Initial IMV: 10-20, PIP: 16-22, PEEP: 5-8.

RESPIRATORY

Intubation

Indications: recurrent or prolonged apnea, intractable seizures, suspected PPHN, surgical abdomen with respiratory compromise, diaphragmatic hernia, shock, respiratory failure (secondary to RDS, BPD, pneumonia, etc.) not responding to nasal CPAP or nasal IMV.

Arterial Line

Indications: FiO2 requirement consistently > .40, mechanically ventilated with increasing O2 requirement, worsening respiratory status, BP monitoring.

SURFACTANT TREATMENT PROTOCOL

(Survanta - Bovine Lung Extract)

Indications:

- Grade II-IV RDS and an O_2 requirement of > 30-35% with inability to wean further.
- May also be beneficial for meconium aspiration syndrome and PPHN.

Preparation: 200 mg phospholipid (8 ml) vial which is premixed and has off-white, light brown color. Warm to room temperature in hand (8 min.) or allow to stand at room temperature for 20 minutes. DO NOT SHAKE.

Dosage: 4 ml/kg/dose given intratracheally. First dose given as soon as possible. Maximum of 4 doses at ≥ 6 hourly intervals usually in the first 48 hours of life.

Administration:

1. Suction and stabilize infant.

2. Administer
   through a #5 Fr end hole feeding tube cut to length of the OET or utilize special Survanta tube.
3. Do not suction for at least 1 hour after each dose.

Nasal Cannula Conversion Table

	.25 L/min	.5 L/min	.75 L/min	1.0 L/min
100%	34%	44%	60%	66%
80%	31%	37%	42%	49%
60%	26%	31%	35%	38%
40%	22%	24%	25%	27%

Table based on Term (3 Kg) infant and, therefore, may not accurately reflect FiO_2 in LBW infant.

Nasal cannula flow required to generate a nasal CPAP of 6 cm.

- NC Flow (L/min)= 0.92 +(0.68 x wt (in kg)).
- NC at flows of 1-2.5 L/min can deliver a positive distending pressure in preterm infants.

RESPIRATORY

OXYGEN MANAGEMENT FOR HIGH-RISK VLBW INFANTS

Mission Statement: While oxygen is clearly a life-sustaining and life-saving therapy for many VLBW (<1500 grams) newborns, oxygen toxicity appears to be a significant risk to the fragile lungs and retinas of this population of infants. The continued high incidence of severe ROP requiring laser therapy and occasionally leading to blindness has become a leading morbidity in the highest risk ELBW (<1000 grams) infant, whose overall survival rate now exceeds 80%. Recent small studies suggest that previously acceptable oxygen saturation levels may, indeed, be highly toxic to the retina of the most preterm infants. While definitive prospective multi-center double-blinded randomized trials appear to be years away, the relatively high incidence of severe ROP necessitates a medical response that utilizes the best available, although admittedly incomplete, data to derive a reasonable plan for oxygen utilization in this high-risk population.

The following Guidelines are recommended with the proviso that prospective analysis is needed to assess their efficacy on an ongoing basis. This analysis should include tracking of ROP rates, incidence of laser therapy, blindness, cerebral palsy, periventricular leukomalalcia, bronchopulmonary dysplasia, and death. Growth parameters should also be tracked.

- All infants **< 1500 grams** who require oxygen therapy should be managed utilizing these guidelines, **beginning at birth**.

RESPIRATORY

- Maintain pulse oximetry oxygen saturations between **88-93%** (although saturations between 85-95% are also acceptable). Pulse oximeter **alarm limits** should reflect these ranges.
- In the **stabilization phase** of the first 2-4 hours of life, FiO2 should be **weaned rapidly (by 5% every 5-10 minutes**) until the oxygen saturation is within the desired range.
- After the acute stabilization phase, FiO2 should be **weaned by 2-3%** at a time for persistent saturations >93% until the O2 saturation is within the defined range unless pulmonary hypertension is a concern.
- **Avoid repetitive and frequent titration of FiO2** in response to transient fluctuations in oxygen saturation. Determine if further assessment of etiology is needed (e.g. PDA). Adjusting other ventilator parameters (e.g. PIP, PEEP, Tidal Volume, Mean Airway Pressure) should also be considered.
- **If increasing FiO2 for events such as apnea, bradycardia, and/or desaturations, a return to baseline FiO2 should occur within 10 minutes**. Large FiO2 changes (>10%) in response to these 'events' should also be avoided if at all possible. If unable to return FiO2 to baseline, MD/NNP should be notified for further assessment.

High Frequency Oscillatory Ventilation (HFOV) (Sensor-Medics)

Indications: pulmonary air leaks, including PIE; respiratory failure and/or hypoxemia on conventional ventilator.

Initial settings

Mean Airway Pressure (MAP) controls oxygenation.

- Preterm: Conventional ventilator (**CV**) MAP plus 1-2 cm H_2O with diffuse alveolar disease; same MAP (or less) with PIE/air leak.
- Term: CV MAP plus 2-4 cm H_2O with diffuse alveolar disease; about same MAP for PIE/air leak.

Amplitude controls ventilation.

- 10-30 cm H_2O; adjust upward in 2-4 cm H_2O increments until chest wall vibrates visually.

Frequency: 60 cycles/min = 1 Hz

- Increasing frequency = increased PCO_2
- Decreasing frequency = decreased PCO_2 and increased oxygenation.
- < 1000 gm: 15 Hz
- 1000-2000 gm: 12 Hz
- >2000 gm: 10 Hz
- MAS: 6-10 Hz

Management

Note: Obtain chest x-ray within about 1 hour of initiation of HFOV to ascertain degree of lung expansion (≥ 8-9 posterior ribs). Also, consider chest x-ray after changing MAP by ≥ 4 cm H_2O or FIO_2 by > 10-20%.

RESPIRATORY

To change pCO2: Adjust amplitude (increasing amplitude will decrease pCO_2). if pCO2 too high--check for pneumothorax, mechanical obstruction, ET placement, atelectasis, need for sedation/paralysis.
To change pO2: Adjust FiO2, MAP (increasing MAP will increase pO_2 unless lungs are over-expanded); suction; if pO_2 too low-check for pneumothorax, mechanical obstruction, ET placement, atelectasis, hypotension, need for sedation/paralysis.

Weaning

1. In general, patient ready to wean when $FiO_2 < 0.50$-0.60.
2. If able to wean FiO_2 to 0.50-0.60, then decrease MAP by 1 cm H_2O every 6-12 hours. Correlate with chest x-ray to evaluate lung expansion.
3. Wean Amplitude by 2-5 cm H2O until pCO_2 = desired pCO_2.
4. Continue to wean Amplitude until at lowest point prior to either extubation or switching to conventional ventilation.
5. Change to conventional ventilation in general when MAP has been weaned to between 7 and 9 cm H_2O.

RESPIRATORY

Pressure-Limited, Time-Cycled, Continuous Flow Ventilation

Most common used mode: SIMV
Definition: Synchronized Intermittent Mandatory Ventilation: Ventilator breaths are triggered by patient's inspiratory efforts. Patient can breathe between ventilator breaths (but not all breaths are assisted).
Ventilator settings:
PIP: 15-25 cm
PEEP: 3-5 cm
Inspiratory Time: 0.35-0.45, Rate of 30-40/min.
Monitoring: Generated Tidal Volume (3-5 ml/kg)

General Effects of Ventilator Moves:

	pCO2	**pH**	**PO2**
Increase PIP	Decrease	Increase	Increase
Decrease pip	Increase	Decrease	Decrease
Increase PEEP	May increase	Varies	Increase
Decrease PEEP	May decrease	Varies	Decrease
Increase rate	Decrease	Increase	Varies
Decrease rate	Increase	Decrease	Varies
Increase I:E	Increase	Decrease	Increase
Decrease I:E	Decrease	Increase	Decrease

RESPIRATORY

Volume Guarantee (VG) modes of ventilation (Baby log 8000):

Principles of operation: VG combines the advantages of pressure-limited, time-cycled, continuous flow ventilation and volume controlled ventilation.

Different Modes:

1. SIMV-VG (Synchronized Intermittent Mandatory Ventilation - Volume Guarantee.
   - The ventilator automatically adjusts the delivered PIP to achieve a target V_T.
   - Vent settings: FiO2, V_T (4-5 ml/kg), PIP (15-25 cm), PEEP (3-5 cm), Rate (30-40/min), iT (0.35-0.4 sec).
2. PS-VG (Pressure Support Volume Guarantee):
   - Patient determines both the rate and duration of inspiration.
   - Vent Settings: FiO2, V_T (4-5 ml/kg), PEEP (3-5 cm), Rate 30-40/min), iT (0.4 sec). DO NOT FORGET TO SET A PIP (no more than 1-2 cm above the PIP needed to generate the target V_T)
3. AC-VG (Assist Control-Volume Guarantee):
   - Patient determines the rate of ventilation.
   - Vent Settings: FiO2, V_T (4-5 ml/kg), PEEP (3-5 cm), Rate (30-40/min), iT (0.3-0.35 sec that is fixed). DO NOT FORGET TO SET A PIP (no more than 1-2 cm above the PIP needed to generate the target V_T).

Abnormal Blood Gases/Possible Solutions

NOTE: **Change of pCO_2 of 10 mm Hg will change pH by approximately 0.08.**

RESPIRATORY

Hypoxia
Definition: paO2 < 50 and/or SaO2 < 90%
Treatment: Increase FiO2, PIP, V_T (tidal volume) flow, 'I' time and/or PEEP

Hyperoxia
Definition: paO2 > 100
Treatment: Decrease FiO2, PIP, V_T, flow, 'I' time and/or PEEP

Respiratory Acidosis
Definition: pCO2 too high-usually >55, pH too low-usually <7.25
Treatment: Increase rate, increase PIP, increase V_T or decrease PEEP

Respiratory Alkalosis
Definition: pCO2 too low-usually < 35, pH too high, usually >7.45
Treatment: Decrease rate, PIP or V_T.

Metabolic Alkalosis
Definition: HCO3 too high- usually >30, positive base excess, pH too high, usually >7.45
Treatment: Determine etiology: possible causes: excess bicarbonate administration, hypokalemia, hypochloremia, excessive GI (acid) losses.

RESPIRATORY

Metabolic Acidosis

Definition: HCO3 too low-usually < 15, base excess ≥ 8-10, pH too low-usually <7.25

Treatment:

1. Treat underlying cause.
2. If correction is necessary:
   a. Calculate **bicarbonate correction** as follows:
      HCO3 = 0.3 x Kg x (BE - 5)
      Give diluted (0.5 mEq/ml) slowly IV over 20-60 minutes.

   b. For severe metabolic acidosis give **bicarb drip** at 0.5meq-1meq/kg/hour:
   - Dilute 50ml D5/D10 or Sterile water with 50ml(50mEq) NaHCO3 = 0.5mEq/ml
   - Determine dose:
     desired dose/kg/hr x Kg = #mEq/hr
   - Determine rate per hour:

$$\frac{\textbf{0.5 mEq}}{\textbf{1ml}} = \frac{\textbf{\# mEq/hr}}{\textbf{ml/hr}}$$

OR

 # mEq/hr x 2 = rate (ml/hr)

ROP

Retinopathy of Prematurity (ROP)

Definition: Vasoproliferative retinopathy of newborn infant, occurring primarily in preterm infants (BW < 1500 grams; GA ≤ 32 wks.)

- Acute phase - interrupted, abnormal vasculogenesis.
- Chronic phase - cicatricial phase resulting in scarring and retinal detachment.

Location of ROP

Zone I- posterior pole or inner zone

A circle with a radius extending from optic disc to twice the disc to the macula distance.

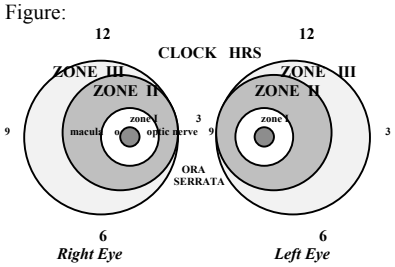
Zone II- middle zone

Extends from the edge of zone I peripherally to the edge of the retina on the nasal side and around to an area near the temporal equator.

Zone III-outer zone

The residual crescent of retina anterior to Zone II, least vascularized, most frequently involved in ROP.

Figure:



ROP

Staging

Stage I

Demarcation line: white and flat, on retinal plane separates the avascular anterior retina from the vascularized posterior retina.

Stage II

Ridge: demarcation line of Stage 1 has increased in volume to extend out of the plane of the retina. Isolated vascular tufts may be seen posterior to the ridge.

Stage III

Ridge with extraretinal fibrovascular proliferation.

Stage IV

Subtotal retinal detachment. (IVA) - extrafoveal; (IVB) - involving the fovea.

Stage V

Total retinal detachment.

Extent of ROP

Recorded as "clock hours" on each eye in the appropriate zone.

"Plus" Disease

Sign of vascular activity which can accompany any stage, indicating greater likelihood of progression to Stage III. Characterized by tortuosity and engorgement of retinal vessels, vascular engorgement and rigidity of iris, and vitreous haze.

Pre-Threshold ROP

ROP with increased likelihood of progression to retinal detachment if left untreated.

- Zone I, any stage
- Zone II, "plus" disease with Stage II or III

ROP

Screening Guidelines

Eye exams should be initiated at 5-6 weeks of age (or at 31 weeks post-conceptional age whichever comes last at discretion of Ophthalmologist) in all newborns of < 1500 grams birth weight or ≤ 32 weeks gestation at birth, regardless of oxygen requirement. Selected infants with birthweights of 1500-2000 grams who have had an unstable clinical course may also be considered for ROP evaluation.

Treatment

Retinal ablation with laser photocoagulation for those progressing to pre-threshold/threshold disease. Decision to treat is at the discretion of the Pediatric Ophthalmologist.

Outcome

Stage I & Stage II

Usually undergoes spontaneous regression by 11 to 16 weeks postnatal age. Treatable ocular abnormalities (strabismus, amblyopia, refractive errors) may occur.

Stage III & Stage IV

May have strabismus, amblyopia, glaucoma. Majority will be myopic. Retinal detachment possible. Vision varies widely with disease from limited correctable acuity to total blindness.

Risk Factors Associated with Poor Prognosis

Posterior location of ROP in Zone I or posterior Zone II., increased severity of Stage, circumferential involvement, plus disease.

Other Web Sites of Interest

www.metrohealth.org/neonatology (Official MetroHealth NICU web site; includes care pathways, statistics, overview of NICU and Premie Clinic operations, NICU medication guidelines etc.).

www.aap.org (Official American Academy of Pediatric web site which includes a wide variety of information relevant to the practice of Pediatrics including clinical practice guidelines, policy statements, reviews of pediatric and child care texts, access to Medline/Pubmed).

www.kidsgrowth.com (Web site of Ross Labs providing a variety of information about the practice of Pediatrics).

www.nationalperinatal.org (Official National Perinatal Association web site providing information on perinatal and neonatal issues; Journal of Perinatology articles also available.)

www.rosspediatrics.com (Web site of Ross Labs providing information on nutrition, Pediatric practice, Pediatric residency, and other Pediatric educational topics.)

www.guidelines.gov (National Guideline Clearinghouse - search engine for medical guidelines/information).

www.uhrad.com (Rainbow Babies & Children's Hospital Pediatric imaging teaching files).

www.virtualpediatrichospital.org (Wide variety of information on Pediatrics).