Neonatal Gastroenterology

Emesis in the Infant

Medical DDx

- Anxiety, excitement, imitation
- Celiac disease
- Congenital adrenal hyperplasia
- Esophageal dysmotility
- Excessive crying
- Food allergies
- Gastroenteritis
- Gastroesophageal reflux
- Improper feeding
- Inborn errors of metabolism
- Infection: Sepsis, UTI, meningitis
- Ingestion maternal blood or mucus
- Kernicterus
- Milk protein allergy
- Necrotizing enterocolitis
- Overfeeding

Surgical DDx

- Annular pancreas
- Appendicitis
- Atresia/stenosis/webbing
- Duplications
- Esophageal atresia
- Functional ileus
- Hernias
- Intussusception
- Malrotation with midgut volvulus (if bilious)
- Meconium ileus
- Meconium plug syndrome
- Necrotizing enterocolitis w/perforation
- Pyloric stenosis
- Testicular torsion
- Tracheoesophageal fistula
- Tumors
- Ulcers
- Vascular rings

Evaluation

Initiate your evaluation in a stepwise fashion for an infant in the NICU, and always start with a KUB before proceeding to any further imaging studies (the following is a suggestive work up depending on your suspicion)

Plain films:

- KUB, left lat. decubitus, possible prone
- Contrast study (upper vs. lower):
  - if concern for malro/volvulus-upper
  - if concern for jejunal/ileal atresia-lower
- Septic evaluation if concern for symptoms of NEC or sepsis
- Bowel rest
- Anti-reflux medications
- Surgical consult

Additional studies depending on etiology/ clinical presentation:

- CBC with diff
- Chem 10
- Blood gas
- Lactic acid
- LFT's, amylse, lipase
- Blood culture
- Urinalysis and culture
- Stool guaiac
- Consider metabolic and endocrine work-up
- Ultrasound for intussusception

Common Obstructive Causes of Vomiting

Bilious or Non-Bilious

- Intestinal atresia
- NEC
- Meconium plug
- Meconium ileus
- Malrotation
- Volvulus
- Hirschsprung Disease

Likely Non-Bilious

- Pyloric stenosis
- Intussusception
- Reflux

Acute Abdomen in the Neonate

"High" Obstruction

- Esophageal atresia
- Duodenal atresia
- Duodenal web
- Annular pancreas
- Malrotation
- Jejunal atresia
- **Main symptom**: vomiting
- **Radiograph**: no distal bowel gas (complete obstruction)

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Acute Abdomen in the Neonate

"Low" Obstruction	• Ileal atresia • Meconium ileus • Meconium plug • Hirschsprung Disease • Anal atresia	• **Main symptom**: constipation • **Radiograph**: dilated small bowel loops and microcolon (unused colon, obstruction proximal to colon)
"Acquired" Disease	• NEC • Hypertrophic pyloric stenosis • Incarcerated inguinal hernia	• Gastroenteritis • Sepsis • Perforated stress ulcer

Indirect Hyperbilirubinemia

All infants

- Jaundice in the first 24 hours of life should ALWAYS be considered pathologic and prompt an immediate serum bilirubin level (both total and direct).

Infants ≥ 35 wks GA

- www.bilitool.org (interactive web resource that incorporates the AAP guidelines)

Premature Infants < 35 weeks gestational age:

Gestational Age (corrected)	Initiate Phototherapy at Total	Exchange Transfusion at Total
<28 0/7	5	11
28 0/7 - 29 6/7	6	12
30 0/7 -31 6/7	8	13
32 0/7 - 33 6/7	10	15
34 0/7- 34 6/7	12	17

Management	Refer to AAP guidelines for levels of phototherapy and exchange transfusion. If the levels are elevated to the high risk/exchange transfusion, then: • Aggressive Phototherapy • Aggressive Hydration (IV + PO) • IVIG (if Coombs positive) • Consider steroids • Consider/anticipate exchange transfusion (call blood bank)

Selected GI Disorders

NEC

Etiology	• Precise etiology unclear • Affects 10% of premature infants with increased incidence at lower gestational age • **Risk Factors:** ▪ Prematurity ▪ IUGR ▪ Perinatal asphyxia ▪ PDA ▪ Shock/Hypotension ▪ Umbilical Arterial Catheter ▪ Cyanotic Heart Disease

Neonatal Gastroenterology

Selected GI Disorders

NEC	
Symptoms and Diagnostics	**Symptoms** • Abdominal distention/discoloration/tenderness • Heme positive stools • Grossly bloody stool • Feeding intolerance: gastric aspirates (large +/- bilious) • Non-specific systemic symptoms: Lethargy, apnea, temperature instability, unexplained acidosis, hyperglycemia, poor perfusion • Lab abnormalities: Hyponatremia, hyperkalemia, metabolic acidosis, leukocytosis or leukopenia, thrombocytopenia • Radiographic abnormalities: Pneumatosis, portal venous gas, free air **Diagnostics** • KUB with left lat. decub. • CBC with differential & blood culture • Electrolytes
Management	**Make NPO** • Place replogle tube • Antibiotics • Surgery consult (STAT if free air) • Start IVF/TPN • Supportive care • Monitor Labs and KUB's every 6 to 8 hours depending on infant status
Malrotation (+/- Mid-Gut Volvulus)	
Etiology	• Developing bowel fails to undergo the usual counterclockwise rotation (4th to 10th week of embryogenesis). Peritoneal bands (normally attaching bowel to the central body axis) compress the duodenum, causing partial obstruction. • Volvulus results in intestinal obstruction. • Superior mesenteric artery may be compressed, leading to ischemia.
Symptoms and Diagnostics	• **Classic**: Newborn <1 month old with bilious vomiting. Other presentations with intermittent abdominal pain and/or vomiting. Associated with diaphragmatic hernia, omphalocele, gastroschisis. • **KUB**: usually unremarkable, may demonstrate small bowel obstruction. • **UGI** (diagnostic study of choice): abnormal position of duodenal-jejunal junction (DJJ). Volvulus classically appears as a spiral corkscrew of the duodenum • **Ultrasound**: may show volvulized small bowel, seen as a "whirled" appearance.
Management	**Emergent Surgical Treatment—Modified Ladd's Procedure** • Division of the peritoneal bands (Ladd bands) around the duodenum • Colon placed on the left and the duodenum on the right to broaden the mesentery • Appendectomy is performed to avoid future confusion with abdominal pain
Duodenal Atresia	
Etiology	• Embryogenic • 1 per 5000 live births • 25% have Trisomy 21
Symptoms and Diagnostics	• Bilious vomiting hours after birth without abdominal distension • KUB with "double bubble" sign – gaseous distension of stomach and proximal duodenum
Management	• NPO, NG suction • Surgical Consult • Duodenoduodenostomy

Selected GI Disorders continued on next page →

Neonatal Gastroenterology

Selected GI Disorders

Jujonoileal Atresia	
Etiology	• Mesenteric vascular accident during fetal life • 1 per 3000 live births
Symptoms and Diagnostics	• Bilious vomiting hours after birth with abdominal distension • Failure to pass meconium • Hyperbilirubinemia • KUB with air-fluid levels
Management	• NPO, NG suction • Surgical Consult • Resection and anastomosis

Meconium Ileus	
Etiology	5% of newborns with cystic fibrosis, and in 1 per 5,000 to 10,000 live births
Symptoms and Diagnostics	• Abdominal distension and vomiting hours after birth • Failure to pass meconium • KUB – distension, air-fluid levels • Contrast enema – microcolon, +/- impacted meconium pellets
Management	• NPO, NG Suction • Water soluble contrast enema • Surgical enterostomy if needed

Nutrition and Fluid Management

*****Nutrition and Fluid Management is also site specific. Here are some general guidelines from BMC's Nutrition Survival Guide.**

Calculating Glucose Infusion Rate (GIR): (% Dextrose x mL/kg/day) / 144

Fluid Requirements (ml/kg/day)

Birth Weight (g)	Day 1-2	Day 3	> Day 5
<1000	100	140	150
1001-1250	80-100	120	150
1251-1500	80	100-120	150
1501-2000	65-80	100	150
>2000	65-80	100	150

Nutrition and Fluid Management

Suggested Enteral Feeding Guidelines		
Birth Weight (g)	**Initial Rate (ml/kg/day)**	**Advance (mL/kg)**
<750	10	10 mL/kg/d
750-1000	10	10 mL/kg/d or 10 mL/kg BID
1001-1500	10	10-15 BID
1501-2000	30	15 BID
Goal Volume		130-150
*For infants > 2 kg and advancing on NG/OG feeds, they may follow the guide for 1501-2000 grams		

Times after birth (hrs)	Expected Volume per feed (mL)	Expected cc/kg/day	
		34-36 weeks (2.0-2.5 kg)	>/= 37 weeks (>/= 2.5 kg)
0-24 (DOL 0)	~5-10	~20-30	~0-20
24-48 (DOL 1)	~10-20	~60	~20-40
48-72 (DOL 2)	~20-30	~80	~60
72-96 (DOL 3)	~30-60	~100	~80

When To Use What		
Supplement	**When**	**Amount**
FeSO4	Full feeds & greater than DOL 14	2 mg/kg (formula) 4 mg/kg (MM only)
Liquid HMF	To supplement MM when < 35 weeks	Max is 2 pkts/50 mL (not for discharge)
Neosure Powder	To supplement MM when >35 wks & >2 kg	Per site specific recipe
Vitamin D	MM fed babies	1 mL Polyvisol/day = 400 IU/day

Enteral Feeding Options

- Breast milk is best!
- <35 weeks, use Special Care 20 if parents decline donor milk: catered for premature needs
- >35 weeks and >2 kg, use Neosure if parents decline donor milk: transitional and post-discharge formula for up to 10-12 months CGA (standard dilution is 22 kcal/oz)
- Fortify to 24 kcal/oz in conjunction with advance to 80 mL/kg of feeds

Nutrition and Fluid Management continued on next page →

Nutrition and Fluid Management

Absolute Contraindications for Breastfeeding	
Infant Characteristics	Diagnosed with galactosemia
Mother Characteristics	• HIV infection • Antiretroviral medications • Active, untreated, tuberculosis • Human T-cell lymphotropic virus type I or type II infection • Using or is dependent upon an illicit drug • Taking certain prescribed cancer chemotherapy agents. • Undergoing certain radiation therapies; however, some nuclear medicine therapies require only a temporary interruption in breastfeeding.

Department of Pediatric Newborn Medicine
Clinical Guideline

Clinical Guideline:	**Parenteral Nutrition Guideline**
Effective Date:	3/13/2015; Revised 5/30/2015; Revised 10/7/2015; Revised 3/7/2016; Revised 9/2/2016; Revised 2/27/2017

INITIATION OF PARENTERAL NUTRITION

Weight at birth	When to initiate
<1800 g	**Neonatal Premix Stock PN** ("Standard PN") ASAP either Central or Peripheral Access to be run at **60 mL/kg/day**
≥1800 g	Clinical judgment: <50 mL/kg/day enteral feedings by 48-72 hours of life and no plan to advance per protocol
Therapeutic Hypothermia (TH)	Start with Standard PN, order custom PN at first AM rounds (refer to TH guidelines)

New order:	Through order sets > Neonatal Parenteral Nutrition
Renewal:	Select "Reorder" on order screen and adjust components from yesterday's order (Do NOT select "Modify")
Titration:	Select "Yes" or "No" if volume may be adjusted for feeding advance and/or total fluid adjustment

MACRONUTRIENT PARENETERAL NUTRITION ADVANCES AND GOALS

	Standard PN (<1800g, TH) *When @ 60 mL/kg/day*, provides:*	Custom PN Day 1	Daily Advances	Goal
Feeding Volume mL/kg/day	*Refer to Enteral Nutrition Clinical Practice Guideline*			
Lipids g/kg/day†	-	1 (5 mL/kg/day)	↑ 1 g/kg/day	3 (15 mL/kg/day)
Glucose Infusion Rate (GIR)** *Central Max D30%; Peripheral Max D12.5%*	GIR: 4.17	GIR: 4-6	For Glucose <120, ↑ GIR 1-2	~12
Trophamine (AA) g/kg/day	3	≥1800g: 3 <1800g: 4	(To goal Custom PN Day 1)	≥1800g: 3 <1800g: 4

**While on Standard PN, provide additional IV fluids to meet hydration needs; †Lipid Volume: 1 g/kg/day Lipids is equivalent to 5 mL/kg/day; **Avoid cumulative GIR from all IV fluids <4-5 mg/kg/min*

APPROVABLE PN SOLUTIONS:

Osmolarity*:	Peripheral ≤ 1050 mOsm/L (Central ≤2000 mOsm/L)	Sterile Water:	Must be > 0 mL

Dextrose and Trophamine are the most osmotic and largest volume additives in a PN solution, therefore:

- Try minor adjustments in Dextrose% or g AA/kg/day with careful attention to optimize energy, GIR and protein provision as much as possible.
- When adjusting AA; adjust cysteine accordingly (**40 mg/kg/day Cysteine per 1 g AA/kg/day**)

**EPIC shows mOsm/L on left hand summary screen when ordering Neonatal PN; alerts >900 mOsm/L*

CYSTEINE◊

g/kg/day AA	mg/kg/day Cysteine
2.5	100
3	120
3.5	140
4	160

MULTIVITAMIN

Wt	Dose
<2500g	2 mL/kg/day
≥2500g	5 mL/day

NEO. TRACE ELEMENTS (NTE)

Wt	Dose
<2500g	0.2 mL/kg/day
≥2500g	0.5 mL/day
Cholestasis *(D. Bili >2)*	0.1 mL/kg/day

HEPARIN

Central PN*:
0.5 units/mL
**Add to peripheral PN if attempt for central access*

SELENIUM

All infants:
2 mcg/kg/day*
**Consider removing or reducing in setting of renal failure*

ZINC

Add if NTE removed (i.e., cholestasis)

Preterm:	400 mcg/kg/day
Term:	250 mcg/kg/day

(Levo)CARNITINE

Add if on PN without EN for ≥14 days

10 mg/kg/day

CALCIUM AND PHOSPHATE GUIDELINES*

	Access	mEq Calcium per 100 mL	mmol Phos per 100 mL
Standard	Peripheral	1.5	0.75
Goal	Central	3	1.5

**Nutrition and/or Pharmacy approval required for any variance to these guideline*

MAGNESIUM

Elevated serum Mg:
0.1 mEq/kg/day
Standard:
0.3 mEq/kg/day

SUGGESTED LABORATORY MONITORING

Electrolytes, BUN, Creatinine	PRN in setting of clinical status. Note: BUN level up to 50 mg/dL reflects utilization of amino acids for energy and, in the absence of other clinical concerns, does not reflect toxicity or renal dysfunction.
Glucose	Daily checks until clinically stable and labs stable on goal GIR; BID when weaning PN and advancing feeds.
Triglycerides	**Check once receiving goal lipids of 3 g/kg/day.** Also consider checking during initial advancement if clinical concern, e.g. hyperglycemia (>180 mg/dL) or ELBW infant <1000g.
	For confirmed TG >250 mg/dL (i.e., not drawn off line infusing lipid): decrease lipids to 1 g/kg/day, follow daily labs and resume 1 g/kg/day advances to goal once <200 mg/dL. Avoid doses <1 g/kg/day if possible.
Calcium, Magnesium, Phosphorus	Once on ≥3 mEq Ca per 100 mL and ≥1.5mmol Phos per 100 mL, then weekly PRN.
Total/Direct Bilirubin; Alkaline Phosphatase	If on PN >2 weeks, follow every other week while on PN/lipids.

**Guidelines represent the minimum recommended frequency of monitoring for stable infants. Frequency of laboratory monitoring should primarily be decided by overall clinical status.*

PARENTERAL NUTRITION WEANING GUIDELINES

Macronutrients					Additives			
Feeding Volume mL/kg/day	40	60	80	100	(Once feeds are fortified)			
Lipids g/kg/day	1-2	**Central:** 0-1 **Peripheral:** 0.5-1		Discontinue PN and IL	**Multivitamin**	1 mL/kg/day	**Calcium**	1.5 mEq/100 mL
Dextrose %	*Maintain %Dextrose in setting of euglycemia;* Ideally ≤ 15%				**Neo. Trace Elements**	0.1 mL/kg/day	**NaPhos**	0.75 mmol/100 mL
Trophamine (AA) g/kg/day:	Fortified Feeds: 1.5-2 Unfortified Feeds: 3-4				**Selenium**	1 mcg/kg/day	**Magnesium**	0.1 mEq/kg/day

Revised February 27, 2017