JOHNS HOPKINS ALL CHILDREN'S HOSPITAL
HEART INSTITUTE

Enteral Nutrition and Reflux in Neonates with Congenital Heart Disease Clinical Pathway

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Johns Hopkins All Children's Hospital

Heart Institute: Enteral Nutrition and Reflux in Neonates with Congenital Heart Disease

Rationale:

This clinical pathway was developed by a consensus group of Johns Hopkins All Children's Hospital (JHACH) physicians, advanced practice providers, nurses, speech therapists, dietitians, and pharmacists to standardize the management of enteral nutrition (EN) and reflux in neonates hospitalized for congenital heart disease (CHD). It addresses the following clinical questions or problems:

1. When to start enteral feeds in preoperative and postoperative neonates with CHD
2. How to advance EN based on a risk category
3. What parameters to use to hold feeds or advancements

Background:

Preoperative feeding in neonates who require early surgical intervention is controversial, and feeding practices vary across institutions. Congenital heart lesions are classified as ductal-dependent pulmonary circulation, ductal-dependent systemic circulation, and ductal-independent mixing lesions. Keeping the ductus arteriosus patent may cause an imbalance of excess blood flow to the pulmonary circulation, causing steal from the splanchnic bed, potentially causing ischemia and placing these neonates at higher risk for necrotizing enterocolitis (NEC). It is unclear if having CHD is an independent risk factor for NEC, but certain cardiac lesions have been shown to have a higher incidence of NEC, such as hypoplastic left heart syndrome (HLHS). Neonates with CHD have an increased resting energy expenditure (REE), and feeding the gut would further increase metabolic demand, leading to gut hypoxia and the potential for NEC. Given these risks, there is often a delay in initiating EN in the pre-surgical period, a critical time when the milestone of oral feeding is typically achieved. Very few published studies evaluate the safety of preoperative feedings in this population to support or refute early initiation of EN. Similarly, in the post-operative setting, these neonates often go several days before introducing EN, depending on the complexity and severity of their surgery and post-surgical course. Surgical palliation can alter the physiologic blood flow through the splanchnic bed, which may impact their success with feeding. For many neonates, the main reason for prolonged post-surgical hospital stay is feeding intolerance, and many neonates often require feeding assistance at discharge. This pathway was created after reviewing feeding guidelines and practices from various institutions for neonates with CHD in the pre-operative and post-operative period.

Clinical Management:

This pathway is intended for any neonate with a corrected gestational age (CGA) ≥ 35 weeks and ≥ 2 kg admitted to the Cardiovascular Intensive Care Unit (CVICU) in the pre-operative and/or post-operative period.

The goal is to start feeds once:

1. No evidence of end-organ ischemia (lactate < 3 mmol/L, pH > 7.3)
2. Epinephrine infusion ≤ 0.05 mcg/kg/minute
3. No significant or anticipated hemodynamic instability

Allow by mouth (PO)/bolus nasogastric (NG), if all criteria are met:

1. Non-invasive respiratory support < 2 L/kg
2. Respiratory rate (RR) < 80 breaths per minute (bpm)
3. No clinical concern for aspiration
4. Speech consult in all patients with arch repair/reconstruction
5. Refer to Appendix A for progression with PO feeds

Hold feeds if:

1. Multiple large-volume emesis
2. Concerning abdominal distension on exam
3. Bloody stools

If feeds need to be held:

1. Re-evaluate in 1 hour and return to the prior step that the patient was tolerating
2. Refer to Appendix B if concerns for gastroesophageal reflux disease (GERD)
3. If having worsening abdominal distension or bloody stools:
    a. Hold feeds and obtain a kidney, ureter, bladder (KUB) x-ray to evaluate for NEC

High-risk patients:

1. Single ventricle
2. Shunts (surgical or ductal stent)
3. Extracorporeal membrane oxygenation (ECMO)
4. Prior history of NEC
5. Prior history of end-organ ischemia
6. Any other patient that the provider deems high risk based on surgical intervention or clinical status

Enteral nutrition and considerations:

1. Use maternal breastmilk, donor breastmilk (if criteria met and available), or hydrolyzed formula in single ventricle physiology patients (refer to Appendix C)
2. Use hydrolyzed formula powder to fortify maternal breastmilk in single-ventricle patients (refer to Appendix C)
3. For low-risk patients, use maternal breastmilk or standard formula
4. If feeding intolerance is present, refer to Appendix B
5. If concerned about chylothorax, refer to the *Heart Institute Chylothorax Clinical Pathway*
6. For additional considerations, please refer to the JHACH Parenteral Nutrition Guidelines or consult with the Dietitian

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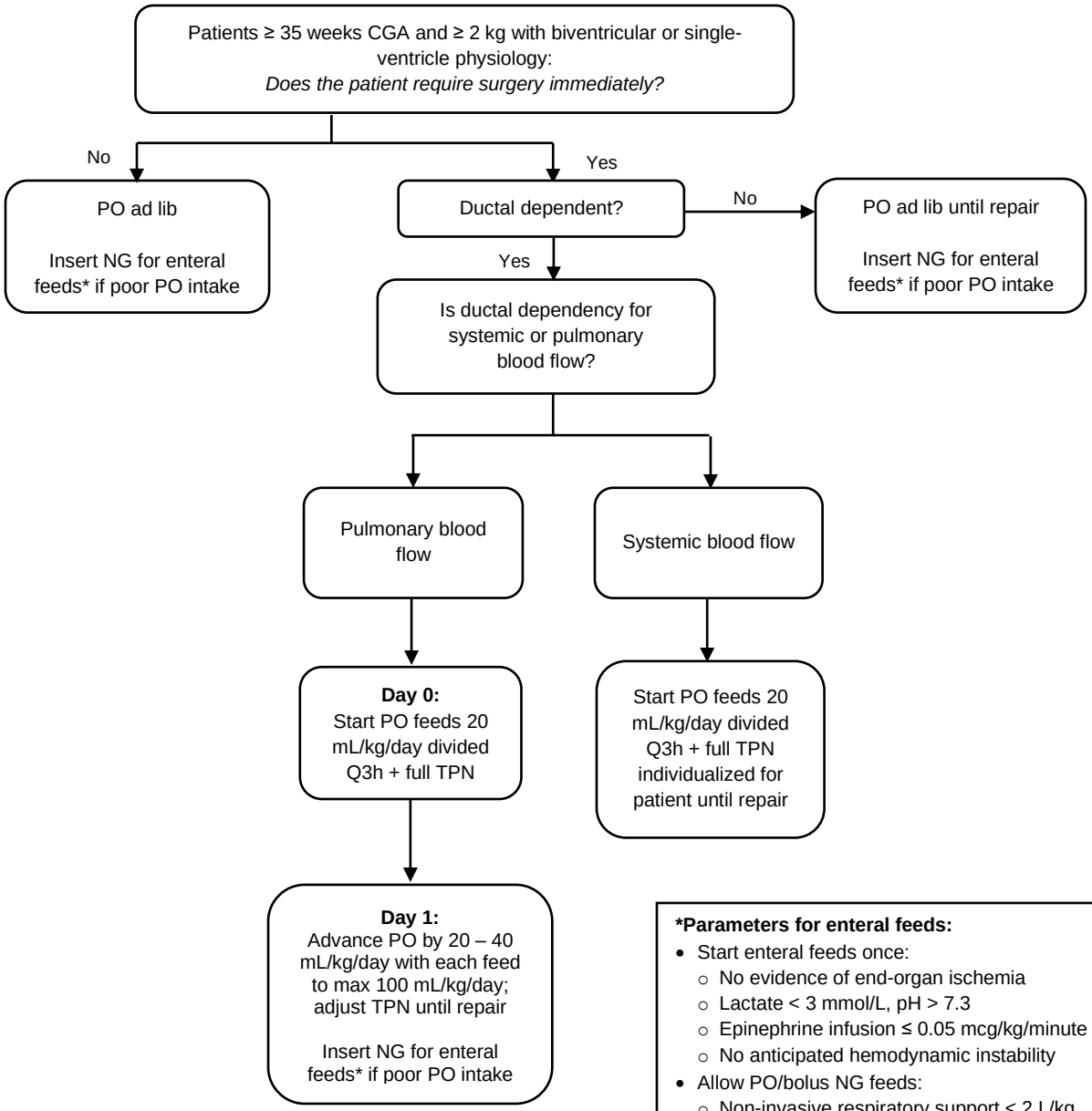
Enteral Nutrition in Neonates with Congenital Heart Disease: Pre-operative Optimized Nutrition Clinical Pathway



***Parameters for enteral feeds:**

- Start enteral feeds once:
  - No evidence of end-organ ischemia
  - Lactate < 3 mmol/L, pH > 7.3
  - Epinephrine infusion ≤ 0.05 mcg/kg/minute
  - No anticipated hemodynamic instability
- Allow PO/bolus NG feeds:
  - Non-invasive respiratory support < 2 L/kg
  - RR < 80 bpm
- Hold feeds if:
  - > 2 large volume emesis in 12 hours
  - Worsening abdominal distension/exam
  - Bloody stools
- If feeds held:
  - Re-evaluate in 1 hour; return to prior step when tolerating
  - If worsening abdominal distention/blood stools, obtain a KUB to evaluate for NEC

Abbreviations: TPN, total parenteral nutrition

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Enteral Nutrition in Neonates with Congenital Heart Disease: Post-operative Optimized Nutrition Clinical Pathway

Patients ≥ 35 weeks CGA and ≥ 2 kg with biventricular or single-ventricle physiology and post-operative repair

Additional Guidance:

- Goal volume/kcal:
  - 140 mL/kg/day or 120 mL/kg/day if intubated
  - Minimum 120 kcal/kg/day
- Hold feeds if:
  - > 2 large volume emesis in < 12 hours
  - Worsening abdominal distension/exam
  - Bloody stools
- If feeds held:
  - Re-evaluate in 1 hour and return to prior step that was being tolerated
  - If worsening abdominal distension/bloody stools, obtain KUB to evaluate for NEC

Does the patient meet criteria for enteral feeds?

- No evidence of end-organ ischemia
- Lactate < 3 mmol/L, pH > 7.3
- Epinephrine infusion ≤ 0.05 mcg/kg/minute
- No anticipated hemodynamic instability

Yes → Low-risk or High-risk?

No → Full TPN until they meet the criteria JHACH Parenteral Nutrition Guidelines

Low-risk

Does the patient meet PO bolus/NG feed criteria?

- Non-invasive respiratory support < 2 L/kg flow
- RR < 80 bpm
- No clinical concern for aspiration
- Speech consult in a patient with arch repair/reconstruction

Yes

Day 0
Start 20 mL/kg/day divided Q3h PO or bolus NG feeds, advance by 1 mL/kg/hour (3 mL/kg if bolus feeds Q3h) every 6 hours + TPN with weans to keep TF at goal (round to nearest whole number)

No

Day 0
Start 20 mL/kg/day continuous feeds, advance by 1 mL/kg/hour every 6 hours via NG/ND tube + TPN with weans to keep TF at goal (round to nearest whole number)

Daily reassess: does the patient meet PO bolus/NG feed criteria?

ADVANCEMENT PLAN
Day 1
Increase by 1 mL/kg/hour every 6 hours towards goal; fortification to 24 kcal/oz once at 80 mL/kg/day if needed

High-risk

- Single ventricle
- Shunts (surgical or ductal stent)
- ECMO
- Prior history of NEC
- Prior history of end-organ ischemia

Does the patient meet PO bolus/NG feed criteria?

- Non-invasive respiratory support < 2 L/kg flow
- RR < 80 bpm
- No clinical concern for aspiration
- Speech consult in a patient with arch repair/reconstruction

Yes

Day 1
Start 20 mL/kg/day divided Q3h via PO or bolus NG feeds for 24 hours + full TPN (round to nearest whole number)

No

Day 1
Start 20 mL/kg/day continuous feeds for 24 hours via NG/ND tube + full TPN (round to nearest whole number)

Daily reassess: does the patient meet PO bolus/NG feed criteria?

ADVANCEMENT PLAN:
Day 2
Increase by 1 mL/kg/hour (3 mL/kg if bolus feeds Q3h) every 6 hours toward goal; begin fortification to 24 kcal/oz once at 80 mL/kg/day; wean TPN to keep TF at goal
(Continuously reassess if patient meets PO bolus/NG feed criteria)

Day 3
Continue to advance every 6 hours to goal; can fortify further if needed
(Continuously reassess if patient meets PO bolus/NG feed criteria)

Abbreviations: ND, nasoduodenal; oz, ounce; TF, total fluids

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Outcome Measures:

Outcome measure: Time to full EN, time to fortification
Process measure: Adherence to feeding guidelines
Balancing measure: Incidence of NEC

Clinical Pathway Team
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Johns Hopkins All Children's Hospital

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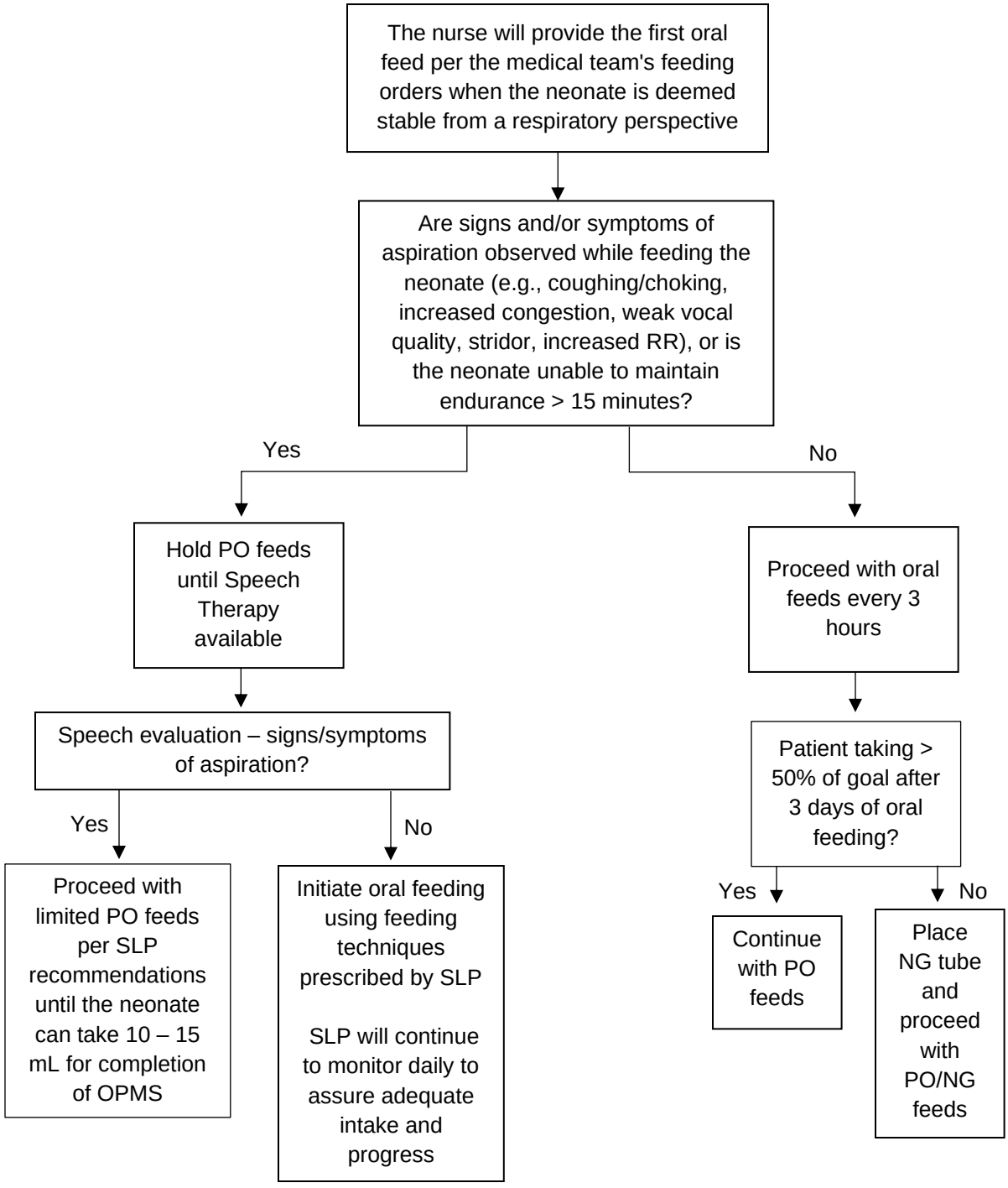
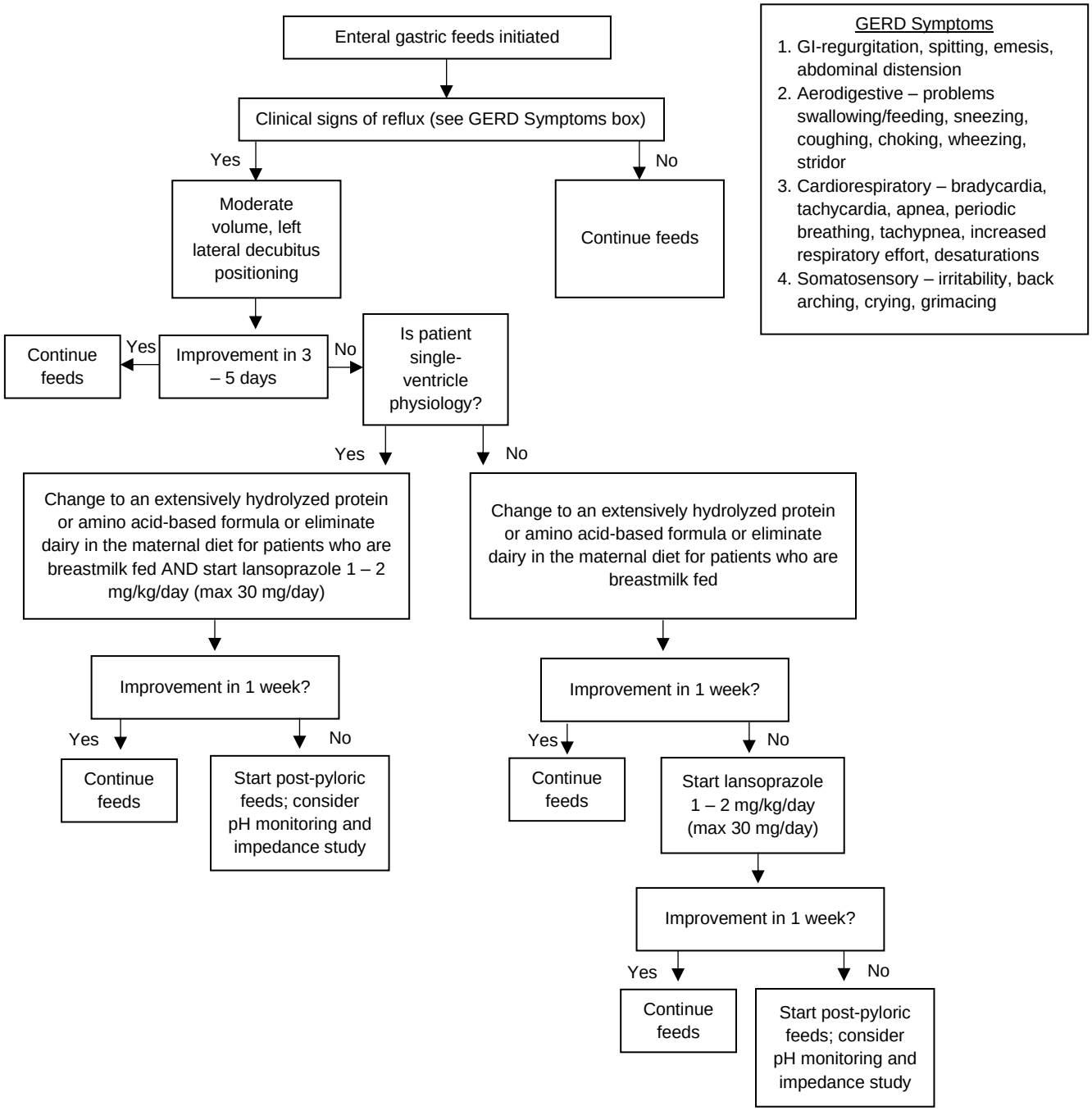
Disclaimer:

Appendix A: Speech Therapy and PO Feeds



Abbreviations: OPMS, Oropharyngeal Motility Study; SLP, Speech-Language Pathologist

Appendix B: Gastroesophageal Reflux Disease



Abbreviations: GI, gastrointestinal

Appendix C

Donor human milk:

It is well understood that neonates with certain CHD are at increased risk for NEC and feeding intolerance. Research has shown that NEC risk decreases with the use of human milk. Therefore, human milk, specifically mother's own milk (MOM), is the preferred source of nutrition for all neonates with cardiac defects.

The nutrients and bioactive properties found in MOM cannot be replicated, and many are lost through the processing of donor human milk (DHM). If providing MOM is not safe or feasible, DHM is preferred for high-risk cardiac neonates as an alternative to formula. Current JHACH criteria for the use of DHM include neonates with (1) CHD that puts them at risk of developing ischemic bowel, (2) history of NEC, (3) intrauterine growth restriction (IUGR) < 3rd percentile

Criteria for use:

1. Diagnoses that qualify:
    a. Single ventricle physiology
    b. High risk for bowel ischemia
    c. History of confirmed NEC
    d. IUGR
2. Signed *Donor Milk Consent Form*
3. Lactation consult if the use of MOM is safe to provide
4. Use of a hypoallergenic formula when fortifying DHM
5. Wean to hypoallergenic formula postoperatively when tolerating feeds at goal volume for 48 hours (refer to Appendix C.1)

Considerations for use:

1. Freezing, pasteurization, and contained transfer can decrease important nutrients and bioactive properties of human milk. Furthermore, the use of DHM has been associated with suboptimal growth. The amount of fortification and/or additives may be higher when compared to MOM.
2. Protein is an important nutrient for growth, especially in critically ill neonates. Human milk, especially DHM, is lower in protein content (refer to Appendix C.2)
3. Feeding human milk continuously or bolus over an extended period can lead to significant nutrient losses in the plastic tubing.
4. If DHM shortages occur, priority will go to the very low birth weight (VLBW) / extremely low birth weight (ELBW) neonates in the Neonatal Intensive Care Unit (NICU)

Hypoallergenic formula:

Due to the increased risk of feeding intolerance in neonates with CHD, when human milk is not available, a hypoallergenic formula is recommended. These formulas are also recommended when fortifying human milk. The use of exclusively hypoallergenic formulas has been adopted by several cardiac centers, although research supporting this practice is limited. The nutrients in these formulas are easier to digest and do not contain intact cow's milk protein. This may help to decrease intolerance, held feeds, and days on TPN.

There are 2 categories of "hypoallergenic" formulas. Refer to the chart below for the most commonly used. They are listed in order of preference as available. Formula shortages may influence availability.

Extensively Hydrolyzed Protein	Elemental / Amino Acid
Alimentum®	EleCare®
Gerber Extensive HA®	Neocate®
Nutramigen®*	PurAmino®
Pregestimil®	Alfamino®

Criteria for use:

1. A hypoallergenic formula will be preferred for all neonates diagnosed with CHD who require formula or breastmilk fortification with formula

Considerations for use:

1. Hypoallergenic formulas are easier to digest and are higher in protein and other micronutrients when compared to standard term formula
2. Except for Nutramigen*, all available hypoallergenic formulas contain medium-chain triglyceride (MCT) oil (ranging from 33 – 55% of total fat)
3. For financial and physiological reasons, suggest a trial of an extensively hydrolyzed formula before an elemental/amino-acid-based formula

Appendix C.1: Donor Milk Weaning Chart

2-Day Transition

	Formula	Donor Milk
Day 1	4 feeds (50% volume)	4 feeds (50% volume)
Day 2	All feeds	---

4-Day Transition

	Formula	Donor Milk
Day 1	2 feeds (25% volume)	6 feeds (75% volume)
Day 2	4 feeds (50% volume)	4 feeds (50% volume)
Day 3	6 feeds (75% volume)	2 feeds (25% volume)
Day 4	All Feeds	---

Appendix C.2: Example Protein Comparison Chart

	Alimentum® 24 kcal/oz	Breastmilk + Alimentum® 24 kcal/oz
Protein Content: (110 kcal/kg)	3.2 g/kg 12% total calories	1.8 g/kg* 7% total calories

	Term	Preterm / Growth Failure
Goals:	2 – 3 g/kg	2 – 3.5 g/kg (9 – 12% total calories)

*Future considerations: Obtain approval for a hypoallergenic protein formula to use on a case-by-case basis (Abbott Extensively Hydrolyzed Liquid Protein Fortifier)