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Pediatric Malnutrition and Fluid Management in Tracheoesophageal Fistula

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ABSTRACT

Esophageal atresia, often accompanied by tracheoesophageal fistula (TEF), is a congenital anomaly that frequently requires urgent neonatal care and surgical repair. Children with TEF are at high risk of early and long-term malnutrition and feeding problems due to preoperative aspiration risk, perioperative fasting, anastomotic strictures, dysmotility, and comorbidities. Appropriate assessment of nutritional status, early targeted nutritional support (enteral and/or parenteral), and careful perioperative fluid and electrolyte management are critical to reduce complications, support healing, and optimize growth. This review synthesizes contemporary evidence on the epidemiology and mechanisms of malnutrition in TEF, nutritional assessment and strategies (TPN, gastrostomy, tube feeding, early oral feeding pathways), and perioperative fluid management principles tailored for neonates and malnourished children with TEF.

Keywords: pediatric anesthesia; perioperative strategies; esophageal atresia

INTRODUCTION

Esophageal atresia with or without tracheoesophageal fistula (TEF) affects approximately 1 in 2,000–3,500 live births and poses immediate airway and feeding challenges in the newborn period. Early management focuses on airway protection, avoidance of aspiration, and surgical repair; however, nutritional risk is a central issue from birth through long-term follow-up. Undernutrition in TEF can be caused by prenatal factors (prematurity, low birth weight), perioperative NPO status, prolonged dependence on parenteral/enteral tube feeding, oral aversion, strictures and dysmotility, and associated anomalies that increase metabolic demands or limit feeding tolerance. Growth faltering is reported frequently during the first year of life and may persist. Optimizing perioperative fluid therapy and nutritional strategies is, therefore, foundational to clinical outcomes.

DISCUSSION

From recent systematic reviews, specialty guidelines, and key observational and interventional studies, to addressing nutrition and fluid care in TEF and neonatal surgical patients. Priority was given to evidence from the past 10 years and to clinical practice guidelines and consensus statements where available. Multiple cohort studies report high rates of malnutrition and growth impairment in children with TEF from epidemiology studies such as:

- Reports indicate early undernutrition and stunting are common in the first year of life among infants with EA; prevalence estimates vary across cohorts, but underweight or malnutrition has been reported in notable proportions, especially in patients with complex or long-gap TEF or associated anomalies.

- Long-term nutritional problems persist for some children and require longitudinal monitoring and multidisciplinary interventions. The International Network on Oesophageal Atresia (INoEA) emphasizes nutritional issues as a major long-term concern.

Key mechanisms of the pathophysiology of TEF include:

1) *Preoperative factors:* polyhydramnios pre-birth and in-utero factors, prematurity, and low birth weight increase baseline vulnerability. Aspiration risk from secretions and TEF leads to frequent respiratory complications and feeding avoidance.

2) *Perioperative fasting and delayed enteral feeding:* neonates are kept NPO to reduce aspiration risk and to allow anastomotic healing; this may necessitate prolonged parenteral nutrition in some cases.

3) *Postoperative complications:* anastomotic leak, stricture formation, gastroesophageal reflux disease (GERD), esophageal dysmotility, and recurrent respiratory infections reduce oral intake and absorption.

4) *Neurodevelopmental and feeding behavior:* oral aversion and disordered feeding skills after prolonged tube dependence or repeated interventions.

Combined, these factors increase the risk of both acute malnutrition and chronic growth impairment. That is why nutrition needs to be assessed, including:

- *Anthropometry:* weight-for-age, length/height-for-age, weight-for-length/BMI-for-age (WHO or local growth charts). Serial growth plotting is more informative than single measurements.

- *Biochemical markers:* electrolytes, albumin/ prealbumin (recognize limitations in acute illness), full blood count, zinc/iron/vitamin D as indicated; glucose monitoring in neonates at risk of hypoglycemia.

- *Feeding assessment:* swallow studies, speech/ feeding therapist evaluation, observation of oral feeding tolerance, and measurement of caloric intake vs. estimated requirements.

- *Risk stratification:* identify preterm, SGA, associated CHD, or other anomalies as high risk for poor nutrition and prolonged dependence on tube/ TPN.

1. Preoperative and immediate perioperative nutrition

NPO and airway management: initial stabilization focuses on airway protection and suctioning; infants are kept NPO to prevent aspiration until definitive management. Early insertion of a Replogle tube to continuous suction is commonly recommended preoperatively to reduce aspiration.

Parenteral nutrition (TPN): Because NPO status can be prolonged, TPN is frequently used to meet metabolic needs in the immediate perioperative period. TPN choice and caloric targets should take into account prematurity, metabolic stress, and fluid/electrolyte balance. TPN reduces catabolism but carries infection and metabolic complication risks; therefore, early transition to enteral intake as soon as safe is desirable.

2. Enteral strategies: nasogastric/og feeds, gastrostomy, jejunostomy

Early tube feeding: When anatomically feasible (e.g., distal fistula ligated or after anastomosis heals), carefully advanced enteral feeding (via nasogastric, orogastric, or gastrostomy) supports gut integrity and reduces TPN-related risks. Feeding protocols commonly transition from parenteral → trophic enteral feeds → progressive bolus or continuous feeds, assessing anastomotic integrity first (contrast study).

Gastrostomy/jejunostomy: For long-gap EA or prolonged feeding difficulties, gastrostomy (± fundoplication) or jejunostomy may be used for reliable enteral delivery and growth support—especially in children at risk for aspiration or severe dysmotility. Early gastrostomy has been reported to be beneficial in selected extremely low birth weight or complex cases to secure growth.

Weaning and oral feeding rehabilitation: Speech and feeding therapy, staged oral trials, and behavioral strategies reduce oral aversion and encourage oral intake. Multidisciplinary protocols that include serial swallow assessments and graduated feeding steps are associated with improved transition outcomes.

3. Energy and macronutrient targets

Caloric and protein needs should be individualized: neonates and infants have high energy needs, amplified by surgical stress and infection. Published perioperative nutrition reviews recommend aiming for age-appropriate targets adjusted for stress, but exact numbers should be tailored by pediatric dietitians and clinicians. Early incremental feeding minimizes refeeding complications in malnourished patients.

Perioperative fluid management principles and TEF-specific considerations: Perioperative fluid management in neonates and malnourished children requires balancing hydration, perfusion, avoidance of electrolyte disturbances (especially hyponatremia), and limiting fluid overload that could affect respiratory function.

Neonates have relatively higher total body water and a greater insensible fluid loss per body weight; they are susceptible to hypoglycemia and hyponatremia with prolonged fasting. Isotonic crystalloids are preferred to minimize hyponatremia risk; glucose-containing fluids are indicated to prevent hypoglycemia in neonates. To conclude, the goal of fluid management is to maintain intravascular volume, ensure organ perfusion, maintain electrolyte homeostasis, and supply maintenance glucose/energy. For major neonatal surgery (e.g., thoracotomy for EA repair), fluid therapy may be outcome-directed (goal-directed) with attention to blood loss and third-space shifts.

Malnutrition-specific cautions:

- *Severe acute malnutrition (SAM) alters fluid distribution and cardiovascular responses:* children with SAM tolerate volume shifts poorly and are at increased risk of fluid overload and cardiac failure if aggressive resuscitation is attempted. WHO guidance for fluid management in SAM emphasizes cautious rehydration and avoidance of rapid volume changes. While these guidelines address broader SAM contexts, the principles apply when EA patients are severely malnourished.

- *Electrolyte repletion and monitoring:* malnourished infants often have depleted intracellular electrolytes (K+, Mg2+, phosphate) despite normal serum levels; refeeding or fluid administration can precipitate electrolyte shifts (refeeding phenomena). Hence, monitor and correct electrolytes proactively.

Practical perioperative recommendations for TEF patients:

1) *Preoperative optimization:* correct dehydration, electrolytes, and hypoglycemia before surgery when possible; start TPN or enteral feeds as clinically indicated to improve nutritional reserves. High-risk infants (preterm, SGA, cardiac anomalies) deserve particular attention.

2) *Maintenance fluids:* use age-appropriate isotonic crystalloids with glucose (e.g., isotonic balanced solutions with dextrose appropriate for neonatal glucose requirements) rather than hypotonic fluids to reduce hyponatremia risk; tailor volume to minimal necessary maintenance plus replacement of losses.

3) *Intraoperative management:* apply goal-directed principles, monitor blood loss and urine output, and consider dynamic measures of volume status in older infants when feasible; avoid unnecessary fluid overload that could worsen pulmonary mechanics post-thoracotomy.

4) *Postoperative period:* transition from IV to enteral nutrition as soon as anastomotic integrity and clinical status permit; continue close electrolyte monitoring. For malnourished children, gradual advancement of calories and careful monitoring for refeeding syndrome are essential.

Complications and outcomes linked to poor nutrition and fluid mismanagement:

- *Increased infectious complications, delayed wound healing, longer length of stay, and higher costs:* impaired nutritional status is associated with a higher risk of postoperative infections and prolonged hospitalizations in pediatric surgical cohorts. Proactive nutrition improves outcomes.

- *Respiratory morbidity:* fluid overload can exacerbate pulmonary edema and impair respiratory function, a critical consideration after thoracotomy or in infants with pre-existing respiratory issues from aspiration.

- *Anastomotic healing:* adequate protein-calorie provision supports wound tensile strength and reduces risk of complications; conversely, malnutrition can increase anastomotic leak risk, though data specific to EA anastomosis are limited.

Multidisciplinary models of care and quality improvement

Best practice emphasizes a team approach: neonatology, pediatric surgery, pediatric anesthesia, nutrition/dietetics, speech and feeding therapy, occupational therapy, and nursing. Standardized pathways for nutrition (preop optimization, TPN indications, criteria for contrast swallow and initiation of feeds, staged feeding protocols) and explicit fluid protocols reduce variation and improve transitions from hospital to home. INoEA and specialty societies recommend standardized follow-up focusing on growth, feeding skill development, GERD management, and stricture surveillance.

Gaps in knowledge and research priorities

- High-quality randomized trials comparing early enteral vs prolonged parenteral strategies specific to EA populations are limited.

- Optimal caloric/protein targets during perioperative stress in EA are not uniformly defined.

- Evidence-based, EA-specific fluid protocols for malnourished neonates (stratified by SAM severity) are lacking; much guidance comes from broader neonatal surgical or SAM literature.

- Longitudinal studies linking early nutritional interventions to adolescent/adult outcomes (growth, pulmonary function, quality of life) are needed.

Practical summary and recommendations (evidence-informed)

1) *Early risk stratification:* identify high-risk infants (premature, SGA, long-gap EA, associated anomalies) and involve nutrition/dietetics early.

2) *Stabilize airway and minimize aspiration risk:* use Replogle suctioning preoperatively; NPO status until safe.

3) *Provide timely nutritional support:* use TPN when enteral feeding cannot meet requirements; transition to enteral feeds as soon as clinically safe. Consider gastrostomy for prolonged needs or long-gap EA.

4) *Fluid therapy:* Use isotonic fluids with appropriate glucose for maintenance in neonates; be cautious in severely malnourished infants, follow SAM rehydration principles, and monitor electrolytes closely. Avoid fluid overload.

5) *Monitor and prevent refeeding complications:* correct electrolytes and start feeds incrementally in severely malnourished children.

6) *Multidisciplinary follow-up:* schedule routine growth and feeding assessments post-discharge and offer speech/feeding therapy early to support oral feeding transition.

CONCLUSIONS

Malnutrition and fluid or electrolyte management are central determinants of outcomes in neonates and children with TEF. A proactive, protocolized, and multidisciplinary approach balances the risks of

aspiration and anastomotic complications with the harms of prolonged malnutrition using TPN judiciously, advancing enteral feeds when safe, and applying careful fluid therapy tailored to neonatal physiology and malnutrition status offer the best opportunity to improve short and long-term outcomes. Substantial gaps remain in TEF-specific high-quality evidence, and future research should prioritize standardized nutrition protocols, fluid therapy trials, and long-term growth and functional outcome studies.

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