FUNDOPLICATION

Surgical Specialty:	General Surgery
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Background:

- General Considerations
  - Fundoplication is the surgical treatment for severe gastroesophageal reflux disease (GERD) commonly due to an incompetent lower esophageal sphincter (LES).
  - The LES becomes functionally mature at 1-2 months of life.
  - The anterior and posterior walls of the stomach are sutured together around the lower esophagus to reinforce the closing function of the LES.
  - May be performed as an open or laparoscopic procedure.
  - Given the elective nature of the procedure, contraindications include uncorrected coagulopathy, hemodynamic instability, and distal GI obstruction.
- Patient Considerations
  - Severe and uncontrolled GERD
    - Severe GERD can cause chronic lung disease including (but not limited to) pneumonitis, bronchiolitis, chronic aspiration pneumonia and/or fibrosis.
    - Lower esophageal reflux alone can cause an increase in vagus nerve activity predisposing to bronchospasm.[1]
    - Chronic GERD can also cause esophageal strictures and bleeding
    - Esophagitis can present as the inability to tolerate feeding with malnutrition and failure to thrive. As a result, many patients present with a gastric tube (G-tube) already in place.
  - Associated Comorbidities/Syndromes
    - Due to parasympathetic and sympathetic involvement in regulating LES tone, children with severe neurological disease are particularly prone to severe GERD.[1]
    - Children with prior surgeries involving the esophagus (tracheoesophageal repair or diaphragmatic hernia repair) are also at high risk for an incompetent LES.[1]

Anesthetic Planning:

- Pre-Anesthetic Evaluation
    - Evaluate respiratory status carefully and elicit historic response to bronchodilators given predisposition to bronchospasm.
        - Ensure the patient is optimized from this standpoint.
        - Consider pre-treatment with albuterol in the preoperative area.
    - Consider the surgical approach (laparoscopic versus open) and whether comorbidities necessitate an open approach from the anesthetic perspective, for example, patients who may be unable to tolerate the hemodynamic effects of pneumoperitoneum.
    - Additional labs/tests indicated during work-up
        - No special labs are required.
        - Review chemistry, complete blood count, and coagulation panel as appropriate to assess kidney and liver function, electrolyte derangements, and bleeding concerns.
        - For laparoscopic cases, confirm cardiopulmonary history & review pertinent studies.
    - Discussions to have with the surgeon and family
        - Many of these patients are at increased risk for aspiration and complications associated with this need to be disclosed.
        - Plan for oral intake postoperatively (i.e., how long do medications need to remain IV versus enteral and when the patient can start oral nutrition, etc.)
        - Code Status as indicated by patient factors.
    - Pre-Anesthetic Anxiolysis
        - Premedication may be indicated to ease anxiety and/or facilitate peripheral intravenous (PIV) line placement in patients requiring rapid sequence intubation (RSI).
        - Consider intranasal midazolam (0.2-0.4 mg/kg) or dexmedetomidine (1-2 mcg/kg) for patients at high risk of aspiration with oral medications (if no G-tube is present).
- Specific or Unique Room Set-up Requirements
    - Airway
        - Whether open or laparoscopic, endotracheal tube (ETT) placement with RSI as appropriate is recommended for airway securement and reduction of aspiration risk.
            - Utilize cuffed ETT to allow for positive pressure ventilation, particularly in laparoscopic cases.
                - In a child with a pre-existing tracheostomy, either exchange uncuffed tracheostomies for a cuffed ETT or inflate the cuff of a cuffed tracheostomy to allow for proper ventilation.
    - Drugs/Infusions
        - Standard induction and maintenance medications unless patient-specific factors indicate otherwise.
            - Includes anxiolytic, analgesic, amnestic, and paralytic.
        - Antibiotic per surgeon preference and patient-specific indications.
        - Postoperative nausea and vomiting prophylaxis based on patient risk factors.
            - Dexamethasone 0.1 mg/kg IV
            - Ondansetron (3 years and older) 0.1 mg/kg IV
            - Consider propofol infusion (20-25 mcg/kg/min) for high-risk PONV

        - Consider dexmedetomidine for postoperative delirium prevention (total 0.5mcg/kg IV).
    - Monitors
        - Standard ASA monitors.
        - Consider an arterial line if the patient has significant cardiac or pulmonary comorbidities.
        - Nasogastric or orogastic tube (NG/OGT) to be placed for stomach decompression, suctioning, and to act as a bougie to prevent an excessively tight wrap from the surgical procedure.[2]
    - Blood Availability
        - Not indicated.
    - PICU Bed Availability
        - Not indicated as a direct outcome of this surgery unless the patient has other comorbidities necessitating ICU level of care.
    - Other Indicated Resources (ex. ECMO standby)
        - None.

Intraoperative Considerations:

- General
    - A laparoscopic approach is primarily associated with several physiologic effects related to:
        - Peritoneal stretch and carbon dioxide (CO_2) absorption secondary to insufflation.
        - Use of reverse Trendelenburg positioning.
    - Pneumoperitoneum effects include[3]
        - Increased intraabdominal pressure
            - Causes compression of splanchnic vessels leading to increased sympathetic tone and vasoconstriction.
                - The outcome is increased venous return and cardiac output.
        - Rapid insufflation can trigger increased vagal tone
            - Manifests as bradycardia; may lead to cardiac arrest if untreated.
            - Consider glycopyrrolate (0.005-0.01 mg/kg IV) pretreatment in high-risk patients.
        - Reduced lung volumes and compliance
            - Causes atelectasis and resultant V/Q mismatch.
            - Manifests as hypercarbia & hypoxemia.
        - Diaphragm elevation
            - Elevation of the diaphragm following insufflation may lead to inadvertent endobronchial intubation.
    - Reverse Trendelenburg positioning can lead to decreased venous return with a reduction of cardiac output and resulting hypotension.
- Induction
    - PIV placement in the preoperative period may be preferable to allow for RSI. If this is not possible, or for lower-risk patients, an inhalational approach may be used.
- Positioning
    - Supine with arms tucked and appropriately padded.
    - Reverse Trendelenburg is typically required; see Anesthetic & Physiologic Implications above.
    - Confirm ETT placement with any position change as well as after insufflation.

- Maintenance
  - Volatile anesthetic unless specific patient comorbidities necessitate otherwise.
- Hemodynamic/Physiologic Goals
  - Normal heart rate, normotension, normovolemia.
  - Monitor end-tidal CO_2 and prevent excessive hypercarbia due to absorbed CO_2 from insufflation by adjusting the ventilator with increased tidal volume and/or respiratory rate as appropriate for patient size.
- Surgical Considerations
  - Place NG/OGT as requested by the surgical team. Likely this will be used as a bougie to prevent an overly tight wrap as well as for possible stomach insufflation as requested by the surgical team.
  - There is the possibility of removing the NG/OGT and replacing it with a separate bougie as indicated by the surgeon's preference.
    - Whether an NG/OGT or bougie is placed, DO NOT force placement. If meeting resistance, inform the surgical team and allow them to insert it to decrease the risk of esophageal perforation.
  - Muscle relaxation
    - Paralysis may be indicated in larger children to minimize intraabdominal pressures and diaphragm movement interfering with the surgical field, but can sometimes be omitted in infants and small children.
    - Reverse neuromuscular blockade as indicated with sugammadex or neostigmine and glycopyrrolate.
  - Blood and fluid losses should be minimal, particularly with the laparoscopic approach.
- Emergence/Disposition
  - Awaken to extubate postoperatively.
  - Transfer to post-anesthesia care unit, then hospital floor bed, unless the patient has comorbidities requiring ICU level care.
- Post-op Pain
  - Multimodal pain management is preferred
    - IV versus enteric medications including acetaminophen and opioids.
    - Ketorolac or other NSAIDs if minimal bleeding intraoperatively and acceptable per the surgical team.
    - The surgical team can inject local anesthetic intraoperatively at incision sites.
  - Consider regional/neuraxial anesthesia if an open procedure is planned
    - Data suggests that epidural anesthesia provides better short-term outcomes, particularly in neurologically impaired children at high risk for postoperative mechanical ventilation as well as autonomic instability.[4]

Case-Specific Complications/Pitfalls

- Perforated Esophagus
  - Potentially due to NG/OGT or bougie placement. Most commonly occurs at the gastroesophageal junction.
- Esophagus sliding out of the wrap leading to decreased LES tone
  - Will likely present as continued GERD symptoms post-operatively.
  - Requires surgical evaluation if suspected.
- Overtightening of LES with surgical sutures
  - Creates an esophageal stricture which can present as dysphagia postoperatively, particularly to solids.

- Avoid esophageal temperature probes as they can interfere with the surgical procedure or get caught in the suture line.
- Complications associated with laparoscopy and insufflation, including, but not limited to:
  - Subcutaneous administration of insufflation.[3]
    - This leads to rapid hypercarbia, which can be addressed via an increase in minute ventilation and fresh gas flow.
    - If this is inadequate, stop insufflation and verify trocar placement.
  - Post-operative referred shoulder pain secondary to insufflation[2]
    - Due to residual sub-diaphragmatic gas.
    - Typically self-resolves within 24-48 hours.
  - Subcutaneous emphysema
    - Common and presents as postoperative crepitus in abdominal, chest, or neck tissues.
    - Typically self-resolves within 24-48 hours.
  - CO_2 embolism[5]
    - Due to the introduction of CO_2 from insufflation to vasculature via direct injection or injury.
    - Causes sudden hypotension, hypoxemia/cyanosis, and arrhythmias.
    - Treatment includes notifying the surgical team, desufflating the abdomen, increasing fresh gas flow as well as FiO_2 to 100%, moving the bed into head down position, and providing supportive care.

References

1. Smith G, Aitkenhead AR, Moppett IK, Thompson JP. Chapter 33: Anesthesia for General Abdominal, Urologic Surgery. Smith and Aitkenhead's Textbook of Anaesthesia. *Textbook of Anaesthesia*. 2013
2. Andropoulos, Dean B., and George A. Gregory. Chapter 31: Anesthesia for Abdominal Surgery. *Gregory's Pediatric Anesthesia*. Sixth Ed. Wiley Blackwell, 2020.
3. Sims C, Weber D, and Johnson C, Ed. Chapter 15: Anesthesia for Pediatric General Surgery. *A Guide to Pediatric Anesthesia.* Second Ed. Springer, 2020.
4. Wilson GA, Brown JL, Crabbe DG, Hinton W, McHugh PJ, Stringer MD. Is epidural analgesia associated with an improved outcome following open Nissen fundoplication? *Paediatric Anaesthesia*. 2001;11(1):65-70. PubMed Link
5. Gutt CN, et al. Circulatory and Respiratory Complications of Carbon Dioxide Insufflation. *Dig Surg*. 2004;21:95-105. Doi:10.1159/000077038 PubMed Link

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