Technologic Devices for Medically Complex Children

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Introduction

- Advances in pediatric medicine have enabled children to survive life-threatening illnesses (prematurity, anomalies, HIE, TBI)
- 12 million children with special health care needs
- Healthy children with simple, self-limited acute illness are less likely to be hospitalized
- More chronic illnesses with acute exacerbations or consequences of underlying illness
- Knowing how to troubleshoot equipment failures is foundation for providing optimal delivery of care

Devices

- Enterostomy Tubes
- Tracheostomy Tubes
- Chest Tubes
- Central Venous Lines
- Cerebrospinal Fluid Shunts
Enterostomy Tubes

- NG / NJ tubes appropriate in short term <3 months
- Gastrostomy
- Gastrojejunostomy
  - Allows J-feeds and venting stomach
- Jejunostomy

Indications

- Failure to Thrive
- High Risk of Aspiration
- Oral Motor Feeding Problems
- Mechanical esophago-pharyngeal obstruction
  - Oclusion, Stricture, Atresia
- Altered Absorption or Metabolism
  - Requires continuous feeds
- Unpalatable Diets or Medications
  - Metabolic diets
  - HIV medications
- Severe Gastroesophageal Reflux

Placement

- Surgically
  - Laparotomy or Laparoscopy
  - +/- Fundoplication
  - Enterostomy tube may worsen GERD
- Endoscopic
- Radiographic
  - Guided placement of tube into jejunum
- Questions about tube before mature stoma should be directed to placing service
- Replaced by low profile button at 2-4 months
- Revisions required in 6% of patients
- GJ Tubes have higher risk of needing revised
Placement

- Placed for 8 weeks to allow track to heal and verify the stomach is adhered to abdominal wall.
- Removed in surgery clinic 8 weeks post-op to low profile tube
- Needs to be secured so tube does not migrate inward obstructing flow of feeds
- Small roll of gauze is placed next to tube to keep it perpendicular to the skin and secured with a flexitract

Low Profile Buttons
**Microvasive Bard Gastrostomy**
- Positives: Secure, Low Maintenance (no balloon), Less Granulation Tissue, Only changed if malfunctioning
- Negatives: No Lock for Continuous feeds, painful to change, must be done by surgery APNs

**Gastrojejunostomy Tube**

**Major Complications**
- May be more difficult to recognize in a neurologically impaired population
- Surgical (19.9%) > Endoscopic (9.4%) > Radiologic (5.9%)
- Dislodgement before maturation
  - Before 4 weeks
  - Likely requires repeat procedure
  - Peritonitis: separation of stomach from abdominal wall
  - After 8 weeks, parents can insert foley until location determined radiologically
More Major Complications

- Intraop aspiration
- GI Bleeding
- Peritonitis
- Severe Wound Infection / Sepsis
- Intussusception
- Fistula – gastrocolocutaneous
  - Diarrhea “like formula”
  - Aspiration of fecal material
- Pneumoperitoneum – expected but can mask underlying pathology

Infections

- vs. Irritant Dermatitis
  - Tape Sensitivity, Leakage
  - Keep area dry and use barrier agents
  - Stomahesive Powder
- 20% w/ infection
- Localized – cleaning, local antibacterial treatment and oral antibiotics
- Cellulitis – systemic antibiotics
  - Staph / Strep = 1st generation cephalosporin
  - ?? MRSA
  - Fungal = topical clotrimazole
- Necrotizing Fasciitis – surgical and infectious emergency
Granulation Tissue

- Most common problem
- Friable, Red and Bleeds Easily
- Can cause leakage, irritation, pain
- Confused with gastric prolapse

Warm Compresses

Silver Nitrate Sticks once a day until gone

Triamcinolone Cream in conjunction with silver nitrate for large ones
Minors Complications

- Dislodgement after Tract Maturation
  - Stoma may close within hours to days
  - Gently insert correct sized foley or spare gastrostomy tube
  - Aspirate gastric contents / insert 10-15 ml of air and listen
  - No radiographic study needed if uncomplicated

- Blockage
  - Duodenum by balloon
  - Warm water, Carbonated Drinks, Pancreatic Enzymes
  - No stylet or other device

More Minor Complications

- Leakage
  - From tube? Or Around Tube
  - Excess mobility w/ leakage is difficult to treat
  - Air Drying, Barrier Agents, Sucralfate Powder, Acid reducing agent, Temporary GJ tube or NPO
  - Removal of Tube for days to weeks to allow stoma to shrink

- Buried Bumper Syndrome
  - Excess Traction leads Internal Bumper to Erode through stomach wall with re-epithelialization covering
  - Rotate tube up to 4x’s / day
  - Abdominal pain with feeds, resistance to flow, inability to rotate tube
  - Requires removal and replacement
Tracheostomy Tubes

- **Indications**
  - Upper Airway Obstruction
    - Congenital or acquired
  - Unable to protect airway
    - Excess secretions
  - Long-term mechanical ventilation
    - Chronic lung disease
    - Traumatic Brain Injury

- **Important Characteristics**
  - Size and dimensions
    - Length
    - Inner diameter
      - 2.5mm to 10mm
      - Same as ET tube
      - Imprinted on flange
    - Outer diameter
      - Varies considerably among manufacturers
      - May need to "downsize" due to different O.D.
  - Cuffed or uncuffed
    - Needs to be deflated before a change
    - Even infants may have cuffed tube
    - Bivona – fill with water or saline
  - Inner cannula
    - For precarious airways
    - Removed for cleaning while outer cannula remains in place
    - Must be in place for assisted ventilation
  - 7 Fenestration
    - Use to phonate
Optimal Size and Shape

- Adequate Diameter to Prevent Airflow Restriction
- Prevents aspiration
- Allows vocalization
- Does not exert pressure on mucosa

Tracheostomy Sizes

<table>
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<tr>
<th></th>
<th>Slavy*</th>
<th>Holinger*</th>
<th>Parson*</th>
<th>Brown*</th>
<th>Serdart*</th>
<th>ET**</th>
<th>Section Call</th>
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<tr>
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<td>6F</td>
<td>6F</td>
<td>3O</td>
<td>3F</td>
<td>—</td>
<td>3.5F</td>
<td>5F (bronch)</td>
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<tr>
<td>Newborn</td>
<td>6F</td>
<td>6F</td>
<td>3F</td>
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<td>3.5F</td>
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<td>5F (bronch)</td>
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<tr>
<td>Newborn</td>
<td>4F-5F</td>
<td>4F-5F</td>
<td>3F</td>
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<td>3.5F</td>
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<td>5F (bronch)</td>
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<tr>
<td>6-12 mo</td>
<td>3-3.5F</td>
<td>3.5-4F</td>
<td>3.5-4F</td>
<td>3.5-4F</td>
<td>3.5-4F</td>
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<tr>
<td>13 mo-2 yr</td>
<td>2F</td>
<td>2.5-3F</td>
<td>3.5-4F</td>
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<td>3.5-4F</td>
<td>3F</td>
<td>5F (bronch)</td>
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<tr>
<td>3-4 yr</td>
<td>2F</td>
<td>3F-4F</td>
<td>4F</td>
<td>4F</td>
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<td>3F</td>
<td>5F (bronch)</td>
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<tr>
<td>5-12 yr</td>
<td>4F</td>
<td>5F-6F</td>
<td>6F-7F</td>
<td>6F-7F</td>
<td>6F-7F</td>
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<tr>
<td>13-15 yr</td>
<td>4F</td>
<td>5F-6F</td>
<td>6F-7F</td>
<td>6F-7F</td>
<td>6F-7F</td>
<td>5F</td>
<td>5F (bronch)</td>
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NOTE: Tracheostomy tubes in infants and young children are usually secured because the airway tends to slide with the underlying tracheostomy tube.

* Based on internal diameter in millimeters.

** For reference, sizes with alternate lengths.

Maintenance
- Change tube weekly
- Need back up tube
- Suction prn
  - Measured depth
- Chain
  - Once a week changes
  - Clean 1-2x/d with alcohol or soap/H2O
- Ties
  - Changes 1-2x’s/d
  - Redness from residual soap

Heat-Moisture Exchanger

Standards Hospital Care
- 24 hour 1:1 care from trained provider
- Frequent RT care and input
- Attention to clearance of secretions
- Humidification
- Available trachs of same size and one size smaller
- Cuffed tubes should be very apparent
Complieations

- Most common
  - Accidental decannulation
  - Obstruction
    - Respiratory distress considered to have obstruction or dislodgement until proven o/w
    - Emergent tx – rarely encountered by physician
- False passage
  - Do not be falsely reassured by tracheostomy tube entering stoma
- Pneumothorax / mediastinum

Infection

- Candidiasis – nystatin powder
- Peritracheal cellulitis
  - Oral antibiotics and local wound care
  - Leads to mediastinitis if untreated
- Lower airway infection
  - Colonized with Staph aureus, Pseudomonas, Candida
  - Normal secretions are clear to white
  - Abnormal secretions are thick, yellow, green, brown or bloody
  - Positive tracheal aspirate, change in respiratory status, fever ↑38°C – start antibiotics
  - Tracheal aspirate is not beneficial in diagnosing viral infections
    - Need nasal aspirate for RSV or influenza

Bleeding

- Inadequate humidification
  - Dry and friable mucosa
  - Ensure heat-moisture exchanger is being used consistently
- Suction trauma
- Granulation tissue
  - Tip of tube or at the cuff
  - Stoma – use silver nitrate
- Erosion into innominate artery
  - Tube should be kept in place – only way to ensure adequate airway
  - Try inflating cuff to tamponade vessel
Skin Breakdown

Emergent Change
- Best performed by two people
  - One secures patient, deflates cuff
  - Other removes and replaces
- Supplies readily available
  - Replacement cannula
  - ETT of smaller size
  - Lubricant
  - Securing Tape or Ties
  - Suction, O2
- Supine with neck extended
- Gentle pressure and arc-like motion
Unable to pass?
- Insert tracheostomy tube ½ size smaller
- Insert endotracheal tube ½ size smaller
  - Careful not to right mainstem
  - Dilate stoma w/ successively larger ETT
- Cover stoma and BVM using upper airway
  - Oral intubation may be exceptionally difficult
    - Especially with UAO
  - NMB should be used with caution

Preparation for Home
- Good training of 2 adult care givers
- Safety
- Cleanliness
- Mortality rate of children with tracheostomy – 11-40%.
- Mortality from complication is rare

Chest Tubes
Maintenance

- ?? Antibiotics
  - No study to show decreased incidence of infxn’s
- Suction to 20 cm H2O
- X-ray
  - Obtain 4 hours after making changes
- Never clamp the tube
- Water seal = off suction

Chest Tubes: Removal

- Removal
  - Indication for placement is gone
  - Minimal pleural drainage - <2ml/kg/d
  - No air leak
  - chest X-ray/assessments confirm re-expansion
- Pre-medicate for pain
- Breathe in & hum out (have pt practice)
- Chest Tube is quickly removed
- Occlusive dressing applied over insertion site
- Pleura seals itself off
- Chest wound heals within a week

Central Venous Lines

- Types
  - External partially implanted / tunneled
    - Broviac, Hickman
    - Groshong – Valve on distal tip prevents back-bleeding; No heparin
  - Totally implanted w/ SubQ port
    - Portacath, Mediport, Infusaport
  - Percutaneously inserted
    - PICC, CVL
- Indications
  - Intermittent infusions
  - Chemotherapy
  - Chronic Transfusions
  - Frequent Blood Draws
  - TPN
**Thrombosis**

- Occurs with all CVCs
- Symptomatic 4.6-9%
- Involves
  - Only catheter,
  - Insertion vessel,
  - Extension
- Pulmonary embolus
  - Asymptomatic 57%

**Infection**

- Exit site
  - Induration, tenderness, erythema, +/- purulent drainage
- Subcutaneous Tunnel
- Sepsis – 4-9%
- Risk factors
  - Frequency of accessing line, 1st month of placement, after 24 months of use, thrombosis or fibrin sheath
  - No difference in risk for different dressing
- Organisms
  - Skin flora
  - Immunocompromised – GNR and Yeast
- Treatment
  - GPC – treat through then antibiotic lock w/ vanc and urokinase
  - GNR or yeast – remove

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**Do you have time for a 15 second alcohol scrub?**

These caps were coated with "microbial" powder that is visible under a black light. Notice the difference in amount of contaminant on the port that had been scrubbed for 15 seconds.

**IT COUNTS!**
Reduce Infections
- “Scrub the hub”
  - No consensus on time or agent
- Decrease the number of entries
  - Use Peripheral IV if possible
  - Coordinate blood draws
- Adequate dressing changes
  - Transparent 7 days unless soiled or loose
  - Gauze every 48 hrs
  - Date is on dressing – Check it
- Remove the line ASAP

Malfunction
- Total occlusion, doesn’t infuse, doesn’t draw, intermittently nonfunctional
- Trendelenburg positioning, raise the arm, hydrate, cough, valsala
- Thrombolytic agents
  - Urokinase 200 to 5000 U for 30 minutes
  - tPA 0.5-1 ml for 2 hours
- 70% ethanol for waxy buildup from TPN/lipids
- 0.1 normal hydrochloric acid for Ca++ deposits
- Catheter breaks and leaks
  - Catheter specific repair kits

Other Complications
- Dislodgement – replace
  - Externalized – dacron cuff is visualized, mobility of catheter inside tunnel, fresh blood at site, unable to aspirate blood
  - Internalized – significant chest trauma, expanding and painful subcutaneous hematoma
- Migration – obtain radiograph
  - Dysrhythmia, pneumothorax, SVC syndrome, cardiac tamponade
- Fractures / breaks
- Non-infectious phlebitis
- Air embolism
  - Sudden onset of ↑ d rr, ↑ d HR, ↓ d BP and LOC
  - O2 and left side Trendelenburg
  - More likely with insertion
  - Keep catheter circuit closed at all time
PICC

- Complications up to 40%
- Occlusion and Infection most common
- External breaks, shoulder pain, phlebitis w/o infxn, exit site irritation
- Non-central (vs. central)
  - Failed sooner (11.4 vs 16.6 days)
  - Fewer patients complete therapy (69 vs 73%)

Cerebrospinal Fluid Shunts

- 0.5 ml/kg/hr of CSF produced
- Proximal site
  - Lateral ventricles
  - 3rd or 4th ventricles
  - Cyst: intracranial or spinal
- Distal site
  - Peritoneal
  - Right atrium
  - Pleural space
Shunt parts
- Proximal catheter
  - Exits CNS via burr hole
- One way valve
  - Unidirectional flow
  - May incorporate reservoir for sampling / meds
  - Antishiphon device prevents excessive run-off
  - On-off valves
  - Externally programmable
- Distal catheter
  - Tunneled under skin to destination
  - Extra length to allow growth

Malfunction
- Complication of 30-40% of all shunts
- 71% of patients have malfunction in lifetime
- HA, N/V, Irritability, ↑ d sz’s, neck pain, back pain, blurred vision
- Bulging fontanelle, separating sutures, papilledema, sun-setting, ALOC
- 85% of CT’s are abnormal from baseline
  - Comparing to prior CT is invaluable
  - Caution! Last CT may have been taken when shunt was malfunctioning
- 15% are disconnections seen on plainfilms

Malfunction
- Onset of symptoms to diagnosis was 11.5 days
- Vomiting, lack of fever and parental suspicion are the most sensitive clinical features
- Parents are as accurate as physicians in diagnosing malfunction before diagnostic testing
- “Pumping” shunt reservoirs
  - PPV= 21%
  - NPV = 78% (22% can have obstruction w/ normal “pump”)
  - Frequent pumping can cause entrapment of choroid plexus in proximal tubing
Infection

- 2-30% of shunts - incidence declining over time
- Risk highest in infants and post-op period
  - 50% in 1st 2 weeks, 80% in 1st 2 mos, 90% in 1st 4 mos
- 50% of infected shunts are also malfunctioning
- Common pathogens in post-op period up to 9 months
  - Staph epi and aureus
  - 6 – 20% GNR
- Late shunt infxn’s
  - Pneumococcus, H. flu

Infection

- Vague and Nonspecific signs / symptoms
  - Fever, irritability, feeding problems, N/V, lethargy, HA,
  - Signs of meningeal irritation are often absent
- Head CT and Shunt Series
- Tap the shunt
  - WBC of 500/mm3 can be nl
  - 17% of patients may have normal gram stain, cell count and chemistries
- Empiric therapy
  - Vanc and 3rd generation cephalosporin
- Removal of shunt
  - w/ systemic antibiotics
  - High probability of resolving infection

Other Complications

- Overdrainage
  - Lead to subdural hematomas or effusions
  - Need to increase resistance of valve
- Subgaleal fluid collection
  - In immediate post op period - do not drain
  - New fluid collection means malfunction – pathway of least resistance
- Inguinal hernia
  - Increased abdominal fluid converts “potential” to recognizable
  - Perforation of intra-abdominal organs or diaphragm
- Intractable hiccup
- Intussusception
- Volvulus around catheter
Discharge Instruction for Technology Assisted Child

- Help family integrate into community
- Medical summary information
- Go-bags
- Written emergency care plans
- Notify community EMS and local utility companies of their residence

References


Resources

- ENT NP
  - Gail Ezell, RN, MSN, CPNP
- General Surgery NP
  - Erin Erkmann, RN, MSN, BC, FNP
- Pediatric Infectious Diseases
  - Robyn Livingston, MD
- Wound Care
  - Carol Hafeman, RN, MA, ET