Pediatric Surgery

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Table of Contents

Introduction to Pediatric Surgery

Welcome to your Pediatric Surgery rotation. This handbook will be a guide for your time on our service. As pediatric surgery is a growing and evolving field, the pathways and treatment options described here may change over time, but the information offered will serve as a reasonable starting point. The goal of this rotation is to provide a rich and unique educational experience in pediatric surgery. For some, it may be the beginning of a career in our discipline. For those who are drawn to other areas of surgery, we hope that your time on the service will be enlightening and will help to round out your surgical educational experience while perhaps providing some unique skills and insights that may serve you in your future field.

We echo the overall principles of the Brown General Surgery Program by stating that teamwork and respect for patients, staff, and one another are fundamental for the care of children. We welcome any feedback that will help to improve our service and the educational experience of future rotating trainees.

Roles, Responsibilities, and Goals

Fellow

The fellow is the keystone of the service. All information should flow through the fellow, both up and down the chain of command, and the fellow is responsible for ensuring the smooth working of the service. He/she is also the face of the Pediatric Surgery Division and is responsible for interacting and communicating with staff from nursing and other services participating in the care of pediatric surgery patients.

Roles and responsibilities:

- To oversee all aspects of the daily functioning of the service
- To round in the NICU and PICU and to oversee the work of the PGY-1 on the floor
- To develop a daily plan for all patients seen by the service
- To oversee all consults performed by the service
- To scrub on all index cases, often with the PGY-4 as a co-scrub
- To organize the care of all patients going to the OR and to ensure their pre-operative preparation is complete (e.g. consent, booking, prep)
- To advise and educate the medical students, PGY-1, and PGY-4
- To organize weekly conference
- To present and/or supervise presentation at bi-weekly M&M
- To present at bi-weekly Pediatric Surgery conference or to arrange for a speaker for this conference
- To attend Fellow's Clinic once a week
- To organize ECMO consults, participate in cannulation, and help to direct patient care while cannulated
- To respond to all Level A and B trauma activations, and Level C activations as needed by the junior on the service
- To act as the surgical team leader in the trauma room

Goals:

- To have, at the completion of a two-year fellowship, the skills and knowledge needed for the independent provision of pediatric surgery care

PGY-4

The duties and responsibilities of the PGY-4 overlap significantly with those of the fellow. During times when the fellow is away or on an off-service rotation (such as NICU or urology) the PGY-4 will assume the responsibilities as described above for the fellow.

Roles and responsibilities:

- To oversee the PGY-1s in completion of floor work and notes
- To oversee the PGY-1 when seeing floor and ED consults

- To assist and oversee the PGY-1 with bedside procedures
- To oversee and teach medical students and PGY-1s
- To help maintain the Hasbro inpatient list and the NICU list
- To round in the PICU and/or NICU, as agreed upon with the fellow
- To place all consults for PICU patients
- To perform post op checks for PICU and NICU patients
- To respond to consults placed by the PICU or NICU
- To communicate plans to the primary teams of consult patients
- To respond to all Level A and B trauma activations, and Level C activations as needed by the junior on the service
- To act as the surgical team leader in the trauma room in the absence of the fellow or attending
- To present at bi-weekly Pediatric Surgery M&M conference
- To complete at least one presentation for bi-weekly Pediatric Surgery Conference
- To coordinate communication among the members of the team (attending, fellow, APPS, and PGY-1s)
- To attend one half day of pediatric surgery clinic per week
    - Normally, this clinic will be with the attending who was on-service the week prior; discuss which day is best with the attending while he/she is on service

<u>Goals of rotation:</u>

- To understand the physiology and care of the neonatal patient
- To understand the unique aspects of the care of critically ill pediatric general and trauma patients, and how this may differ from the care of similarly ill adults
- To gain experience in the performance of pediatric cases, including pyloromyotomy and hernia repair
- To gain exposure to more complicated cases, such as esophageal atresia repair, through co-scrubbing with the fellow

PGY-1

The PGY-1 is the hub of care for pediatric surgery patients admitted to the general floor. They are expected to manage all floor issues and to be the face of the service on the floor for both patients and other staff

<u>Roles and responsibilities:</u>

- To complete all daily floor-work and notes for patients on the pediatric surgery floor
- To answer all floor pages
- Ensure all tests and studies discussed in the morning are completed
- To call all consults for floor patients
- To perform post op checks for floor patients

- To complete all discharge summaries for floor patients, arrange for follow up appointments, write for home prescriptions, and arrange for home services as needed
- To round in the afternoon before sign out
- To update patient and families regarding the results of test performed and any changes in plan
- To maintain the floor list
- To respond to consults from the floor and ED
- To review all consults with the PGY-4/fellow
- To communicate plans to the primary teams of consult patients
- To inform the senior or fellow of any changes in patient status
- To attend and provide sign out before and after each shift
- To respond to all trauma activations
- To attend weekly Pediatric Surgery Conferences on Wednesday morning
- To present once during the rotation at Pediatric Surgery conference
- To oversee and teach medical students on the rotation
- To attend Burn Clinic on Wednesday afternoons
- To attend one half day of pediatric surgery clinic per week
    - Normally, this clinic will be with the attending who was on-service the week prior; discuss which day is best with the attending while he/she is on service

<u>Goals of rotation:</u>

- To gain a better understand of the care of the pediatric surgery patient
- To understand the physiology and care of common pediatric surgery conditions, such as pyloric stenosis and appendicitis
- To gain technical experience in the OR by scrubbing on cases such as umbilical hernia repairs and appendectomies
- To gain confidence with common procedures such as chest tube removal and abscess drainage

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HASBRO Phone numbers

Operator 444-4000

Daily Rounds

I. Sign Out

- Intern AM sign out: 6am in the 6th floor call room
    - For AM sign out, the night intern will have updated, printed copies of the list ready and will review pertinent overnight events as well as new patients
    - The night intern will also obtain the I/O's and calculate the UOP (cc/kg/hr) for the day team
- Senior AM sign out: 6 am, in Fellow's office or on the go to NICU or PICU
- APP AM sign out: with seniors or at 8 AM after morning rounds
- PM: team sign out with interns and on-call senior and APPS, in MOC-190 conference room

II. NICU Rounds

- Vitals, I/O's, labs and studies should be obtained from Cerner
- Important information on AM rounds:
    - Weight and weight changes
    - Input and output (including stool), urine in cc/kg/hr and stool in mg/kg/day if ostomy present or concern for dumping
    - NGT output, including color
    - Chest tube output, presence of air leak
    - TPN: calories, access, total lipids
    - Drips
    - Amount and type of oral feeds
    - Medications
    - Results of labs and studies in last 24 hours
    - Physical exam, including appearance of bowel (gastroschisis), ostomy, wound
    - Vent settings, if applicable, or respiratory support
        - Other information can be obtained from the Results --> Fellow's View tab. This includes any supplemental respiratory support, A/B/D events, what the baby is taking orally and how much and any medications the patient is on.
- When rounding in the NICU, try to speak to the overnight nurses for updates
- White coats are not to be worn in patient rooms and hands must be sanitized prior to entering each room as well as on exit
- The NICU fellow should be updated at the completion of rounds. They may be found between 6-630 in the fellow call room on the 2nd floor (code 1704#)

III. Hasbro Rounds

PICU

- Rounds at Hasbro typically start in the PICU with the most ill child
- Nurses should be in rounds in order to get overnight updates.
- Evaluation during rounds proceeds by systems (Neurological, respiratory, cardiovascular, GI, GU/FEN, ID, Heme, lines, etc.).
- Please note all of the issues listed above for NICU patients, as well as obtain input from the PICU service if they are involved in the patient's care
- Long term patients should have a discharge document started which should be updated every Friday

Floor

- From the PICU, rounds typically start on the highest floor-highest patient
    - Exceptions are made if there are floor patients of high concern
- Effort should be made to review patients with the overnight nurses
- Please do a full exam in the morning (heart/lungs/abdomen/wound/other pertinent areas). Do not document an exam is one is not performed
- Please make note of all ins and outs, including ostomy output, NGT (including color and nature of fluid), and urine output (measures in cc/kg/hour)
    - A note about documentation: please use ONLY approved abbreviations in H&P/Consults/progress notes. A list of approved abbreviations can be found here: http://clinical.lifespan.org/abbreviations
- Please check the chart for notes from other services and have this information ready for rounds
- Please be cautious about publishing plans before discussing them with the attending or fellow. Giving other services/nursing staff only one morning plan will help to decrease confusion
- If it is anticipated that a patient will be discharged in the next 48 hours, please start the discharge summary which will be added to as needed and think proactively about medications/services/etc. which may be needed for home care
- Long term patients should have a discharge document started which should be updated every Friday

Weekly Schedule

Monday
OR: Luks (will start after 11 am if in clinic at St. Ann's in the morning)
Clinic: MOC 190: Honeyman 9 am – 12 PM
MOC 190: PA/NP 9 am - 12 PM
Fall River (St. Ann's): Luks and Lorenco, alternating weeks

Tuesday
General Surgery Grand Rounds: 7-8 AM
OR: Renaud
Clinic: LL GI clinic: Intestinal Failure Clinic 1 PM – 4 PM (1st, 3rd, 5th Tues of month)
MOC 190: Kim 10 AM-12 PM
MOC 190: Monteagudo 9 AM-12 PM and 1-3:30 PM

Wednesday
General Surgery M&M: 7-8 AM
Pediatric Surgery Conference Time: 8-10 AM
1st Wednesday: 9-10 AM Clinical Case Conference with radiology
2nd and 4th Wed: 8-9 AM Tumor Board, 9-10 AM Pediatric Surgery M&M
5th Wednesday: Joint conference with Oncology
OR: Kim (staring at 10 AM after conference)
Clinic: MOC 190: PA/NP 10 am – 12 PM
COOP clinic 1st floor: Burn Clinic 1 PM – 4 PM
MOC 190: Renaud 1-4 PM

Thursday
OR: Monteagudo
Clinic: MOC 190: Luks 9 AM-12 PM
MOC 190: Vascular Anomalies Clinic 12-2 PM, first Thursday of month
MOC 190: Honeyman 1 PM – 4 PM

Friday
OR: Honeyman
Clinic: MOC 190: Renaud 9 AM-12 PM
MOC 190 PA/NP 1 PM-3:30 PM

Role of the Advanced Practice Provider (APP)

The role of the Advanced Practice Provider (APP) on the Pediatric Surgery Service is multi-faceted and incorporates both the inpatient and outpatient environments.

- Outpatient responsibilities include specified clinic days (Monday/Weds/Fri) for post-op visits, wound/ostomy/gastrostomy tube care, bowel management, and new consults at the discretion of the attending.
- Inpatient responsibilities include participation in the care provided by the Pediatric Surgery team.
    - When not present for morning rounds, the APP will do daily assessments of the patients they are responsible for that day.
    - The APPs collaborate with the entire Pediatric Surgery team to optimize the care of the patient through all phases of hospitalization.

Roles and responsibilities:

- To round in the NICU and PICU, or Hasbro Floors (depending on coverage), to help as needed, and to support the PGY-1/PGY-4/Fellow

- To see consults as needed both in the PICU/NICU or in Hasbro

- Help formulate and enact a daily plan for all patients seen by the service

- If the Fellow/PGY-4 is unavailable, to act as a senior backup for the PGY-1 seeing floor and ED consults

- To organize the care of all patients going to the OR and to help to ensure their pre-operative preparation is complete (e.g. consent, booking, prep)

-To participate in OR cases and to act as the proceduralist for bedside and sedated procedures as needed

- To respond to all Level A and B trauma activations, and to cover Level C activations as needed by the availability of the junior on the service

- To participate in national organizations in some capacity

-To participate in and ensure active credentialing within specialty/interests (PALS/BLS, ATLS, ABLS, Airway, Bowel management)

- In additional to contributing to the education of rotating residents and medical students, the APP will proctor both PA and nurse practitioner students as scheduling allows

Transfer of NICU Patients to Hasbro

Non-Emergent Operation

-When a NICU patient will be undergoing a scheduled operation at a future date, the patient's name and DOB along with the exact booking information should be given to the surgeon's administrative assistant.

-Consent should be obtained in a timely fashion so that it can be sent to the OR and added to the EPIC chart prior to day of surgery (Hardcopy blank Lifespan consent forms are at each NICU desk, do not use W&I consent forms as RIH will not accept them).

-When the case has been scheduled and an account has been created in EPIC, an H&P should be entered into chart in a timely fashion before the day of surgery.

Emergent Transfer

-If there is an emergent transfer to either PICU or the OR:

1. Contact Express Care (LifePact)
    a. Provide Name, DOB of patient, the diagnosis and name of attending surgeon
    b. Fax NICU face sheet to Express Care:
2. Express care upon receipt of the necessary info will create an EPIC chart for this patient
3. Upon creation of an EPIC chart, enter the patient station tab and click on the surgery or admission
4. When you are in the account, the OR case can be booked under orders. Call to confirm the OR has received the booking.
5. Appropriate H&P/orders can be entered when the chart has been created
6. Consent should be obtained via hardcopy in the NICU and brought to OR or can be loaded up via Haiku to the patient account by taking a picture with a phone

Non-Emergent Transfer

-If a surgical NICU patient requires transfer to Hasbro for ongoing care:

- The face sheet from the NICU should be given to the Case Manager at Hasbro at the earliest convenience. They will complete insurance authorization.
- A tentative date of transfer will be set. Non-emergent transfers should be avoided on Mondays and Fridays
- On the day of transfer, Express Care () needs to be called in order to create the admission account.
- NICU RN to Hasbro RN report should be given via phone or face to face at the time of transfer

- The NICU discharge summary should be completed by the NICU staff, printed out, and be available to Hasbro staff for review at time of transfer.

Pediatric Sedation

-Moderate sedation is a state in which a patient responds purposefully to voice or tactile stimulation, and maintains a patent airway and adequate spontaneous ventilation. This is further defined as the administration of 2 agents in combination to achieve a desired effect, i.e. administering a narcotic in conjunction with a benzodiazepine.
-Moderate sedation for procedures may **NOT** be provided on the general care units.
-The provider of moderate sedation cannot concurrently perform the planned procedure unless a separate credentialed professional (RN or LIP) is entirely dedicated to monitoring the patient at all times.
-The proceduralist does not need to have credentials for moderate sedation when the sedation is being provided and monitored by a credentialed individual.

Analgesia:
For patients that require wound care or other scheduled care that is painful, narcotics can be considered and administered. Depending on the patient's status IV or PO can be used; this should be discussed with a senior or attending prior to ordering. Medications commonly used on the general floors:

-IV morphine ()
-PO oxycodone liquid or tablet ()

Dilaudid can be considered, but use of this medication must be discussed with senior team members/attending prior to ordering/administering.
Fentanyl is NOT approved for the general floors.

Anxiolysis
For patients that require care that could be stressful or anxiety inducing (i.e. placement of nasogastric tube), a benzo can be considered. Again, discuss with your senior or attending before use. On the general floors:
-IV Versed ()
-IN Versed ()
-IV Ativan ()
-PO Ativan ()

For any escalation of care to include moderate sedation or deep sedation, the Pediatric Sedation Team or Pediatric Anesthesia team should be notified. Consultation of these teams requires prior discussion with Pediatric Surgery senior members including the appropriate Pediatric Surgery Attending.
These patients would need to be NPO:
-Clear Liquids: 2 hours
-Breastmilk: 4 hours
-Infant Formula: 6 hours
-Nonhuman milk: 6 hours
-Regular diet: 6 hours

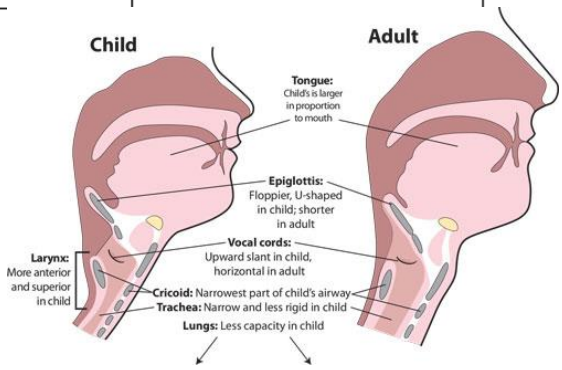
Pediatric Sedation:
Under the direction of the Pediatric Critical Care service, this team can provide moderate and deep sedation so that the patient will spontaneously breathe and not require intubation. Agents used by this team include but are not limited to fentanyl, propofol, ketamine, versed and precedex. The patient must have IV access prior to arrival in the Pediatric Sedation suite; if Anesthesia is providing sedation, an IV is required prior to arrival in the PACU. A consultation order for Pediatric Sedation should be placed through EPIC, but this must be followed by a call to Pediatric Sedation by an APP, the fellow, or the attending.

PEDIATRIC VENTILATORY MANAGEMENT

Signs of Airway Obstruction	
poor movement of air	tracheal tug
faint or absent breath sounds	intercostal retractions (between ribs)
substernal retractions (below sternum)	subcostal retractions (below rib cage)
use of accessory muscles	rocking in chest /abdominal motion
stridor	lack of chest rise
head bobbing	nasal flaring
cyanosis	lack of end-tidal CO2

Indications: high respiratory rate, labored breathing decreased level of consciousness, inability to protect airway, hypercarbia, chest trauma, aspiration

Airway Obstruction: Infants and toddlers tire easily when they have airway or respiratory compromise. Respiratory distress can easily progress to respiratory failure



Children are NOT little adults:

- Children have smaller, shorter airways.
- Increased airway resistance → increased work of breathing.
- Pediatric airway is anterior / superior. Glottis opening higher (C2/C3 vs C6 adult)
- Children have larger tongues relative to oropharynx. Posterior displacement → obstruction
- Epiglottis is long, narrow, floppy, and angled away from axis of trachea
- Narrowest portion in children is below vocal cords at level of cricoid cartilage and larynx is funnel shaped. Narrowest portion for adults is glottis inlet and larynx is cylindrical

Ventilator Variables:

- **Trigger**: ventilator-triggered or patient-triggered breath
  - The variable that causes inspiratory valve to open (start of breath).
  - Patient-assisted: Patient makes an effort to take a breath and ventilator senses and supports this (senses negative inspiratory pressure / or inspiratory flow)
  - Machine-controlled: Ventilator decides frequency of breaths based on set respiratory rate.
- **Limit:** flow (volume) limited or pressure-limited (Figure 1)
  - Flow/Volume-limited: A fixed tidal volume / flow rate is given and maintained throughout inspiration to ensure adequate tidal volume
  - Pressure-limited: Pressure is not allowed to surpass a set limit
- **Cycling**: volume, time, flow, pressure cycled
  - Volume, time, flow and pressure stop inspiration / start expiration

Types of Ventilation

- **Assist Control**:
  - Ventilator senses patient breaths and delivers set volume or pressure at set rate in addition to patient-triggered breaths.
  - Mandatory breaths: Vent delivers preset volume / flow rate at a set rate. In addition to this, the vent will deliver the preset volume / flow for every additional breath the patient takes. Ex: Rate set at rate 18, Vt 80; if patient breathes 28 breaths / min, the additional 10 breaths would receive a Vt of 80.
  - Pressure Control: Volume delivery varies, Inspiratory pressure constant, Inspiratory flow varies. Good for neonates / infants <6-8kg.
  - Volume Control: Volume delivery constant; Inspiratory pressure varies; Inspiratory flow constant. Good for children / adolescents > 8-10kg.
  - Factors to control:
    - Ventilation: RR, Vt, Pi
    - Oxygenation: PEEP, FIO2, I:E ratio (1:2)
- **SIMV:**
  - Ventilator detects patient breaths and waits until patient exhales to deliver mechanical breath.
  - Ventilator delivers time-triggered assisted breath.
  - If patient breathes between mandatory breaths, vent allows patient to breathe normal breath; may add some pressure-support for patient (non-vent) breaths. **Good weaning mode.** (Figure 2)
- **Bilevel / APRV**: (Figure 3) Good for severe ARDS. High level of continuous positive airway pressure (P_{high}) that is maintained for a long period of time (T_{high}) coupled with a short period (T_{low}) during which the pressure is released (P_{low}).
  - The prolonged period of high pressure facilitates oxygenation and pulmonary recruitment.
  - Need to have inverse I: E ratio.
  - Oxygenation is often improved with APRV from increased mean alveolar pressure and volume from longer time above functional residual capacity or by creation of auto-PEEP.
  - Patient MUST be able to breathe spontaneously (i.e. not be paralyzed).
- **CPAP**: Continuous pressure throughout the ventilatory cycle. Patient-triggered breaths with ventilator giving a constant pressure during inspiration and expiration. No pre-set rate, all patient's own breaths. No pre-set volumes. Good weaning mode.

- **High-flow Oscillatory Ventilator**: Lung-protective ventilatory mode. Often used when conventional modes failed. Reduces risk of volume-trauma. Alveoli stay inflated at a constant mean airway pressure. Oscillation prevents the lung inflate–deflate cycle. Good for oxygenation.
    - Factors to control: Mean airway pressure (keep low), frequency (Hz), Pressure amplitude, FIO2, bias flow
        - Mean airway pressure: Pressure to optimize lung volume and to increase the alveolar surface area for gas exchange. Recruits alveoli. Should initially be set at 2-3cm H_2O above the corresponding mean airway pressure on conventional vent. Helps oxygenation.
        - FIO2: Same as on conventional ventilator; helps oxygenation
        - Amplitude: Variation around MAP. Determines tidal volume. Controls ventilation – increase the amplitude if under-ventilated. Normal amplitude 20-30 in neonates
        - Chest Wiggle: Seen from clavicles to lower ribs. Increased by increasing amplitude. Controls ventilation. When decreased / absent, may have mucous plugging, ETT disconnection/displacement, pneumothorax
        - Frequency: Controls ventilation – decrease frequency if under-ventilated if amplitude is maximized
- **High frequency Jet Ventilator**: Through a pneumatic valve, releases short jets of gas in the inspiratory circuit, and expiration is passive. Good for gentle ventilation of neonates (ex: CDH). Has reduced peak airway pressures.
    - Basic settings:
        - Rate: 420
        - Valve time : 0.20 seconds
        - PIP: 30 (or 20% increase from PIP on the conventional vent)
        - PEEP: MAP-4 on the conventional vent
        - Should do CXR 1h after placing patient on jet to look for lung expansion
    - Factors to control:
        - Ventilation: Change PIP or (rare) rate
        - Oxygenation: Changing FIO2 or PEEP

Fig 1

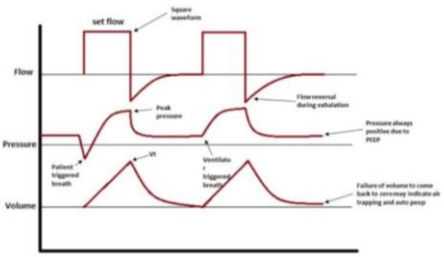


Fig 2

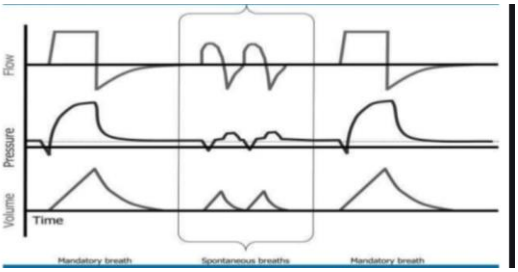
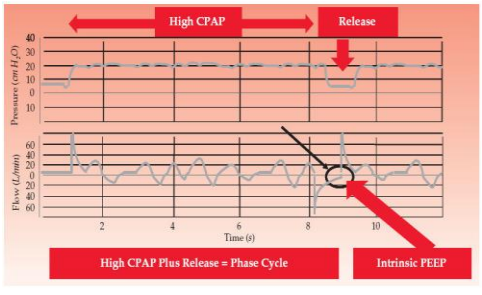


Fig 3



Quick reference for Hasbro neonatal and pediatric ECMO

Consults called for:

1. Meconium aspiration
2. Persistent pulmonary hypertension (PPHN)
3. Congenital diaphragmatic hernia (CDH)
4. Sepsis
5. Cardiac failure
6. Respiratory failure
7. If any doubt about indication for ECMO speak with on call ECMO attending or ECMO director

Exclusion criteria

1. Less than 34 weeks gestation
2. Weight less than 2000 grams (relative contraindication)
3. Grade II or greater Intraventricular Hemorrhage
4. Irreversible organ injury (unless eligible for transplant)
5. Severe associated Anomaly (Trisomy 13/18) or other lethal chromosomal abnormality
6. Prolonged cardiac arrest
7. Unwitnessed or out-of-hospital cardiac arrest
8. On ventilator for greater than 10-14 days –chronic lung disease secondary to disease & iatrogenic
9. Tonic Clonic Seizures in newborns
10. Evidence of brain death or massive neurologic injury (exception: bridge to organ donation)
11. Uncontrolled bleeding diatheses or contraindication to anticoagulation

Oxygenation index

Not as important as the trend of the blood gases, ventilator settings, pressors, urine output, but often communicated by the NICU and PICU. You must be at the bedside watching how the patient responds to titrations in the ventilator and drips.

Oxygenation Index greater than 35-45 on two or more blood gases is concerning for need for ECMO.

OI = (MAPxFi02x100)/PaO2

Cannulation strategy

Should be calculated and documented in a note in the EMR even if that patient does not imminently need ECMO so that it can be referenced if the clinical status changes.

Type of ECMO – Options include Veno-Arterial (VA) or Veno-Venous (VV) ECMO

- **Veno-Venous (VV)** – Purely respiratory problem, requires adequate heart function on echocardiogram
    - Need for pressors does not necessarily obviate the use of VV ECMO
- **Veno-Arterial (VA) –** Poor cardiac function, heart failure, cardiac arrest, septic shock
- Hybrid cannulations, i.e. VAV or VVA

Cannula Size

- Calculation for full flow
    - Neonates less than 30 days – 150 cc/kg/min
    - Infants/children greater than 30 days – BSA x 2.4
    - Sepsis typically requires higher than usual ECMO flows, utilize the largest cannulas possible
        - For femoral cannulations would not recommend using an arterial cannula greater than 17 French for risk of limb ischemia
- Look at chart (to follow) to see which size cannula can handle the calculated flow, have available cannulas that are one size smaller just in case

Target vessels for cannulation

- Children <5 years old– Cannulate neck vessels (RIJ, RCCA preferable), femoral vessels are too small
- Children > 5 years & ~15kg– Cannulate femoral vessels (femoral artery/vein), avoids ligating carotid artery if going on VA ECMO and increasing stroke risk
    - If enough time prior to cannulation, place arterial/venous central lines so that you can exchange over a wire to cannulas
    - Will need Distal Perfusion Catheter (DPC) – usually use 5F, coordinate with vascular surgery for placement early (even prior to cannulation)

May consider using arterial cannulas in venous position, i.e. an arterial cannula in RIJ as a pull cannula especially in hybrid cannulations.

Example of cannulation strategy to be documented in a note:

CANNULATION STRATEGY:

VA ECMO
17 French Biomedicus arterial cannula to right femoral artery
21 French Biomedicus venous cannula to right femoral vein
5 French Distal Perfusion catheter to right SFA
Total flow: 4.3 L/min
Ht: 177.8 cm
Wt: 63.5 kg
BSA: 1.79 m2
Cardiohelp circuit with 3/8" tubing

Phone calls to make if proceeding with cannulation:

1. ECMO specialist (Respiratory shift supervisor):
2. OR team:
3. Blood bank: For infants, you will need 3 units PRBC to prime circuit. Call to blood bank can be made by PICU clerk. Have someone run to get the blood while RT ECMO specialists build the pump
4. Pharmacy: Place orders for meds for ECMO circuit and cannulation via the ECMO order set in Epic. Meds for pump can be over ridden in the Omnicell. Order heparin bolus and make sure the picu/ bedside nurse can administer.
5. PICU attending: should be "running the medical code" during cannulation. Titrating ventilator, medications/pressors/code meds, overseeing compressions if necessary if the cannulation is performed in the PICU.
6. Vascular surgery: if needing distal perfusion catheter (for ALL femoral cannulations) call and speak directly to the attending.

ECMO Cannula Chart

VENOUS

Central

Biomedicus				Lighthouse				Right Angle Metal	
8fr	550cc/min	1/4"	.025 Wire	14fr	950 cc/min			12fr	900 cc/min
10	1000	1/4"	.025 Wire	16	1300			14	1700
12	1500	1/4"	.025 Wire	18	1850			16	2100 1/4" / 2000 3/8"
14	2000	1/4"	.025 Wire	20	2400			18	2800 1/4" / 2800 3/8"
15	1500	**3/8"**	**.038 Wire**	22	3000			20	3400
15A	2100	**3/8"**	**.038 Wire**	24	3600			22	4400
17A	2700	**3/8"**	**.038 Wire**	26	4400			24	5000+
17	2100	**3/8"**	**.038 Wire**	28	5200			28	6000+
19	3000	**3/8"**	**.038 Wire**	30	6000+			31	7000+
21	4300	**3/8"**	**.038 Wire**	32	6000+				
23	5000	**3/8"**	**.038 Wire**	34	7000+				

****use BM pediatric perc kit for 8 -14fr****

DLP			
16A	2300	1/4"	

Origen VV			
13	450	1/4"	
16	850	1/4"	
19	1050	1/4"	

****use Origen dilator kit****

Avalon VV			
13	600cc/min	1/4"	.038 Wire
16	900	1/4"	.038 Wire
19	1500	1/4"	.038 Wire
20	1400	**3/8"**	.038 Wire
23	2200	**3/8"**	.038 Wire
27	3400	**3/8"**	.038 Wire
31	4700	**3/8"**	.038 Wire

****use Avalon dilator kit****

ARTERIAL

Central

Biomed.	Size	80% CPB BQ for long term	
640cc/min	***8fr***	1/4"	BM Peds Perc kit w/.025 wire
1280	***10***	1/4"	BM Peds Perc kit w/.025 wire
1800	***12***	1/4"	BM Peds Perc kit w/.025 wire
2400	***14***	1/4"	BM Peds Perc kit w/.025 wire
DLP	**Flow**		
16	3000	1/4"	
EOPA	**Flow**	*****EOPA's can be used peripheral also*****	
18	3900	**3/8"**	**.038 Wire**
20	4700	**3/8"**	**.038 Wire**
22	5700	**3/8"**	**.038 Wire**
24	>5700	**3/8"**	**.038 Wire**

Peripheral

Biomed.	Size	80% CPB BQ for long term	
640cc/min	***8fr***	1/4"	BM Peds Perc kit w/.025 wire
1280	***10***	1/4"	BM Peds Perc kit w/.025 wire
1800	***12***	1/4"	BM Peds Perc kit w/.025 wire
2400	***14***	1/4"	BM Peds Perc kit w/.025 wire
3500*	***15***	**3/8"**	**.038 wire**
4200	***17***	**3/8"**	**.038 wire**
5000	***19***	**3/8"**	**.038 wire**
>5000	***21***	**3/8"**	**.038 wire**

Pediatric Nutrition

NUTRITIONAL REQUIREMENTS

The hospital and JCAHO **mandate** that all patients be screened for nutritional status after three days (ICU patients sooner).

- You will see these screening notes from Nutrition Services on the chart and the dietitian may speak to you about their concerns.
- **These must be relayed to the fellow or service attending for discussion**.

Consultations for nutritional support from the GI service are only obtained upon attending request. However, the **intestinal failure** patients are now managed by a multidisciplinary team consisting of Surgical staff, GI, Nutrition, Social Work, OT, PT, and Speech. **All intestinal failure patients (short gut) who are admitted will require consultation for all these services**.

Caloric requirements:

0-1 year 90-120 kcal/kg/day
1-7 years 75-90 kcal/kg/day
7-12 years 60-75 kcal/kg/day
12-18 years 30-60 kcal/kg/day

- Physical status (metabolic condition, bedridden, active) will affect these baseline values.
- For infants, the basic principle is that sufficient calories need to be supplied to assure continued growth and development.
- For chronically hospitalized infants it is important to **maintain an accurate growth record in EPIC**. If weights are ordered they will be populated in an age-appropriate growth chart. Please order daily weights for admitted patients, especially infants and those with ongoing illnesses.
    - The expected weight gain is 1% of the infant's weight per day. i.e. a 2 week old, 1kg, 34 week gestation infant should gain about 10 g/day.
    - In very small infants it can be difficult to achieve a certain caloric intake without exceeding fluid intake limitations. For that reason, both ml/kg/d and kcal/kg/d should be calculated daily.

PARENTERAL NUTRITION

Indications for Initiation of Parenteral Nutrition

Prematurity: Required within 24-48 hour of birth secondary to low nutrient reserves, increased energy expenditure, immaturity of the GI tract and increased risk for acute or chronic illness

Gastrointestinal conditions potentially requiring Parenteral Nutrition:

Congenital

- Esophageal/intestinal atresia
- Tracheoesophageal fistula
- Malrotation with volvulus
- Hirschsprung's disease
- Anorectal malformation
- Abdominal wall defects

Sort term and long term GI disorders

- Severe inflammatory bowel disease
- Pseudo-obstruction/obstruction
- Motility disorders
- Acute pancreatitis
- High output fistulas
- Necrotizing enterocolitis
- Short bowel syndrome

Critical illness

- Hemodynamic instability
- Enteral feeding intolerance
- Chyle leaks if unresponsive to enteral feedings

Oncology

- Graft vs host disease
- Radiation enteritis
- Cachexia

Miscellaneous

Organ failure (If enteral nutrition is contraindicated and in the setting of catabolism or in preparation for transplant)

TOTAL PARENTERAL NUTRITION (TPN)

When writing TPN orders, there are some additional principles to adhere to beyond the simple provision of calories. We can divide this conceptually, into the provision of carbohydrate, protein and fat intravenously.

Carbohydrate: The amount of dextrose supplied per day, the caloric density and particularly the rate at which it is administered are critical.

- The caloric density of carbohydrates in solution is 3.4 kcal/g glucose.
- From this one can derive the caloric density of any % dextrose solution.
    - Example: D10W solution has 10g glucose/100 ml and provides (10gm x 3.4kcal/g)/100ml = 0.34kcal/ml; D20 W solution has twice the caloric density, 0.68kcal/ml. The other solutions' density can be similarly calculated.
    - D5W 0.17 kcal/ml; D10W 0.34 kcal/ml; D12.5W 0.42 kcal/ml; D15W 0.51 kcal/ml; D17.5W 0.59 kcal/ml; D20W 0.68 kcal/ml; D25W 0.76 kcal/ml D30W 0.85 kcal/ml
- Peripheral TPN, (rarely used in surgical patients) should not exceed D12.5W or 900 mOsm/L and central TPN should not exceed D20W, unless there are severe restraints on fluid intake.
    - D25W - D30W have osmolarities of between 1200 and 1700 mOsm/L. These solutions are useful for patients on ECMO support where not only are the fluids restricted, but the large cannula in the atrium also allows for prompt dilution of the infusion.

TPN order sets

-TPN order sets are provided in EPIC.

- They are weight based and offer a standard admixture of macro and micro-nutrients based on age groups (infant, child, adolescent).

- They are also displayed as Cyclic TPN for the infant, child, and adolescent.

- Lipid orders are linked to each and the prescriber may choose TPN with standard lipid emulsions or SMOF lipids. These will be described later in this text.

Indications for Initiation and Advancement of Macronutrients in Parenteral Nutrition

Dextrose Requirements:

When initiating TPN, the rate of glucose provision should be increased incrementally.

- In neonates and premature neonates this requires calculation of total grams of glucose provided per day and at an initial rate probably not exceeding **6.5mg/kg/hr**.

- For older infants and children this can be accomplished most easily by starting with **D10TPN** and progressing to D20TPN over about 3-4 days, while providing it at rates sufficient to support maintenance fluid requirements.

- Alternatively, in an older child one can start with D20TPN, but infuse it at a rate 25% of the ultimate goal rate and increase by 25%/day. This requires other fluids to be infused concurrently to meet fluid requirements. (This may not be feasible when IV access is limited and you have a line that you want to devote to TPN only).

- To monitor tolerance of the dextrose infusion, urine should be dipped for glucose and bedside blood glucose monitoring should be obtained every 6 – 8 hours until 24 hours at the goal rate have been attained. Then monitoring decreases to once a day.

Fat Requirements:

Fat is used as an energy source and to provide essential fatty acids (linoleic and linolenic acid). With a caloric density of **9 kcal/g,** it is a valuable source of calories in parenteral nutrition.

- 20% intralipid (20g fat/100ml fluid) solution has a caloric density of 2kcal/ml.
    - Normally 30-40% of total calories are provided by fat in the form of 20% intralipid solution. It is generally undesirable to exceed 30% of calories.
    - Exogenous fat is handled and metabolized in the same manner as that presented as chylomicrons. Lipid emulsions should therefore be infused cautiously. The enzyme lipoprotein lipase can be saturated by an excessive infusion, which results in lipidemia.

- Guidelines for infusion of 20% intralipid(g/kg/day):

    Premie-term infant Initial 0.5-1 grams per kg/day. Increase daily by: .0.25-0.5 gm/kg/d, Max dose: 3 gms/kg/d. Monitor the effect of infusion by measuring the serum triglyceride level. The goal is <200mg %.

    Caution should be used in infusing fat emulsion in all patients with pulmonary insufficiency, liver failure, jaundice and coagulation disorders. In older children, an allergy to egg whites is a contraindication to use of intralipid.

Standard lipid emulsions are derived from Soy. There are various forms of lipid now available. SMOF is a combination of soy, MCT, Olive oil, and Fish oil. Omegaven is

derived from Fish oil. Both SMOF and Omegaven have been reserved for long term TPN patients due to their anti-inflammatory properties which are believed to mitigate/prevent the onset TPN cholestasis

Protein Requirements:

The amino acid composition of neonatal, childhood and adult TPN differ as there are some amino acids that appear to be conditionally essential during the early phases of life. Further changes occur when there is impairment of either renal or hepatic function.

The calories that could potentially be derived from these solutions are not calculated into the calorie provision. Protein requirements for growth and repair must be met and are generally age dependent. (See table)

Protein requirement (g/kg/day)

Premature-term neonate 0 to 1 month 3.0-3.5

infant 1-12 months 2.5-3.0

children 1-12 years 1.5-2.5

adolescents 12-18 years 1.0-1.5

The **"total calorie" to nitrogen ratio** of the TPN formulation has great impact on the optimal utilization of the carbohydrate calories and potentially on the incidence of TPN associated liver disease. Ideally it ranges from 150-180:1. In order to calculate this ratio you must calculate a total number of kilocalories provided by both the dextrose and fat emulsion over one day and divide it by the grams of nitrogen infused with that same volume of TPN. EPIC calculates the Nitrogen to non- nitrogen calorie ratio and it appears in the left margin of the order set.

An **example** for calculating the Nitrogen to non-nitrogen calorie ratio is as follows:

An infant is receiving 500 ml/day of TPN, which consists of D20 solution and 50ml of 20% intralipid. He is also receiving 3g/kg/d of protein. His weight is 5 kg.

500ml x 0.68kcal/ml = 340 kcal/day from TPN

50ml x 2kcal/ml = 100 kcal/day from intralipid

3g/kg/day x 5kg = 15 g protein

conversion to nitrogen grams: 6.25g protein = one gram Nitrogen

15 / 6.25 = 2.4 g Nitrogen

Total calorie: Nitrogen ratio = (340+100)/2.4 = 183 :1 This same example serves to illustrate how ml/kg/day and kcal/kg/day are calculated.

The total volume infused is 500 + 50 =550ml/d. For a 5kg infant this is 110ml/kg/day. The caloric provision is 340kcal/day from TPN and 100kcal/day from fat. Divided by 5kg yields 88kcal/kg/day.

These components of TPN exist in infant and pediatric formulations and are ordered on a per kg basis. There are specific instances when these substances need to be reduced or even withheld. This will be indicated by the fellow or attending monitoring the TPN orders in collaboration with Nutrition and Pharmacy services.

An example for calculating goal TPN/Intralipid volumes for an infant or child:

You are asked to start TPN on a 20kg child. The estimated caloric need is **80 kcal/kg/day**. The total fluid rate will be approximately **20%** higher than this number, i.e. 80+16=**96ml/kg/d** That would be **20kg x 96 = 1920ml/d = 80ml/hr** 10% of this rate should be the intralipid rate and the other 90% should be TPN infusion rate.

IL @ 8ml/hr = 192ml/d = 384kcal/day

TPN @ 72ml/hr = 1728ml/d; if D20 then 1726ml x .68kcal/ml = 1175kcal/day;

Total kcal/day = 1175+384 =1559 divide by 20kg= 78kcal/kg/d.

If the child is getting close to 3g/kg/d of protein in the TPN, then the cal:N ratio will be 162:1. Remember that these are the goal concentrations/rates for infusion and not the initial ones! For instance: initiate D10TPN at 72ml/hr and 20 % IL at half the goal rate 4ml/hr. The next day advance to D15TPN at 72ml/hr and increase IL to 6ml/hr, then advance to D20TPN at 72ml/hr and IL at 8ml/hr, if glucose and lipid tolerance are verified. (Dextrostix and triglyceride levels). Careful monitoring of fluid status and weight gain will allow for subsequent adjustments.

Micronutritents

As earlier described the Pediatric TPN order sets cover the infant, child and adolescent and are weight based. The order sets for each age group come with standard electrolyte dosing for each age group based on daily requirements. These doses may be altered based on deficits and ongoing losses. Electrolytes within TPN may be adjusted to offset these deficits but caution should be taken to avoid repleting electrolytes using TPN unless the corrections are minor. It must be noted that orders placed for TPN on a given day will not be administered until 9 pm that night so any corrections/responses to repletion using TPN orders will be delayed. The following are guidelines for dosing parenteral nutrition electrolytes and multivitamin. Dosing for trace elements is standardized and is usually not individually dosed except during times of drug shortages. The pharmacy staff should guide you on making those decisions.

Electrolyte	**Preterm Neonates**	**Infants/Children**	**Adolescent >50kg**
Sodium	2-5 mEq/kg	2-5 mEq/kg	1-2 mEq/kg
Potassium	2-4 mEq./kg	2-4 mEq.kg	1-2 mEq/kg
Calcium	2-4 mEq/kg	0.5-4 mEq/kg	10-20 mEq/day
Phosphorus	1-2 mmol/kg	0.5-2 mmol/kg	10-40 mEq/day
Magnesium	0.3-0.5mEq/kg	0.3-0.5 mEq/kg	10-30 mEq/day
Acetate	As needed for acid base balance		
Chloride	As needed for acid base balance		

Parenteral Vitamins

< 1 kg	1.5 mL
≥1 to <3 kg	3 mL
≥3 kg	5 mL

Cyclic TPN

Cycling TPN is a maneuver to further reduce the pathophysiologic consequences of TPN administration. It needs to be achieved gradually and the usual goal is to infuse the necessary volume of TPN and intralipid over a **16 – 18 hour period**. One hour at each end of the infusion time will have the solution running at half the normal rate to allow the pancreas to adjust insulin/glucagon secretion to prevent hypo- or hyperglycemia. EPIC will calculate the ramp up and ramp down one hour before and after TPN is cycled off. You must use the Cycled TPN order sets for cycling TPN. Bear in mind that infants and very young infants may not tolerate long periods of time off TPN unless a sufficient volume of enteral feeds have been initiated to offset nutritional requirements that are absent when cycled off. Older children may be cycled off for 8-12 hours once stable and in preparation for home nutrition support.

To calculate these rates divide the total volume of TPN/day by the number of hours for infusing minus one to obtain the rate of infusion during the main period of infusion. One half that rate is the step-up and step-down rate.

Example: for the previous 20-kg child:

- The 1920cc volume is to be infused over 18 hours.
- 1920/ (18-1) = 113cc/hr
- Start the infusion at 56cc/hr x 1 hr, then increase to 113cc/hr x 16 hours, then decrease to 56cc/hr x 1 hr, then stop TPN for 6 hours before resuming the cycle.
- .Intralipids are not tapered, so the rate of the intralipid will be 192/18 = 10.6cc/hr x 18hrs

Running D10 solution or other fluid should be unnecessary if the patient has been gradually tapered to this regimen from a 24-hour infusion protocol. This is a lot of calculator time, but some of this is calculated within the EPIC platform. The purpose of providing the calculations to you is to give you a better understanding of the complexity of TPN administration.

Frequency of Short-and Long-Term Metabolic Monitoring

CMP Magnesium and phosphorus- Initially monitored daily and modified to three times weekly, then weekly when stable. Once stable and transitioned to long term TPN, these labs may be repeated every other week. However, during acute illness or hospitalization these parameters may be monitored more frequently even in a long term patient who has been stable on TPN.

Prealbumin, Triglycerides, CBC, LFTs and GGTP- Initially weekly and monthly once stable

Iron studies, Zinc, Selenium, Manganese, Copper Chromium Carnitine- Initially every 3 months and every 6 months once stable

Fat soluble vitamins, B12- Initially every 3 months and every 6-12 months once stable.

Note: While in the hospital setting blood drawing from a central line used for TPN should be kept to a minimum and care should be taken to avoid breaking into a line while the TPN is infusing. Our general protocol is to avoid blood sampling until the new TPN is hung or the TPN from the previous day is taken down in the evening hours except when results are otherwise clinically advisable (Drug levels, blood cultures for temperature spikes etc.)

ENTERAL NUTRITION

A simple approach to infant formulas

Multiple formulas attempt to provide nutrients in a similar composition to human breast milk. The primary components of any nutritional product are the 1) protein source, 2) carbohydrate source and 3) fat source. The manner in which these components are supplied is the chief difference between the various infant formulas and breast milk. The osmolarity of the solution and electrolyte composition have additional and significant effects; these components must be considered in the enteral nutrition of the premature newborn, in particular. Most formulas are either premixed as a liquid concentrate or a powder that is reconstituted with water; reconstitution permits changes in the caloric density (and osmolarity). This form of titration can be used for dilution of feedings in order to reduce the osmolar load when starting feeds. The caloric density for breast milk and infant formulas unless specifically noted is 20kcal/ounce =20kcal/30cc = 0.68kcal/cc.

The list below is a simple description of the most commonly used formulas; there are many more highly specialized formulas on the market that are described elsewhere.

Infant formulas

Milk based formulas:

Similac, Enfamil, Good Start: The protein source is from non-fat milk, whey or casein; can also be milk protein isolate for patient with intolerance. The fat source is primarily coconut and soy oils. The Protein:Fat:CHO ratios are about the same and the osm for 20kcal formula is 300 mOsm/kg of H2O. Very similar products from different manufacturers.

Lactose free formulas:

Isomil, Prosobee and Similac Soy: Sucrose or corn syrup solids are the CHO source. The protein source is soy protein in all three and the fat source is coconut, soy or safflower oil. Again, similar products from different manufacturers.

Protein hydrolysate formulas (for infants with absorption problems):

Alimentum, Nutramigen, Pregestimil and Portagen: These are all casein hydrolysates. Their CHO and fat sources vary. There is significant variability in the osmolarity in these formulas, with Pregestimil being closest to normal. Alimentum, because of its higher osmolarity, needs to be used with caution. Nutramigen differs from Pregestimil and Portagen in that the latter two are appropriate for situations in which the long chain fatty acids need to be limited. However, Portagen provides lactose, which may be a problem for some infants.

The Premie formulas:

Enfamil Premature, Similac Special Care, Similac Neosure: These formulas are lactose based with other carbohydrate sources, the protein source is whey/casein and the fat source is a combination of MCT/soy safflower, sunflower and coconut

oils. They differ from their regular infant formula counterparts in that they have 1) other sources of CHO, 2) twice-higher amounts of sodium and calcium per 100 ml and 3) slightly more iron. Please note: mixing the regular infant formulas to a higher strength still does not provide the necessary electrolytes and significantly raises the osmolarity. This has particular implications in the setting of malabsorption as in the case of intestinal failure.

(24kcal Similac has 380mOsm/kgH2O vs 24kcal Similar Special Care which has 300mOsm)

Free Amino Acid Formula

Elecare Infant, Neocate Infant: These formulas are elemental. The protein source is free amino acid or free L-amino acid. The CHO source is corn syrup solids and the fat source is primarily a combination of high oleic safflower oil, MCT, refined vegetable oil, and soy oil. These formulas are primarily reserved for conditions associated with malabsorption or milk protein allergy.

Toddler Formulas

After the first year of life as Cow's Milk had previously been avoided until after the first year. However recent recommendations from the American Academy of Pediatrics suggest cow's milk may be introduced before one year of life.

The composition of formulas for children over one year who are dependent on tube feedings or non-solid nutrition also changes. Typical formulas include **Pediasure, Isocal, Osmolite, and Ensure**. Again, CHO and protein as well as fat sources differ. They have a higher caloric density, usually 30kcal/oz (one kcal/cc) and come in low or high residue varieties (containing fiber). These products vary in complexity. There are polymeric enteral products that include **Boost kid Essentials, Boost Kid Essentials 1.5 (1.5 kcal/mL), and Compleat Pediatric** (composed of "real food") in a liquidized form. Peptide based pediatric formulas include **Peptamin Jr. Peptamin 1.5 and Vital Jr**. Some of the more palatable formulas are used as supplements that are taken by mouth when children are unable to tolerate enough nutrition from an age-appropriate diet to meet demands for growth.

Enteral Nutrition in Pediatrics

Role of Enteral Nutrition

In patients with a functional and safely accessible gastrointestinal tract, enteral nutrition is preferred over parenteral nutrition. It supports normal endocrine, paracrine, and neural function. It improves mesenteric blood flow, decreases permeability within the gastrointestinal tract and prevents structural and functional alterations of the gut barrier. Enteral nutrition also plays a role in the promotion of pancreatic and biliary secretions. In addition, it lowers the risk of metabolic complications such as glucose and electrolyte abnormalities. Lastly, it reduces infection risk, lowers cost of nutrition support, and promotes gut-related immune system function.

Indications for Enteral Nutrition. The following indications include but are not limited to:

Inadequate oral intake for demand

- Cystic Fibrosis
- BPD
- CHD
- Renal disease
- Infection
- Surgery
- Burn, Trauma
- Failure to thrive

Developmental

- Preterm birth
- Prolonged intubation in a neonate or infant
- Neuromuscular disorders
- Neurological impairment

Behavioral

- Feeding aversions
- Unpalatable diet
- Eating disorders

Anatomical

- Cancer, burns, mucositis
- Congenital malformation
- Tracheosophageal fistula

Airway Protection

Anatomical

- Tracheosophageal fistula
- Paralyzed vocal cord
- Severe reflux requiring postpyloric feeding

Developmental

- Neurodevelopmental delay
- Cerebral palsy

Inadequate Intestinal Function

Malabsorption

- Intestinal failure (short bowel syndrome)
- Hi output ostomy
- Crohn's disease
- Pancreatic insufficiency

Tube Feeding Methods

Method of delivery depends on the child's age, condition, diagnosis and placement of the feeding tube

Intermittent bolus feedings: More closely approximate normal physiologic GI function (gastrocolic reflex)

Continuous infusion: For severe malabsorption, dysmotility disorders, or in conditions where the patient does not tolerate peaks and troughs of osmolarity associated with bolus feeding.

Combination of intermittent and bolus: May be used when transitioning from continuous to bolus feeds

Post pyloric/Enteric: For infants with severe reflux, delayed gastric emptying, or both

Methods for Advancement of Continuous and Bolus/Intermittent Feeds

The following are guidelines only and advancement may be highly individualized, dependent on anticipated tolerance and based on the child's responses and underlying condition. It is recommended that you make one change at a time when adjusting feeds both in volume and concentration and the patient should be monitored to assess for feeding intolerance (distended abdomen, emesis, diarrhea, cramping etc.). Bolus feeds are not recommended in post pyloric feeding tubes.

Bolus

In children **up to one year** unless otherwise indicated, bolus feeds may be started at 10-15 mL/Kg every three hours. Feeds may be advanced by 10-30 mL per feed as tolerated to goal.

In Children **one year to 6 years**, start at 5-10 mL/kg every three hours. Feeds may be increased by 1mL/kg every feed or every other feed as tolerated to a maximum of 15-20 mL/kg every 4-6 hours

Children **7 years and up** may be started at 25 mL/hr and increased by 25 mL every feed or every other feed as tolerated with a maximum of 330 to 480 ml every 4-6 hours.

Continuous*:* May be indicated in delayed gastric emptying, risk for aspiration, malabsorption.

Children **up to one year of age** may be started at 1-2 mL/kg/hour and advanced by 1-2 mL/kg every 3-8 hours based on tolerance and not to exceed 6 mL/kg/hour.

Children from **1-6 years of age** may be started at 1 mL/kg/hour and increased by 1mL/kg every 3-8 hours not to exceed 5 mL/kg/hour.

Children **7 years and up** may be started at 25 mL/hour and advance by 25 mL every 3-8 hours not to exceed 100-150 mL/hour.

Enteral and Parenteral Access will be discussed in another section.

Meconium Ileus

TERMINOLOGY

Simple meconium ileus:
Extensive plugging of the intestinal tract, including small and large bowel, with thick, inspissated, tar-like meconium

Complicated meconium ileus:
Pre- or perinatal presentation of meconium ileus complicated by meconium peritonitis, volvulus and/or intestinal atresia

Cystic fibrosis:
95% of cases of true meconium ileus occur in patients with cystic fibrosis. Conversely, 20% of infants with cystic fibrosis present with meconium ileus. (A syndrome that is identical in presentation to meconium ileus can occur without associated cystic fibrosis – most often in patients of Eastern-Asian descent.)

Meconium ileus equivalent:
Obstipation syndrome in older children with cystic fibrosis, in whom thick stools can cause an acute intestinal obstruction

Meconium plug syndrome:
A completely different pathology, characterized by *normal* meconium that is blocked from evacuation by a thick, whiteish luminal plug (often in mid- or proximal colon). Once the plug is evacuated, stooling is normal. Meconium plug is NOT associated with cystic fibrosis. It is sometimes used interchangeably with Small left colon syndrome. Both these conditions can be associated with Hirschsprung disease (10%).

DIAGNOSIS

Prenatal History and diagnosis:

- Familial history of cystic fibrosis in 30% (both parents carriers, but not themselves affected; male patients are sterile)
- Prenatal diagnosis include, in addition to genetic testing for CF): intestinal dilation, echogenic bowel, calcifications and pseudocyst (the latter two in case of complicated meconium ileus).

Presentation:

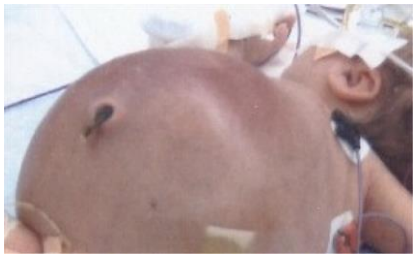
Abdominal distension

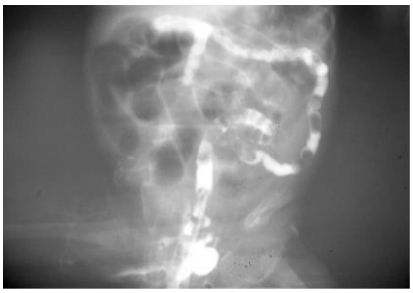
-As this is a congenital condition, meconium ileus presents at birth

-Like most forms of lower intestinal obstructions, the main feature is severe abdominal distension, sometimes associated with (bilious) vomiting. (In upper intestinal causes of obstruction in newborns, abdominal distension is less prominent, and the abdomen can even be scaphoid.)

-Differential diagnosis includes anorectal malformations (imperforate anus), Hirschsprung disease, ileal and colonic atresia and midgut volvulus.

-On palpation, the abdomen feels doughy ("putty sign") – unlike distal intestinal atresia or anorectal obstructions, where the abdomen is tympanic. In complicated meconium ileus, there may be significant discoloration and edema of the abdominal wall, from irritation by (prenatal) meconium peritonitis (figure below).





Imaging:

-KUB

- Multiple gas-distended intestinal loops (as with other forms of lower GI obstructions)
- Superimposed "soap bubble" or "ground glass" opacities representing meconium-filled loops
- Absence of air-fluid levels on cross-table lateral, as the air is trapped in the tenacious meconium and does not rise to the top
- Speckled calcifications or calcified rim of a pseudocyst, if complicated meconium ileus

-Ultrasound

- Abdominal ultrasound is not necessary, but can add to the diagnosis: calcifications (from prenatal perforation) may be more obvious by U/S

-Contrast enema

- If meconium ileus is suspected, a rectal contrast study is indicated
- **IV fluid resuscitation is crucial before a contrast study**

- **NO barium should be used** (in case of intestinal perforation, barium peritonitis will severely complicate the condition and treatment)
- An iso-osmolar water-soluble contrast enema will show a microcolon (distal to the obstruction) with filling defects caused by pellets of stool (figure above).

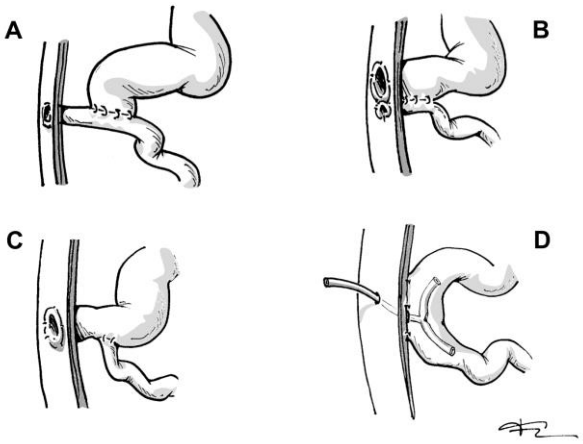
TREATMENT

-Non-operative management is indicated in a stable newborn without signs of complicated meconium ileus.

- Hyperosmolar water-soluble contrast enema can be successful in dislodging the thick meconium through its hygroscopic properties, drawing fluid into the intestinal lumen
- **Adequate IV fluid resuscitation is crucial, as the osmotic effect of the enema can rapidly cause cardiovascular collapse in the borderline-dehydrated infant:** at least 150 mL/kg/d in a full-term neonate (if already euvolemic); follow with urine output and heart rate (urinary catheter mandatory); oro- or nasogastric decompression (Replogle), IV antibiotics, Type & Crossmatch for 2 U of PRBC.
- Successful therapeutic enema requires reflux of contrast into the meconium-filled dilated small bowel loops.
- Dislodgement of a (whiteish) meconium plug, followed by copious evacuation of normal-appearing meconium, suggests meconium plug syndrome. No further treatment may be necessary – but 10% of these patients may prove to have Hirschsprung disease
-

-Operative treatment is indicated in any of the following situations:

- Complex meconium ileus with evidence of (prenatal) intestinal perforation
- Intestinal perforation during non-operative attempts (contrast enema)
- Inability to reflux contrast into the dilated small bowel loops (suspect atresia)
- Inability to resolve the intestinal obstruction despite several enema attempts



OPERATIVE MANEUVERS

-Laparotomy: typically, transverse supra-umbilical incision – offers widest exposure

-<u>Clearing the obstructing meconium</u>

- Enterotomy of the (distal) ileum and manual evacuation of the (mostly sterile) thick, tarry meconium – in a cephalad and caudad direction. Can be a tedious and lengthy maneuver; avoid serosal or mesenteric trauma
- Irrigation of the intestine with warm saline, with or without added acetylcysteine (Mucomyst®), 4 mL of a 10% solution, diluted to 10 mL with normal saline
- Primary closure of the enterotomy if entire bowel is effectively cleared of meconium
- **However**, most surgeons will prefer to leave access to the intestines for post-operative irrigation:
  - Bishop-Koop (end-to-side, or "distal chimney") enterostomy (A)
  - Divided (double barrel) ostomy (B)
  - Santulli (side-to-end, or "proximal chimney") enterostomy (C)
  - T-tube (D)
- Factors to consider in choosing a stoma technique:
  - Evacuation of tenacious meconium is easier through a large enterotomy or transected bowel – leading to either a double-barrel or chimney stoma
  - If all meconium is evacuated, a T-tube may be best
  - In case of <u>atresia</u> and diameter discrepancy between proximal and distal bowel, a Bishop-Koop enterostomy allows primary repair with a "pop-off" and irrigation valve

        - Appendectomy is not mandatory, but often performed: it can be an elegant way to an irrigation enterostomy, and pathology exam can help in the diagnosis

-Intestinal resection

- In case of frankly ischemic bowel (volvulus) or atresia, resection is necessary.
- Bowel resection should be limited, if possible, to avoid short gut syndrome (consider second-look for borderline ischemic loops)
- Anastomosis: see above – primary anastomosis without decompression stoma is rarely safe

-Meconium peritonitis

- Prenatal perforation often leads to a meconium pseudocyst
- Overly aggressive lysis of dense adhesions may jeopardize bowel length
- Proximal stoma (and mucous fistula) may the safest first-line treatment

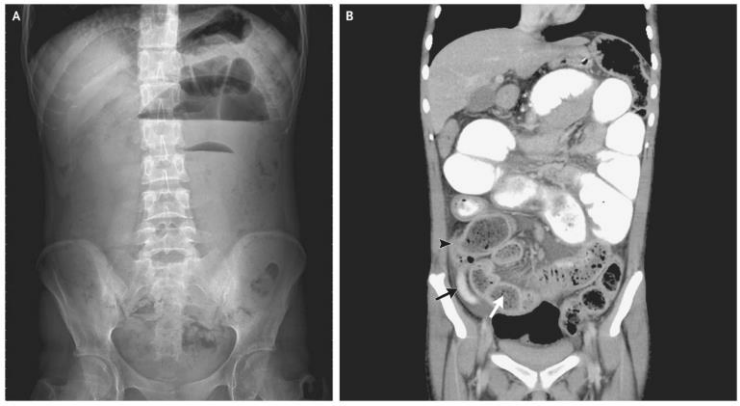
POSTOPERATIVE CARE

-Immediate postoperative period

- Continue Iv antibiotics for 48 h, or longer if clinically indicated
- Adequate postoperative hydration: Depletion of the intravascular space is bound to continue as water is drawn into the bowel
- Start irrigations with Mucomyst® on 3rd-4th postoperative day – daily dose, until full feeds
- Early consultation with pulmonary/CF specialist
- Confirmation of CF diagnosis (sweat test at 1 month, typically)
- Transition to enzyme replacement

-Long-term management

- Infants with CF who present with meconium ileus are NOT at greater risk of severe disease – in fact, neonatal presentation (because of meconium ileus) may allow early preventive measures to avoid recurrent pulmonary complications
- Meconium ileus equivalent is a form of intestinal obstruction in older children and adults with CF, mimicking the neonatal condition (figure below). Hyper-osmolar enema treatment can be attempted, but aggressive IV fluid hydration must precede the procedure, as cardiovascular collapse is a significant risk.



Suggested Readings:

1. Kronfi R, Maguire K, Walker GM. Neonatal stomas: does a separate incision avoid complications and a full laparotomy at closure? *Pediatr Surg Int* 29: 29:299–303, 2013.
2. Carlyle BE, Borowitz DS, Glick PL. A review of the pathophysiology and management of fetuses and neonates with meconium ileus for the pediatric surgeon. *J Pediatr Surg* 47:772-81, 2012.
3. Burke MS, Ragi JM, Karamanoukian HL, et al. New strategies in nonoperative management of meconium ileus. J Pediatr Surg 2002;37:760-764.
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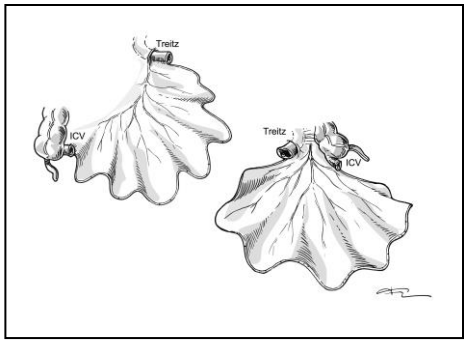
Malrotation and Midgut Volvulus



TERMINOLOGY

Key features of normal intestinal rotation:

1) the duodenum describes a "C-loop" with the third portion of the duodenum (at the ligament of Treitz) to the left of the midline,
2) the superior mesenteric artery runs in front of the third portion of the duodenum,
3) the mesentery is attached posteriorly along a broad line that runs from the ligament of Treitz (left upper quadrant) to the cecum (right lower quadrant), and
4) the colon describes a frame with the cecum and ascending colon fixed along the right side of the abdomen and the descending colon fixed along the left side.

Malrotation:

- most commonly used to describe non-rotation: failure of the duodenum to form its characteristic "C-loop" and instead coursing in a straight cephalocaudal line into the proximal jejunum.
- Other rotational anomalies: incomplete rotation, reverse rotation, and errors of intestinal fixation, typically of the cecum and the ascending and descending colon.
- Incidence of isolated malrotation: 1 in 500 live births; much more common in a number of genetic, chromosomal and congenital disorders.
- **Errors of intestinal rotation usually do not affect intestinal function**
- **They do place a child at risk of midgut volvulus – a life-threatening that causes acute obstruction of the root of the SMA, resulting in ischemia of the entire midgut: from the ligament of Treitz to the ascending colon.**
- **Midgut volvulus** demands rapid operative correction!

DIAGNOSIS

Presentation:

Bilious emesis

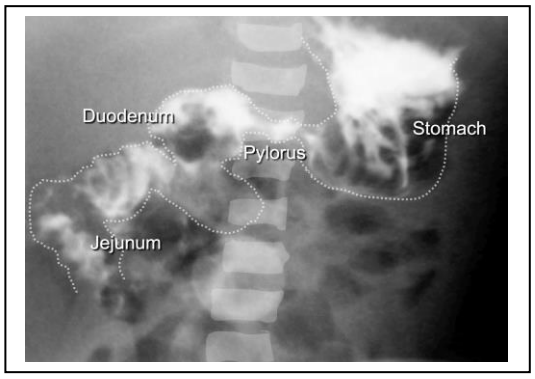
- Suspect midgut volvulus in **any** infant or newborn presenting with bilious vomiting.
    - Seen in ½ of the infants presenting with malrotation or midgut volvulus, and in 1/3 of those older than one month.
- Not pathognomonic for malrotation: seen with duodenal atresia, annular pancreas, small bowel atresia, meconium ileus, Hirschsprung disease

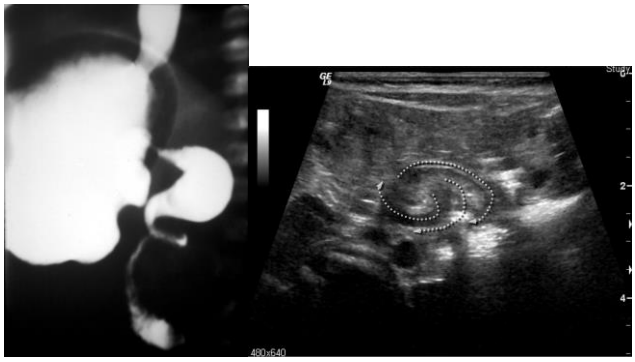
Physical exam/other findings

- Scaphoid abdomen
    - May be absent later in the course due to gastric distention, distention of ischemic bowel, ascites
- Bloody stools (late findings)
- Tachcardia, poor capillary refill
- Oligo or anuria
- Metabolic acidosis on labs

Imaging:

- KUB
    - Non-specific
    - Can suggest presence of malrotation/volvulus due to "double bubble" from tight Ladds' bands, although distal gas can be present
    - NEVER used to rule out volvulus; if suspicion high, go to UGI
- Upper gastrointestinal contrast series (UGI)
    - Most reliable diagnostic method
    - Done on stable patients; unstable patients with peritonitis should go to the OR
    - Normal rotation: duodenal C-loop crosses the midline, ligament of Treitz (duodenojejunal junction) located to the left of the spine and at least as high as the pylorus
    - Malrotation or non-rotation: ascending and transverse colon are located to the left of the spine; also, right-sided position of the majority of small bowel loops and absence of typical colonic frame
    - Midgut volvulus: corkscrew (or apple peel) appearance of the first jejunal loops, best seen in a lateral view





- Ultrasound
    - Not the gold-standard for detecting malro or volvulus
    - Has become more accurate over time
        - Identification of 3rd portion of duodenum crossing spine suggest normal rotation
        - Superior mesenteric artery (SMA) posterior and to left of vein in normal rotation
            - Malro: SMA to right of SMV
            - Midgut volvulus: torsion of vessels cine as a swirl or "whirlpool" pattern on Doppler ultrasound

- Contrast enema
    - Less reliable: partially or completely rotated colon does not rule out duodenal malrotation
- CT
    - Can see whirlpool sign and duodenal obstruction
    - Not the diagnostic procedure of choice, especially for neonates

TREATMENT

- Immediate intervention for **midgut volvulus** diagnosed by UGI or strongly suspected (acutely obtunded infant with bilious vomiting)
    - IV fluid resuscitation, NGT, foley as you **GET THE PATIENT TO THE OR**
- Urgent intervention for malrotation without obstruction in otherwise well patient
    - UGI may miss intermittent volvulus or partial obstruction

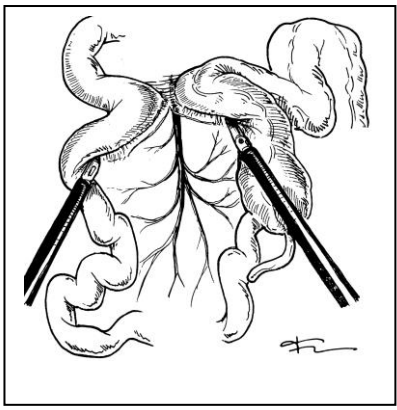
Surgical repair

Midgut volvulus should be treated with *open* repair; *laparoscopy* can be considered for elective or semi-urgent operation for malrotation.

Open repair

- Generous transverse upper abdominal incision for newborns and infants, midline laparotomy for older children
- Intestinal contents are exteriorized completely and assessed.
- If volvulus is present, the small bowel must be rotated in a ***counterclockwise*** fashion to undo
    - Even if initially ischemic, detorsion and decompression can produce significant or complete return of normal color and perfusion.
    - Detorsion is complete when the base of the mesentery is visualized (small bowel on right of midline and colon on left)
- Ladd's bands: may run from the cecum to the right abdominal wall. Can obstruct the duodenum or duodenojejunal junction. If present, they are

divided
- Avascular attachments between the duodenum and the ascending colon are divided. This allows the duodenum to fall back in the right gutter and the ascending colon to the left.
- Operation is complete when the main trunks of the SMA and SMV are exposed (figure right).
- In the stable patient, appendectomy is performed as well



If **bowel necrosis** is present, resection may be necessary. Guiding principles:
- If no contamination and limited extent of necrosis, resection with primary anastomosis is safe
- If spillage or significant contamination or the patient is unstable, ostomies are safer
- In case of extensive ischemia, limited resection, if possible, followed by second-look might preserve some bowel length

SUGGESTED READINGS

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Spigland N, Brandt ML, Yazbeck S. Malrotation presenting beyond the neonatal period. *J Pediatr Surg* (1990) 25:1139-1142

Lessin MS, Luks FI. Laparoscopic appendectomy and duodenocolonic dissociation (LADD) procedure for malrotation. *Pediatr Surg Int* (1998) 13:184-185

Vascular Access

- Vascular access is an important part of the management of Pediatric Surgery patients for resuscitation, phlebotomy, medication, and other indications
- Most commonly vascular access is established via a peripheral IV.
- Other forms of access may be required if:
    - It is expected that the patient would have a prolonged hospitalization (>7 days)
    - The patient will require ongoing medical management in the outpatient setting (i.e. antibiotics or parenteral nutrition)
    - The patient is reported to be a "difficult access" or requires frequent phlebotomy

Peripherally Inserted Central Catheter (PICC Line) (Brands: Bard)

- Placed in a peripheral vein with the catheter terminating most commonly in a central vessel (SVC/IVC).
- Placement is performed with sterile technique at the bedside.
    - Done by direct visualization/palpation, transillumination or ultrasound guidance
- Classified as a midline catheter or a central line.
    - **Important**: the location of the termination of the line will direct what therapies can be infused.
- Can be single, double or even triple lumen.

Hasbro Children's Hospital's PICC line team is also its Pediatric Sedation team.

- Consults can be placed in Epic and the team can be contacted at 4-6091.
- When asking for a PICC line consult, establish with the PICC team the indication for the consult as well as how many lumens are preferred.

Non-Tunneled Central Line (Brands: Cook, Arrow).

- Can be placed either at bedside or in the OR.
- Sterilely placed by either ultrasound guidance or anatomical landmarks, sutured in place.
- Stable vascular access for duration <2 weeks for patients who are not PICC Line candidates for various reasons or are too critically ill to tolerate a trip to the OR
- As these lines are sutured in place and the catheter can be a short as 5cm in length, **preservation of these lines is paramount**.
    - Daily assessments to ensure intact sterile dressing and sutures are needed

Tunneled Central Lines.

- Placed in the OR
- Used for patients who require long term central access
- Vascular access obtained with ultrasound guidance or anatomical landmarks.

- After access of the vessel, the catheter is tunneled under the skin away from the needle site; commonly exits in the pectoral region.
- Fluoroscopy is used to correctly position tip, usually in SVC or at SVC/RA junction
- Sutured in place at time of placement to help preserve the line
- Implanted cuff on the catheter is subcutaneous and over time will adhere to surrounding tissue to maintain placement and prevent dislodging
- Removal requires disrupting/mobilizing the cuff and holding pressure at the **ENTRY** vessel, not the entry site of the catheter
    - Can be done in the OR or at the bedside for some patients
- Common names: "Hickmans," "Broviacs," "Tunneled Central lines"

Port-a-cath

- Central venous catheter completely implanted under the skin with a pierceable reservoir
    - Silastic top of reservoir allows for needle access
    - Silastic tube travels under skin from reservoir to major vein
- Used for chemotherapy and other chronic treatments
- Can also be used for blood draws
- Placed in OR with image guidance or anatomical landmarks
    - Vessel cannulated, catheter tunneled from the reservoir site where it has been connected
- Removal requires OR
- For children >10kg due to size and equipment limitations

Consult a for central line

When another service requests a consult for central line placement, the following must be established:

1. Indication for consults
2. Duration that line will be needed
3. Existing access which the patient has in place
4. How many lumens the requested line should have

If the consult is from the Pediatric Hematology/Oncology team:

1. Establish indication/diagnosis for the request for vascular access
2. Determine if the request is for a port or a broviac, and the number of lumens needed
3. The patient and/or family must be aware of the diagnosis from the primary team and be anticipating a surgical consult. This is the expectation before any member of the pediatric surgery team will see the patient to perform the consult.

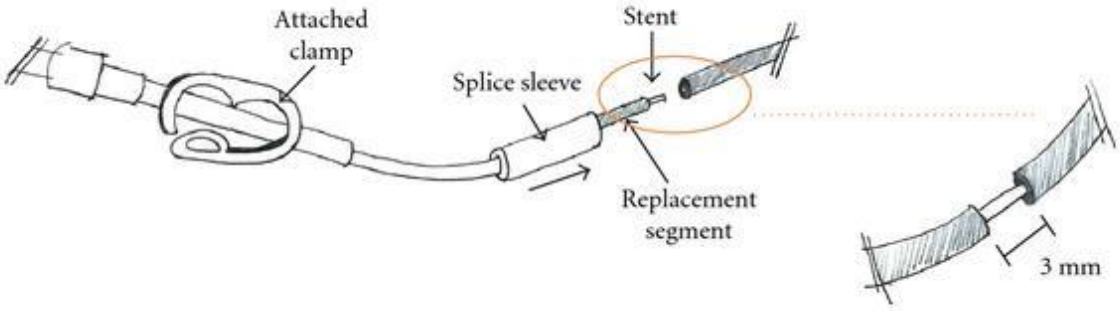
4. There **MUST** be clear documentation by the primary team, signed by the Heme/Onc attending, attesting to the type of line (port vs. broviac) prior to going to the OR for placement

Note: often the consult for a new oncology diagnosis will be Attending to Attending.

Problem Shooting Central Lines

Repair of a Broken Tunneled Central Line

A consult one might encounter will be for the "broken Broviac" or "broken tunneled central line (CVL)." In certain settings the catheter can be repaired at the bedside. Timely interventions when the damage is discovered (clamp catheter, protect from contamination) will be done by the consulting team but a Pediatric Surgery team member should immediately assess that these steps are taken. Repair kits can be found on floors PICU, 4th and 5th as well as the ED and Central Supply. Repair kits come in sizes 4F, 7F, 9F. The Pediatric Surgery team member must verify the correct size repair kit in relation to the damaged line



Repair process

1. Establish the catheter is clamped with no active bleeding or fluid leakage from damaged area
2. Establish the correct size repair kit to be used
3. Note what type of damage is present: dissection, tear, hole, ballooning
4. At least 5cm of the catheter distal from the insertion site must remain; if it is a double lumen, at least 2.5 cm should remain distal to the bifurcation
5. Under sterile technique the sterile occlusive dressing should be taken down and site cleaned thoroughly
6. The new catheter in the repair kit should be flushed with normal saline. Glue within the kit should be prepared in provided syringe.
7. Proximal to area of damage, the old catheter should be cut and removed from table.
8. The new catheter should be inserted and applied with some force to establish silastic portions line up with no visible gaps. The sliding sleeve should be placed over the area of repair. Glue should be generously administered at both ends of the sleeve so that the repair is completely encompassed with glue.
9. A splint such as a tongue depressor or IV board should be secured along the sleeve joint for 48 hours to better protect the repair. A new sterile dressing should be applied at the earliest opportunity.

10. The repaired line should be **GENTLY** flushed with 20units/2ml of heparin and left heparin locked for 4 hours before using
11. If the patient has a double lumen, blood cultures should be obtained, and prophylactic antibiotics should be administered. If single lumen, blood culture and antibiotic should be done at the conclusion of 4 hours. The provider at conclusion of repair will be expected to leave a note describing the procedure how well it was tolerated

Repair Kits: Inventory and Location

All repair kits can be found in Central Supply. When asking for a kit, it best to use the locator/inventory number to identify the kit.

Double Lumen Kits
5 Fr #107915
6 Fr #156260
7 Fr #378391

Single Lumen Kits
4.2 Fr #1788
9.6 Fr #1789

Larger kits (which are rarely used) can be obtained from Adult Oncology.

A limited number of single lumen kits can be found in the HCH 4 and 5 treatment rooms (double lumen repair kits are not stocked on the floor)

Single Lumen Kits
4.2 Fr #1788
9.6 Fr #1789

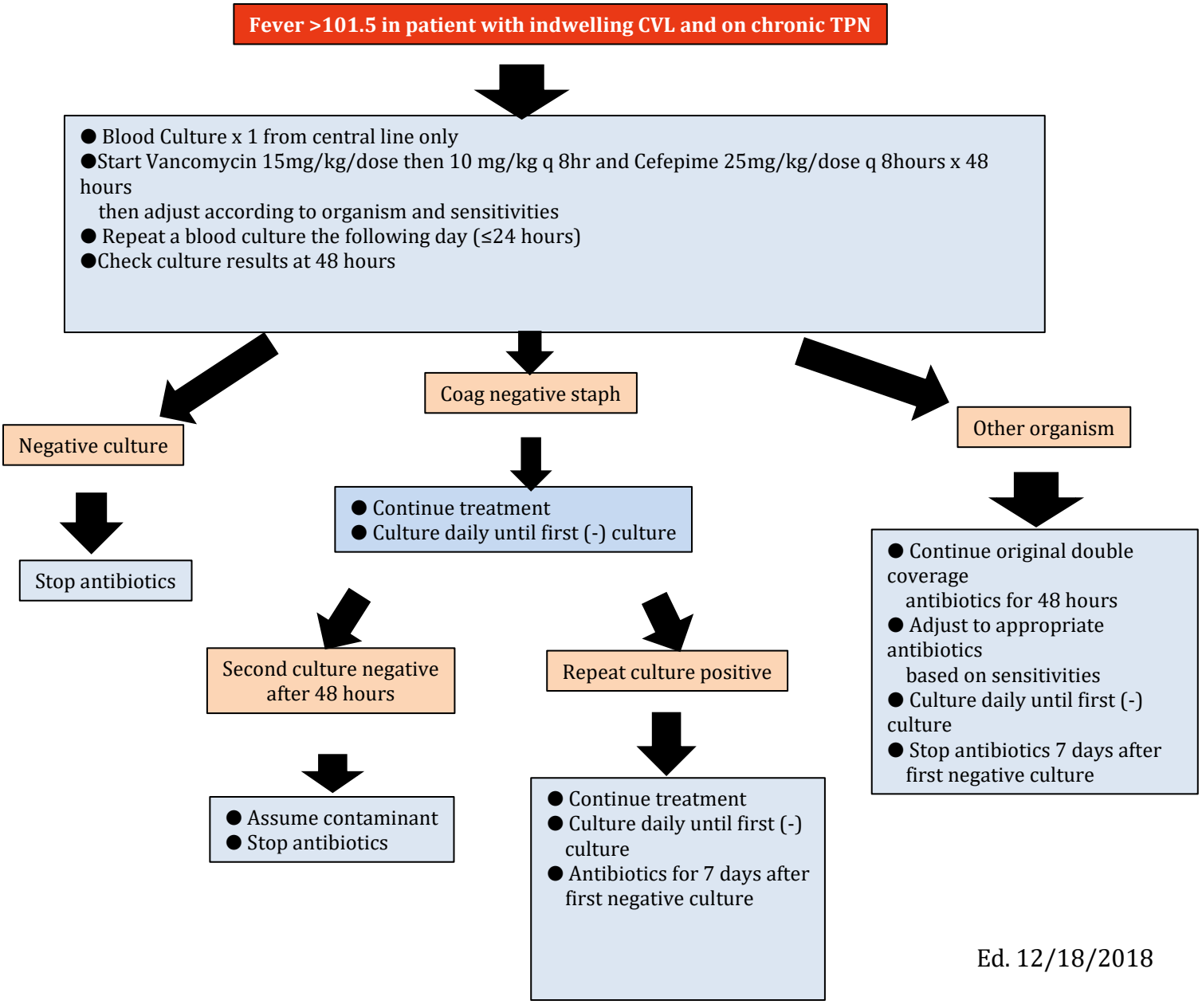
TPA/Alteplace/CathFlo
Central/Midline catheters are at risk of thrombotic events with occlusion of the catheter. This results in sluggishness or inability to infuse and/or lack of blood return. Alteplase/CathFlo can ordered and administered by nursing. Alteplase/Cathflo is a specific order in Epic and standard dosing for catheter clearance is 1mg (1mg/1ml). This will be instilled by the bedside RN. The dwelling time should be 90 mins and at which time the nurse will assess for blood return and the ability to infuse. If the problem still exists, this process can be repeated. Dosing remains the same (1mg/1ml).

TPA Administration for Intra-abdominal/Chest tube catheters

TPA can be administered in non-vascular catheters. Chest tubes and abdominal drains can become occluded after insertion. Administration of fibrinolytics can re-establish patency. At attending discretion, TPA can be ordered in ratio of 1mg TPA to 10ml Normal Saline. For instance, in an adult size adolescent an order of 4mg TPA in 40ml NS is appropriate and can be administered through a chest tube or catheter. Due to limits in volume, small patients might require small doses 2mg/20ml NS or 1mg/10ml syringes. Using aseptic technique the syringe should be attached appropriately to luerlock or the available port of 3-way stopcock. Administration should continue until patient endorses pain. Upon completion of instillation the catheter must be clamped for 60-90 minutes. Nursing must be made aware of this as they will need to record the total output of infusion as well as the amount that drains out at the conclusion of the 60-90minutes.

Central Line Infections

Patients may need tunneled lines for chronic TPN at home. When such a patient presents with fever, the line is assumed guilty until proven innocent. The flow diagram below describes the pediatric surgery service's approach to the evaluation and treatment of suspected line infections in children on home TPN.



Ed. 12/18/2018

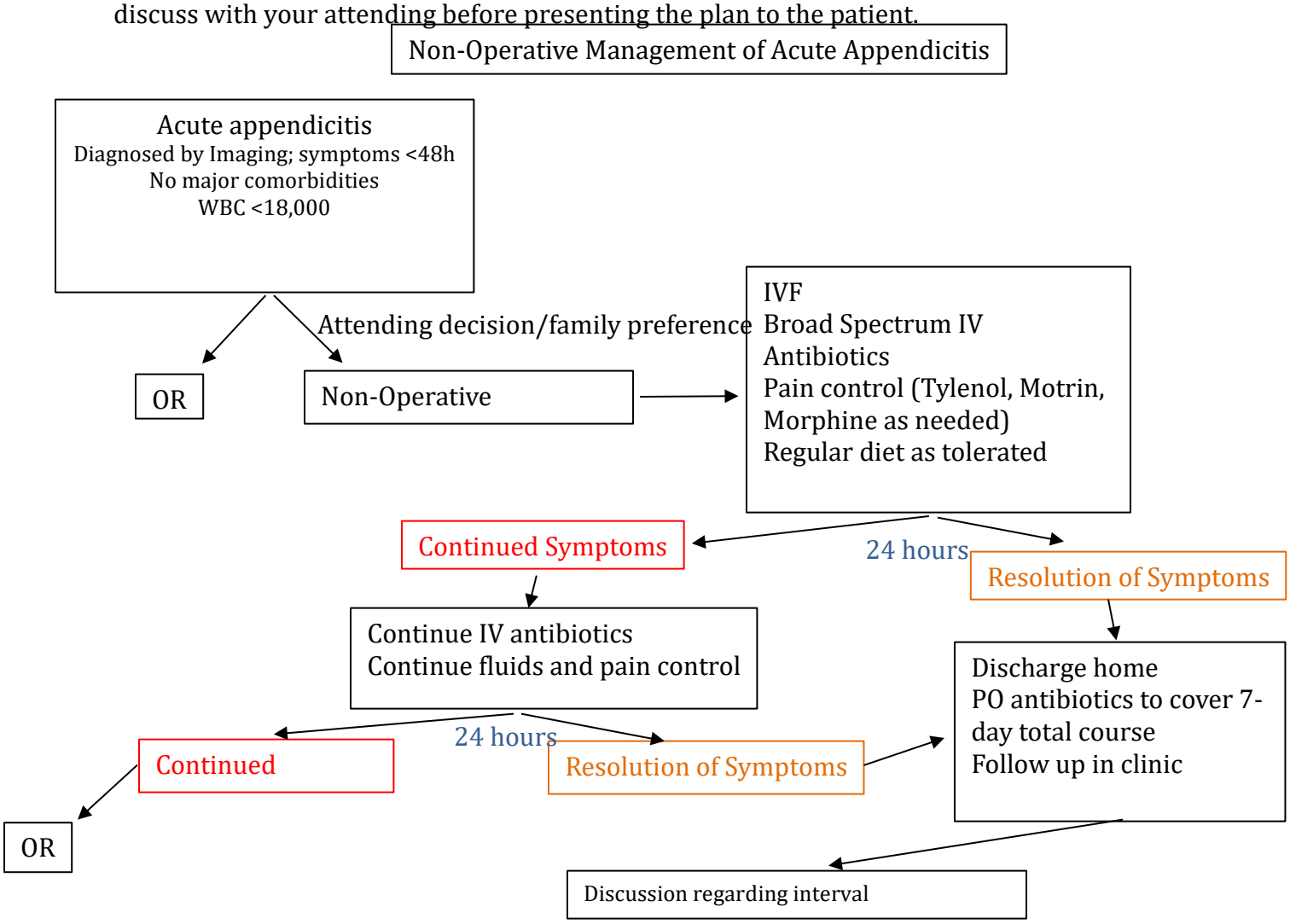
Non-operative Management of Acute Appendicitis

The Division of Pediatric Surgery currently has two care pathways for treatment of appendicitis: non-operative management of acute appendicitis, and advanced appendicitis.

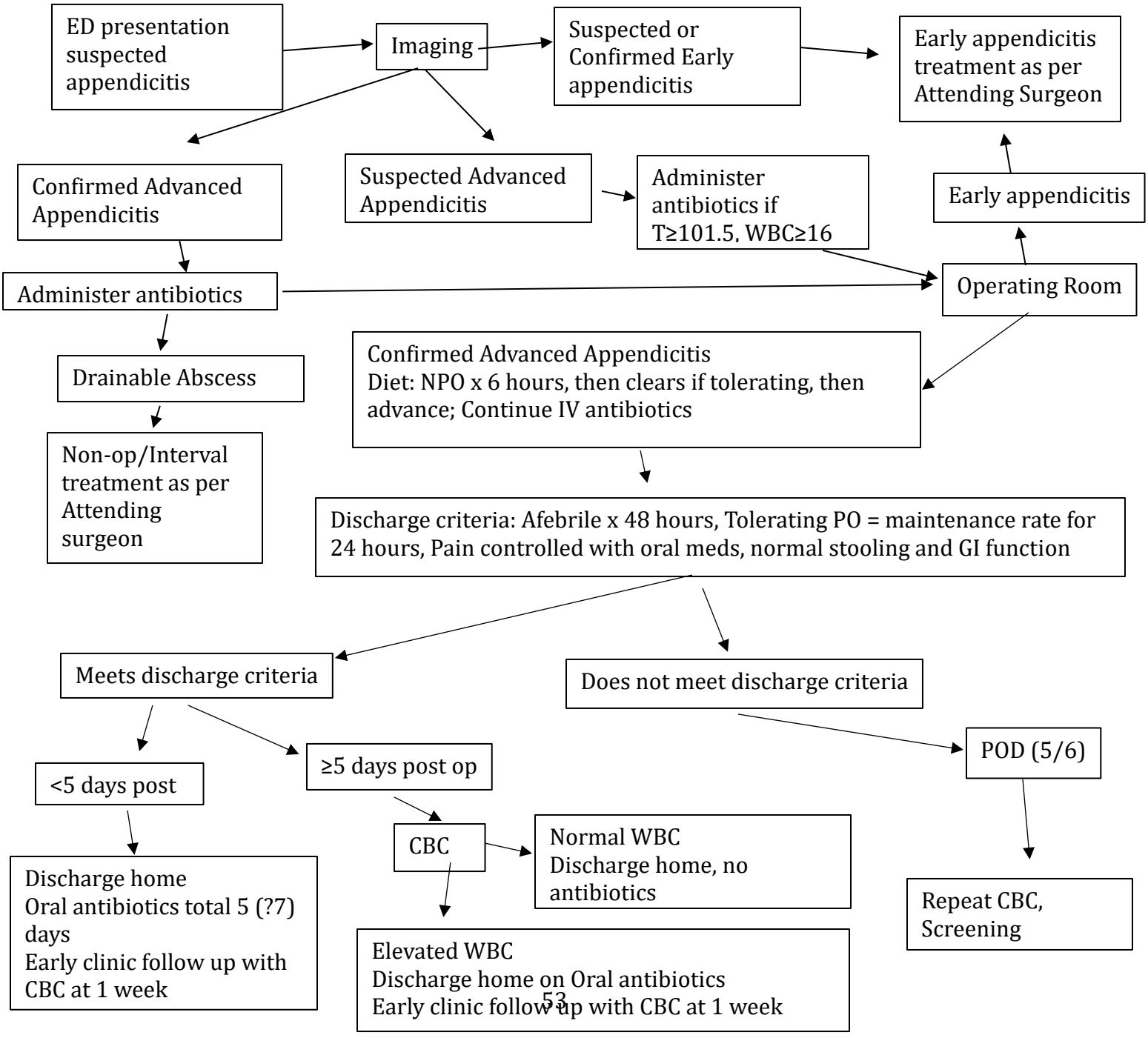
Non operative management of acute appendicitis: The treatment of acute appendicitis non-operatively is controversial. There is evidence that it can be used effectively, but there is a high recurrence rate of appendicitis within one year of treatment (as high as 30%). The option to treat non-operatively **MUST** be discussed with your attending before presenting it as a potential treatment option for patients. This pathway may be an option for patients who are COVID positive or have some other co-morbidity that would increase the risk of general anesthesia.

The broad-spectrum antibiotic usually chosen is Zosyn. Ciprofloxacin and flagyl may be an option in penicillin-allergic patients.

By the current pathway, patients are considered a "failure" of non-operative management if they have persistent unresolving abdominal pain, inability to tolerate PO, or fever at 48 hours. At this point surgery would be considered. Again, discuss with your attending before presenting the plan to the patient.

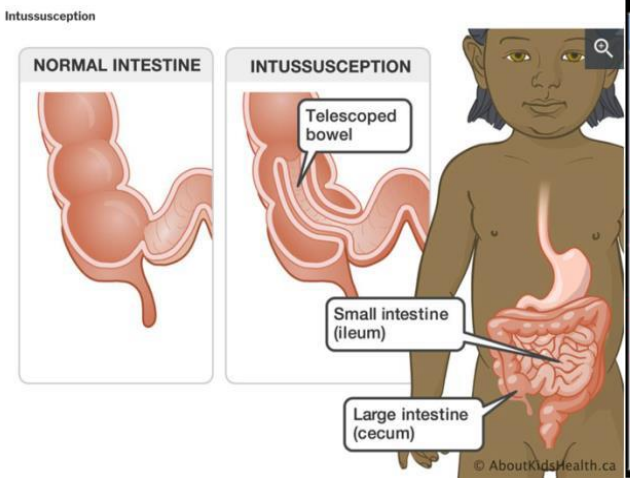


Advanced Appendicitis Pathway: "Advanced appendicitis" refers to any form of appendicitis beyond acute – gangrenous, suppurative, and perforated. This pathway addresses the operative management of these forms of appendicitis. We currently do not have pathways for non-operative management of advanced appendicitis or for management of appendicitis that presents with a well-defined abscess. Please discuss these two situations with your attending.
The most common antibiotic choice is Zosyn, with Ciprofloxacin/Metronidazole for penicillin allergy.
Definitions: *early appendicitis* – acute, non-suppurative by radiology; *advanced* – gangrenous, purulent, perforated by radiology
CBC can be performed POD 5; imaging, starting with ultrasound, may be more useful on POD 6



Ileocolic Intussusception

Definition: Intussusception occurs when a part of the intestine folds into itself like a telescope, with one segment slipping inside another segment.
Presenting Symptoms/Signs: Patients usually present between 3 months and 4 years of age. They will experience intermittent colicky abdominal pain occurring every15-20 min with drawing up of the legs, abdominal distention, vomiting or passage of bloody and/or jelly-like stool. These symptoms may have been present for only a few hours or for several days. Intussusception may be seen more frequently in cooler seasons when viruses are prevalent. With later presentations, a child maybe dehydrated, septic and/or lethargic.
Cause: Due to alterations in bowel motility, although a lead point may be present, especially in older children. Lead points include Meckels diverticulum and polyps. Intussusceptions cause intraluminal obstruction, proximal distention, potential vascular compromise to blood supply, dehydration, and sepsis.
Evaluation/Management: The Pediatric Surgery team will be consulted by the ER to help with suspected bowel obstruction (colicky pain followed by distension), abdominal pain/vomiting, or lower GI bleed. The child will likely have had blood work, an AXR and a confirmatory ultrasound of abdomen demonstrating intussusception.



Etiology

Children	Adults
Spontaneous: (without anatomical leading point) in 90% of cases: •Mucosal edema & lymphoid hyperplasia after viral gastroenteritis.	**Spontaneous**: (without anatomical leading point): •Celiac disease. •Scleroderma. •Whipple disease.
Leading point: •Meckel's diverticulum. •Polyp. •Enterogeneous cyst. •Ectopic pancreas. •Purpura.	**Leading point (90%):** •Tumor: Usually benign in small intestine & malignant in large intestine. •Polyp, •Ulcer, •Foreign body.

-Start with the ABCs, followed by assessing the overall wellness of the child
-Obtain your own history from the caregiver including the length of symptoms
-Examine the child to assess the severity of dehydration, presence of abdominal mass, and any evidence of peritoneal irritation
-Resuscitate the child with appropriate fluids depending on your evaluation of the degree of dehydration and monitor urine output
-Review the ultrasound to confirm the diagnosis. This is usually the definitive study for diagnosis of this disease.

-Some surgeons may consider starting a prophylactic antibiotics on making the diagnosis while waiting for treatment; check with your attending for guidance on this issue

Treatment: Either radiologic or surgical. If the child is hypo-responsive with a prolonged history of symptoms (> 3-4 days) or has signs of peritonitis, a surgical option may be considered early. In a stable patient, an air enema can be used to reduce the intussusceptum from intussuscipient. The reduction is performed by a radiologist and the resolution of intussusception is confirmed by reflux of air into the proximal portion of ileum or intestine. Depending on how far the intussusceptum has advanced into colon, the radiologist may elect to reduce in multiple attempts (usually 3-4 times) over several hours depending on their progress. The general incidence of recurrence following air enema reduction is ~10 %. Although it may vary from institution to institution, patients are admitted for observation overnight following the initial reduction. If symptoms recur, the air enema will be repeated. One should consider a lead point as a cause of intussusception if there are multiple recurrences or failure of reduction

-Patients need an IV prior to arriving in radiology.

-It is important for **the pediatric surgical team to be present during air enema reduction.** Air enema reduction may cause bowel perforation and even cardiorespiratory arrest. This is an emergency situation with a rapid insufflation of abdomen and potential compromise of respiration and circulation. In addition to rapidly arranging for surgical intervention, one should be prepared to decompress the abdomen if tension pneumoperitoneum is present by careful insertion of a #14 gauze angio-catheter through the abdominal wall

- As noted above, surgical indications for intussusception are peritoneal signs with prolonged presenting history, failure to reduce, and multiple recurrences with the confirmation of a lead point as a cause of intussusception. The child should be prepared for laparoscopy or laparotomy, possible reduction of intussusception, possible bowel resection, possible stoma.

-The above information primarily describes the evaluation and treatment of ileocolic intussusception. Pediatric Surgery may occasionally be consulted for small bowel-small bowel intussusception. This entity can often be seen on ultrasound when a patient has gastroenteritis or other conditions increasing bowel motility. Most often it is not a cause of symptoms and will self-resolve. Occasionally, it may need treatment depending on the duration of persistence of the intussusception on imaging, the length of the intussusception, signs of bowel obstruction proximal to the intussusception, or presence of a lead point. Conditions such as Peutz-Jeghers or Henoch-Schonlein Purpura may increase the likelihood of a lead point and need for treatment. Patients should be individually evaluated and discussed with your senior and attending.

Reference:

1. Diagnosis and treatment of Intussusception- A surgical condition Mark M. Ravitch Pediatrics 1966;38;122

2. Pediatrics International (2012) 54, 948–958, e35–e42

Skin and Soft Tissue Infections

Both cellulitis and abscess are common skin and soft tissue infections in children. Cellulitis typically appears as erythema, edema and warmth after bacteria has violated the skin barrier. An abscess is a collection of fluid, pus and/or blood within the dermis or subcutaneous space. Both may occur in otherwise healthy children with no known predisposing factors. The most common cause of cellulitis is Streptococci, while the most common pathogen associated with abscess is Staphylococcus aureus.

Patient evaluation

- Identify risk factors for MRSA (family or personal history, family member in healthcare etc.)
- Identify underlying medical conditions (malignancy, immunocompromised state)
- Ask about a history of prior abscesses
- Evaluate for recent trauma (including animal or insect bites), recent rashes, use of antibiotics (sometimes prescribed by a Pediatrician prior to Surgery evaluation)
- Obtain travel history
- Ask about allergies to medications

Physical Examination

- Temperature, heart rate, blood pressure
- Evaluate for erythema, Induration, fluctuance, presence of pustule
- Ask if the area has spontaneously drained or been previously drained
- Note: ultrasound is not necessary for diagnosis!

Treatment

Incision and Drainage

- Can be performed in the Emergency Department, Pediatric Sedation, Operating Room
- If performed in ED, the need for sedation is based on patient age, medical history, associated medical disorders, location/size of abscess and timing of last PO
    - Discuss sedation options with ED provider. These may include IN Fentanyl, IN Versed, IV Morphine, IV Versed, IV Ketamine
- Discuss plan for incision and drainage with patient and family and obtain consent for the procedure. If being done under moderate sedation in the Emergency Department or Pediatric Sedation consent is not needed because the procedural consent is included as part of the sedation consent
- Document consent and procedure in a Procedure Note
- Supplies to gather:

- Local Anesthetic: Lidocaine
- #11 blade
- Chlorhexadine prep OR Betadine
- Towels
- Gauze
- Normal Saline 10 cc flush
- Vessel loop OR penrose drain OR plain/Iodoform packing **discuss choice with Attending
- Culture swab
- Kelly OR Jake OR Mosquito
- Suture material if needed
- Dressing supplies (gauze, Tegaderm, tape, Hypafix etc.)

- Discuss details of the procedure with Senior On-Call prior to performing I&D. This will guide decision making in terms of drain placed and wound care to follow.

Antibiotic Therapy

- Indications: Cellulitis and induration with systemic signs and no indication for I&D OR persistent cellulitis and systemic signs after I&D
- Nafcillin 150 mg/kg/day divided Q6H AND Clindamycin 25-40 mg/kg/day divided Q8H
- PO options if patient is to be discharged:
    1. Clindamycin 30-40 mg/kg/day divided Q8H
    2. Keflex 25-50 mg/kg/day divided Q6H
    3. Bactrim 8-12 mg/kg/day divided Q12H

Wound Care

- Warm Compresses: usually used if an area of cellulitis is not yet "ripe" enough for drainage and the patient is on antibiotics. May encourage "pointing" of the infection which will allow drainage
- Sitz baths: often used after pilonidal abscesses or perineal/labial abscesses
- VNA care: sometimes needed, depending on comfort level and resources of family
- If a packing is left, it should be removed within 48 hours by family or VNA
- If a drain is left, it should be removed in Pediatric Surgery Clinic 3-5 days post-operatively
- Tylenol and/or Motrin for pain control with wound/dressing care

Pilonidal Disease

Pilonidal disease refers to pits, abscesses, sinuses or pseudocysts of the natal cleft. The disease varies in presentation. The exact cause of pilonidal disease is unknown, but hair plays a role. The hair involved is most likely "lose hair" that, as a result of friction within the intergluteal cleft, breaks off and falls into an open pit. Filled with hair and debris, these pits serve as a site of incubation for bacteria. Pilonidal disease is most common in teenage males. Risk factors for the disease include increased weight, sedentary lifestyle, a deep natal cleft, and excessive hair growth.

Patient presentation with acute disease

I. History and symptoms
- Pain within intergluteal cleft
- Swelling or redness
- Bloody, mucoid or purulent drainage
- Fever

II. Physical Examination
- Findings are superior to, lateral to or within natal cleft
- Erythema
- Tenderness
- Fluctuant Mass
- Midline Pits
- Sinus Tracts
- Granulation Tissue
- Bloody, mucoid or purulent drainage
- Excessive hair growth

Treatment

III. Incision and Drainage
- Performed in Emergency Department, Pediatric Sedation, or Operating Room
- If performed in ED: assess the need for sedation based on patient age, medical history, associated medical disorders, and timing of last PO
  - Discuss sedation options with ED provider. These may include IN Fentanyl, IN Versed, IV Morphine, IV Versed, IV Ketamine
- Discuss plan for incision and drainage with patient and family and obtain consent for the procedure. If being done under moderate sedation in the Emergency Department or Pediatric Sedation, consent is not needed because the procedural consent is included as part of the sedation consent
- Document procedure and consent in a Procedure Note

- Incise over point of maximum fluctuance
- Incise off midline
- Supplies Needed:
  - Local Anesthetic: Lidocaine
  - Chlorhexadine prep OR Betadine
  - #11 blade
  - Culture swab
  - Kelly OR Jake OR Mosquito
  - Tweezers
  - Saline Flush
  - Razor OR Clippers
  - Plain Packing versus Vessel Loop versus Penrose Drain
  - Gauze
  - Tape
  - Tegaderm OR Hypafix

IV. Antibiotics
- Consider only if cellulitis and tenderness with no evidence of fluctuant mass OR if extensive cellulitis remains following I&D
- Oral Ciprofloxacin, Flagyl, Augmentin, Clindamycin, Bactrim

V. Wound Care
- Provide extensive education to family regarding wound care (review with senior and attending)
- If packing is present, removal to be performed within 48 hours
- If drain or vessel loop is present, removal to be within 3-5 days in Pediatric Surgery Clinic
- Sitz Baths, Showering, dressing changes may be part of wound care
- Hair removal (once acute wound is healed): depilatory cream, laser hair removal
- Tylenol and/or Motrin for pain control with wound/dressing care

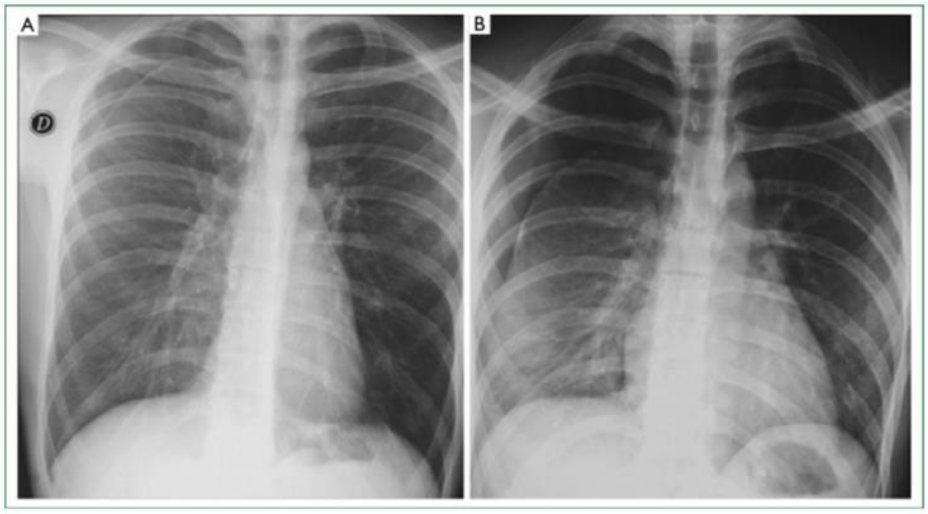
Definitive treatments

Pit Picking
- Minimally invasive
- Performed in Operating Room
- Discharged to home following procedure
- Wound care dictated by operating Surgeon

Excision
- Options include marsupialization, wide excision with secondary healing, wide excision with primary midline closure and excision with off-midline closure

Pneumothorax

Definition: Pneumothorax refers to the presence of air in the pleural space between the lung and the chest wall. "Primary spontaneous" pneumothorax occurs without any precipitating traumatic or iatrogenic mechanism. When there is a known cause, the pneumothorax is "secondary" to the



Cause: Most commonly, emphysematous blebs, asthma, and tobacco have been attributed. It is commonly thought that young males with Marfan syndrome, a common inherited disorder of connective tissue, are prone to spontaneous pneumothorax. If younger children present with spontaneous pneumothorax or recurrent pneumothorax, uncommon underlying diagnoses including CPAM and pleuropulmonary blastoma may need to be considered.

Evaluation/Management: The pediatric surgical team will be asked to consult in ER when spontaneous pneumothorax is suspected (pleuritic chest pain with or without shortness of breath). The child will likely have had blood work and CXR (sometimes with insp/exp views).

1. Always start with the ABCs, followed by getting a general feel for acuity of the shortness of breath or severity of dyspnea including color, resp rate and nasal flare etc

2. Obtain your own history from the patient or caregiver including the length of symptoms

3. Examine the child to confirm your assessment for the severity of RR, SOB, saturation and any evidence of tracheal shift or tension pneumothorax:

3. Assess and resuscitate the child with appropriate respiratory support while conducting your history and examination

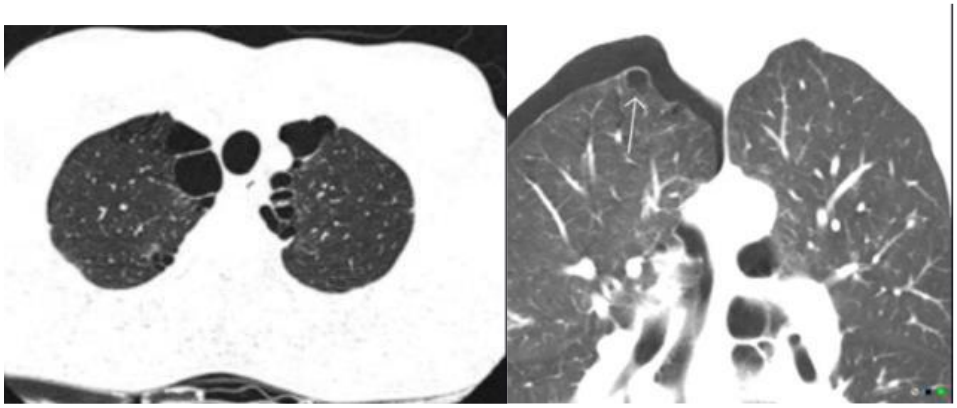
4. Depending on the acuity and severity of pneumothorax, the surgical team will place a pigtail chest catheter or tube urgently or emergently with local anesthesia and possibly mild sedation. The tube should be STABLY secured to the chest wall. A follow up chest X-ray should be obtained immediately to

check the position of the chest tube and expansion of the lung while the chest tube is under 10-20 cm suction

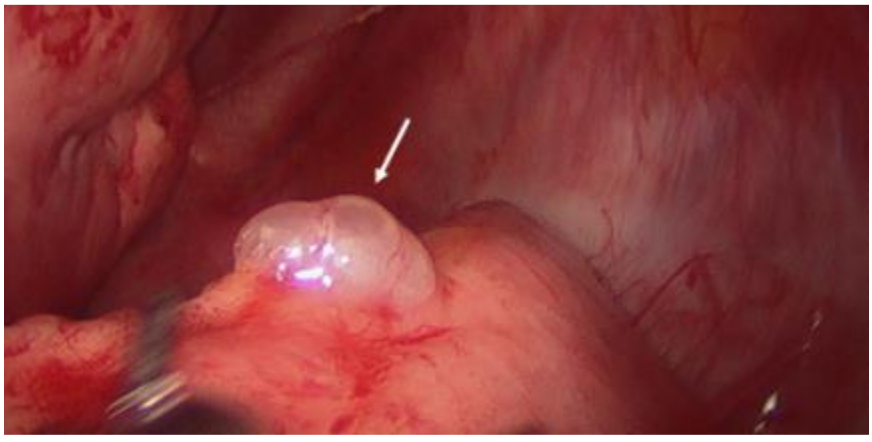
5. Make sure that the patient is comfortable with the chest tube in situ, and consider incentive spirometry to encourage full expansion of the lung:

6. Although there may be a variance in opinion, some surgeons prefer to get a CT scan of chest during the first visit to document suspected causes such as blebs in the apices of upper and lower lobes

7. Recurrent pneumothorax is the most common complication after an initial episode and has been documented in 30-50% of children. Primary spontaneous pneumothorax recurrence rates are highest (22.4% to 36.8%) in children 13 to 18 years of age, with almost half developing ipsilateral recurrence and 14% developing contralateral recurrence. Most surgeons would offer surgical treatment on recurrence while most primary presentations will be treated expectantly with chest tube.



Operative Intervention: Surgery usually consists of Video Assisted Thoracoscopy with resection of any blebs and mechanical or chemical pleurodesis. Post operatively, the chest tube will be kept to suction for a period of time (check with your attending for duration) before removal in order to keep the lung expanded and to promote adhesion formation. While pneumothorax can recur after surgery, the pleurodesis helps to prevent complete collapse of the lung and to mitigate accompanying symptoms.



References:

a. Management of spontaneous pneumothorax. An American College of Chest Physicians Delphi Consensus Statement. Chest 2001:119: 590-602
b. Management of Spontaneous Pneumothorax. Chest. 2015;148(4_MeetingAbstracts):435A. doi:10.1378/chest.2280584

Colorectal bundle

Colorectal procedures have a high risk of surgical site infection. In adults, bundles can reduce this risk. The Pediatric Surgery Service has developed a Colorectal Bundle which is tailored to the needs of its pediatric patients; this differs slightly from the one developed for adult patients.

Bundle elements:

- Preoperative Bath night before and/or morning of surgery
  - Can be: Bathing with soap and water; bathing with chlorhexidine-containing solution; wiping with a chlorhexidine-impregnated cloth; non-medicated bath cloths
- Hair removal: Age-appropriate hair removal with clippers prior to draping, otherwise omit
- Glucose testing: For patients who are known diabetics or receiving preoperative therapies that increase the risk of hyperglycemia (steroids), glucose testing is performed immediately after induction of anesthesia
- Oral antibiotic prep: Oral antibiotic prep the day before surgery for elective procedures (Neomycin 15 mg/kg/dose, maximum 1000 mg/dose, and Metronidazole 15 mg/kg/dose, maximum 1000 mg/dose, at 7 pm and 11 PM)
- Ancef/flagyl dosed within 60 minutes prior to incision, with substitutions for patients with allergies (Vancomycin and fluoroquinolones administered 0-120 minutes prior to incision)
- Ancef re-dosed if case longer than 3 hours, or appropriate re-dosing for substitutions
- Temperature: Patient temperature ≥ 36.0 C from incision to wound closure (monitored with pediatric-appropriate probes)
- Change of gloves and gowns before closing
- Use of dedicated age appropriate "clean closure" tray for closing

Notes:

- Does not include patients < 1 month of age
- Ask attending whether the Bundle applies to a patient's operation
- Depending on the case, other preop measures may include mechanical bowel prep, enemas, or clears for a defined period before surgery. Please review these details with the attending.

Ovarian Torsion

Definition: Twisting of the ovarian vascular pedicle, sometimes involving the fallopian tube, which results in:

Lymphatic and venous obstruction –> edema –> arterial occlusion –> ischemia and necrosis of ovary

Risk factors
- **Ovarian enlargement** due to a cyst or other mass
    - 51-85% of torsions associated with a cyst or mass
    - Cyst > 5 cm increases the risk of torsion
- **Elevated hormone levels** (ovulation induction, PCOS, maternal exposure in the neonate)
- **Abnormally long fallopian tube, mesosalpinx, mesovarium**

Classic Presentation
- **Sudden severe** unilateral abdominal or pelvic pain
    - Associated nausea, vomiting, dysuria - can be synchronous with onset of pain
- Exam: tenderness, possible unilateral mass on palpation

Differential diagnosis
- Premenarchal
    - Appendicitis, nephrolithiasis, mesenteric adenitis, intussusception, UTI, gastroenteritis
- Adolescent
    - Pelvic inflammatory disease, tubo-ovarian abscess, ectopic pregnancy, ovarian cyst, hemorrhagic cyst, ovarian mass, Mittelschmerz, UTI, gastroenteritis

Studies
- Labs
    - Pregnancy test if post-pubescent
    - If mass is suspected: αFP, β-HCG, inhibins A &B, CA-125, CEA, CA 19-9, LDH
- Imaging
    - Ultrasound
        - Doppler for blood flow: can be unreliable as arterial flow may be present in torsed ovaries and may be absent in normal ovaries of a young patient
        - Twisted vascular pedicle – harder to see in young children
        - Atypical location – midline or on contralateral site from origin
        - Adnexal mass or cyst
        - Morphology important

- Unilateral ovarian enlargement due to edema or hemorrhage
    - Compare with established normal volumes for age
    - ≥3x volume of contralateral side – concerning for torsion
- Complex or cystic structure
- Follicles only on periphery or absent
    - Follicular enlargement with fluid-debris levels: indicate edema and hemorrhage

▪ Drawbacks
- Ovaries are smaller and more difficult to identify in young pediatric patient than they are in adults
- Pediatric ovaries may be displaced into abdomen rather than in pelvis

o MRI
▪ Findings
- Ovarian enlargement
- Central hemorrhage and edema with peripheral follicles
- Poor enhancement suggesting infarction or necrosis
- Contrast enhancement can detect swirling of twisted pedicle

▪ Disadvantages
- Cost, time for exam

Treatment

- Surgery required
    - Laparoscopy for detorsion and ovarian preservation; can perform open if necessary
    - Cystectomy can be considered if cyst present; oophorectomy if tumor confirmed
        - Attempt to preserve ovary if possible
        - Black or necrotic ovaries can still be treated with detorsion and possible preservation
            - Folliculogensis has been well documented following ovarian detorsion
        - Suspected tumor
            - 1.8% risk of malignancy in masses found in torsion in pediatric patients; increased risk if mass >8cm
            - Interval evaluation can be considered for torsed ovaries if mass is suspected but there are no overt signs of malignancy

    - Detorse, leave mass in place, check tumor marker results, interval surgery

Recurrence

- Due to anatomic predisposition: laxity of utero-ovarian ligaments, long fallopian tube
- Risk range 5-18%
- Oophoropexy: plication of adnexal ligaments or fixation of adnexa using non-absorbable suture to pelvic sidewall
    - Concern about impact on fallopian development or fertility
    - Evidence that recurrence can still occur after pexy; no evidence to support pexy at first episode of torsion

Follow-up: Consider imaging around 3 months to document presence of ovarian follicles, sooner if concern for neoplasm