Pedi Crisis

CRITICAL EVENTS CHECKLISTS
For use in the peri-anesthesia setting

Call for help!

Code Team
PICU
Fire
Overhead STAT
ECMO

Notify surgeon/team

Use expert clinical judgment when using this and all emergency manuals.

Revision Jan 2020. Available at:
- Notify team, stop nitrous oxide and volatile agents. Increase O\textsubscript{2} to 100%.

- Stop air entrainment: Find air entry point, stop source, and limit further entry.

- Ask surgeon:
  - Flood wound with irrigation/soaked saline dressing
  - Stop all pressurized gas sources, e.g. laparoscope, endoscope
  - Place bone wax or cement on exposed bone edges
  
  - Check for open venous lines or air in IV tubing
  - Lower surgical site below level of heart (if possible)
  - Perform Valsalva

- Consider:
  - Compress jugular veins intermittently if head or cranial case

- If hypotensive:
  - Give EPINEPHrine 1-10 MICROgrams/kg IV, consider infusion EPINEPHrine 0.02-1 MICROgrams/kg/min IV or NOREPInephrine 0.05-2 MICROgrams/kg/min IV
  - Chest compressions: 100-120/min to force air through lock, even if not in cardiac arrest
  - If available, call for TEE/US

- If cardiac arrest, see ‘Cardiac Arrest’ card

\(\text{EtCO}_2\quad \text{SaO}_2\quad \text{BP, mill-wheel murmur}\)
### Anaphylaxis

**Rash, bronchospasm, hypotension**

- Increase O\textsubscript{2} to 100%
- Remove suspected trigger(s)
  - If latex is suspected, thoroughly wash area
- Ensure adequate ventilation/oxygenation
- If HYPOtensive, turn off anesthetic agents

<table>
<thead>
<tr>
<th>Indications</th>
<th>Treatments</th>
</tr>
</thead>
<tbody>
<tr>
<td>To restore intravascular volume</td>
<td>NS or LR, 10-30 mL/kg IV/IO, rapidly</td>
</tr>
<tr>
<td>To increase BP and reduce mediator release</td>
<td>▪ EPINEPHrine 1-10 MICROgrams/kg IV/IO, as needed  or 0.01 mg/kg IM q5-15 min as needed</td>
</tr>
<tr>
<td></td>
<td>▪ May need EPINEPHrine infusion 0.02-1 MICROgrams/kg/min IV</td>
</tr>
<tr>
<td></td>
<td>▪ If BP remains low, give Vasopressin 10 MILLIunits/kg IV</td>
</tr>
<tr>
<td>To reduce histamine-mediated effects</td>
<td>DiphenhydrAMINE 1 mg/kg IV/IO (MAX 50 mg) or Famotidine 0.25 mg/kg IV (MAX 20 mg) or Ranitidine 1 mg/kg IV (MAX 50 mg)</td>
</tr>
<tr>
<td>To reduce mediator release</td>
<td>MethylPREDNISolone 2 mg/kg IV/IO (MAX 100 mg)</td>
</tr>
<tr>
<td>To reduce bronchoconstriction</td>
<td>Albuterol (Beta-agonists) 4-10 puffs, repeat as needed</td>
</tr>
</tbody>
</table>

- Send tryptase
- Consider Differential (partial):
  - Severe bronchospasm from URI or underlying condition: go to Bronchospasm card
  - Air, fat, thrombotic, or cement embolus: go to Air Embolism card
  - Sepsis: support BP, antibiotics

### Common causative agents:
- Neuromuscular blockers
- Latex
- Chlorhexidine
- IV colloids
- Antibiotics
Increase $O_2$ to 100%

**Intra-operative Treatments**

### Airway collapse
- Increase FiO$_2$
- Add CPAP for spontaneous ventilation; add PEEP for controlled ventilation
- Reposition to lateral or prone
- Ventilate via rigid bronchoscope

### Cardiovascular collapse
- Give fluid bolus
- Reposition to lateral or prone
- Ask surgeon for sternotomy and elevation of mass
- Consider ECMO

**Preoperative Considerations**

### High Risk Factors
- **Etiology:**
  - Hodgkin’s and non-Hodgkin’s lymphoma
- **Clinical signs:**
  - orthopnea, upper body edema, stridor, wheezing
- **Imaging findings:**
  - tracheal, bronchial, carinal, or great vessel compression; SVC or RVOT obstruction; ventricular dysfunction; pericardial effusion

### Anesthetic Plan
- Perform surgery under local anesthesia, if possible
- Pre-treat with irradiation or corticosteroids
- Maintain spontaneous ventilation and avoid paralysis
- Ensure availability of fiberoptic and rigid bronchoscope
- Cardiopulmonary bypass or ECMO
- Type and cross and sternal saw (for surgeons) available
**Bradycardia**

- **Definition:**
  - If hypotensive, pulseless, or poor perfusion, start chest compressions. See ‘Cardiac Arrest’ card
    - Give EPINEPHrine 10 MICROgrams/kg IV
    - Call for transcutaneous pacer (see inset)
      - Start pacing, when available
  - Confirm NSR. If heart block or slow junction/ventricular, call EP
  - If NOT hypotensive or pulseless:

<table>
<thead>
<tr>
<th>Etiology</th>
<th>Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hypoxia (most common)</td>
<td>- Give 100% O₂</td>
</tr>
<tr>
<td></td>
<td>- Good ventilation</td>
</tr>
<tr>
<td></td>
<td>- See ‘Hypoxia’ card</td>
</tr>
<tr>
<td>Vagal</td>
<td>- Atropine 0.01-0.02 mg/kg IV</td>
</tr>
<tr>
<td>Surgical Stimulation</td>
<td>- Stop stimulation</td>
</tr>
<tr>
<td></td>
<td>- If laparoscopy, desufflate</td>
</tr>
<tr>
<td>Ca-Channel Blocker Overdose</td>
<td>- Calcium chloride 10-20 mg/kg IV or Calcium gluconate 50 mg/kg IV</td>
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<tr>
<td></td>
<td>- If ineffective, Glucagon as dosed below</td>
</tr>
<tr>
<td>Beta-Blocker Overdose</td>
<td>- Glucagon 50 MICROgrams/kg IV, then 0.07 mg/kg/hour IV infusion (MAX 5 mg/hr)</td>
</tr>
<tr>
<td></td>
<td>• Check blood sugar</td>
</tr>
</tbody>
</table>

**Instructions for PACING**

1. Place pacing ECG electrodes AND pacer pads on chest per package instructions
2. Turn monitor/defibrillator ON, set to PACER mode
3. Set PACER RATE (ppm) to desired rate/min. (Can be adjusted up or down based on clinical response once pacing is established)
4. Increase the milliamperes (mA) of PACER OUTPUT until electrical capture (pacer spikes aligned with QRS complex; threshold normally 65-100mA)
5. Set final mA to 10mA above this level
6. Confirm pulse is present
7. Must change pacing pads hourly to avoid burns

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**Age** | **HR**
---|---
< 30 days | < 100
≥ 30 days | < 80
≥ 1 yr | < 60

Revision June 2018
## Bronchospasm

### Intubated Patient
- Increase FiO2 to 100%
- Auscultate the chest:
  - Equal breath sounds?
  - Endobronchial ETT?
  - Wheezing?
- Check ETT:
  - Kinked?
  - Secretions/blood in ETT? Needs suctioning?
- Consider albuterol 2-10 puffs, repeat as needed
- Consider deepening anesthetic
- If needed, give ketamine 1-2 mg/kg IV
- If severe, consider EPINEPHrine 1-2 MICROgrams/kg IV (MAX 1 mg)
- Consider IV steroids: methylprednisolone 2 mg/kg IV (MAX 60 mg) or dexamethasone 0.15-0.25 mg/kg (MAX 16 mg)
- Consider chest radiograph
- For refractory bronchospasm, consider magnesium sulfate 50-75 mg/kg (MAX 2 grams) bolused over 20 minutes, (CAUTION, may cause hypotension)

### Non-Intubated Patient
- If ETT in, go to ‘Intubated Patient’ column on this card (at the left)
- Administer supplemental oxygen
- Auscultate the chest, differentiate from stridor/extrathoracic airway obstruction
- Consider inhaled albuterol (with spacer) 2.5-5 mg. If severe, 5-20 mg/hr inhaled
- Consider chest radiograph
- Consider IV steroids: methylprednisolone 1 mg/kg IV (MAX 60 mg) or dexamethasone 0.15-0.25 mg/kg (MAX 16 mg)
- If severe, consider EPINEPHrine 1-2 MICROgrams/kg IV (MAX 1 mg) or 10 MICROgrams/kg subcutaneous/intramuscular (MAX 0.5 mg)
- If severe, consider ICU and/or advanced airway management.

### Differential Diagnosis
- Endobronchial intubation
- Mechanical obstruction of ETT
  - Kinking
  - Solidified secretions or blood
  - Overinflation of tracheal tube cuff
- Inadequate depth of anesthesia
- URI/tobacco exposure
- Foreign body
- Pulmonary edema
- Tension pneumothorax
- Aspiration pneumonitis
- Pulmonary embolism
- Persistent coughing and straining
- Asthmatic attack
- Anaphylaxis
**Cardiac Arrest**

- Notify team, call for help and code cart/defibrillator
- Increase oxygen to 100%. Turn off anesthetics
- If ETT, 100-120 chest compressions/min + 10 breaths/min. Avoid hyperventilation.
- If no ETT, 15:2 compression:ventilation ratio (100-120 chest compressions/min + 8 breaths/min)
- For chest compressions, maximize EtCO$_2$ > 10 mmHg (see next card for more details):
  - Switch compressor every 2 min
  - Use sudden increase in EtCO$_2$ for ROSC, Do NOT stop compressions for pulse check
- Obtain defibrillator. **Attach pads.** If VF/VT, shock 2 joules/kg. Continue chest compressions x 2 minutes.

**Repeat sequence below until return of spontaneous circulation:**

- If still in VF/VT, shock 4 joules/kg q2 min (up to 10 joules/kg on subsequent shocks)
- Resume chest compressions immediately regardless of rhythm
- EPINEPHrine 10 MICROgrams/kg IV q 3-5 min while in arrest (MAX 1 mg)
  - If still no ROSC after second dose of EPINEPHrine, **activate ECMO** (if available)
- Check pulse & rhythm q 2 min during compressor change
- Check for reversible causes (Hs and Ts) early and often (see table below)
- Lidocaine 1 mg/kg bolus (MAX 100 mg); may repeat (total: 2 doses) OR amiodarone 5 mg/kg bolus; may repeat (total: 3 doses)
- Repeat sequence in this box until return of spontaneous circulation

### Hs and Ts: Reversible Causes

<table>
<thead>
<tr>
<th>Hs</th>
<th>Ts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hypovolemia</td>
<td>Tension Pneumothorax</td>
</tr>
<tr>
<td>Hypoxemia</td>
<td>Tamponade (Cardiac)</td>
</tr>
<tr>
<td>Hydrogen ion (acidosis)</td>
<td>Thrombosis</td>
</tr>
<tr>
<td>Hyperkalemia/Hypoglycemia</td>
<td>Toxin (anesthetic, β-blocker)</td>
</tr>
<tr>
<td>Hypothermia</td>
<td>Trauma (surgical or nonsurgical bleeding)</td>
</tr>
</tbody>
</table>
Cardiac Arrest: Supine/Prone Chest Compressions

- Chest compression instructions (see previous card for full CPR instructions):
  - Place patient on backboard, maintain good hand position; if prone, see instructions below
  - Maximize EtCO₂ > 10 mmHg with force/depth of compressions
  - Allow full recoil between compressions
  - Switch compressor every 2 min
  - Use sudden increase in EtCO₂ for ROSC, Do NOT stop compressions for pulse check

### Prone: Children/Adolescents

- **If no midline incision:**
  Compress with heel of hand on spine and second hand on top

- **If midline incision:**
  Compress with heel of each hand under scapula

### Prone: Infants

- Compress with encircling technique:
  - **If no midline incision:**
    thumbs midline
  - **If midline incision:**
    thumbs lateral to incision

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Figure 1: From Dequin P-F et al. Cardiopulmonary resuscitation in the prone position: Kouwenhoven revisited. Intensive Care Medicine, 1996;22:1272
Figure 2: From Tobias et al, Journal of Pediatric Surgery, 1994:29, 1537-1539
Figure 3: Original artwork by Brooke Albright-Trainer, MD

Revision Mar 2018
Difficult Airway, Unexpected

- Increase O₂ to 100% and maintain continuous oxygen flow during airway management.
- Call for help, surgical airway expert and cart, rigid bronchoscope and tracheostomy kit.
- If unable to mask ventilate, ask for 2-handed assistance and:
  - Insert oral and/or nasal airway;
  - If unsuccessful, insert supraglottic airway (e.g., LMA);
  - Decompress stomach with orogastric tube;
  - Consider reversing rocuronium or vecuronium with sugammadex (16 mg/kg). Call to obtain if not in OR.
- If able to re-establish pt spontaneous ventilation:
  - Consider awakening patient;
  - Consider reversal of neuromuscular blocker.
- After two attempts: change providers and consider alternative approaches to intubation (see table).
- If macroglossia (e.g. Beckwith-Wiedemann, Pierre-Robin), or mediastinal mass, consider prone or lateral position.
- If still unable to ventilate:
  - Younger children: Emergency non-invasive airway such as rigid bronchoscopy;
  - In older children: Jet ventilation or emergency invasive/surgical airway such as cricothyrotomy or tracheostomy.

Alternative Approaches for Intubation

- Different blade
- Re-position head
- Different provider
- Video-laryngoscope
- Bougie
- Intubating LMA
- Fiberoptic scope
- Intubating stylet
- Blind oral
- Blind nasal

Revision May 2019
Fire: Airway

- Simultaneously:
  - Disconnect circuit from tracheal tube then remove tracheal tube
  - Stop all gas flow (O₂, N₂O)
  - Remove sponges and other flammable materials from airway
  - Pour saline into airway
- Re-intubate and re-establish ventilation
  - If intubation difficult, don’t hesitate to obtain surgical airway
- Consider bronchoscopy to assess for thermal injury
  - Look for tracheal tube fragments
  - Remove residual material
- Impound all equipment and supplies for later inspection
- Maintain ventilation. Assess for inhalation injury
- Consider input from ENT, pulmonary, plastic surgery
- Consider PICU
- Shut off gases to affected OR if fire not self-contained
  - Verify gases are not shut off to adjacent rooms

Picture from ECRI: www.ecri.org

Revision May 2019
**OR Fire (non-airway)**

- **Simultaneously:**
  - Stop flow of medical gases
  - Remove drapes and all burning and flammable material from patient
  - Make one attempt to extinguish fire by pouring saline on fire

- **If fire not extinguished on 1st attempt, use CO₂ fire extinguisher**

- **If fire persists:**
  - **Activate fire alarm**
  - Remove patient from OR
  - Confine fire by closing all OR doors
  - Turn off O₂ gas supply to OR

- **Maintain ventilation. Assess for inhalation injury**

- **Consider input from ENT, pulmonary, plastic surgery**

- **Consider PICU**

- **Shut off gases to affected OR if fire not self-contained**
  - Verify gases are not shut off to adjacent rooms

- **Impound all equipment and supplies for later inspection**
Hyperkalemia

Serum K+ > 6 mEq/L

Treatment:

- If hemodynamically unstable, start CPR/PALS
- Hyperventilate with 100% O₂
- IV calcium gluconate 60-100 mg/kg or calcium chloride 20 mg/kg
  - Directly visualize site to avoid infiltration
  - Flush tubing after calcium administration
- Stop K+ containing fluids (LR/RBC); switch to NS
- Dextrose IV 0.5-1 g/kg and insulin IV 0.1 Unit/kg (MAX 10 units)
- Albuterol puffs or nebulized, once cardiac rhythm stable
- Sodium bicarbonate IV 1-2 mEq/kg
- Furosemide IV 0.5-1 mg/kg
- Consider terbutaline 10 MICROgrams/kg load, then 0.1-10 MICROgrams/kg/min
- If cardiac arrest > 6 min, activate ECMO (if available)
- Dialysis if refractory to treatment
- If transfusion required, use washed or fresh RBC

Causes of Hyperkalemia:

- Excessive intake: massive or “old” blood products, TPN, cardioplegia, KCl infusion
- Shift of K+ from tissues to plasma: crush injury, burns, succinylcholine, malignant hyperthermia, acidosis
- Inadequate excretion: renal failure
- Pseudohyperkalemia: hemolyzed sample, thrombocytosis, leukocytosis

Manifestations:

- Tall peaked T wave
- Heart block
- Sine wave
- V fib or asystole

From: Slovis C, Jenkins R. BMJ 2002

Revision Mar 2018
**Acute Hypertension**

- In pediatrics, hypertension is almost always treated by addressing likely causes such as light anesthesia or measurement error:
  - Ensure correct BP cuff size: cuff bladder width ~ 40% of limb circumference
  - Ensure arterial line transducer is at level of heart
    - Consider placing arterial line if not already present

*CAUTION:* Anti-hypertensive drugs are almost never needed for routine pediatric cases. These medications are used almost exclusively for specialized cardiac, neurosurgical, or endocrine (pheochromocytoma) cases. Consult an expert before use. Rule-out increased ICP.

### Hypertensive Blood Pressure Range*

<table>
<thead>
<tr>
<th>Age (yr)</th>
<th>Systolic</th>
<th>Diastolic</th>
</tr>
</thead>
<tbody>
<tr>
<td>newborn</td>
<td>&gt;97</td>
<td>&gt;70</td>
</tr>
<tr>
<td>1-3</td>
<td>&gt;105</td>
<td>&gt;61</td>
</tr>
<tr>
<td>4-12</td>
<td>&gt;113</td>
<td>&gt;86</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Action</th>
<th>Drug (IV Dosing)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct smooth muscle relaxation</td>
<td>▪ Sodium nitroprusside 0.5-10 MICROgrams/kg/min</td>
</tr>
<tr>
<td></td>
<td>▪ HydrALAZINE 0.1-0.2 mg/kg (adult dose 5-10 mg)</td>
</tr>
<tr>
<td>β-Adrenergic blockade</td>
<td>▪ Esmolol 100-500 MICROgrams/kg over 5 min, then 25-300 MICROgrams/kg/min</td>
</tr>
<tr>
<td></td>
<td>▪ Labetalol (also α effect) 0.2-1 mg/kg q 10 min; 0.4-3 mg/kg/hour (infusion)</td>
</tr>
<tr>
<td>Calcium channel blockade</td>
<td>▪ niCARdapine 0.5-5 MICROgrams/kg/min</td>
</tr>
<tr>
<td></td>
<td>▪ Clevidipine 0.5-3.5 MICROgrams/kg/min</td>
</tr>
<tr>
<td>D1-dopamine agonist</td>
<td>▪ Fenoldopam 0.2-0.8 MICROgrams/kg/min</td>
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</tbody>
</table>
Hypotension

- Ensure oxygenation/ventilation
- Turn anesthetic agents down or off
- Check cuff size and transducer position
- Consider placing arterial line if not already present
- Give appropriate treatment (see table below)

### Causes

<table>
<thead>
<tr>
<th>Causes</th>
<th>↓ Preload</th>
<th>↓ Contractility</th>
<th>↓ Afterload</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Hypovolemia</td>
<td>Negative inotropic drugs (anesthetic agents)</td>
<td>Drug-induced vasodilation</td>
</tr>
<tr>
<td></td>
<td>Vasodilation</td>
<td>Arrhythmias</td>
<td>Sepsis</td>
</tr>
<tr>
<td></td>
<td>Impaired venous return</td>
<td>Hypoxemia</td>
<td>Anaphylaxis</td>
</tr>
<tr>
<td></td>
<td>Tamponade</td>
<td>Heart failure (ischemia)</td>
<td>Adrenal crisis</td>
</tr>
<tr>
<td></td>
<td>Pulmonary embolism</td>
<td>Hypocalcemia/blood product administration</td>
<td>Hypocalcemia</td>
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<tr>
<td></td>
<td>IVC compression (prone,</td>
<td></td>
<td>Thyroid crisis</td>
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<tr>
<td></td>
<td>obese, surgical)</td>
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<tr>
<td></td>
<td>Pneumothorax/</td>
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<tr>
<td></td>
<td>pneumoperitoneum</td>
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<tr>
<td></td>
<td>Increased PIP or PEEP</td>
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</tbody>
</table>

### Treatment

<table>
<thead>
<tr>
<th>Treatments</th>
<th>↓ Preload</th>
<th>↓ Contractility</th>
<th>↓ Afterload</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expand circulating blood volume</td>
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<tr>
<td>(administer fluids rapidly, consider albumin)</td>
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<tr>
<td>Trendelenberg position</td>
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<tr>
<td>Place or replace IV; consider intraosseous line</td>
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<tr>
<td>Start inotrope infusion</td>
<td></td>
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<tr>
<td>(DOPamine, EPINEPHrine), as needed</td>
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<td></td>
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<tr>
<td>Consider calcium IV</td>
<td></td>
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<tr>
<td>Review ECG for rhythm disturbances</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>or ischemia</td>
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<tr>
<td>Send ABG, Hgb, electrolytes</td>
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<tr>
<td>Start vasopressor infusion: phenylephrine, norepinephrine</td>
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<tr>
<td>Go to ‘Anaphylaxis’ card, if appropriate.</td>
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<tr>
<td>Administer steroids for adrenal crisis</td>
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</tr>
</tbody>
</table>
- Turn FiO₂ to 100%
- Confirm presence of end-tidal CO₂, look for any changes in capnogram
- Hand-ventilate to assess compliance
- Listen to breath sounds
- Consider DOPE: displacement, obstruction, pneumothorax, equipment failure
- Check:
  - ETT tube position and patency. Correct if mainstem or supraglottic, suction to r/o mucous plug, secretions, or kink
  - Consider circuit integrity: kink in circuit or ETT, bronchospasm, obstruction, mucous plug
  - Pulse oximeter: try new probe or changing placement
  - Check BP and HR
- Further assessment: Draw blood gas. Perform bronchoscopy, CXR, TEE, ECG
- Is airway cause suspected? (see appropriate table below)

### YES, Airway Cause IS Suspected

**Lungs**
- Bronchospasm
- Atelectasis
- Aspiration
- Pneumothorax
- Pulmonary Edema

**ETT**
- Mainstem intubation
- Mucous Plug
- ETT kinked or dislodged

**Machine**
- Ventilator settings: RR, TV, I:E ratio, auto-PEEP
- Machine malfunction

### NO, Airway Cause is NOT Suspected

**Drugs/Allergy**
- Recent drugs given
- Allergy / anaphylaxis (see ‘Anaphylaxis’ card)/dose error
- Methylene blue/dyes or methemoglobinemia

**Circulation**
- Embolism – air (see ‘Air Embolus’ card), fat, CO₂, pulmonary, septic, MI, CHF, cardiac tamponade
- Severe sepsis
- If associated with hypotension, see ‘Hypotension’ card
Increased Intracranial Pressure

- If GCS < 9, respiratory distress, hemodynamic instability:
  - Secure airway
  - Provide sedation prior to transport
- Keep PaCO$_2$ 30-35 mmHg and PaO$_2$ > 60 mmHg
- Maintain cerebral perfusion pressure (discuss goal CPP with team)
- Discuss target ICP with neurosurgery, will often want ICP < 20
- Use vasopressors (phenylephrine or NOREPInephine) as needed to maintain BP and CPP
- Consider head of bed at 30°
- Hypertonic saline (3% saline via central venous catheter) 1-5 mL/kg over 20 min, then 0.1-2 mL/kg/hour; goal ICP <20 mmHg
  - Monitor serum sodium
  - Keep osmolarity <360 mOsm/L
- If hypertonic saline not available, can give mannitol 0.25-1 g/kg, over 20 minutes to decrease ICP
- Consider furosemide 1-2 mg/kg (starting MAX 20 mg) to decrease ICP
- Consider seizure prophylaxis: Keppra (levetiracetam) 10-30 mg/kg IV (MAX 2500 mg)
- Refractory elevated ICP treatment, consider:
  - Barbiturate coma
  - Paralysis with non-depolarizing agent
- **AVOID:**
  - Compression of neck vessels
  - Hyperthermia
  - Hyperglycemia & dextrose containing solutions (maintain glucose level < 200 mg/dL)
Laryngospasm

Loss of EtCO2 due to vocal cord closure, often during stage 2 anesthesia

Signs and Symptoms:
- Inspiratory Stridor, Accessory Muscle Use, Sternal Retractions, Paradoxical Chest Movement, Airway Obstruction, ↓SpO2, ↓HR, loss of EtCO2

Treatment:
- Notify team to cease stimulation/surgery
- Give 100% O₂, evaluate ventilation
- Apply CPAP and jaw thrust
- Confirm or establish adequate IV access
- Deepen anesthesia with IV and/or inhaled agents. Consider propofol 1-3 mg/kg
- Give succinylcholine 0.1-2 mg/kg (if no IV: 2-4 mg/kg IM)
- If bradycardia, give atropine 0.02 mg/kg IV (if no IV: 0.04 mg/kg IM)
- Consider direct laryngoscopy to secure the airway and/or suction
- Avoid further patient stimulation during stage 2 anesthesia
- If further airway instrumentation needed, consider airway topicalization with lidocaine
- Monitor for negative pressure pulmonary edema (pink frothy secretions). If present, consider ETT, PPV, PEEP, ICU

Differential Diagnosis:
- Circuit disconnect or obstruction
- Upper airway obstruction
- Lower airway obstruction/bronchospasm
- Stop local anesthetic
- Request Intralipid kit
- Secure airway and ventilation
- Give 100% O₂
- Confirm or establish adequate IV access.
- Confirm & monitor continuous ECG, BP, and SaO₂
- Seizure treatment:
  - Midazolam 0.05-0.1 mg/kg IV
  - Be prepared to treat resultant hypoventilation
- Treat hypotension with small doses of EPINEPHrine 1 MICROgram/kg
- **Avoid** propofol, vasopressin, calcium channel blockers and beta blockers
- Start Intralipid therapy (see inset box)
- If cardiac instability occurs:
  - Start CPR/PALS
    - Continue chest compressions (lipid must circulate). May need prolonged compressions
- Consider: alert nearest cardiopulmonary bypass/ECMO center & ICU if no ROSC after 6 min
- Monitor and correct acidosis, hypercarbia and hyperkalemia
- Consider Differential (partial):
  - Anaphylaxis: go to Anaphylaxis card
  - Air, fat, thrombotic, or cement embolus: go to Air Embolism card

### Intralipid Dosing
- Bolus Intralipid 20% 1.5 mL/kg over 1 min
- Start infusion 0.25 mL/kg/min
- Repeat bolus every 3-5 min up to 4.5 mL/kg total dose until circulation is restored
- Double the rate to 0.5 mL/kg/min if BP remains low
- Continue infusion for 10 min after hemodynamic stability is restored.
- MAX total Intralipid 20% dose: 10 mL/kg over first 30 min
Loss of Evoked Potentials

- Notify all members of health care team. Call a "time out"

- Loss of evoked potentials (EP) requires definitive steps to re-establish perfusion/remove mechanical cause; MEP loss for > 40 min may increase possibility of long term injury
  - Assure the presence of attending surgeon, attending anesthesiologist, senior neurologist or neurophysiologist, and experienced nurse
  - Each service: review situation, report on management and corrective actions taken
    - Surgeon: rule out mechanical causes for loss/change
    - EP technologist: rule out technical causes for loss/change
    - Anesthesiologist: assure no neuromuscular blockade is present; reverse NMB if necessary

- Check patient positioning (neck, upper and lower extremities)

- Review the anesthetic and consider improving spinal cord perfusion by modifying:
  - Mean arterial pressure: MAP > 65 mmHg using ePHEDrine 0.1 mg/kg IV (MAX 10 mg/dose) and/or phenylephrine 0.3-1 MICROgrams/kg IV (MAX 100 MICROgrams/dose), with repeated doses as needed
  - Hemoglobin: if anemic, transfuse RBC to improve oxygen delivery
  - pH and PaCO\(_2\): ensure normocarbia or slight hypercarbia (↑ I/E ratio, ↓ PEEP)
  - Temperature: ensure normothermia
  - Check for "unintended" drugs given (e.g. neuromuscular blocker)
  - Decrease depth of anesthetic

- Discuss feasibility of a useful wake-up test:
  - Patient is appropriate candidate if capable of following verbal commands

- Consider high-dose steroid if no improvement:
  - MethylPREDNISolone 30 mg/kg IV over one hour, then 5.4 mg/kg/hour IV for 23 hours
Malignant Hyperthermia

- Get MH Cart, dantrolene, and help
- Notify team and stop procedure, if possible
- Stop volatile anesthetic, succinylcholine.
- Attach charcoal filter. Turn O₂ flow to 10 L/min
- Hyperventilate patient to reduce EtCO₂

- Give dantrolene 2.5 mg/kg IV, rapidly, through large bore IV if possible, every 5 min until symptoms resolve. May need up to 10 mg/kg (if no response at this dose, consider alternative diagnoses)
  - Dantrium/Revonto: Assign dedicated person to mix these formulations of dantrolene (20 mg/vial) with 60 mL non-bacteriostatic sterile water
  - Ryanodex: 250 mg is mixed with 5 mL non-bacteriostatic sterile water

- Transition to non-triggering anesthetic
- Give sodium bicarbonate 1-2 mEq/kg IV for suspected metabolic acidosis
- Cool patient:
  - Apply ice externally to axilla, groin and around head
  - Infuse cold saline intravenously
  - NG and open body cavity lavage with cold water
  - Stop cooling when temperature < 38°C

- Hyperkalemia treatment:
  - Calcium gluconate 30 mg/kg IV or calcium chloride 10 mg/kg IV;
  - Sodium bicarbonate 1-2 mEq/kg IV;
  - Regular insulin 0.1 units/kg IV (MAX 10 units) and dextrose 0.5-1 g/kg IV

- VT or afib treatment: Do NOT use calcium channel blocker; give amiodarone 5 mg/kg
- Send labs: ABG or VBG, electrolytes, serum CK, serum/urine myoglobin, coagulation
- Place urinary catheter, maintain UO > 2 ml/kg/hr
- If cardiac arrest occurs, begin CPR & consider ECMO, see ‘Cardiac Arrest’ card
- If no response after 10 mg/kg dantrolene, consider other dx: sepsis, NMS, serotonin synd., myopathy, pheochromocytoma
- Call ICU to arrange disposition. For post-acute management, see: http://www.mhaus.org

MH hotline  1-800-644-9737

Revision Mar 2018
Massive Hemorrhage

- Notify Blood Bank immediately, send blood sample for type and cross
- Activate institutional pediatric massive transfusion protocol. Consider RBC : FFP : Platelets = 2:1:1 or 1:1:1
  - Use un-crossmatched O negative PRBCs and AB+ plasma until crossmatched blood available
  - Consider intraoperative blood salvage (e.g., Cell Saver)
- Obtain additional vascular access if needed
- Watch for hyperkalemia, if needed give calcium gluconate 60 mg/kg or calcium chloride 20 mg/kg while directly visualizing IV site (if peripheral)
- Warm the room
- Send labs/perform point of care testing q 30 min: CBC, platelets, PT/PTT/INR, fibrinogen, rapid TEG, ABG, Na, K, Ca, lactate
- Blood product administration:
  - Use 140 micron filter for all products
  - Use a blood warmer for RBC and FFP transfusion (NOT for platelets)
  - Consider use of rapid transfusion pumps
  - Monitor ABG, electrolytes, and temperature
- When under control: call blood bank to terminate

### Treatment

- **HCT < 21% or Hgb < 7:**
  - 4 ml/kg PRBC increases Hct by 3
- **Platelet count < 50,000 (< 100K for brain injury), rapid TEG-MA < 54mm:**
  - 10 ml/kg apheresed platelets increases platelet count by 30 – 50k
- **INR > 1.5 (or > 1.3 brain injury), rapid TEG-ACT >120 sec:**
  - 10ml/kg thawed plasma increases coagulation factors by 20%
- **Fibrinogen < 100 mg/dL or rapid TEG-angle<66°, k value >120 sec:**
  - 10 ml/kg pooled cryoprecipitate increases fibrinogen by 30-50 mg/dL
- **Refractory hemorrhage**
  - Consider factor VIIa, up to 90 MICROgrams/kg
Myocardial Ischemia

Treatment:

- Improve O₂ Supply:
  - Increase O₂ to 100%
  - Correct anemia
  - Correct hypotension

- Decrease O₂ Demand:
  - Reduce heart rate
  - Correct hypertension
  - Restore sinus rhythm

- Drug therapy (rarely needed in peds, consult a pediatric cardiac expert):
  - NitroGLYCERIN 0.5-5 MICROgrams/kg/min
  - Consider heparin infusion 10 Units/kg bolus, then 10 Units/kg/hour

Potential Causes:

- Severe hypoxemia
- Systemic arterial hypo- or hypertension
- Marked tachycardia
- Severe anemia
- Coronary air embolus
- Cardiogenic shock
- Local anesthetic toxicity

Recognition

- ST depression >0.5 mm in any lead
- ST elevation >1 mm (2mm in precordial leads)
- Flattened or inverted T waves
- Arrhythmia: VF, VT, ventricular ectopy, heart block

Diagnostic studies

- 12-lead ECG:
  - II, III, aVF for inferior (RCA)
  - V5 for lateral ischemia (LCx)
  - V2, V3 anterior ischemia (LAD)
- Compare to previous ECGs
- Request Pediatric Cardiology consult and echocardiogram

Revision Mar 2018
Initial Management

- Give 100% O₂ Call stat for inhaled nitric oxide (iNO) 20-40 ppm. ↓ O₂ saturation may not be immediate
- Consider stat TEE and ECMO
- Deepen anesthetic/sedation, consider fentanyl 1 MICROgram/kg or ketamine 0.5-1 mg/kg
- Administer muscle relaxant
- If poor perfusion, consider chest compressions early

Hypotension management

- If hypotensive, give vasopressin 0.03 units/kg bolus, then:
  - To maintain perfusion:
    - Vasopressin 0.17-0.67 milliunits/kg/minute = 0.01 to 0.03 units/kg/hour
    - or
    - NOREPInephrine 0.05-0.3 MICROgrams/kg/min

Ventilation

- Ventilate with low airway pressures & long expiratory phase to maintain adequate tidal volume, avoid atelectasis and preserve FRC. Maintain normocapnia or mild hypocapnia. PEEP may worsen pulmonary hypertension

Further management

- Administer isotonic fluid to achieve normovolemia and to reduce acid load, correct acidosis with sodium bicarbonate
- Maintain NSR and AV synchrony
- Temperature: ensure normothermia

Crisis Management

- If cardiac arrest occurs or is imminent, give epinephrine 1-10 MICROgrams/kg
- If cardiac arrest occurs, begin CPR and call for ECMO as CPR may be ineffective if no intracardiac communication
Tachycardia, unstable

- Call for defibrillator and code cart. Typically infant >=220 bpm, child >=180 bpm
- Place pt on backboard. Attach defibrillator pads
- Give 100% O₂, stop anesthetic agents, notify team, consider cardiology consult
- If NO pulse present, start CPR/PALS; go to ‘Cardiac Arrest’ card
- If pulse present, administer appropriate treatment (see table below)

<table>
<thead>
<tr>
<th>Narrow complex: narrow complex: p waves present before every QRS</th>
<th>SVT, tachyarrythmia</th>
<th>Wide complex</th>
<th>Torsade de Pointes: polymorphic VT with prolonged QT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Probably sinus tachycardia</td>
<td>Adenosine: 1st dose 0.1 mg/kg IV, rapid push (6 mg MAX); 2nd dose 0.2 mg/kg IV (12 mg MAX)</td>
<td>Amiodarone 5 mg/kg IV bolus over 20-60 min OR</td>
<td>Magnesium sulfate 25-50 mg/kg IV/IO (MAX 2 g)</td>
</tr>
<tr>
<td>Identify and treat underlying etiology</td>
<td>Synchronized cardioversion: 0.5-1 joule/kg, additional shocks @ 2 joules/kg</td>
<td>Procainamide 15 mg/kg IV bolus over 30-60 min OR</td>
<td>Lidocaine 1 mg/kg IV (MAX 100 mg)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Synchronized cardioversion: 0.5-1 joule/kg, additional shocks @ 2 joules/kg</td>
<td>Sodium bicarbonate (for quinidine-related SVT) 1 mEq/kg IV</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Temporary pacing (see ‘Bradycardia’ card)</td>
</tr>
</tbody>
</table>
**Tamponade, Cardiac**

**Signs & Symptoms**
- Beck’s Triad: muffled heart tones, distended neck veins, decreased systolic blood pressure
- Pulsus Paradoxus: cyclic inspiratory decrease in systolic BP of more than 10mmHg
- Electrical Alternans: cyclic alteration in magnitude of p waves, QRS complex & t-waves
- Typical presentation of acute tamponade = sudden hypotension, tachycardia & tachypnea; patient may be unable to lie flat

**Diagnosis**
- Echocardiography/ultrasound: diastolic compression or collapse of RA/RV, leftward displacement of ventricular septum, exaggerated increase in RV size with reciprocal decrease in LV size during inspiration

**Treatment - imaging is key in deciding treatment**
- Pericardiocentesis awake/local for large effusions prior to GA
- Surgical for postoperative tamponade (cause is often local collections of clotted blood)

**Anesthetic Considerations**
- Progressive decrease in SV with an increased CVP → systemic hypotension → cardiogenic shock
- Goals: maintain sympathetic tone and CO via ↑ HR and contractility/fluid bolus prn
  - Induction: Ketamine (1-2 mg/kg IV), muscle relaxant
  - If CV collapse: EPINEPHrine 0.05-0.1 MICROgrams/kg IV bolus or infusion (0.01-0.1 MICROgrams/kg/min)
  - Access: Large bore PIV; arterial line ideal but should not delay treatment in hemodynamically unstable patient
  - Avoid: cardiac depression, vasodilation, ↓ HR; ↑ airway pressure (will ↓ venous return) so may need small tidal volumes or hand ventilation

**Differential Diagnosis**
- CHF, PE
- If pulsus paradoxus: respiratory distress, airway obstruction, COPD, PE, RV infarction

First Published Nov 2018
Tension Pneumothorax

- Stop N₂O; increase O₂ to 100%
- Secure airway with endotracheal tube
- Reduce positive ventilation pressure
- Consider CXR, lung ultrasound, transillumination to confirm diagnosis (see inset)
- Administer vasopressors for circulatory collapse
- Perform immediate needle decompression, then chest tube placement

Needle decompression:
- 2\textsuperscript{nd} rib space superior to 3\textsuperscript{rd} rib, mid-clavicular line
  - 14-16g angiocath for teens/adults
  - 18-20g angiocath for infants/children

Chest tube insertion
- 5-6\textsuperscript{th} intercostal space, mid-axillary line

If no improvement in hemodynamics after a rush of air, consider:
- Needle decompression of contralateral side
- Presence of pneumopericardium
- Scan both lungs with ultrasound or transillumination to evaluate for alternate side or insufficiently decompressed pneumothorax

Lung Ultrasound Instructions
- High frequency probe, place longitudinally on chest, 2\textsuperscript{nd} intercostal space. Slide probe downwards to observe pleural sliding
  - If see pleural sliding, 100% positive predictive value no pneumothorax
  - If no pleural sliding, consider pneumothorax, ARDS, fibrosis, acute asthma, pleurodesis

Revision Mar 2018
For All Reactions:
- Stop transfusion
- Disconnect donor product and IV tubing
- Infuse normal saline through clean tubing
- Examine blood product ID; determine correct pt
- Send product to Blood Bank

<table>
<thead>
<tr>
<th>Hemolytic</th>
<th>Non-Hemolytic</th>
<th>Anaphylactic</th>
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</thead>
<tbody>
<tr>
<td>Signs: Hemoglobinemia,</td>
<td>Signs: ↓ BP, bronchospasm,</td>
<td>Signs: Erythema, urticaria,</td>
</tr>
<tr>
<td>hemoglobinuria, DIC, ↓ BP,</td>
<td>pulmonary edema, fever, rash</td>
<td>angioedema, bronchospasm,</td>
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<tr>
<td>↑ HR, bronchospasm</td>
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<td>tachycardia, shock</td>
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<tr>
<td></td>
<td></td>
<td>Support airway and</td>
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<td></td>
<td></td>
<td>circulation as necessary</td>
</tr>
<tr>
<td>Furosemide 1-2 mg/kg IV (MAX</td>
<td>Treat fever</td>
<td>EPINEPHrine 1-10 MICROgrams/kg IV</td>
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<tr>
<td>40 mg)</td>
<td>Treat pulmonary edema</td>
<td></td>
</tr>
<tr>
<td>Mannitol 0.25-1 g/kg</td>
<td>Observe for signs of hemolysis</td>
<td>DiphenhydrAMINE 1 mg/kg IV</td>
</tr>
<tr>
<td>Support BP to maintain</td>
<td></td>
<td>MethylPREDNISolone 2 mg/kg IV</td>
</tr>
<tr>
<td>renal perfusion</td>
<td></td>
<td>Maintain intravascular</td>
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<tr>
<td>Maintain urine output at</td>
<td></td>
<td>volume</td>
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<tr>
<td>least 1-2 mL/kg/hour</td>
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<tr>
<td>Prepare for cardiovascular</td>
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<tr>
<td>instability</td>
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<tr>
<td>Send blood and urine</td>
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<tr>
<td>sample to laboratory</td>
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Revision Mar 2018
Set-up prior to patient arrival to OR:
- Assemble team and assign roles
- Estimate weight and prepare emergency drugs
- Warm the room
- Gather equipment:
  - Airway supplies
  - Line placement and monitoring devices
  - Fluid warmer/rapid infusion device
  - Code cart with programmed defibrillator
- Type and cross blood products. Activate massive transfusion protocol if indicated

On patient arrival to OR:
- Maintain c-spine precautions for transport
- Secure/confirm airway (often aspiration risk, unstable c-spine)
- Ensure adequate ventilation (maintain PIP < 20 cm H₂O)
- Obtain/confirm large-bore IV access (central or intraosseous if peripheral unsuccessful)
- Assess hemodynamic stability. Pre-induction fluid bolus recommended if hypovolemic
  - 20 mL/kg LR or NS (repeat x 2) and/or 10 mL/kg RBCs or 20 mL/kg whole blood
- Arterial and central venous line placement if indicated
- Maintain normothermia
- Monitor and treat associated conditions
  - Anemia, coagulopathy, acidosis, electrolyte derangements
- Continuously assess for undiagnosed secondary and/or developing injuries, blood loss
MATERNAL CRISIS
**ATTENTION:** This checklist is for ADULT-SIZED maternal patients ONLY

- Prepare for crystalloid and blood product resuscitation
- Obtain vascular access with 2 large-bore IVs
- Call Blood Bank to activate Massive Transfusion with PRBC:FFP:platelet in a 4:2:1 ratio. Ask blood bank to prepare next round when each round is picked up.
  - Give calcium chloride ADULT DOSE 200-500mg/Unit PRBCs, in separate line. Monitor for hyperkalemia
  - Consider giving tranexamic acid early
  - If refractory hemorrhage, consider fVIIa and cryoprecipitate or fibrinogen concentrate

- Give uterotonics
- Call for rapid transfuser or pressure bags
- Warm room, patient and fluids (NOT platelets)
- Send CBC, PT/PTT/INR, fibrinogen, calcium, K, ABG

### Obstetric Interventions

<table>
<thead>
<tr>
<th>Consider</th>
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<tbody>
<tr>
<td>Arterial line</td>
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<tr>
<td>If awake, convert to general anesthesia</td>
</tr>
<tr>
<td>Embolization in IR</td>
</tr>
<tr>
<td>TEG/ROTEM monitoring</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Obstetric Interventions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intrauterine balloon</td>
</tr>
<tr>
<td>External uterine compression sutures</td>
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<tr>
<td>Uterine artery ligation</td>
</tr>
<tr>
<td>Hysterectomy</td>
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</tbody>
</table>

### Treatment

**ADULT MATERNAL Uterotonics:**

- **Oxytocin** ADULT DOSE 3-5 Units rapid infusion, then start 40 Units slow infusion
- **Methylergonovine** (Methergine) ADULT DOSE 0.2mg IM NOT IV, may repeat in 2 hours (AVOID in HTN and pre-eclampsia)
- **Carboprost** (Hemabate) ADULT DOSE 0.25mg IM NOT IV, may repeat q 15 minutes up to 8 doses (AVOID in asthma, pulmonary hypertension)
- **Misoprostol** ADULT DOSE 800-1000 MICROgrams rectal

### Hemostatics:

- **Tranexamic acid** ADULT DOSE 1g
- If low fibrinogen, give cryoprecipitate ADULT DOSE 10 units or Fibrinogen concentrate
- If refractory hemorrhage, consider factor VIIa 90 MICROgrams/kg, up to 3 doses

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**Revision Dec 2018**