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Guidelines for the Evaluation and Management of Pediatric Organ Donors
(weight < 40 kg)

I. Purpose

These guidelines are intended to maximize the donation potential of pediatric organ donors by providing optimal and consistent care to the organs and tissues of infants, children and adolescents who have met criteria for brain death and whose parents or guardians have consented to organ donation. These guidelines may not be suitable for the management of living patients or adult donors and will be updated regularly.

II. Initial Evaluation

Documentation

1. History of injuries and treatment; current febrile illness, current infection and/or bacterial colonization
2. Past medical and social history (including malignancy and risk factors for HIV, hepatitis B and C)
3. Home medications and drug allergies
4. Current medications including those administered in the 24 hrs prior to Mid-America Transplant arrival and all antibiotics administered since hospital admission
5. All blood transfusions administered since hospital admission
6. Physical exam including height, dry weight and body surface area (see Appendix for calculation of BSA)
7. Periods of significant hypotension (see Appendix for age based norms); for cardiopulmonary arrest, estimate the duration of CPR and the time until return of spontaneous circulation
8. From the start of Mid-America Transplant management note the hourly: intake/output, CVP, O2 saturations by pulse oximetry, systolic/diastolic BP, core temperature, and vasoactive medications
9. Copy of donor medical chart

Transplant Labs

1. Serology and NAT testing: 2 purple and 2 tiger (SST) top tubes. (Minimum of 5 mL divided between one purple and one tiger top.) Obtain pre and post transfusion if hemodilution has occurred. Pre transfusion samples must be negotiated with medical examiner.
2. ABO typing (Neonates and Infants may not be able to be subtyped)
3. HLA typing: 1 yellow for Labs Midwest, 3 green for Barnes and 4 yellow for SLUH

Cultures

1. Blood: 2 sets of 2 aerobic cultures from arterial and central lines (label clearly)
2. Tracheal aspirate: gram stain and culture
3. Urine: urinalysis and culture
Guidelines for the Evaluation and Management of Pediatric Organ Donors (weight < 40 kg)

Lines
1. Arterial line (radial preferred) for ease of maintenance and possible reduction in infection risk
   a. Grade 1A evidence for unfractionated heparin infusion at 0.5 units/mL at 1 mL/h to maintain patency in peripheral arterial lines in infants and children (Monagle et al. Chest 2012)
   b. Consider additional infusion of papaverine through the arterial line for suspicion of arterial spasm (mix 60 mg papaverine in 500 mL NS; run at 0.5 mL/hr)
2. Central line for blood draws and CVP monitoring (right internal jugular preferred; femoral CVPs may be inaccurate particularly with abdominal distension, the lack of a good blood return from the CVP lumen and/or a poor waveform

Studies
1. Chest radiograph (with qualified physician interpretation)
2. Bronchoscopy (potential lung donors only, daytime requests appreciated)

III. Mid-America Transplant Organ Recovery Center

Decision to Transport
1. Transport of the organ donor to the Mid-America Transplant Organ Recovery Center helps to control costs, reduce cold ischemic time, decrease surgeon travel and improve the predictability of OR availability. There may be other benefits. Transport should not occur when movement of the donor is likely to adversely affect their donation potential. Adverse events during transport are inversely related to the stability of the donor and directly related to the time spent in transport.
2. The decision is made by the Director of Organ Procurement (or designee) in consultation with the clinical coordinators and associate medical director. In general, most suitable candidates for transport will meet the following criteria:
   a. Stable airway that includes a cuffed endotracheal or tracheal tube
   b. An oxygen saturation of ≥ 95% on an FiO2 ≤ 60%, a positive end expiratory pressure (PEEP) ≤ 8 cm H2O and the ability to maintain adequate gas exchange in a conventional mode of mechanical ventilation on a transport ventilator
   c. Normal sinus rhythm
   d. Circulatory support limited to dopamine at ≤ 10 mcg/kg/min (excluding low dose vasopressin and thyroid replacement)
3. All other donors will be considered on a case-by-case basis.

Pediatric Transport Considerations
1. Complications are often secondary to inadequate stabilization of the airway and/or lack of appropriate monitoring to recognize dislodgement of the ETT or other devices. The ETT, vascular access lines and chest tubes are shorter and more easily displaced than similar adult devices.
   a. Inspect and secure ETT, central lines, arterial lines, chest tubes, foley catheter, NG tubes, etc. prior to transport
   b. Monitor ETCO2, pulse oximetry, ECG and arterial blood pressure during transport.
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c. The transport team should have the skills and equipment to reestablish a lost pediatric airway using head positioning, jaw thrust, oral airway, laryngeal mask airway (LMA) and bag-valve-mask (BVM) ventilation. Competency in endotracheal intubation is preferable although LMA and BVM can be used until a skilled individual is available. A cuffed replacement ETT must accompany the donor at all times.
d. Understanding basic concepts of mechanical ventilation and the potential complications associated with positive pressure ventilation will be necessary to address gas exchange and hemodynamic problems.
e. In the event venous access is lost, the transport team should be skilled in IV or intraosseous needle placement until vascular access can be (re) established.
f. Familiarity with needle drainage of pleural air will be necessary in the event of a pneumothorax until a chest tube can be placed.

2. Core temperature stability may be compromised in infants and small pediatric donors during extremes in temperature; bundle donor accordingly in cold weather.

IV. Organ Specific Testing & Evaluation

Kidney

1. Urinalysis with micro: at the time of admission (if available); at initiation of Mid-America Transplant management; and within 24 hrs of cross clamp
2. BUN, creatinine and creatinine clearance (see Appendix for calculation): at the time of admission (if available); peak values; and within 4 hrs of organ offer
3. Optional: Ultrasound for suspected pathology (history of kidney stones, polycystic disease or other urologic abnormalities)
4. Optional: See Appendix for Renal Protective Protocol prior to cardiac catheterization or CT scan with contrast

Pancreas

1. Hemoglobin A1C
2. Amylase at admission (if available) and at initiation of Mid-America Transplant management
3. Lipase at initiation of Mid-America Transplant management
4. Blood glucose (see Management Protocols)

Liver

1. AST (SGOT), ALT (SGPT), alkaline phosphatase, bilirubin (total and direct), GGT and albumin at admission (if available), at initiation of Mid-America Transplant management and within six hours of organ offer. Utilize Piccolo liver panel cartridge at Mid-America Transplant.
2. PT, INR, PTT at initiation of Mid-America Transplant management and within six hours of organ offer
3. Optional: DIC panel if donor is currently in DIC or at risk
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V. Donor Types

No specific SCD or ECD definitions exist for pediatric patients at this time.
VI. Pediatric Donor Management Protocols (initiate on every donor)

**Goals** (*The Pediatric Organ Donation Bundle*)
1. Mean arterial pressure (mmHg) ≥ 1.5 x age in years + 55; Newborns ≥ gestational age +5
2. Minimize pressors to dopamine at < 10 mcg/kg/min
3. CVP <12 mm Hg
4. Urinary output >0.5 -3 cc/kg/hr
5. pH 7.30-7.45
6. Serum Na+ <160 mEq/L
7. Serum glucose 60-180 mg/dL
8. PaO2:FiO2 ratio ≥ 3

**Monitoring**
1. Continuous ECG
2. Arterial and central venous pressure waveforms
3. Respiratory rate, SpO2 Core temperature (goal 35°-37.5° C; 95°-99.6° F)
   a. Warming may be achieved with an external warming device, increasing the inspired air temperature (watch for precipitation in the vent circuit), or warming infused fluids and blood products; consider warmed NG lavage if the core temperature is less than 93.2° F
   b. Cooling may be achieved with evaporative cooling techniques or use of a cooling blanket

**Labs** (confirm the smallest quantity of blood required)
1. **ABG challenge** Q4 hrs (see below): standard ABG 30 min following vent changes
   a. ABG challenge on PEEP 5 cm H2O and 100% FiO2 (allow 30 min for equilibration); target PaO2 > 300 mm Hg
   b. Standard ABG on current PEEP and lowest FiO2 (preferably ≤40%) to maintain a PaO2 of >100 mm Hg
   c. Record peak inspiratory and plateau pressures with all ABGs
2. **Electrolytes** (Na+, K+, Cl-, HCO3-) every Q4 hrs and after electrolyte replacement; keep potassium between 3-5 mmol/L
3. **Ionized calcium** Q4 hrs, more frequent checks and aggressive replacement may be necessary for hypocalcemia and/or poor cardiac function or arrhythmias
4. **Glucose** Q4 hrs; Q1 hr while on insulin infusion
5. **Magnesium** Q8 hrs, more frequent checks and aggressive replacement may be necessary for hypomagnesemia and/or arrhythmias
6. **Hemoglobin and hematocrit** Q8 hrs, more frequent checks and transfusion may be necessary for severe anemia and/or active bleeding
7. **Lactate** Q 8 hrs, more frequent checks may be necessary for persistent metabolic acidosis
Guidelines for the Evaluation and Management of Pediatric Organ Donors (weight < 40 kg)

8. **BUN, creatinine and creatinine clearance** (see Appendix for calculation) Q24 hrs and within 4 hrs of organ offer (see also Organ Specific Testing and Evaluation: Kidney)

9. **Liver panel** (AST [SGOT], ALT [SGPT], alkaline phosphatase, bilirubin [total and direct], GGT and albumin) Q24 hrs and within 6 hrs of organ offer (see also Organ Specific Testing and Evaluation: Liver)

10. **PT, INR and PTT** Q24 hrs and within 6 hrs of organ offer (see also Organ Specific Testing and Evaluation: Liver)

11. **CPK (total and MB%) and troponin I** Q24 hrs, repeat Q8 hrs if elevated and within 6 hrs of organ offer (see also Organ Specific Testing and Evaluation: Heart)

12. **Amylase and lipase** at initiation of Mid-America Transplant management and as requested by the transplant center (see also Organ Specific Testing and Evaluation: Pancreas)

13. **HCG** for female donors >12 yrs of age at initiation of Mid-America Transplant management

14. **Blood, urine and tracheal aspirate cultures** at initiation of Mid-America Transplant management (see also Initial Evaluation: Cultures)

**Maintenance fluid**

1. Enteral nutrition should be stopped unless instructed otherwise by a transplant surgeon

2. Strict measurement of intake and output each hour is essential

3. Total fluid volume should be 1200-1500 mL/m²/day including maintenance fluids, medication infusions, backup fluids, scheduled medications, etc. Standard calculations for daily pediatric fluid requirements (e.g. 100 mL/day for the 1st 10 kg, 50 mL/day for the 2nd 10 kg and 20 mL/day for all subsequent kg) typically overestimate the needs of the ventilated patient by 20%. Obesity may also contribute to an overestimation of fluid needs.

   a. Hourly intake may exceed expected volumes during fluid resuscitation and when administering the hypernatremia protocol

   b. Goal is to achieve urine output of >0.5-3 mL/kg/hr, adequate organ perfusion without evidence of rising lactic acidosis and minimal organ tissue edema

   c. Be prepared for rapid changes in sodium with diabetes insipidus or SIADH

   d. Use the two tables below to select the initial maintenance fluid. Dextrose may be omitted if the donor is hyperglycemic. Usually easier to administer additional potassium that "take it away"

<table>
<thead>
<tr>
<th>Serum Sodium</th>
<th>Base Fluid</th>
</tr>
</thead>
<tbody>
<tr>
<td>Equal to or less than 140 meq/L</td>
<td>D5 NS or NS</td>
</tr>
<tr>
<td>141 – 150 meq/L</td>
<td>D5 ½ NS or ½ NS</td>
</tr>
<tr>
<td>151 – 160 meq/L</td>
<td>D5 ¼ NS or ¼ NS</td>
</tr>
<tr>
<td>161 or greater meq/L</td>
<td>D5 ¼ NS or ¼ NS (see hypernatremia protocol)</td>
</tr>
</tbody>
</table>
Guidelines for the Evaluation and Management of Pediatric Organ Donors
(weight < 40 kg)

Phone: 314-735-8200 / Fax: 314-735-1785

SOP-ORG-LOC-67, Rev. 7

<table>
<thead>
<tr>
<th>Serum Potassium (KCl/liter)</th>
<th>KCl bolus</th>
<th>KCl bolus</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt;5.0 meq/L</td>
<td>none</td>
<td>none</td>
</tr>
<tr>
<td>4.0-5.0 meq/L</td>
<td>10 meq</td>
<td>none</td>
</tr>
<tr>
<td>2.5-3.9 meq/L</td>
<td>20 meq</td>
<td>See hypokalemia protocol</td>
</tr>
<tr>
<td>&lt; 2.5 meq/L</td>
<td>20 meq</td>
<td>See hypokalemia protocol – consider IV replacement</td>
</tr>
</tbody>
</table>

Medications

1. Lacrilube PRN and eyes closed with tape to prevent infection and corneal abrasions in potential eye donors

2. Solumedrol 15 mg/kg IV x 1 over 30 min

3. T4 mixed 200 mcg/250 mL D5 ½NS (this has been concentrated and run at 500 mcg/250 mL when additional volume was problematic)
   a. May eliminate dextrose if hyperglycemic and run in NS or ½NS
   b. There are OPOs who mix in ¾NS or D5W depending upon serum sodium and dextrose concentrations. The 1/4NS infusion may be sufficiently hypoosmotic to promote hemolysis-use with some caution. There is little data on the use of D5W as a carrier fluid for T4.
   c. Follow the age based dosing protocol below

<table>
<thead>
<tr>
<th>AGE</th>
<th>Bolus (mcg/kg)</th>
<th>Infusion (mcg/kg/hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-6 mos</td>
<td>5</td>
<td>1.4</td>
</tr>
<tr>
<td>6-12 mos</td>
<td>4</td>
<td>1.3</td>
</tr>
<tr>
<td>1-5 yrs</td>
<td>3</td>
<td>1.2</td>
</tr>
<tr>
<td>6-12 yrs</td>
<td>2.5</td>
<td>1</td>
</tr>
<tr>
<td>12-16 yrs</td>
<td>1.5</td>
<td>0.8</td>
</tr>
<tr>
<td>&gt;16 yrs</td>
<td>0.8</td>
<td>0.8</td>
</tr>
</tbody>
</table>

d. Increase the infusion as needed to a maximum of 1.4 mcg/kg/hr to wean pressors

e. Measure glucose within 30 min of starting T4; measure K+ within 2 hrs of starting T4

f. After 30 min the donor may become tachycardic; temperature and blood pressure may also rise; T4 has also been associated with elevated K+ requirements and acidosis

g. T4 should be infusing for at least 4 hrs prior to the initial echocardiogram (see also Organ Specific Testing and Evaluation: Heart); if pressor requirements are high it may take 6 or more hours to see the full effects

6. Continue Hospital antibiotics until you receive Sputum GS results. Then review with CMO or AMD for antibiotic orders. (see also Initial Evaluation: Cultures and Organ Specific Testing and Evaluation: Lung)

7. Albuterol 2-4 puffs MDI Q4 hrs
Guidelines for the Evaluation and Management of Pediatric Organ Donors (weight < 40 kg)

Studies

1. CXR Q6 hrs read by radiologist or qualifying physician. May space radiographs to Q8 hrs if film clear and no deterioration in oxygenation over time. Repeat within 3 hrs of organ offer (see also Organ Specific Testing and Evaluation: Lung). May space radiographs to Qday if lungs ruled out (still want to insure ETT position, etc)

2. Bronchoscopy as needed (see also Organ Specific Testing and Evaluation: Lung)

3. Echocardiogram no earlier than 8 hrs after the first examination consistent with brain death. T4 should be on for at least 4 hrs prior to echocardiogram (see also Organ Specific Testing and Evaluation: Heart)

4. See Appendix for Renal Protective Protocol prior to any cardiac catheterization or CT scan with contrast

Ventilator and lungs

1. General goals
   a. PaO2 > 300 (during trials on FiO2 100% and PEEP 5 cm H2O)
   b. pH 7.30-7.45
   c. PaCO2 35-45 mm Hg

2. Cuffed endotracheal tube inflated to 25 cmH2O

3. Elevate HOB 30° (VAP prophylaxis)

4. Suction ETT and hypopharynx Q2 hours and as needed (Pediatric ETts are smaller than adult tubes and can readily become obstructed with secretions. Instill 3-5 mL of sterile saline down the ETT for thick secretions prior to suctioning.)

5. High lateral turns Q2 hrs and PRN

6. Chest physiotherapy Q4 hrs
   a. Vest therapy can be used for infants, children and adolescents > 1 yr of age
   b. Vibratory and/or percussive therapy can be used for infants < 1 yrs of age
   c. The Intrapulmonary Percussive Ventilator (IPV) can be used to aid in mucus removal. Follow the manufacturer instructions to set up and add either normal saline or hypertonic saline; lower the ETT cuff pressure slightly to aid the movement of mucus and avoid occlusion of the ETT when excessive secretions are present (a PEEP valve may be useful on the expiratory outlet of the IPV machine if saturations drop). Driving pressures are set between 20-30 psig and initial frequency is set at 300 Hz. The frequency should be dropped in 50 Hz increments every 5 minutes reaching a final setting of 100 Hz for the last 5 minutes. (www.cincinnatichildrens.org/health/i/ipv/)

7. Ventilator settings (may not be possible in the setting of ARDS, pneumonia, etc.)
   a. Volume controlled ventilation, humidified circuit
   b. Tidal volume 6-8 mL/kg
   c. PEEP 8-10 cmH2O
   d. FiO2 40%
   e. PIP < 30 cmH2O
   f. I:E ratio in the range of 1:1 or 1:2
8. Consult Pediatric Critical Care if unable to achieve goals

VII. Problems & Adjustments

Fluid balance and electrolytes

1. Intravascular volume
   
   a. Hypervolemia (AKA volume overload; CVP >12 mmHg; may see pulmonary vascular congestion)
      
      1) Review fluid balance, goal volume requirements and reduce/eliminate unnecessary infusion volume
      
      2) If on low dose vasopressin (0.5-10 milliunits/kg/hr) for diabetes insipidus consider reducing dose or stopping infusion briefly to allow urine output to “catch up”
      
      3) Administer furosemide (Lasix®) 0.5-1.0 mg/kg IV (max initial dose 20 mg), consider small initial doses and increase as needed
      
      4) If repeated doses of furosemide are ineffective consider bumetanide (Bumex®) 0.1 mg/kg IV Q6 hrs (max initial dose 2 mg), refractory urine output suggests renal insufficiency or overestimation of volume status
      
      5) Mannitol 25% 0.5 grams/kg IV over 3-5 min may be tried to enhance diuresis, repeat as necessary Q4-6 hrs to maintain urine output

   b. Hypovolemia (CVP <5 mmHg, heart rate high, low urine output low)
      
      1) Review fluid balance and goal volume requirements; determine cause of hypovolemia
      
      2) If diabetes insipidus is present (dilute, large volume urine in the absence of diuretics or excessive glucose load; rising serum sodium) initiate vasopressin infusion at 0.5 milliunits/kg/hr. Double the dose every 15 min to a maximum of 10 mcg/kg/hr targeting urine output of 1-2 mL/kg/hr. If urine output remains high at the maximum vasopressin dose you may need to consider cc per cc hourly replacement of urine output greater than 2 mL/kg/hr with ¼ NS.
      
      3) NS or lactated Ringers may be used to increase CVP into the 5-12 mmHg range; bolus 10-20 mL/kg over 30 min and repeat as necessary
      
      4) Consider a 10-20 mL/kg bolus of 5% albumin for hypovolemia presenting with hypoalbuminemia (<2 mg/dL); administer over 60 min
      
      5) Consider administering PRBC (10 mL/kg) for hypovolemia presenting with anemia (hemoglobin <7 g/dL)
      
      6) Avoid CVP >12 mmHg during fluid resuscitation

2. Sodium (normal range typically 130-150 meq/L)
   
   a. Hypernatremia (may be associated with primary liver non-function)
      
      1) Treat hypovolemia and/or diabetes insipidus aggressively (see under “Hypovolemia” above)
      
      2) Change IVF in accordance with Management Protocols: Maintenance fluid recommendations; consider remixing other large volume infusions in ¼ NS
      
      3) If serum sodium >160 meq/L institute the “Hypernatremia Protocol”
Guidelines for the Evaluation and Management of Pediatric Organ Donors (weight < 40 kg)

1. What is the weight of the pediatric organ donor?

2. What is the phone number for contact?

3. What is the fax number for contact?

4. What is the address for contact?

5. What are the specific guidelines for the evaluation and management of pediatric organ donors with weight < 40 kg?

b. Hyponatremia

1) Change IVF in accordance with Management Protocols: Maintenance fluid
2) Vasopressin may be associated with a fall in serum sodium; consider reducing the dose if possible
3) Consider replacing sodium as levels drop below 130 meq/L. Enteral sodium supplementation can be very effective in raising serum sodium and does not require central access. Begin with 1 meq/kg NaCl via NG Q4 hrs. If IV correction is required begin with 3-5 mL/kg 3% saline IV over 1 hr.

3. Potassium (normal range 3-5 meq/L, cardiac function best 4.0-5.0 meq/L)

a. Hyperkalemia

1) If potassium exceeds 5.5 meq/L stop all sources including IV and PO supplements as well as IVFs
2) If potassium exceeds 6 meq/L and/or if there are EKG changes consult with associate medical director

- Administer albuterol 5 mg neb to temporarily decrease serum potassium by 0.2-0.4 meq/L and furosemide (Lasix®) 1 mg/kg IV (max initial dose 20 mg) to increase actual (urinary) removal of potassium from the body, replace excessive diuresis with NS or administer empiric 10 mL/kg

- If EKG changes are present, IV calcium chloride (20 mg/kg) or calcium gluconate (50 mg/kg) has a rapid onset of action (1-3 min) and will last for 30-60 min; IV sodium bicarbonate (1-2 meq/kg) also works quickly (5-10 min) and lasts for 1-2 hours; flush lines well between doses of calcium and bicarbonate; IV glucose (5 mL/kg D10W) followed by insulin (0.1 units/kg) may also be useful and last for 4-6 hrs

- NG (clamp x 60min) or rectal (retention enema x 60 min) sodium polystyrene sulfonate (Kayexalate®) is often necessary in severe hyperkalemia to remove potassium from the body. This is particularly true in renal failure.

b. Hypokalemia

1) Change IVF in accordance with Management Protocols: Maintenance fluid; the KCl per liter of IVFs may be increased from 20 meq/L to 60 meq/L for significant hypokalemia and/or ongoing losses/displacement
2) NG replacement of potassium (1 meq/kg to max of 20 meq) Q2 hrs is effective and safe for moderate hypokalemia (2.5-3.9 meq/L) without significant arrhythmias
3) For hypokalemia <2.5 meq/L and/or significant arrhythmias consult with associate medical director; consider IV KCL 1 meq/kg (max 20 meq) over 60 min
4) Note that T4, albuterol, furosemide (Lasix®), bicarbonate, and insulin may lower serum K+ levels.
4. **Glucose** (goals 60-180 mg/dL)
   a. **Hyperglycemia**
      1) If glucose remains >180 mg/dL x 2 measured an hour apart, begin insulin drip at 0.1u/kg/hr. Monitor hourly and titrate by 0.01u/kg/hr - avoid insulin boluses as this may result in “see-saw” glucose levels
      2) If glucose persistently >300 mg/dL consult Pediatric Critical Care
   b. **Hypoglycemia**
      1) Maintenance fluids in accordance with Management Protocols: Maintenance fluid; additionally, the T4 infusion can be run in dextrose
      2) For continued hypoglycemia may bolus D2SW at 2-4 mL/kg and then increase dextrose in maintenance fluids (D12.5 max concentration in peripheral line, higher concentrations may run in a central line)

5. **Calcium** (total 8.0-10.5 mg/dL; ionized 1.13-1.32 mmol/L or 4.5-5.3 mg/dL)
   a. **Hypercalcemia**
      1) For significant elevation administer normal saline (10 mL/kg) and follow with furosemide (Lasix®) at 0.5-1.0 mg/kg (max initial dose 20 mg)
      2) Caution: Hypercalcemia in conjunction with hyperphosphatemia may cause tissue precipitation of calcium phosphate
   b. **Hypocalcemia** (hypotension)
      1) Administer calcium chloride 20 mg/kg IV over 1 hour (max 1 gram); also can use calcium gluconate IV 50 mg/kg over 1 hr (max 1 gram)
      2) Aggressive replacement of calcium may be needed to optimize circulatory function of the donor. Repeat ionized calcium after administration of supplemental calcium
      3) Use caution administering calcium in the presence of high phosphate levels, it may cause tissue precipitation of calcium phosphate

6. **Magnesium** (1.3-2.0 meq/L)
   a. **Hypermagnesemia**
      1) Modest elevations are rarely problematic
      2) For significant elevation administer normal saline (10 mL/kg) and follow with furosemide (Lasix®) at 0.5-1.0 mg/kg (max initial dose 20 mg)
   b. **Hypomagnesemia** (arrhythmias)
      1) Administer magnesium sulfate (50 mg/kg IV, max dose 1.5 grams) over 1 hr

7. **Phosphorus** (3.2-6.3 mg/dL)
   a. **Hyperphosphatemia**
      1) Modest elevations are rarely problematic
      2) Hyperphosphatemia may be indicative of renal insufficiency, eliminate sources of extra phosphate
      3) Phosphate binders (NG) are usually not very effective
Guidelines for the Evaluation and Management of Pediatric Organ Donors  
(weight < 40 kg)

b. **Hypophosphatemia** (poor cardiac contractility, rhabdomyolysis)

1) Phosphorous replacement is complicated by the various sodium and potassium contents of replacement products which, while allowing some flexibility may limit the dose or rate of infusion

2) Severe hypophosphatemia (< 1.5 mg/dl)

   - 0.16-0.32 mM phosphate/kg/dose IV over six hours
   - Na phosphate: 3 mM phosphate and 4 mEq Na per milliliter
   - K phosphate: 3 mM phosphate and 4.4 mEq K per milliliter (do not exceed 0.5-1 mEq/kg/hr of potassium when infusing this formulation)

3) Moderate hypophosphatemia (< 3.2 mg/dl)

   - Consider Neutra-Phos powder containing 250 mg (8 mmol) P, 7.125 mEq Na, and 7.125 mEq K per packet. Dose at 20mg/kg/dose per NGT every 6 hours for a maximum dose of 80mg/kg/day

4) Consult Associate Medical Director for hypophosphatemia with concurrent hyponatremia, hyperkalemia and/or renal insufficiency

Hemodynamics and arrhythmias

1. **Hypertension** (requiring treatment)

   a. Definition

      1) Sustained systolic BP greater than 150 mm Hg; or
      2) Sustained systolic BP greater than the 99th percentile + 5 mm Hg adjusted for age, sex and 50th percentile height (see Appendix)

   b. Treatment

      1) Labetolol: 0.25 mg/kg IV; may repeat or double dose Q10 min PRN to a maximum bolus dose of 20 mg; half-life 5.5 hrs in adults although this varies with age; BP control with bolus therapy might be maintained by starting an infusion at 0.4-1 mg/kg/hr and titrating to a maximum of 3 mg/kg/hr; avoid use in patients with bradycardias, heart block, asthma and CHF
      2) Nicardipine: start infusion at 1 mcg/kg/min IV and titrate to a maximum of 3 mcg/kg/min
      3) Nitroprusside: start infusion at 0.1 mcg/kg/min IV and titrate every 5 min not to exceed 5 mcg/kg/min; avoid use in pulmonary or renal disease, side effects include thiocyanate and cyanide toxicity which may be attenuated by mixing 10 mg thiosulfate per 1 mg nitroprusside

2. **Hypotension**

   a. Definition

      1) Mean arterial pressure (mm Hg) < 1.5 x age in years + 55 (see Appendix)

   b. Treatment

      1) Confirm sinus rhythm
2) Aggressively treat hypovolemia and electrolyte abnormalities (particularly potassium, calcium, magnesium and phosphorus) in accordance with Problems and Adjustments: Fluid Balance and Electrolytes

3) Ensure T4 protocol has been initiated in accordance with Management Protocols: Medications; increase infusion as needed to 1.4 mcg/kg/hr

4) Inotropes and vasopressors
   - Dopamine: initiate infusion at 5 mcg/kg/min and titrate to a maximum dose of 20 mcg/kg/min; may increase heart rate and cause arrhythmias. Children <2 yrs of age clear dopamine readily and may require higher doses.
   - Epinephrine: initiate infusion at 0.05-0.1 mcg/kg/min; may be associated with arrhythmias, tachycardia.
   - Vasopressin: initiate at 0.3 milliunits/kg/min and titrate to 2 milliunits/kg/min (note: not the same dose for treating diabetes insipidus); watch for acidosis or other signs of excessive vascular constriction, may also cause fluid retention and hyponatremia
   - Norepinephrine (Levophed®): initiate infusion at 0.05-0.1 mcg/kg/min; watch for acidosis or excessive vascular constriction, may be associated with exacerbation of preexisting right ventricular impairment in contractility

5) Consider echocardiography or other diagnostic studies per Organ Specific Testing and Evaluation: Heart

3. Arrhythmias
   a. Aggressively treat hypovolemia and electrolyte abnormalities (particularly potassium, calcium, magnesium and phosphorus) in accordance with Problems and Adjustments: Fluid Balance and Electrolytes
   b. Consult with associate medical director

Blood and blood products

1. Anemia (< 7 g/dL)
   a. Consider the transfusion guidelines below and measure the hemoglobin Q6 hrs, use a blood warmer for multiple transfusions, profound hypothermia or DIC
   b. Borderline Hgb may be acceptable if BP stable, off pressors, no active bleeding, hemodilutional anemia only or if harvest planned within a few hrs.

2. Coagulopathy (INR ≥2 x control)
   a. Consider the transfusion guidelines below for the administration of fresh frozen plasma (FFP) and vitamin K; repeat PT, PTT and INR Q6 hr

3. Thrombocytopenia (platelet count <50 K)
   a. Consider the transfusion guidelines below for the administration of platelets

4. Hypoalbuminemia
   a. Consider the transfusion guidelines below for the administration of albumin
Guidelines for the Evaluation and Management of Pediatric Organ Donors (weight < 40 kg)

<table>
<thead>
<tr>
<th>Value</th>
<th>Infusion and Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hemoglobin &lt; 7 g/dL</td>
<td>Transfuse leukocyte reduced PRBC’s 10ml/kg over 2 hrs (if CMV negative or unknown, transfuse CMV negative blood)</td>
</tr>
<tr>
<td>INR ≥2 times control</td>
<td>Transfuse FFP 10ml/kg over 1 hr, consider vitamin K (phytonadione) 1 mg (infant), 2 mg (child) or 10 mg (adolescent) IV x 1</td>
</tr>
<tr>
<td>Platelets &lt;50K or &lt;100K with active bleeding</td>
<td>Transfuse random donor platelets 10 mL/kg over 2 hrs</td>
</tr>
<tr>
<td>Albumin &lt;2 mg/dL and significant edema or interstitial fluid losses</td>
<td>Transfuse 5% albumin 10 mL/kg over 1 hr, if volume sensitive may administer 1 gram/kg of 25% albumin over 6 hrs</td>
</tr>
</tbody>
</table>

Gas exchange and ventilator troubleshooting

1. Oxygenation problems
   a. Low FiO2 or profound alveolar hypoventilation are unlikely mechanisms of hypoxemia on standard ventilator settings with supplemental oxygen
   b. Rule out congenital heart disease with intra- or extra-cardiac shunting (history, echocardiogram)
   c. Rule out chronic lung disease (history, previous CXRs)
   d. Rule out pulmonary hemorrhage (blood from endotracheal tube)
   e. Rule out likelihood of pulmonary edema by CXR appearance; a cardiogenic source may be identified by echocardiogram or PA catheter and addressed via ionotropic support and correction of volume overload; specific therapy for neurogenic pulmonary edema is largely anecdotal and currently is addressed by avoidance of hyper- or hypotension, correction of fluid overload and titration of PEEP. Consult with associate medical director.
   f. Address possible pneumonic or inflammatory (noninfectious aspiration, contusion) infiltrates with empiric antibiotic therapy (see Management Protocols: Medications) adjusted for results from tracheal aspirates; therapeutic maneuvers for atelectasis may also be useful (see below)
   g. Atelectasis
      1) Early therapeutic bronchoscopy
      2) High lateral turns Q2 hrs and PRN
      3) Intrapulmonary Percussive Ventilator (IPV)- see suggested protocol under Organ Specific Testing and Evaluation- Lung
   4) Recruitment
      - Adjust tidal volume to 10-12 ml/kg of ideal body weight; avoid plateau airway pressures >50 cm H2O
      - Adjust I:E ratio to 1:1 if not previously done
      - Increase PEEP to 8-10 cm H2O if PaO2 <300 torr or if PaO2 drops by >50 torr from previous value on ABG challenge (see Management Protocols: Labs). Maintain PEEP of 10 cm H2O during management and allocation. ABG challenge will continue to be on PEEP of 5 cm H2O (30 min prior and during
ABG). Titrate PEEP downwards if PIP > 35 cm H2O, decline in BP significant enough to require increased pressor requirements or donor instability.

- Consider prone positioning. Typically, the optimal effect is seen after 12-18 hrs

Preparation for proning:
- Assure that the tip of the ETT is in the lower third of trachea
- Assess security of the ETT, vascular lines, drainage catheters and Spo2 probe and reinforce if necessary
- Protect and cover eyes (if donating eye tissue)
- Move ECG electrodes to lateral aspect of arms and hips
- Coil and secure bladder catheter to inner thigh
- Suction the ETT and oropharynx
- Temporarily cap nonessential vascular lines and drainage catheters
- Acquire necessary blankets, sheets, pillows for optimal positioning

Turning to prone position:
- Infants can possibly be turned by two people, older children and adolescents will need at least three people. In either situation one person is always dedicated to the security of the head and ETT.
- Always turn towards the ventilator; do not disconnect the ETT (turn oxygen to 100% during maneuver)
- Levitate technique (infants/toddlers): levitate up, turn 45 degrees, set back down on side, pause/reassess, levitate up, turn prone, position pillows and blankets to avoid kinking vascular catheters and ETT, set donor down
- Mummy technique (school age/adolescents): slide donor to the edge of the bed on the opposite side from the ventilator, place new draw sheet over the donor, place desired pillows and blankets over the draw sheet, place additional full sheet over pillows and blankets and tuck underneath the donor, turn donor 45 degrees toward the ventilator, pause/reassess, position donor prone and remove old linens
- Keep head in alignment with the body, arms next to torso, toes of the upper leg pointed in the direction of the turn.

After turning:
- Reassess security and patency of all lines, catheters and tubes
- Recheck vitals
- Reattach capped off lines and catheters
- Start weaning FiO2

Returning to supine position:
- Precautions as above
Always turn away from the ventilator; do not disconnect the ETT (turn oxygen to 100% during maneuver)
- Reassess all lines, catheters and tubes after turning
- Check vitals
- Consider timing suctioning and CXR after turn to supine position
  - Consider APRV mode
    - Improves functional residual capacity (FRC) and oxygenation through sustained pressure (P$_{\text{High}}$) over a prolonged time period (T$_{\text{High}}$). As with conventional ventilation, the use of an initial P$_{\text{High}}$ > 30 cm H$_2$O is avoided to prevent stretch injury (however may be needed in donors with restrictive lung disease). Ventilation occurs during release of that P$_{\text{High}}$ over a very short time period (T$_{\text{Low}}$). During T$_{\text{Low}}$ airway pressures fall to nearly reach a pre-set lower pressure (P$_{\text{Low}}$). (Airway pressures are rarely allowed to settle at P$_{\text{Low}}$, rather some degree of deliberate “air trapping” is desirable.) To maximize the release volume (and ventilation) the default P$_{\text{Low}}$ will usually be set at 0 cm H$_2$O. T$_{\text{Low}}$ is set to achieve termination of expiration when the expiratory flow falls between 25-75% of the maximum expiratory flow velocity (see diagram below). The combination of T$_{\text{Low}}$ and T$_{\text{High}}$ represents the entire respiratory cycle in DNDD donors; respiratory cycles (T$_{\text{Low}}$ + T$_{\text{High}}$) of 3-4 seconds will provide functional respiratory rates of 15-20 br/min.

Initial Settings
- P$_{\text{High}}$: when transitioning from volume control start at the plateau pressure (= peak pressure if airway resistance is low); when transitioning from pressure control ventilation or HFOV start at 2-3 cm H$_2$O above the mean airway pressure
- P$_{\text{Low}}$: start at 0 cm H$_2$O
- T$_{\text{High}}$: 2-5 seconds (start with T$_{\text{High}}$ + T$_{\text{Low}}$ = 3-4 seconds)
- T$_{\text{Low}}$: 0.2-0.8 seconds (set to terminate expiration when the expiratory flow has fallen to 25-75% of the maximum expiratory flow)
2. Ventilation problems (including increased PIP)
   a. DOPE algorithm
      1) Displacement of endotracheal tube (check EtCO2, ETT depth)
      2) Obstruction of airway (kinked ETT, mucus plug, bronchospasm)
      3) Pneumothorax (listen to breath sounds, stat CXR)
      4) Equipment (have Respiratory Therapy to examine circuit, vent, airleaks)
   b. Respiratory acidosis (hypoventilation with elevated PaCO2)
Guidelines for the Evaluation and Management of Pediatric Organ Donors (weight < 40 kg)

1) Address issues identified by the DOPE algorithm
2) Consider worsening lung compliance (edema, atelectasis, etc.)
3) Increase rate and/or TV (consider consulting associate medical director)
   c. Respiratory alkalosis (hyperventilation with falling PaCO2)
      1) Decrease rate and/or TV

Metabolic acid-base disorders

1. Metabolic acidosis (base deficit > 4-5 meq/L)
   a. Normal anion gap (Na⁺ – (Cl⁻ + CO₃⁻) = ≤12 meq/L)
      1) GI or renal losses of bicarbonate (diarrhea, RTA most common)
      2) Addition of a carbonic type acid or chloride (saline administration, TPN most common)
      3) Treatment
         • Address underlying cause (diarrhea, saline infusions, etc)
         • Buffer pH into an acceptable range (> 7.2) by administering the following IV sodium bicarbonate correction over one hour

         \[ \text{mEq sodium bicarbonate} = \left( \frac{\text{weight kg}}{\text{base deficit}} \right) \times 0.6 \]

   b. Elevated anion gap (Na⁺ – (Cl⁻ + CO₃⁻) = >12 meq/L)
      1) Renal failure with decreased acid excretion
      2) Increased keto-acid production (DKA, starvation, EtOH most common)
      3) Ingestants and intoxicants (methanol, ethylene glycol, salicylate, NSAIDs and paraldehyde most common)
      4) Carbohydrate malabsorption and metabolic disorders resulting in organic acidemias
      5) Increased lactate production (tissue hypoxia, muscular exercise, systemic disease, and inborn error of metabolism most common)
      6) Treatment
         • Address underlying cause. If lactate is elevated (>3.5 mmol/L) and CVP is < 5 mmHg, infuse 10-20 mL/kg NS to improve tissue perfusion. If lactate is elevated and CVP is 5-10 mmHg, rule out cardiac dysfunction
         • Buffer pH into an acceptable range (> 7.2) by administering the following IV sodium bicarbonate correction over one hour

         \[ \text{mEq sodium bicarbonate} = \left( \frac{\text{weight kg}}{\text{base deficit}} \right) \times 0.6 \]

2. Metabolic alkalosis (base excess > 4-5 meq/L)
   1) Excessive loss of H⁺ (prolonged NG drainage, vomiting most common)
   2) Excessive administration or absorption of bicarbonate (including profound hypokalemia, hyperaldosteronism, Cushing syndrome, etc)
   3) Contract alkalosis from loss of extracellular fluid
Guidelines for the Evaluation and Management of Pediatric Organ Donors
(weight < 40 kg)

4) Treatment
   - The need to correct this abnormality in a donor is unusual. Discuss with associate medical director

VIII. Appendix

BSA calculation

- Mosteller’s formula for BSA (m²) = \( \sqrt{\left[ \frac{\text{weight (kg)} \times \text{height (cm)}}{3600} \right]} \)

- NATCO (m²) = \( \frac{4 \times \text{wt (kg)} + 7}{90 + \text{wt (kg)}} \)

Mean blood pressure by age (50th percentile MAP at 50th percentile height)

- Mean arterial pressure (mm Hg) = 1.5 x age in years + 55

Systolic Blood Pressure by age (50th percentile)
Systolic arterial pressure (mm Hg) = 2 x age in years + 85

Severe hypertension by age (> (99th percentile + 5 mmHg) at 95th percentile height)

<table>
<thead>
<tr>
<th>Age (yrs.)</th>
<th>Boys systolic</th>
<th>Boys diastolic</th>
<th>Girls systolic</th>
<th>Girls diastolic</th>
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<td>71</td>
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<td>152</td>
<td>102</td>
<td>144</td>
<td>98</td>
</tr>
</tbody>
</table>
Guidelines for the Evaluation and Management of Pediatric Organ Donors (weight < 40 kg)

Creatinine clearance calculations

\[
\text{Age} < 1\text{yrs} \quad \text{CrCl (mL/min)} = \frac{(0.45)(\text{height cm})(\text{BSA})}{\text{serum creatinine}}
\]

\[
\text{Ages } 1-18\text{yrs} \quad \text{CrCl (mL/min)} = \frac{(0.48)(\text{height cm})(\text{BSA})}{\text{serum creatinine}}
\]

Renal Protective Protocol (pediatric)

15 mg/kg IV/PO n-acetylcysteine q12 hrs for 24 hrs prior to contrast study and 24 hrs afterwards (4 doses). Additional hydration (1½-2x maintenance) prior to and during the contrast administration is essential.
Guidelines for the Evaluation and Management of Pediatric Organ Donors (weight < 40 kg)

Bronchoscopy (Pediatric)

<table>
<thead>
<tr>
<th>LMA Size</th>
<th>Patient Weight (kg)</th>
<th>LMA ID (mm)</th>
<th>Cuff Volume (ml)</th>
<th>Largest ETT Inside LMA ID (mm)</th>
<th>Largest FOBT Inside ETT (mm)</th>
<th>Type of FOBT That Will Pass through ETT</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>&lt; 5.5</td>
<td>5.25</td>
<td>2-5</td>
<td>3.5</td>
<td>2.7</td>
<td>Olympus PF-27M, ENF-P2, BF-N20; Pentax FB-10H, F1-10P</td>
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<tr>
<td>2</td>
<td>6.5-20</td>
<td>7.0</td>
<td>7-10</td>
<td>4.5</td>
<td>3.5</td>
<td>Olympus ENF-P9, BF-3C20; Pentax FN-L155</td>
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<tr>
<td>2.5</td>
<td>20-30</td>
<td>8.4</td>
<td>14</td>
<td>5.0</td>
<td>4.0</td>
<td>Olympus LF-1, LF-2</td>
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<tr>
<td>3</td>
<td>30-70</td>
<td>10</td>
<td>15-20</td>
<td>6.0 cuffed</td>
<td>5.0</td>
<td>Olympus BF-27R, BF-P200D</td>
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<td>4</td>
<td>&gt;70</td>
<td>10</td>
<td>25-30</td>
<td>6.0 cuffed</td>
<td>5.0</td>
<td>Pentax FB-19H, FB-19H3</td>
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<tr>
<td>5</td>
<td>&gt;90</td>
<td>11.5</td>
<td>35-40</td>
<td>7.0 cuffed</td>
<td>6.5</td>
<td>Many brands</td>
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</table>

Equipment (pediatric)

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Newborn</th>
<th>6 Months</th>
<th>1-2 Years</th>
<th>5 Years</th>
<th>8-10 Years</th>
<th>12 Years</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ventilation</td>
<td>newborn</td>
<td>infant/child</td>
<td>child</td>
<td>child</td>
<td>small/adult</td>
<td>adult</td>
</tr>
<tr>
<td>ETT</td>
<td>3.0-3.5 cuff</td>
<td>3.5-4.0 cuff</td>
<td>4.0-4.5 cuff</td>
<td>4.5-5.0 cuff</td>
<td>6.5-6.0 cuff</td>
<td>6.5-7.0 cuff</td>
</tr>
<tr>
<td>Laryngoscope</td>
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<td>1 Miller</td>
<td>1-2 Miller</td>
<td>2 Miller</td>
<td>2-3 Miller or</td>
<td>2-3 Miller or</td>
</tr>
<tr>
<td>Blade</td>
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<td>1</td>
<td>1-2</td>
<td>2</td>
<td>2-3</td>
<td>2-3</td>
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<tr>
<td>Inline Suction</td>
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<td>8 Fr.</td>
<td>8-10 Fr.</td>
<td>10 Fr.</td>
<td>12 Fr.</td>
<td>12-14 Fr.</td>
</tr>
<tr>
<td>BP Cuff</td>
<td>newborn</td>
<td>infant</td>
<td>child</td>
<td>child</td>
<td>child/sm adult</td>
<td>sm adult</td>
</tr>
<tr>
<td>NG/OG</td>
<td>3-8 Fr.</td>
<td>8 Fr.</td>
<td>10 Fr.</td>
<td>10-12 Fr.</td>
<td>14-16 Fr.</td>
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<tr>
<td>Chest tube</td>
<td>12-18 Fr.</td>
<td>14-20 Fr.</td>
<td>14-24 Fr.</td>
<td>20-32 Fr.</td>
<td>28-38 Fr.</td>
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<td>Foley</td>
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<td>10-12 Fr.</td>
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</table>
IX. References

Transport


Guidelines for the Evaluation and Management of Pediatric Organ Donors (weight < 40 kg)


