UNYTS Pediatric Donor Management Guidelines

Obtain an accurate weight on the pediatric donor. Most everything you order will be based on the child’s weight

Vitals/Hemodynamic Stability

Vital Signs - Acceptable ranges

<table>
<thead>
<tr>
<th>Age</th>
<th>Heart Rate</th>
<th>SBP</th>
<th>DBP</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neonate 0-30 days</td>
<td>80-180</td>
<td>60-90</td>
<td>20-60</td>
<td>~3-5 kg</td>
</tr>
<tr>
<td>Infant 1-12 months</td>
<td>75-160</td>
<td>87-105</td>
<td>53-66</td>
<td>~5-10 kg</td>
</tr>
<tr>
<td>Toddler 1-3 years</td>
<td>60-110</td>
<td>95-105</td>
<td>53-66</td>
<td>~10-15 kg</td>
</tr>
<tr>
<td>Preemies 2.0 - 3.0</td>
<td>60-110</td>
<td>95-112</td>
<td>53-71</td>
<td>~15-20 kg</td>
</tr>
<tr>
<td>Newborns - 6 mo</td>
<td>60-110</td>
<td>97-112</td>
<td>57-71</td>
<td>~20-30 kg</td>
</tr>
<tr>
<td>6 - 18 mo</td>
<td>50-90</td>
<td>112-128</td>
<td>66-80</td>
<td>~30-50 kg</td>
</tr>
</tbody>
</table>

- Infants have a higher risk of hypothermia, bradycardia, and acidosis. They don’t have the ability to regulate body temperature until the age of four.
- In children >1 year of age, the rule of thumb for minimum acceptable systolic blood pressures is $\text{SBP (mmHg)} = 70 + (2 \times \text{age in years})$

Airway - ETT Size = (age in years + 16) / 4

<table>
<thead>
<tr>
<th>Age</th>
<th>Size of ETT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preemies</td>
<td>2.0 - 3.0</td>
</tr>
<tr>
<td>Newborns-6 mo</td>
<td>3.5</td>
</tr>
<tr>
<td>6 - 18 mo</td>
<td>4.0 - 4.5</td>
</tr>
<tr>
<td>&gt; 2 yrs</td>
<td>(age + 16) / 4</td>
</tr>
</tbody>
</table>

- ET tubes < 5.0 are not usually cuffed, making aspiration and dislodgement very easy.
- Check ETT often, especially if there is instability

Fluid Balance and Electrolytes

- Administer IV fluids to maintain urinary output of 1 - 3 ml/kg/hr, CVP 4 - 8
- Bolus 5 - 10 ml/kg NS or LR q 10 min to obtain CVP 4 - 8 and/or SBP >80.

<table>
<thead>
<tr>
<th>CVP</th>
<th>PAWP (&gt; 5 yrs of age)</th>
<th>UOP</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 - 8 mmHg</td>
<td>5 - 15 mmHg</td>
<td>1 - 3 mL/kg/hr</td>
</tr>
<tr>
<td>Weight</td>
<td>Maintenance Rate</td>
<td>1 - 3 mL/kg/hr</td>
</tr>
<tr>
<td>&lt; 10 kg</td>
<td>4 mL/kg/hr</td>
<td></td>
</tr>
<tr>
<td>10 - 20 kg</td>
<td>40 mL + (2 mL/kg/hr for each kg over 10 kg)</td>
<td></td>
</tr>
<tr>
<td>&gt; 20 kg</td>
<td>60 mL + (1 mL/kg/hr for each kg over 20 kg)</td>
<td></td>
</tr>
</tbody>
</table>

Estimation of Pediatric Circulating Blood Volume

<table>
<thead>
<tr>
<th>Age of Child</th>
<th>Blood Volume (mL/kg body weight)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age Group</td>
<td>Age Range</td>
</tr>
<tr>
<td>--------------</td>
<td>-----------</td>
</tr>
<tr>
<td>Neonate</td>
<td>85 - 90</td>
</tr>
<tr>
<td>Infant</td>
<td>75 - 80</td>
</tr>
<tr>
<td>Child</td>
<td>70 - 75</td>
</tr>
<tr>
<td>Adolescent</td>
<td>65 - 70</td>
</tr>
</tbody>
</table>

- **Signs of Poor Systemic Perfusion**
  - Tachycardia
  - Mottled color, pallor
  - Cool skin, prolonged capillary refill
  - Oliguria (< 1 ml/kg/hr UOP)
  - Metabolic acidosis
  - Diminished peripheral pulses
  - Late signs are hypotension and bradycardia

- **Hepatocardiac Reflex**: When pressure is applied to the liver, it forces blood out of the liver and into systemic circulation. If this increases BP, the child most likely needs fluid. If there is no change in BP, an inotrope may be needed.

- **Hypotension**:
  - Initiate Dopamine infusion. Start infusion at 5 mcg/kg/min. May titrate to a maximum of 20 mcg/kg/min to maintain stability.
  - Give Solumedrol 30 mg/kg and consider starting a T4 drip. (See T4 protocol for pediatrics) You may give a second dose of 15 mg/kg IV Solumedrol 12 hrs after the initial dose.
  - If Solumedrol was given, but the T4 protocol was not begun, do not give another dose if starting the T4 protocol at a later time.
  - Fluid resuscitation of 10 - 20 ml/kg LR or NS bolus over 15 minutes. May repeat to maintain CVP 4 - 8 and normal SBP.
  - If hypotension still persists after fluid resuscitation and Dopamine infusion is begun, consider 5% Albumin 0.5 - 1 gram/kg/dose. Check with accepting lung surgeon first.
  - If CVP is > 8 and Dopamine is > 10mcg/kg/min, consider adding another Inotropic Drug
    - **Vasopressin** (0.5 mU/kg/hr)
    - **Norepinephrine** 0.05 - 1.0 mcg/kg/min
    - **Neosynephrine** (only used in extreme cases of hypotension) 0.04 - 3.0 mcg/kg/min
    - **Epinephrine** 0.05 mcg/kg/min. May titrate to a maximum of 2 mcg/kg/min to maintain stability.
    - **Dobutamine** 2 - 20 mcg/kg/min (Makes a bad heart look good)

<table>
<thead>
<tr>
<th>Clinical Condition</th>
<th>Colloid/Blood Products</th>
<th>Dosages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anemia/Acute hemorrhage</td>
<td>PRBCs</td>
<td>10 mL/kg</td>
</tr>
<tr>
<td>Acute hemorrhage</td>
<td>Platelets</td>
<td>0.1 unit/kg</td>
</tr>
<tr>
<td>Active Hemorrhage/Coagulopathy</td>
<td>FFP</td>
<td>10 mL/kg</td>
</tr>
<tr>
<td>Hypotension</td>
<td>Albumin 5% (50 mg/mL)</td>
<td>10 mL/kg</td>
</tr>
</tbody>
</table>

- **Hypertension**
  - SBP > 120 if < 1 year of age or SBP > 150 if over 1 year of age
  - Assess airway and oxygenation
  - Tachycardia and Hypertension
- **Nipride Infusion**: start at 0.5 - 5 mcg/kg/min.
- **Nitroglycerin Infusion**: IV 0.1 - 10 mcg/kg/min
- **Esmolol Infusion**: start at 50 mcg/kg/min. Titrate to a maximum dose of 200 mcg/kg/min (no loading dose for pediatrics)
- **Labetalol**: IV 0.25 mg/kg (may increase dose to a maximum of 4 mg/kg)
- ***It can be difficult to place the heart if the donor is on a beta blocker drip such as Esmolol or Labetalol***

**Fluid Balance**
- Increased Urine Output
  - Consider Diabetes Insipidus
  - Monitor fluid balance
  - Monitor electrolytes and replace as needed
  - Give crystalloid boluses as needed to replace urine output.
  - Administer DDAVP if urinary specific gravity is ≤ 1.005 or UOP is > 5 ml/kg/hr. Infuse 0.05 - 0.1 mcg/kg in D5W over 20 minutes. (May repeat dose at 0.2 mcg/kg after 2 hrs if no response) **Do not give within 4 hours of OR**
  - Consider Vasopressin at 0.5 - 1 mU/kg/hr if DI persists. Titrate to keep UOP 2 - 4 ml/kg/hr

- Decreased Urine Output
  - Check patency of Foley catheter
  - If CVP is < 4, fluid boluses may be given
  - Administer Lasix 1 mg/kg IV push if CVP >8, urinary output is < 1mL/kg/hr, and SBP >90. Repeat at 2 mg/kg after 1 hr if no response. May repeat every 2 hrs
  - May also administer Mannitol 25% 0.25 - 1.0 gm/kg/dose IV over 30 min if UOP is < 1mL/kg/hr (May repeat every 2 hrs)
  - Consider Dopamine at 2 - 3 mcg/kg/min to increase renal perfusion

**Electrolytes**
- *Recheck levels of any electrolyte that interventions have been done to correct*

<table>
<thead>
<tr>
<th>Serum Sodium</th>
<th>Fluid Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 130</td>
<td>D5 NS</td>
</tr>
<tr>
<td>131 - 140</td>
<td>D5 ½ NS</td>
</tr>
<tr>
<td>141 - 155</td>
<td>D5 ¼ NS</td>
</tr>
<tr>
<td>&gt;156</td>
<td>Hypernatremia protocol</td>
</tr>
</tbody>
</table>

**Hypernatremia Protocol**
- Remove sodium from IV infusions
- Give free water down the NG/OG tube (50 - 200 ml, clamp for 45 min, place to suction for 15 min. Repeat hourly).
- Calculate volume deficit
  - Body H2O calculation: 0.6 x kg of donor = kg of H2O
- Fluid volume deficit
  - Current serum Na x body H2O / 155 (desired Na) = X (deficit in liters)
- Administer deficit over 16 - 20 hrs in addition to maintenance fluid.
• Hypokalemia

<table>
<thead>
<tr>
<th>Serum Potassium</th>
<th>KCl per liter of MIVF</th>
<th>KCl Infusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt; 5.0</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>4.0 - 5.0</td>
<td>20 mEq/liter</td>
<td>None</td>
</tr>
<tr>
<td>3.0 - 4.0</td>
<td>40 mEq/liter</td>
<td>0.5 mEq/kg over 1 hr</td>
</tr>
<tr>
<td>&lt; 3.0</td>
<td>Consult with medical director/or intensivist</td>
<td>1.0 mEq/kg over 2 hrs</td>
</tr>
</tbody>
</table>

• Hyperkalemia
  - Severe = > 7.0. Mild to moderate = 6.0 - 7.0
  - Give Calcium Chloride 20 mg/kg IV over 3 - 5 min. May repeat in 10 min. (Protects the heart)
  - Give D\textsubscript{25}W 2 mL/kg with 0.1 unit/kg IV Insulin IV over 30 min (moves potassium into cells). May repeat in 30 - 60 min. Monitor glucose hourly.
  - Give NaHCO\textsubscript{3} 1 - 2 mEq/kg IV over 5 - 10 min (may be used even in the absence of acidosis)
  - May also use Lasix, Albuterol, and Kayexalate
    - Kayexalate NG/OG or PR (1 - 2 gm/kg q 6hrs)
    - Lasix (1 mg/kg)
    - Albuterol (0.1 - 0.2 mg/kg q 4 - 6hrs)

• Hyperglycemia
  - Can be caused by excessive dextrose infusions or steroid replacements
  - Remove all dextrose from IV fluids. Administer regular insulin IV 0.1 unit/kg for glucose > 200. Check glucose levels every 30 min. Repeat same dose if glucose > 250. Initiate insulin drip to maintain normalized glucose levels.

<table>
<thead>
<tr>
<th>Blood Sugar</th>
<th>Regular Insulin units/kg/hr</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤ 119</td>
<td>Off</td>
</tr>
<tr>
<td>120 - 179</td>
<td>0.025</td>
</tr>
<tr>
<td>180 - 239</td>
<td>0.05</td>
</tr>
<tr>
<td>240 - 299</td>
<td>0.075</td>
</tr>
<tr>
<td>≤ 300</td>
<td>0.1</td>
</tr>
</tbody>
</table>

• Hypoglycemia
  - Can develop rapidly in stressed infants. Neonate and infants have continuously high glucose needs and low glycogen stores.
  - Administer D\textsubscript{25}W 2 - 4 mL/kg slow IVP over 3 - 5 minutes
  - Follow with continuous infusion
    - Neonates: 10% dextrose 4 mL/kg/hr
    - Infants: 5% dextrose 4 mL/kg/hr
  - *Check blood sugars every 30 minutes after infusion and boluses

• Hypocalcemia
  - Ca < 8.5 or ionized Ca < 4.0
  - Administer Calcium Chloride 20 mg/kg (0.2 mL/kg of 10% solution) slow IVP for serum Ca < 8.5 mEq/liter.
  - Consider Calcium Chloride infusion 10 - 30 mg/hr to maintain therapeutic levels (can assist in cardiac function)
- May substitute Calcium Gluconate 100 mg/kg if blood sugars are normal. May repeat dose.
- Monitor phosphorus levels

- **Hypomagnesemia**  Mg < 2.0

<table>
<thead>
<tr>
<th>Serum Magnesium Level</th>
<th>Magnesium Replacement</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.4 - 1.9</td>
<td>25 mg/kg MgSO₄</td>
</tr>
<tr>
<td>&lt; 1.4</td>
<td>50 mg/kg MgSO₄</td>
</tr>
</tbody>
</table>

- Watch BP as MgSO₄ may cause precipitous hypotension

- **Hypophosphatemia**  < 1.8 serum phosphorus

<table>
<thead>
<tr>
<th>Serum Phosphorus Level</th>
<th>Phosphorus Replacement</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 1.8</td>
<td>0.16 mMol/kg KPhos over 3 - 4 hrs</td>
</tr>
<tr>
<td>&lt; 0.5</td>
<td>0.32 mMol/kg KPhos over 3 - 4 hrs</td>
</tr>
</tbody>
</table>

* May use NaPhos if K is elevated and if Na level is low or within normal range.

**Oxygen and Ventilation**

- **Goals**
  - SaO₂ > 95%
  - PaO₂ > 100 on FiO₂ ≤ 40%
  - pH 7.35
  - pCO₂ 35 - 45
  - HCO₃ 22 - 28

- **Types of Ventilation for infants and children**
  - **PC (Pressure Control)** Controlled pressure cycled ventilation. Variables set on the ventilator include respiratory rate, PEEP, and PIP. Allows ventilation at lower peak inspiratory pressures than other forms of ventilation. Gas distribution is often better, atelectic areas of the lungs may expand, resulting in better oxygenation.
  - **A/C or VC (Assist/Control or Volume Control)** – Volume controlled ventilation, tidal volume, respiratory rate, and PEEP are set.
  - **High Frequency Ventilation** - Uses rapid respiratory rates and smaller tidal volumes to achieve adequate oxygenation and ventilation. The advantage is to avoid large increases in airway pressures.
  - **High Frequency Oscillatory Ventilation** - moves very small volumes of gases to and from the alveoli at extremely high frequencies. The effective tidal volumes are delivered by airway resistances. Ask for assistance from RT or attending physician.
  - **ECMO** (Extra Corporeal Membrane Oxygenation) - Provides support of cardiac or pulmonary function using external cardiopulmonary bypass with a membrane oxygenator. There are several methods of ECMO. All require removal of venous blood from the body, oxygenation of the blood, carbon dioxide removal, warming the blood in the oxygenator, and returning the blood to the body. Cannulas are inserted to conduct the patient’s blood to the oxygenator and to return the blood to the patient. (Patients are extremely unstable and usually require multiple
vasopressors. Utilize the attending/primary intensivist to maintain stability in these patients).

- **Suggested Ventilator Settings** (Utilize RT and Intensivist to help ventilate donor)
  - **PC or VC**
    - PEEP 5 - 15. Check with intensivist or lung surgeon prior to increasing to maximum of 15.
    - Tidal volume 8 - 10 ml/kg. Maximum 15 ml/kg
    - Inspiratory time 0.75 - 1 second
    - Adjust respiratory rate to normalize pCO₂
    - Frequent chest x-rays to evaluate changes
    - Frequent suctioning and turning
  - **Pressure Control**
    - PC to maintain PIP < 30
  - **Assist Control/Volume Control**
    - Tidal volume 8 - 10 ml/kg

- **Respiratory Medications**
  - **Albuterol**: 1.25 - 2.5 mg nebulized in 2.5 ml saline q 2 hrs (Albuterol may decrease serum potassium levels. Monitor and treat low K+ levels per protocol)
  - **Atrovent**: 0.5 mg nebulized with Albuterol (or consider Combivent nebs)
  - **Solumedrol**: 15 mg/kg IV over 30 minutes. Administer as soon as possible and repeat q 12 hrs.

- **Acidosis (pH < 7.35, pCO₂ > 45)**
  - Adjust tidal volume and ventilation rate to maintain pCO₂ between 35 - 45.
  - May administer NaHCO₃ to correct persistent acidosis
    - Give NaHCO₃ 1 mEq/kg IV over 15 minutes for pH < 7.25.
    - Repeat ABGs and reevaluate.
    - May repeat if necessary.
    - Correct all electrolytes and maintain oxygenation.

- **Alkalosis (pH > 7.5 and/or pCO₂ < 35)**
  - Adjust minute ventilation to keep pCO₂ 35 - 45
  - Decrease ventilation rate and recheck ABGs
  - Decrease tidal volume and recheck ABGs

- **Infiltrates**
  - Consider usage of diuretics (Lasix IV 1mg/kg)
  - Continue Solumedrol treatments (Solumedrol 15mg/kg IV over 30 minutes q 12 hrs)
  - Consult Pulmonologist/Intensivist for other treatments
  - Repeat Chest X-rays

- **Pulmonary Edema**
  - Decrease IV fluids
  - May give Lasix IV 1mg/kg

- **Atelectasis**
  - Increase PEEP
  - Consider early bronchoscopy
  - Aggressive pulmonary toilet
Thermoregulation

• **Hypothermia**
  - Common in brain dead patients
  - Consider the use of warming blankets
  - Consider warming IV fluids
  - Consider increasing inspired air temperature on ventilator circuit

• **Hyperthermia**
  - Less common in brain dead patients
  - Consider the use of cooling blankets
  - Consider cooling IV fluids
  - Rule out infection
    - Monitor WBCs
    - Blood, urine, an sputum cultures

Antibiotic Coverage

• **Rocephin** 50 mg/kg IV q24 hrs
• **Ampicillin** 50 mg/kg IV q6hrs
• If sputum gram stain indicates yeast administer **Diflucan** 6 mg/kg IV one dose

Emergencies

(Usage of PALS protocols/pathways) see attached pathway

• **Primary cardiac arrest is rare in pediatrics. Respiratory arrest is more common.**
• **Assess oxygenation, electrolyte balances, and fluid balances.**
  - **Bradycardia:**
    - Assess O₂ delivery and airway
    - Give Epinephrine 0.01 mg/kg IV push
    - Atropine will not work on a brain dead patient
    - Begin compressions for heart rate < 80.
    - If unable to ventilate, reintubate and reevaluate
  - **Asystole/PEA:**
    - Begin CPR per PALS protocol
    - Epinephrine 0.01 mg/kg IV push. May repeat q3 - 5 min
  - **V-Fib/V-Tach:**
    - Begin CPR per PALS protocol
    - Defibrillate at 2 joules/kg. Increase to 4 joules/kg and repeat.
    - Epinephrine 0.1 mg/kg IV
    - Lidocaine 1 mg/kg IV
    - Amiodarone 5 mg/kg IV
    - Consider Magnesium 25 - 50 mg/kg IV (max 2 grams) for torsades de pointes
  - **Cardiac Arrhythmias (usage of PALS protocol)**
    - Check fluid volume balances, electrolyte balances, and oxygenation.
    - **SVT** (Supraventricular Tachycardia)
• Give **Adenosine 0.1 mg/kg** rapid IV push under guidance of primary intensivists. Max dose 6 mg. Expect a short period of asystole. May repeat dosage to 0.2 mg/kg (max 2nd dose 12 mg)
• Cardiovert at 0.5 - 1 joules/kg. Increase to 2 joules/kg and repeat

### Extra considerations

• Please utilize primary physicians and Intensivists for medical management guidance to maximize organ function.

• Keep the child warm. Children do not tolerate hypothermia well and can become unstable if cold.

• **Spinal Reflexes:** Spinal reflexes may be very uncomfortable for families to witness and may cause distress to the donor families. Consider usage of paralytics on brain dead donors.
  - **Pavulon (Pancuronium)**
    - 0.05 mg/kg IV
    - may titrate to 0.1 mg/kg
    - may repeat dose if necessary.
  - **Norcuron (Vecuronium)**
    - 0.05 mg/kg IV
    - may titrate to 0.1 mg/kg
    - may repeat dose if necessary for effect

### Brain Death Declaration in the Pediatric Population

Determination of neurological death in pediatrics remains a clinical diagnosis and is no different than declaring adult brain death. However, some hospitals may have age related issues with confirmatory brain death testing. Each hospital can be different, so look thoroughly through hospital policies and procedures for determination of brain death in pediatrics, especially newborns and infants. The chart below summarizes certain criteria for confirmatory brain death that may be used in hospitals. Tests and evaluations will be ordered by attending physicians and/or neurologists.

<table>
<thead>
<tr>
<th>Age</th>
<th>Examinations/Tests which may be performed</th>
</tr>
</thead>
<tbody>
<tr>
<td>7 days - 2 months</td>
<td>2 examinations and 2 EEGs 48 hrs apart</td>
</tr>
<tr>
<td>2 months - 1 yr</td>
<td>2 examinations and 2 EEGs 24 hrs apart, or 1 cerebral angiogram</td>
</tr>
<tr>
<td>&gt; 1 yr</td>
<td>2 examinations, no confirmatory test may be required</td>
</tr>
</tbody>
</table>

### Pediatric T4 Protocol

• **Medications Needed:**
  - Levothyroxine (T4) 200 mcg or 400 mcg
  - SoluMedrol 30 mg per kg
- **Regular Insulin**: 0.3 units per kg
- **Dextrose**: 2 mL per kg of D\textsubscript{25}W
- **D5W**: 500 mL bag or 1000ml bag
- **T4 bolus**: 0.7 mcg per kg

**Procedure:**
- **Prepare the T4 drip solution.**
  - Reconstitute the vial of Levothyroxine.
  - Add 200 mcg to 500 mL D\textsubscript{5}W or 400 mcg to 1000 mL D\textsubscript{5}W.
  - Label bag (T4 drip 0.4 mcg/mL D\textsubscript{5}W)
- **Prepare the following boluses to be given prior to starting the T4 drip.**
  - **Regular Insulin 0.3 units/kg IVP**
  - **SoluMedrol 30 mg/kg IVP**
  - **Dextrose (D\textsubscript{25}W) 2 ml/kg IVP**
  - **T4 bolus 0.7 mcg/kg**

**Administer IV boluses in rapid sequence.**

**Begin T4 drip at 2.5 ml/hr. May titrate to 5-7.5 ml/hr (max)**
- 2.5 ml/hr = 1 mcg/hr
- 5.0 ml/hr = 2 mcg/hr
- 7.5 ml/hr = 3 mcg/hr

- Before starting T4 drip, be sure that serum potassium levels are within normal range. If potassium is < 0.5 give KCl boluses per protocol. Monitor potassium levels every 4 hrs after starting T4 drip.

- Monitor PT levels after starting the drip. The use of T4 may potentate the affects of anticoagulants.

- T4 drips are usually maintained from the beginning of donor management until crossclamp, but may be weaned off if hypertension occurs and persists.

**References**


Nakagawa, T, MD (2005) Pediatric Donor Management Guidelines, NATCO.