CLINICAL MANAGEMENT OF PEDIATRIC PATIENTS WITH DEVASTATING BRAIN INJURIES

Patient evaluated in ED or PICU with devastating brain injury

- Traumatic or non-traumatic neurological injury
- Evaluated by Neurosurgery and/or Neurology and deemed to be non-survivable with no benefits from neurosurgery intervention
- Still requires resuscitation by Trauma/Critical Care Services-consult to be obtained during course of treatment
- Patient should weigh less than 45 kg

Note: All patients with devastating brain injury have the potential to be organ donors. However, organ donation should not be discussed with the family unless directed by the attending M.D.

Initial Steps of Management

- ABG/Serum lactate
- CBCw/diff, PT/PTT, Electrolytes, Hepatic function panel
- Type & Crossmatch 4 PRBC. Transfuse to maintain Hct > 30, INR < 1.4, Platelets >100, fibrinogen > 100
- Bolus 20 ml/kg NS
- Protect from hypothermia
- Central line (large lumen) & arterial line placement
- Control active bleeding*
- Maintain MAP > 50-79 (dependent of patient’s age) with fluid bolus
  - If CVP > 8-10 and MAP < 50-79, add dopamine drip at 5 mcg/kg/min or if tachyarrhythmia develops switch to norepinephrine drip at 0.1 mcg/kg/min, titrate to MAP > 50-79
  - If UOP > 1-2 ml/kg/hr, check serum osmolality, urine osmolality and urine specific gravity

Call One Legacy to refer patient within one hour of being intubated and having GCS < 5 and/or loss of one or more brainstem reflexes

CAUTION:
Avoid hypotension and hypoxia in all head injury patients
Patient can go from hypertension to hypotension rapidly

Yes

- Continue maintenance fluids and correct lab abnormalities and weak pressors as tolerated
- End points of resuscitation should include normalization of base deficit, lactate, CVP and of PAOP 8-15 and minimal use of pressors (i.e: dopamine drip at < 5 mcg/kg/min)
- Goal: SBP 60-110mm Hg (age dependent), UOP > 1-2 ml/kg/hour, PaO2 > 100, PCO2 < 35
- Maintain fluids; either NS or LR, adjust as indicated

Patient MAP > 50-79

No

- Continue to fluid resuscitate with 25% albumin 4 ml/kg or NS 20 ml/kg if patient still hypovolemic. Continue this protocol until MAP > 50-74 depending on patient’s age: age < 1 month: >50; 1 month to 2 years: >72; 2 years and older: >74
- Double dopamine drip q 5 min to maintain MAP of 50-74 (depends on age). Once dopamine is at 20 mcg/kg/min, if MAP is less than above parameters start epinephrine drip at 0.1 mcg/kg/min
- Double epinephrine drip q 5 min and bolus over 20 min with 20 ml/kg NS or 4 ml/kg of 25% albumin as needed

Yes

CVP > 8-10

- Maintenance fluids
- Add hormone replacement therapy (see next page)
- Wean pressors accordingly if MAP reaches target

No

- Continue to bolus with NS, albumin, or blood products as needed
- Clinical symptoms and lab values suggestive of Diabetes Insipidus: UOP > 3-4 ml/kg/hr, serum sodium > 150, urine specific gravity < 1.005, urine osmolality < serum osmolality. If serum sodium > 145, change from NS to LR

Each patient is an individual and the response may vary. This is a clinical guideline only.

- Start vasopressin at 0.5 millunits/kg/hr. Titrate to effect.
  Half life: 10-20 min. Replace UOP > 2-3 ml/kg/hr with ½ NS every hour

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ABBREVIATIONS
ABG – arterial blood gases
CBC – complete blood count
CVP – central venous pressure
DI - diabetes insipidus
DIC – disseminated intravascular coagulation
FFP – fresh frozen plasma
HB - hemoglobin
Hct – hematocrit
H & H – hematocrit & hemoglobin
LFT – liver function test
LR – lactated ringsers
LVEDP – left ventricle end diastolic pressure
LVHF – left ventricle hypertrophy
LVF – left ventricle ejection fraction
MAP – mean arterial pressure
NS – normal saline
PA – pulmonary artery
PAOP – pulmonary arterial occlusion pressure
PCWP – pulmonary capillary wedge pressure
SBP – systolic blood pressure
SVR – systemic vascular resistance
UOP – urine output
Hormone Replacement Protocol (to be initiated only after primary attending approval)

Goal: To maintain hemodynamic stability in patients with devastating brain injuries

Pretreatment:
1. Hydrate donor to a minimum CVP of 8-10
2. Give blood to achieve a H & H above 10 and 30
3. Correct electrolyte imbalances

Prerequisite:
Donor is requiring a combined vasopressor of greater than 15 mcg/kg/min (all vasopressor doses added) to maintain systolic pressure of 60-110 after the pre-treatment is completed.

Hormone Replacement Protocol:
1. Administer IV boluses of the following in rapid succession:
   - 25% Dextrose:
     - < 6 months: 0.5 gm/kg/dose (2 ml/kg/dose)
     - > 6 months: 1 gm/kg/dose (4 ml/kg/dose)
   - 50% Dextrose:
     - Adolescents: 25-50 ml
   - Hydrocortisone: 2 mg/kg (max 100 mg) and additional doses of 1 mg/kg (max 100 mg) IV every hour may be administered if needed

   OR:
   - Infusion: administered for 12 hours
     - < 25 kg: 1 mg/kg/hr
     - 25-35 kg: 50 mg/hr
     - 35-45 kg: 75 mg/hr
     - > 45 kg: 100 mg/hr
   - Regular Insulin: 0.01 units/kg/hr, titrate to maintain glucose between 80-150 mg/dl

2. Start a drip of 200 mcg Levothyroxine (T-4) in 500 ml of NS (0.4 mcg/ml). Administer at ½ the recommended mcg/kg/hr infusion dose initially. Reduce levels of other vasopressors as much as possible and then adjust T-4 as necessary to maintain desired pressure.

Thyroxin (T4):

<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>
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</tbody>
</table>

3. Maintain CVP at desired level by replacing urine output

** After 30-60 min of initiation, the donor will usually become tachycardic with an increase in temperature and blood pressure.

Common Problems and Special Considerations

- *DIC*: If a patient has clinical signs of DIC, transfuse immediately with 10 ml/kg of FFP. Delaying transfusion while waiting for lab results with uncontrolled hemorrhage is not indicated. Maintain Hct > 30 with PRBC.
- *DI*: If patient is normotensive, serum sodium > 148 and UOP > 3-4 ml/kg/hr, start DDAVP continuous infusion 0.5 mcg/hr (half-life of 75 to 90 min) and replace UOP ml for ml with ½ NS q hour for UOP > 3-4 ml/kg. If patient’s serum sodium > 150, UOP > 2-3 ml/kg, replace ml for ml with ½ NS every hour. If patient is hypotensive, then use the above protocol. Common error: Assuming high UOP is from DI, but is really from ED furosemide and/or mannitol. Replace diuretic fluid loss with NS or LR. (Another marker of DI: urine specific gravity <1.005).
- *Tachycardia and hypotension*: This commonly occurs prior to complete herniation and should not be treated.
- *Neurogenic pulmonary edema*: This may occur and decreases the PO2; increase ventilator support as needed. With severe problems of oxygenation, use the oscillating ventilator.
- *Hyperglycemia or hypokalemia*: Use sliding scales as needed
- *Cardiac arrest*: Follow PALS code guidelines
- *Potential lung donors*: Hemodynamically stable patients (pressor requirement less than 5 mcg/kg/min). Management considerations: Head of bed elevated 30 degrees; early use of thyroid replacement therapy if hypotension occurs; minimize IV fluids if patient remains hemodynamically stable; mannitol 0.5 gm/kg IV bius for diuresis (only if patient hemodynamically stable)
- *DO NOT* risk a cardiac arrest secondary to under-resuscitation in an attempt to maximize the condition of the lungs.

If a patient’s neurologic exam has deteriorated and brain death is suspected, based on the loss of brainstem reflexes, please refer to the Declaration of Brain Death Guidelines and Form and contact the attending physician immediately.

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