MANAGEMENT OF PATIENTS WITH CATASTROPHIC, NON-SURVIVABLE HEAD INJURY

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☐ Minor Changes ***(or)***		☐ Changes are substantial and require a thorough reading of this CPG ***(or)***	
☐ Significant Changes			

1. **Goal.** Provide useful guidelines for the management of casualties with catastrophic, non-survivable head injury at Level II and Level III facilities.

2. **Background.**

   a. Catastrophic head injury, for the purpose of this guideline, is defined as any head injury that is expected after imaging evaluation and /or clinical exam to result in the permanent loss of all brain function above the brain stem level. **NOTE: For patients with potentially survivable but severe Traumatic Brain Injury, refer to CENTCOM JTTS CPG, *Management of Patients with Severe Head Trauma*).**

      i. The intent of this guideline is to provide clinically useful recommendations that will allow providers at all echelons who encounter these injuries to optimize the opportunity for these patients to be transported safely and appropriately to the next echelon of care.

      ii. It is not the purpose of this guideline to address the complexities of brain death determination, or at what echelon of care and by what types of providers this determination should be made.

      iii. If appropriately resuscitated and hemodynamically normalized, these patients are more likely to be re-united with their families at Level IV and/or Level V facilities. Additionally, their suitability for possible organ donation (should patient's previous wishes and those of the family permit) may be preserved.

   b. Catastrophic head injury is associated with profound physiologic alterations that result in diffuse vascular regulatory disturbances and widespread cellular injury.[1, 2] Severe alterations in metabolism[3,4,5] , endocrine function,[6-9] immunology[10] and coagulopathy[11-17] also commonly manifest. These disturbances frequently lead to multiorgan system failure, cardiovascular collapse and asystole in up to 60% of patients if not appropriately managed.[3]

   c. It is known from animal studies that this cardiovascular deterioration is associated with impaired oxygen utilization, a shift from aerobic to anaerobic metabolism, a depletion of glycogen and myocardial high-energy stores, and the accumulation of lactate.[3,5,9] This irregular metabolism has been associated with low levels of triiodothyronine (T_3), thyroxin (T_4), and to a lesser extent cortisol and insulin.[6-9] Therapeutic replacement with T_3 has been associated with complete reversal of anaerobic metabolism and subsequent stabilization of cardiac function when applied to human brain dead subjects.[6,7] In

addition, the use of T_3 has been associated with significant improvements in cardiovascular status, reductions in inotropic support, and decreases in donors lost from cardiac instability.[5, 18-20] The etiology of this functional "hypothyroid state" is poorly understood, but may be a result of lower than normal thyroid stimulating hormone levels caused by the irreversible damage to the hypothalamus and pituitary from ischemia. Another explanation is a decrease in the peripheral conversion of T_4 to its more potent analogue T_3, similar to the euthyroid sick syndrome.

d. The complex hemodynamic, endocrine and metabolic dysfunction associated with catastrophic brain injury is frequently associated with major complications. If inappropriately treated, these complications can progress to cardiovascular collapse with rapid death and loss of valuable organs for potential transplantation. In a recent examination of 69 brain dead organ donors from Los Angeles County Medical Center, high rates of vasopressor requirement (97.1%), coagulopathy (55.1%), thrombocytopenia (53.6%), diabetes insipidus (46.4%), cardiac ischemia (30.4%), lactic acidosis (24.6%), renal failure (20.3%) and acute respiratory distress syndrome (13.0%) were identified. Interestingly, with the implementation of an aggressive organ donation management protocol, including hormonal supplementation, these complications did not adversely affect the average number of organs retrieved from this donor pool.

3. Treatment.

a. The clinical management of catastrophic brain injury consists of three aspects: (1) early identification of the degree of injury and identification of potential donors, (2) intensive care unit admission and management by a dedicated team, and (3) early and aggressive resuscitation with fluids, vasopressors and endocrine / hormone therapy.

b. Vasopressors such as epinephrine and dopamine should be utilized if the mean arterial pressure (MAP) remains less than 70 mmHg despite adequate fluid resuscitation. In casualties with catastrophic head injury who require a combined vasopressor need of greater than 10 mcg/kg/min (either epinephrine or dopamine alone, or in combination) strong consideration should be given for addressing the endocrine abnormalities associated with these injuries that can contribute to ongoing hemodynamic instability. These adjuncts (the components of the LA County "T_4 protocol") are:

   i. 1 ampule 50% dextrose

   ii. 2 g solumedrol

   iii. 20 units regular insulin, and

   iv. 20 micrograms of thyroid hormone (T_4), if available

   This is given as an initial bolus followed by followed by a continuous infusion of 10 mcg/hr of T_4, if it is available.

c. An appropriately aggressive approach should also stress early identification and management of catastrophic brain injury-related complications such as (see addendum for management points on each):

   i. disseminated intravascular coagulation (DIC)

   ii. diabetes insipidus (DI)

iii. neurogenic pulmonary edema (NPE)

iv. hypothermia

v. cardiac arrhythmias

4. **Transfusions Considerations.** The use of blood products and associated resources for these patients is a complex issue. If the patient responds hemodynamically to the previous interventions and appears that he will survive his initial insult, a reasonably aggressive approach should be taken to correct coagulopathy rapidly and transfuse PRBCs to a level sufficient to optimize oxygen delivery to tissue and organs.

5. **Determining futility and the Appropriateness of Transport.**

   a. If the patient does not respond rapidly to the above interventions, heroic efforts are not likely to salvage the patient from hemodynamic collapse or salvage organs for potential donation. If the patient cannot be stabilized hemodynamically after rapid resuscitation with these adjuncts, no further efforts should be pursued and withdrawal of ventilatory support with dignity is the most respectful and appropriate course of action. The tactical situation will also heavily dictate the resources that should be dedicated to these pursuits, with patients of this presentation placed in the expectant category during any mass casualty situation or if the needs of other patients likely to survive with reasonable brain function are more pressing.

   b. If these patients achieve successful stability, then discussion with AE regarding transport should be undertaken so that they can potentially be re-united with family members at a higher echelon of care and be formally evaluated for organ donor possibilities by a dedicated team at a level IV or V facility. The movement of these patients does not in and of itself validate the need for the call of an urgent AE mission, but all efforts to move such patients to the next level of care expeditiously should otherwise be taken as appropriate.

   c. Providers presented with these patients are encouraged to engage in early communication with colleagues and counterparts across the echelon spectrum of movement and the AE system regarding their status and planned disposition. These situations are fortunately not common, but constitute the most challenging of clinical and ethical management dilemmas that one can face during care in the AOR.

6. **Author**. Maj. Joe DuBose is the primary author of this CPG.

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Opinions, interpretations, conclusions, and recommendations are those of the authors and are not necessarily endorsed by the Services or DoD.

APPENDIX A

Catastrophic Brain Injury / Brain Death Fluid Management Protocol

Adapted from LAC & USC Medical Centers

Initially follow ATLS guidelines and:

Avoid hypotension and hypoxia in all head-injured patients.

Patient evaluated in ER

ASAP

1. Labs obtained: ABG/serum lactate/CBC/PT/PTT/lytes head-injured patients
2. Transfuse to maintain Hct > 30
3. Bolus 1 liter NS or 500 ml 3% saline
4. Control active bleeding
5. Place large trauma central line
6. Transfer ASAP to STICU following CT scan

Normotensive Patient

YES

See lung donors Appendix B, para 8

Continue to fluid resuscitate as needed, and correct lab abnormalities (end points of resuscitation should include normalization of base deficit/lactate, CVP and/or PCW 8-15, and minimal use of pressors dopamine<5.)

Rules of 100's: SBP>100mm Hg, UOP > 100, PaO_2 > 100.

NO

Caution: Patients may go from hypertension to hypotension rapidly.

1. Continue to fluid resuscitate with NS
2. Start Thyroxine protocol (see below)
3. Double the dose of dopamine q5 minutes to maintain blood pressure
4. Once dopamine is at 20 □g/kg/min, if MAP < 70, start epinephrine drip.
5. Double epinephrine drip q5 minutes and bolus over 20 minutes, 1 liter NS with 100cc of 25% albumin.
6. Are CVP and/or PCW (wedge) > 17?
   NO: Continue to bolus with above NS.
   YES: Does the patient have:
   - clinical symptoms and laboratory values suggestive of DI (diabetes insipidus)?
   - UOP > 600 cc/hour or urine specific gravity < 1.005?

   NO: Consider starting norepinephrine if CI > 4
   YES: Start vasopressin at 1-8 units/hour, and replace UOP over 200cc with 1/2 NS cc for cc every hour or, if patient is hypertensive, DDAVP 2 mcg IV Q2-6 hours for UOP <200ml hr.
   - Norepinephrine and vasopressin should not be used if SVR > 1100)

All patients require q4 hour ABG's, serum lytes, serum lactate, and cardiac output if available (even after declaration of brain death.)

APPENDIX B

Management Protocols for Specific Adverse Sequelae of Catastrophic Brain Injury and Brain Death

1. **DIC**
   - Begin correcting any coagulation lab abnormalities (thrombocytopenia, increased INR) early, before clinical DIC.
2. **DI**
   - If patient is normotensive, serum sodium > 150 and UOP > 600cc/hr, give 1-2 micrograms of DDAVP IVP (q 2-8 hours as needed) and replace UOP cc for cc with 1/2 NS q hour for UOP > 200 (example: for UOP of 1000cc replace with 800cc of 1/2 NS). If patient's serum sodium > 150 and UOP > 300cc/hr, replace UOP cc for cc with 1/2 NS q hour for UOP > 200cc. If patient is hypotensive, then use above protocol. Common error: Assuming high UOP is from DI, but is really from Emergency Department or operative suite diuretics and/or Mannitol. Replace diuretic fluid loss with NS or LR. (Another marker of DI: urine specific gravity < 1.005).
3. **Tachycardia and Hypertension**
   - This commonly occurs prior to complete herniation and should not be treated. Abrupt fluctations in blood pressure during the period before and immediately after herniation are common. Aggressive treatment of hypertension will only further exacerbate the hypotension that may follow during the natural physiologic course of the herniation process.
4. **Neurogenic Pulmonary Edema**
   - This may occur and decreases the PO2; increase ventilator support as needed. With severe problems of oxygenation, use the percussinator ventilator.
5. **Hypokalemia and/or Hyperglycemia**
   - Use sliding scales as needed.
6. **T_4 Protocol**
   - Many patients have a T-3/T-4 abnormality and require additional thyroxin. Start patients on thyroxin protocol (T-4 Donor Protocol- SEE ATTACHED) once the injury has been deemed catastrophic and beyond the scope of surgical or medical intervention to restore meaningful brain function. Be aware that potassium will likely need to be aggressively replaced once thyroxin is started.
7. **Cardiac Arrest:**
   - Follow ACLS code guidelines
8. **Potential Lung Donors**
   - Criteria
     - Those hemodynamically stable patients (vasopressor requirement less than 5 mcg/kg/min) with relatively clear chest radiograph without bronchoscopic evidence

of pneumonia (documented pus in the airway) should be considered for additional management as potential lung donors.

- Management Considerations
  - Keep HOB elevated 30°
  - Early use of throxime protocol.
  - Minimize IV fluids if the patient remains hemodynamically stable.
  - Mannitol 0.5 gm/kg IV bolus for diuresis (only if the patient is hemodynamically stable).

DO NOT risk a cardiac arrest secondary to under-resuscitation in an attempt to maximize the condition of the lungs.

APPENDIX C

Donor Protocol

Adapted from LAC / USC T-4 Donor Protocol

1. **Pretreatment**
   - Hydrate donor to a minimum CVP of 7
   - Give blood to achieve an H&H above 10 and 30
   - Correct electrolyte imbalances
2. Prerequisite
   - Donor is requiring a combined vasopressor need greater than 15 mcg (all VP added) to maintain a systolic pressure of 100 after the pre-treatment is completed or becomes hemodynamically unstable. However, the T_4 protocol may be used in all brain dead patients irrespective of hemodynamic condition.
3. T-4 Protocol
   - Administer IV boluses of the following in rapid succession:
   - 1 Amp of 50% Dextrose
     - 2 Gms of Solumedrol
     - 20 units regular insulin
     - 20 mcg Thyroxin (T-4)
   - Start a drip of 200 mcg T-4 in 500cc Normal Saline (.4mcg/cc). Administer at 25cc (10mcg) per hour initially. Reduce levels of other vasopressors as much as possible and then adjust T-4 as necessary to maintain desired pressure.
     - Donors > 100 lbs give above dose
     - Donors 50-75 lbs give 13cc = 5-2 mcg/hr
     - Donors 75-100 lbs give 19cc = 7-6 mcg/hr
   - After 30 to 60 minutes, the donor will usually become tachycardiac with an increase in temperature and blood pressure.
     - Monitor K+ levels carefully. The only perceived complication of T-4 identified to this point is an unusually high K+ requirement in some cases.
     - Maintain CVP at desired level by replacing urine output

APPENDIX D

ADDITIONAL INFORMATION REGARDING OFF-LABEL USES IN CPGs

A. Purpose.

The purpose of this Appendix is to ensure an understanding of DoD policy and practice regarding inclusion in CPGs of "off-label" uses of U.S. Food and Drug Administration (FDA)–approved products. This applies to off-label uses with patients who are armed forces members.

B. Background.

Unapproved (i.e., "off-label") uses of FDA-approved products are extremely common in American medicine and are usually not subject to any special regulations. However, under Federal law, in some circumstances, unapproved uses of approved drugs are subject to FDA regulations governing "investigational new drugs." These circumstances include such uses as part of clinical trials, and in the military context, command required, unapproved uses. Some command requested unapproved uses may also be subject to special regulations.

C. Additional Information Regarding Off-Label Uses in CPGs.

The inclusion in CPGs of off-label uses is not a clinical trial, nor is it a command request or requirement. Further, it does not imply that the Military Health System requires that use by DoD health care practitioners or considers it to be the "standard of care." Rather, the inclusion in CPGs of off-label uses is to inform the clinical judgment of the responsible health care practitioner by providing information regarding potential risks and benefits of treatment alternatives. The decision is for the clinical judgment of the responsible health care practitioner within the practitioner-patient relationship.

D. Additional Procedures.

1. Balanced Discussion. Consistent with this purpose, CPG discussions of off-label uses specifically state that they are uses not approved by the FDA. Further, such discussions are balanced in the presentation of appropriate clinical study data, including any such data that suggest caution in the use of the product and specifically including any FDA-issued warnings.

2. Quality Assurance Monitoring. With respect to such off-label uses, DoD procedure is to maintain a regular system of quality assurance monitoring of outcomes and known potential adverse events. For this reason, the importance of accurate clinical records is underscored.

3. Information to Patients. Good clinical practice includes the provision of appropriate information to patients. Each CPG discussing an unusual off-label use will address the issue of information to patients. When practicable, consideration will be given to including in an appendix an appropriate information sheet for distribution to patients, whether before or after use of the product. Information to patients should address in plain language: a) that the use is not approved by the FDA; b) the reasons why a DoD health care practitioner would decide to use the product for this purpose; and c) the potential risks associated with such use.