JOINT TRAUMA SYSTEM CLINICAL PRACTICE GUIDELINE (JTS CPG)

Anesthesia for Trauma Patients (CPG ID: 40)

Guidelines incorporate the induction and maintenance of anesthesia into an ongoing resuscitation during surgery for a trauma patient in extremis.

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SUMMARY OF CHANGES

1. Use Whole Blood (WB) if available. FDA-approved cold stored WB is preferred over fresh WB (non-FDA approved).
2. Initiate infusion of 1 gm Tranexamic Acid (TXA) over 8 hours if TXA 1 gm administered pre-operatively
3. Carefully follow calcium concentration during massive transfusion. Consider giving empiric calcium chloride if hypotensive
4. Stronger evidence exists for use of vasopressin in hemorrhagic shock. Consider vasopressin bolus of 2-4 units followed by a vasopressin infusion (0.04 U/min) in cases of refractory shock.

BACKGROUND

Resuscitation goals for trauma patients have undergone significant change in the past decade. Appropriate blood product transfusion ratios, use of pharmacologic adjuncts (e.g., TXA) and other modalities have improved survival for the wounded combatant. In the operating room (OR), resuscitation occurs in the context of providing an anesthetic which minimizes hemodynamic instability in the severely injured patient. It is imperative, therefore, that the management of this resuscitation occurs simultaneously with surgery and anesthesia. While recent review articles, checklists and textbooks have drawn attention to the role of anesthetic resuscitation concurrent with surgical correction of injury, there is no guideline for the induction, maintenance and transfer of anesthetic care of the military trauma patient in extremis.[1-4]

SPECIFIC CONSIDERATIONS FOR TRAUMA ANESTHESIA

PRE-INDUCTION

- Hypothermia is one of the arms of the lethal triad of coagulopathy, acidosis and hypothermia.[5] As such, it is important to warm the OR to greater than 30C and have a warmed intravenous (IV) line, forced air warmer, and rapid infuser with warming capability immediately available. Standard checks (e.g., anesthesia machine check, airway equipment is in proper working order) assure that vital equipment is ready for immediate use.
- Establishment of a massive transfusion protocol and effective communication with the blood bank is essential and can improve survival.[6] The *Damage Control Resuscitation CPG*[7] defines the massive transfusion protocol for the combat theater. At all roles of care, awareness of the individual military medical facilities (MTFs) on-hand resources (including walking blood bank) and applicable protocols are key considerations.
- The presence of anesthesia in the trauma bay is necessary for smooth transition of care to the OR and offers the opportunity to assist with invasive procedures. Identification of team roles prior to patient arrival facilitates effective transfer from the delivering team.

INDUCTION OF ANESTHESIA

1. Induction of anesthesia in the exsanguinating patient can be challenging. **Ongoing volume resuscitation** to prevent occurrence of cardiac arrest in the peri-anesthetic period is critical.

2. After a patient is identified for surgery, **verification of functioning vascular access** (either intravenous or intraosseous) and placement of monitoring devices (e.g., oxygen saturation, blood pressure, and electrocardiogram) must occur quickly.

3. **Do not delay induction of the patient in extremis in order to place the central venous access or invasive monitoring.** Placing monitors at the same time as the surgical prep and drape can save time in a crisis. A wide draping procedure with “arms out” ensures adequate surgical exposure, while affording access to the arms as needed after the start of surgery. Pre-oxygenation with four full vital capacity breaths can “de-nitrogenate” the end alveoli sufficiently to optimize oxygenation prior to rapid sequence induction. In the obtunded patient, it may not be possible to achieve four vital capacity breaths prior to induction, and one must proceed with induction relying upon apneic oxygenation.

4. There are a variety of **sedative hypnotics** available for induction of anesthesia. Standard induction dosages should be reduced and titrated to balance the induction of anesthesia with hemodynamic changes. Ketamine (1 mg/kg) will not decrease the systemic vascular resistance to the same extent as other sedative hypnotics. While Propofol is a standard induction agent, it can decrease the systemic vascular resistance

significantly. It is prudent to use reduced doses of Propofol (0.5-1 mg/kg) in hypotensive patients. Ongoing volume resuscitation is vital to prevent vascular collapse.

5. **Neuromuscular relaxation** sufficient to facilitate endotracheal intubation can be achieved in approximately 45 seconds with succinylcholine in a standard rapid sequence induction dose (1mg/kg). Rocuronium is a non-depolarizing neuromuscular relaxant useful in cases where succinylcholine may be contraindicated (e.g., burns, spinal cord injury, hyperkalemia). An increased dose of Rocuronium (1-1.2 mg/kg) can produce intubating conditions similar to succinylcholine in approximately 60 seconds.

6. **Prompt endotracheal intubation of the trachea following induction** mitigates the risk of aspiration. Rapid sequence induction (RSI) with direct laryngoscopy is a safe and effective method to secure the airway of the trauma patient.[8, 9] The efficacy of in-line stabilization during RSI is somewhat controversial; however, it remains prudent to minimize the manipulation of the cervical spine to the extent possible during laryngoscopy. Regardless, it is re-assuring to know that spinal cord injury following direct laryngoscopy rarely causes or worsens cervical spine injury.[10]

7. A variety of **airway adjuncts** are available to the laryngoscopist. The gum elastic bougie can be helpful in securing a challenging airway and is a low-cost, effective airway adjunct.[11] Video laryngoscopy can provide an improved view of the vocal cords during intubation. This does not necessarily improve successful first pass intubation or result in faster time to intubation.[12] It remains prudent to have a limited number of immediately available airway adjuncts with which one is familiar, rather than a larger selection of less familiar equipment.[13] An alternate plan, including equipment for surgical airway management, must also be immediately available. (See *Airway Management of Traumatic Injuries CPG*[14])

8. After intubation of the trachea and verification of end tidal carbon dioxide, communication with the surgeon ensures that the operation proceeds in a timely fashion. **Placement of an orogastric tube** at this point may potentially decrease the risk of aspiration.

MAINTENANCE OF ANESTHESIA

- **Maintenance of anesthesia can be accomplished via an inhalational volatile agent or via a total intravenous anesthetic (TIVA).**[15] Both approaches must be carefully titrated to the hemodynamic profile while assuring adequate sedation/hypnosis and analgesia. Awareness during anesthesia and the acute pain response can be mitigated during TIVA by assuring that both a sedative hypnotic (e.g., Propofol, benzodiazepine) and an analgesic (e.g.; narcotic) are being administered. Narcotic dose can be titrated to hemodynamics.
- **Adequate IV access** must be assured immediately (e.g., large bore peripheral IV, intraosseous, rapid infusion catheter (RIC), Cordis central line). Placement of additional IV access or an arterial line (if indicated for continuous monitoring of beat-to-beat blood pressure) can be undertaken without delaying the start of the operation.
- Sending **a baseline set of labs**, to include coagulation studies and base excess, at the start of the case can set a reference point for the remainder of the resuscitation. Consider validation of Point of Care (POC) testing (e.g., iSTAT values) with traditional laboratory assays. Ensure all laboratory equipment and POC equipment are maintained within the manufacturer's biomedical engineering standards.
- The maintenance of anesthesia and the resuscitation can be guided by following the trend in **mean arterial pressure (MAP).** While the ideal blood pressure is controversial, a MAP < 55 mmHg has been associated with acute kidney injury and myocardial injury during anesthetics for non-cardiac surgery.[16] Maintaining a MAP > 60 mmHg will facilitate end organ perfusion without exacerbating any unsecured bleeding.

- **Traumatic brain injury (TBI)** represents a unique situation in which isolated episodes of hypotension can worsen mortality.[17] It is, therefore, advisable to maintain systolic blood pressure > 110 mmHg in patients with documented or suspected TBI. (See *Neurosurgery and Severe Head Injury CPG*[18])

RESUSCITATION

NOTE: *See Damage Control Resuscitation CPG*[7]

- **Ratios of fresh frozen plasma (FFP): packed red blood cells (PRBC)** approaching 1:1 have been demonstrated to confer a survival benefit in military and civilian trauma patients.[19, 20] While the ideal ratio of FFP: PRBC remains somewhat controversial, it is fair to say early administration of plasma and platelets is appropriate for the trauma patient in extremis.[21] When available, use cold stored whole blood. Fresh whole blood may also be safely used. A more exhaustive discussion of damage control resuscitation is found elsewhere in the CPGs and is recommended reading for this subject. Communication with the surgical team regarding the progress of the resuscitation and the stage of the surgery is an important factor in overall success.

- **TXA** is a potent synthetic lysine derivative that functions as an anti-fibrinolytic. Administration of 1 gm of TXA over 10 minutes within 3 hours of injury has been demonstrated to improve survival in a highly powered, randomized trial of international trauma patients.[22] A survival advantage was also demonstrated with the use of TXA in military trauma.[23] A recent analysis of prehospital dosing strategies for TXA in moderate to severe TBI found a significantly improved neurologic function at 6 months with a 2 gm bolus given prehospital compared to a 1 gm bolus + 1 gm infusion or placebo for the subset of patients with confirmed intracerebral hemorrhage, and no difference in survival or complications for either dose or placebo for all patients treated based on prehospital Glasgow Coma Scale (GCS) 3-12.[24] In other work, when prehospital TXA was administered within 1 hour of injury to patients in severe shock there was a 30 day mortality benefit.[25] More detailed analysis of timing and dosing regimens is on-going, but in the meantime it is safe to administer an initial 2 gm bolus of TXA. For those patients who receive a bolus of 1 gm, an infusion of 1 gm over 8 hours must be initiated afterwards.

- **Hydrocortisone** is a potent mineralocorticoid which can augment blood pressure during shock states when the hypothalamic–pituitary–adrenal (HPA) axis is suppressed and unable to mount an effective stress response. Administration of hydrocortisone 100 mg can improve vasopressor responsiveness in critically ill trauma patients.[26,27]

- **Hypocalcemia** must be avoided in massive blood transfusion. Hypocalcemia is often due to chelation of calcium by the citrate preservative in stored blood. Trauma patients can be hypocalcemic even prior to blood product administration.[28] Severe hypocalcemia (iCa <0.9), has been associated with higher lactate, lower pH and worsened mortality.[29 30] Administration of 1 gm calcium chloride can correct this potentially life-threatening hypocalcemia, and the hypotension associated with it. Consider following ionized calcium levels with POC chemistry analysis. If this in unavailable, then consider empiric administration of 1gm calcium chloride after each 4th unit of blood.[31]

- **Use of vasopressors** in trauma is generally associated with higher mortality.[32] In one analysis evaluating trauma patients who received vasopressor support, vasopressin was found to be the only vasopressor in which the 95% confidence interval for mortality crossed unity, suggesting non-significance.[33] Vasopressin was further evaluated by in a randomized controlled trial in which trauma patients received a vasopressin bolus followed by an infusion. The vasopressin group required fewer blood products, had similar mortality and complication rates.[34] In cases of refractory hypotension, a vasopressin bolus (2-4 units) followed by infusion (0.04 U/min) can be given in concert with aggressive blood product administration.

- **Timely administration of antibiotics** can decrease the incidence of post-operative infections and is part of the anesthetic resuscitation. Consider agents that will be effective against skin flora (Gram positive

organisms) or, in the event of bowel injury, gastrointestinal flora (anaerobes and Gram negative organisms). The *Infection Prevention in Combat-Related Injuries CPG* identifies the optimal antibiotics for multiple clinical scenarios.

POST-OPERATIVE/EMERGENCE

- **Low lung volume ventilation** (6mL/kg) can decrease mortality in critically ill patients with the acute respiratory distress syndrome.[35] Even in patients who have not developed the acute respiratory distress syndrome; initiation of low lung volume ventilation can improve outcome. Consider initiation of low lung volume ventilation in the OR.
- **Communication with the next role of care** is vital to maintaining continuity of care. In the deployed setting this may entail a face-to-face conversation with the intensive care unit team, or a report transmitted to a critical care air transport team. (See *Interfacility Transport of Patients between Theater Medical Treatment Facilities CPG)* A detailed written report/anesthetic record documents the operative resuscitation and facilitates transition to the next role of care. Being immediately available in the post-operative period to answer any questions can clarify any issues that may arise.

PERFORMANCE IMPROVEMENT (PI) MONITORING

POPULATION OF INTEREST

1. All trauma patients who undergo surgery within 24 hours of arrival to first surgical role of care (includes all surgeries performed).
2. Patients who receive endotracheal tube/cricothyroidomy/tracheostomy before the initial surgery AND undergo surgical procedure at Role 2 or Role 3.

INTENT (EXPECTED OUTCOMES)

1. Anesthesia care is documented on an anesthetic record and uploaded to Theater Medical Data Story (TMDS).
2. Trauma patients in the OR maintain a body temperature > 36˚C during surgery.
3. Anesthesia following major trauma will be induced and maintained with less than 20% drop in initial blood pressure.
4. Patients undergoing massive transfusion will receive blood products in 1:1:1:1 ratio (plasma:platelets:RBC: cryoprecipitate).
5. Calcium chloride or calcium gluconate is administered to patients who have received: one unit and after every 4 units of red blood product transfused.
6. Antibiotics are administered to all patients prior to initiation of surgery incision.

PERFORMANCE/ADHERENCE METRICS

1. Number and percentage of patients in the population of interest who have anesthesia record received.
2. Number and percentage of trauma patients who maintained a body temperature > 36˚C during surgery (as recorded on anesthesia record).

3. Number and percentage of patients who do not drop systolic blood pressure more than 20 mmHg during the first 15 min after induction of anesthesia.

4. Number and percentage of patients undergoing massive transfusion (>10 u RBC + whole blood with 24 hours after injury) who received blood products in an FFP:RBC ratio between 0.5:1 to 1:1.5 while in the OR (as recorded on anesthesia record).

5. Number and percentage of patients undergoing massive transfusion (>10 u RBC + whole blood with 24 hours after injury) who receive platelet or whole blood transfusion while in the OR (as recorded on anesthesia record).

6. Number and percentage of patients who received more than 1 units of blood products transfused who also received calcium chloride or calcium gluconate (as recorded on anesthesia record).

7. Number and percentage of patients who received antibiotic before surgery or documented no antibiotic indicated.

DATA SOURCE

- Patient Record
- Department of Defense Trauma

SYSTEM REPORTING & FREQUENCY

The above constitutes the minimum criteria for PI monitoring of this CPG. System reporting frequency will be performed annually; additional PI monitoring and system reporting may be performed as needed.

The system review and data analysis will be performed by the JTS Chief and the JTS PI Branch.

RESPONSIBILITIES

It is the Chief of Trauma or equivalent's responsibility to ensure familiarity, appropriate compliance and PI monitoring at the local level with this CPG.

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APPENDIX A: TRAUMA ANESTHESIA CHECKLIST

BEFORE PATIENT ARRIVAL

- ☐ Room temperature > 30˚C
- ☐ Warm IV line
- ☐ Machine check
- ☐ Airway equipment check
- ☐ Emergency medication check
- ☐ Blood Bank notified to have blood available per unit SOP

PATIENT ARRIVAL

- ☐ Patient identified for surgery as soon as possible
- ☐ Blood Bank notified to deliver blood per unit SOP
- ☐ Ensure large bore IV or CVC access
- ☐ Monitors (SaO2, BP, ECG)
- ☐ Pre-oxygenation

INDUCTION

- ☐ Sedative hypnotic (Ketamine vs. Propofol)
- ☐ Neuromuscular blockade (Rocuronium vs. succinylcholine)

INTUBATION

(Per Airway Management CPG)

- ☐ (+) ETCO2
- ☐ Place orogastric tube

ANESTHETIC

- ☐ Consider TIVA
- ☐ (Volatile anesthetic and/or benzodiazepine) + narcotic
- ☐ Insert additional IV access and/or arterial line if needed

RESUSCITATION

(per Damage Control Resuscitation CPG)

- ☐ Send baseline labs, type and cross if not yet done
- ☐ Follow MAP trends
- ☐ Goal FFP: PRBC: Plt 1:1:1 if Massive Transfusion. Use Cold Stored Whole Blood (if available)
- ☐ Activate walking blood bank to obtain Fresh Whole Blood (if needed)
- ☐ Goal urine output 0.5-1.0 mL/kg/hr
- ☐ Consider TXA if <3 hours from injury and at risk for hemorrhagic shock
- ☐ Consider calcium chloride 1 gm
- ☐ Consider hydrocortisone 100 mg
- ☐ Consider vasopressin 2-4 IU + 0.04 IU/min
- ☐ Administer appropriate antibiotics
- ☐ Special considerations for TBI as indicated in *Severe Head Injury CPG*

CLOSING/POST-OPERATIVE

- ☐ Low volume ventilation per *Acute Respiratory Failure CPG*

APPENDIX B: ADDITIONAL INFORMATION REGARDING OFF-LABEL USES IN CPGS

PURPOSE

The purpose of this Appendix is to ensure an understanding of Department of Defense (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.

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.

ADDITIONAL INFORMATION REGARDING OFF-LABEL USES IN CPGS

The inclusion of off-label uses in CPGs 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 of off-label uses in CPGs 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.

ADDITIONAL PROCEDURES

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.

Quality Assurance Monitoring

With respect to such off-label uses, the 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.

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.