

CME **A Checklist for Trauma and Emergency Anesthesia**

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Death from traumatic injury is the leading cause of death in children and adults younger than 45 years of age. For adults older than 45 years of age, trauma is the third leading cause of death, the primary causes being cardiovascular events and malignancies. Despite this huge burden, the Anesthesiology Residency Review Committee of the Accreditation Council for Graduate Medical Education has as a requirement that residents in anesthesiology programs only manage 20 trauma cases during their residency. The requirement does not define what constitutes “trauma” and does not specify the educational objective for their experience providing care to patients who have sustained trauma.

Once they finish training, anesthesiologists will be involved in the management of patients who have sustained traumatic injuries. If they work in a rural area, they may not be challenged with the kind of penetrating injuries common in an urban level I trauma center. However, trauma is ubiquitous, and rural medical centers see severe trauma from motor vehicle crashes, from farming or manufacturing mishaps, and from natural accidents. Because residency may impart limited training in management of trauma, we propose that anesthesiologists use a standardized “trauma and emergency checklist” to facilitate the care they provide these patients and (hopefully) improve outcomes.

Checklists have been shown to decrease patient morbidity and mortality by assuring that the health care provider does not overlook some important aspect of care. Checklists are used when preparing an anesthetic workstation at the beginning of the day. The algorithms promulgated by the Advanced Trauma Life Support and Advanced Cardiac Life Support courses are checklists. Even trauma surgeons in the military, who have a great deal of experience in managing

patients who sustain blast injury, use checklists. Military surgeons use checklists to manage trauma for the same reason that anesthesiologists use checklists when checking an anesthesia workstation, or that an airline pilot uses a checklist before every takeoff and landing. The checklist assures that critical steps are not missed. Checklists are easy. Missing critical steps can be deadly.

Checklists have been shown to decrease inpatient complications and death.¹ Standardized checklists can be especially useful during emergencies.^{2,3} A trauma and emergency anesthesia checklist can serve as a template of care for the initial phase of operative anesthesia, as well as resuscitation. The goal of this manuscript is not to provide a definitive checklist. The definitive checklist, if it ever exists, should be created, and vetted, by a learned society within the trauma anesthesiology community. Our goal for this manuscript is to initiate a discussion about what should be on a trauma anesthesia checklist, providing a nidus for a definitive document (Fig. 1).

Before Patient Arrival**Prevent Hypothermia**

Hypothermia impairs antibody and cell-mediated immune defense, increases perioperative infection rates, and contributes to coagulopathy.⁴⁻⁶ The cycle of hypothermia, coagulopathy, and metabolic acidosis is well described.⁷ In one retrospective review, patients with a temperature <35°C, an International Normalized Ratio >1.5 and a pH <7.2 had a mortality of 47%.⁸ Active fluid warming with fluids heated to 40°C through 45°C can mitigate heat loss in the surgical patient,⁹ helping abort the trauma triad of hypothermia, coagulopathy, and acidosis. Thus, the specific steps related to hypothermia are:

1. The operating room (OR) temperature should be warm (25°C or higher). Maintaining a warm OR on patient arrival helps keep patients warm, reducing the effects of hypothermia.
2. Have additional warming devices available, including a forced air device system, fluid warmers on the IV line, warm IV solutions, and warm blankets.
3. Have a system to warm all solutions that are to be used in the surgical field.
4. Verify that a warm IV line is available.

A routine anesthesia machine check and verification that airway equipment, including a difficult airway cart, are immediately available are a standard part of OR preparation and should not be overlooked.

It takes time for the blood bank to prepare blood to treat massive hemorrhage. Before arrival:

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BEFORE PATIENT ARRIVAL

- Room temperature 25C or higher
- Warm IV Line
- Machine Check
- Airway Equipment
- Emergency Medications
- BLOOD BANK: "6U O Neg PRBC, 6U AB FFP, 5-6 Units of random donor plat (1 standard adult dose) available"**

PATIENT ARRIVAL

- Patient identified for trauma / emergency surgery?
- BLOOD BANK: "Send blood for T&C and initiate MTP now!"**
- IV Access
- Monitors (SaO₂, BP, ECG)
- SURGEON: "PREP & DRAPE!"**
- Pre-oxygenation

INDUCTION

- Sedative hypnotic (ketamine v. propofol v. etomidate)
- Neuromuscular Blockade (succ v. roc)

INTUBATION

- (+) ETCO₂ → SURGEON: "GO!"**
- Place Orogastric Tube

ANESTHETIC

- (Volatile Anesthetic and/or Benzodiazepine) + Narcotic
- Consider TIVA
- Insert additional IV access if needed and an arterial line

RESUSCITATION

- Send baseline labs
- Follow MAP trend
- Goal FFP:PRBC controversial, but consider early FFP
- Goal Urine Output 0.5-1 mL/kg/hr
- Consider tranexamic acid if <3 hr after injury; 1 gm over 10 min x1, then 1gm over 8 hrs
- Consider calcium chloride 1 gm
- Consider hydrocortisone 100 mg
- Consider vasopressin 5-10 IU
- Administer appropriate antibiotics
- Special Considerations for TBI (SBP > 90-100 mmHg, SaO₂>90%, pCO₂ 35-45mmHg)

CLOSING / POST-OP

- ICU: "Do you have a bed?"**
- Initiate low lung volume ventilation (TV = 6mL/kg ideal body weight)

Figure 1. Checklist for trauma and emergency anesthesia.

1. Verify that 6 units "O Negative" packed red blood cells (PRBCs), 6 units "AB" fresh frozen plasma (FFP), and 5 to 6 units of random donor platelets (1 standard adult dose) are available.
2. Activate the massive transfusion protocol. In one study using an historical control, mortality improved from 45% to 19% after institution of a massive transfusion protocol.¹⁰ Although there was no significant difference in the ratio of red blood cells to FFP administered, a decreased mean time to administration of first blood product was noted. This illustrates the role that timely and effective communication with the blood bank can play in management of the trauma patient.

Patient Arrival

1. As soon as a patient is identified as an emergency and/or trauma patient, the OR staff and anesthesiologist should be notified. Ideally, the anesthesiologist should be involved in the initial evaluation and management in the trauma bay and communicate with the blood bank immediately to free up prearranged assets in a timely fashion.
2. Obtain large bore vascular access. A 14-gauge IV (flow rate over 300 mL/min) is ideal but may be challenging to place in a cold patient who has suffered significant blood loss. A 16-gauge IV (flow rate 200 mL/min) offers flow rates double that of an 18-gauge IV (flow rate 100 mL/min) and can be easier to place. While a large bore central line (8.5 Fr × 3.5 in) offers significantly higher flow rates under pressure at 300 mm Hg, operative management of a trauma patient in extremis should not be delayed for placement of central venous access.¹¹ Consider replacing small bore IVs with rapid infusion catheters, available in 7 and 8.5 Fr sizes. Also consider having an ultrasound machine available to assist with placement of central venous access. Consider placement of an intraosseous line if vascular access is otherwise not possible.
3. Connect the patient to monitoring. At a minimum, an oxygen saturation probe can record a heart rate and serve as a surrogate for peripheral perfusion. Poor peripheral perfusion is demonstrated in a low quality, "dampened" oxygen saturation waveform, as well as low end-tidal carbon dioxide.¹²
4. Place an arterial line when possible to establish reliable arterial blood pressure monitoring and to facilitate ease of blood draws. Do not, however, delay surgery for placement of an arterial line.
5. Consider having a transesophageal echocardiography machine available for personnel skilled in its use.
6. Instruct the surgical/interventional radiologic team to prepare and drape the patient immediately upon arrival in the OR. Recognition of hemodynamic/metabolic instability is a responsibility of the anesthesiologist and should be discussed during the decision-making process.

Induction

1. Rapid sequence induction (RSI) followed by orotracheal intubation is an effective method to secure the airway of trauma patients. A Norwegian study evaluated 240 trauma patients requiring prehospital endotracheal intubation and documented a 99.2% success rate.¹³ In a 10-year analysis of emergency intubation at a level I trauma center, 6088 patients required intubation within the first hour of admission. RSI with direct laryngoscopy was the standard approach used throughout the study period. Only 21 patients (0.3%) required a surgical airway due to failed intubation.¹⁴ This illustrates the fact that in the hands of experienced anesthesiologists, RSI followed by direct laryngoscopy and tracheal intubation is a remarkably effective approach to emergency airway management. While RSI is safe in skilled hands, an appreciation of relevant pharmacology is necessary for success.
2. Induce IV anesthesia.
 - a. Ketamine (an *N*-methyl-D-aspartate receptor antagonist) produces surgical anesthesia while maintaining airway reflexes and mean arterial blood pressure (MAP). Ketamine may not increase intracranial pressure (ICP) in head-injured patients to the extent previously thought. During 82 ketamine administrations in 30 patients, ketamine actually decreased ICP in patients undergoing "potentially distressing interventions" (e.g., endotracheal suctioning, bed linen change). Ketamine was used in the same study to decrease intracranial hypertension by an average of 33% in patients with persistently elevated ICP.¹⁵ In a review of ketamine use in patients with neurological injury, ketamine was noted to preserve hemodynamic stability, helping maintain cerebral perfusion pressure, and may have had neuroprotective properties.¹⁶ While ketamine has been recommended by the Defense Health Board as a battlefield anesthetic, a more thorough review would be helpful. Until then, ketamine should be used with caution in head-injured patients.
 - b. Propofol (a γ -aminobutyric acid type A agonist) is a common sedative hypnotic. Propofol can result in hypotension in patients with hypovolemic shock and should be used in reduced dosages in this setting. In one hemorrhagic shock model in swine, exsanguination followed by resuscitation with lactated Ringer's solution demonstrated the increased potency of propofol.¹⁷
 - c. Etomidate (a γ -aminobutyric acid agonist) is not as likely as propofol to decrease systemic vascular resistance but can inhibit 11 β and 17 α hydroxylase. Reviews and small studies have shown that even single doses of etomidate can produce suppression of the hypothalamic-pituitary-adrenal axis. In a randomized trial of 30 patients requiring RSI, 18 received etomidate and 12 received fentanyl/midazolam. The etomidate group had significantly lower cortisol levels, longer intensive care unit length of stay (LOS), longer hospital LOS,

and more ventilator days.¹⁸ Another trial randomized 655 patients to ketamine or etomidate for emergency intubation. No difference in intubating conditions was noted; however, the occurrence of adrenal insufficiency was higher in the etomidate group.¹⁹ In a retrospective trauma registry query, rates of etomidate exposure, hemorrhagic shock, and requirement for vasopressor support were all higher in cortisol stimulation test nonresponders, suggesting some degree of hypothalamic-pituitary-adrenal axis suppression with etomidate.²⁰

The effect that this has on outcome is less clear. One study compared liberal etomidate use to limited etomidate use and found no difference in mortality, intensive care unit days, or hospital LOS. Of note, limited etomidate use produced more episodes of hypotension, presumably due to the use of other less hemodynamically stable medications.²¹ A review showed significantly lower cortisol levels in elective surgical patients induced with etomidate, however, without an effect on mortality.²² In a retrospective review, 35 patients intubated using etomidate were found to have a higher incidence of acute respiratory distress syndrome.²³

Although some clinicians have challenged the use of etomidate for RSI due to these concerns, it is less likely to cause hypotension in hemorrhagic shock and remains the most frequently used drug for RSI outside of the OR.²⁴

d. Succinylcholine can produce intubating conditions in 30 to 45 seconds and has withstood the test of time as the most reliable neuromuscular blocking drug in emergencies for fast, ideal intubating conditions. While acute burns and acute paralysis are not contraindications to the use of succinylcholine, it should not be administered 24 hours after sustaining such injuries due to the risk of hyperkalemia. Succinylcholine is contraindicated if severe hyperkalemia is suspected (e.g., rhabdomyolysis, renal failure). The increase in ICP seen after administration of succinylcholine is of limited clinical relevance in head-injured patients and succinylcholine can be used as needed. In one study, 10 ventilated patients with elevated ICP were administered either saline or succinylcholine, with no significant difference in MAP, electroencephalogram, or ICP.²⁵

e. Rocuronium produces intubating conditions in 60 to 90 seconds with a longer duration of action than succinylcholine.²⁶⁻³⁰ The availability of a nondepolarizing neuromuscular blocking drug for RSI is imperative in the trauma setting, because succinylcholine may be contraindicated in certain patients. A rocuronium dose of 0.9 to 1.2 mg/kg will provide adequate intubating conditions within 60 seconds of administration.

3. Intubate the trachea.

a. Effort should be made to minimize manipulation of the cervical spine to the extent possible. While the efficacy of manual in-line stabilization has been debated, it is reasonable to include this as part of

the approach to intubation of the trauma patient if the mechanism of injury is consistent with cervical spine injury.³¹⁻³⁴ A Macintosh 4 blade and gum elastic bougie are sufficient to secure most airways in urgent/emergent situations.^{35,36} An emergency airway cart, including a surgical airway capability, should be immediately available.

b. As soon as end-tidal carbon dioxide is noted, communicate with the surgeon/interventionalist. While such a step is obvious, a checklist aims to improve these types of basic communication during critical events.

c. Placement of an oral gastric decompression tube mitigates the risk of aspiration that RSI hopes to avoid. If esophageal or gastric injury is suspected, communication with the surgical team is important to avoid placement of the oral gastric tube into the mediastinum, chest, or abdominal cavity.

4. Initiate volatile or IV anesthetic.

Resuscitation

1. Send baseline labs as soon as feasible. Follow base excess/deficit, coagulation profile, and arterial blood gas to guide the resuscitation. Base deficit is the amount of base required to bring a sample of blood at body temperature to a pH of 7.4, assuming a carbon dioxide tension of 40 mm Hg. Ideally, this allows one to evaluate the metabolic status of the patient independently from any respiratory contribution. The base deficit is often available rapidly in the OR and offers the ability to guide the resuscitation more immediately than other laboratory values. While rapid clearance of lactate during an emergency portends improved survival, the value of a lactate level during the acute resuscitative phase is less clear.

2. Follow trends in MAP.³⁷ During the initial phase of resuscitation, titrate fluid administration to restore consciousness and radial pulse. Following trends in blood pressure is a more sensitive measure of the adequacy of resuscitation and is superior to reliance on any single number. The concept of hypotensive resuscitation is hotly debated. Any advantage of hypotensive resuscitation is limited to penetrating trauma, and administration of medication to decrease the blood pressure is probably ill advised. Similarly, "chasing a blood pressure" to achieve a "normal" blood pressure in the trauma patient may also be poorly advised.

A reasonable goal would be to maintain a MAP of 60 mm Hg until definitive surgical control of bleeding can be achieved. Fluid treatment should be aimed to a systolic blood pressure of at least 100 mm Hg in patients with hemorrhagic shock as well as head trauma. While a single case report has documented consciousness during cardiopulmonary resuscitation which maintained a MAP >50 mm Hg, there are insufficient data to recommend a single blood pressure goal for all trauma patients.³⁸

- While the ideal FFP to PRBC ratio is subject to debate and continuing research, it is reasonable to consider the early use of FFP.³⁹⁻⁴² Avoid excessive crystalloid resuscitation and consider early transfusion of blood products as needed, particularly if a large crystalloid infusion has been required.

The available evidence supporting higher FFP to PRBC ratios is inconclusive. Currently, American and European evidence-based guidelines recommend early intervention with FFP but without a preset FFP:PRBC ratio. Some centers strive to have a unit of FFP administered for every unit of PRBCs, while others administer 3 units of FFP for every 2 units of PRBCs. The exact ratio of PRBC to FFP is currently being investigated in the Pragmatic Randomized Optimal Platelets and Plasma Ratios (PROPPR) trial (<http://cetirtmc.org/research/proppr>).

- Tranexamic acid is a synthetic lysine derivative that binds lysine sites and is an effective antifibrinolytic. Tranexamic acid has been demonstrated to confer a mortality benefit to severely injured patients in both the civilian and military settings.^{43,44} The greatest benefit is obtained if the patient is bleeding and tranexamic acid is administered within 3 hours of injury. If these criteria are met, consider administration of tranexamic acid 1 g in 100 mL 0.9% saline IV over 10 minutes once, followed by 1 g in 100 mL 0.9% saline IV infusion over 8 hours.
- If the patient has received a significant blood transfusion, then consider administration of calcium chloride 1 g. The citrate preservative in blood products can lower calcium levels and contribute to hypotension. Furthermore, hypocalcemia in patients requiring massive transfusion can increase mortality.⁴⁵
- Consider administration of hydrocortisone 100 mg during unremitting hypotension. Adrenal suppression is a well-described phenomenon in critical illness.^{46,47} Hydrocortisone can benefit trauma patients as well. Twenty-three trauma patients treated with hydrocortisone were more sensitive to α -1 adrenoreceptor stimulation; and another group of 16 trauma patients, who were cosyntropin stimulation test non-responders, were more likely to have prolonged vasopressor dependency.^{48,49}
- Consider bolus administration of vasopressin 5 to 10 Units. Vasopressin is a potent vasoconstrictor which spares cerebral, pulmonary, and cardiac vascular beds; essentially shunting blood "above the diaphragm."⁵⁰ Vasopressin has shown promise in animal models of hemorrhagic shock, as well as case reports,^{51,52} and is effective in late stage, irreversible shock states.⁵³
- Administer appropriate antibiotics. First generation cephalosporins will treat Gram-positive organisms found on the skin. If gastrointestinal contamination is a concern, then consider a second generation cephalosporin for broad Gram-negative coverage. Allergic cross reactivity between penicillins and cephalosporins has an incidence of approximately 5% to 10%. Cephalosporins should therefore be used with caution in penicillin-allergic patients.

- In traumatic brain injury, systolic blood pressure <90 mm Hg and Pao₂ <60 mm Hg are independently associated with increased morbidity and mortality.⁵⁴ Maintain systolic blood pressure higher than 90 mm Hg and oxygen saturation more than 90%. Prophylactic hyperventilation is no longer recommended, and a reasonable goal Pco₂ is 35 to 45 mm Hg.

Postoperative Plan

- Request a bed assignment early from the intensive care unit and speak with the receiving intensivist. Effective communication with the next phase of the critical care continuum is important for efficient transfer of care.
- Initiate low lung volume ventilation.⁵⁵ Tidal volumes of 6 mL/kg ideal body weight decrease stretch-induced lung injury and may be appropriate to initiate in the OR in preparation for transfer to the intensive care unit.

Conclusion

The institution of a trauma and emergency anesthesia checklist can improve communication in the care of critically ill patients requiring an anesthetic. The challenges of producing strong prospective data in the trauma population make definitive suggestions difficult; however, a well-referenced guide to the emergent induction and operative resuscitation of these critically ill patients can serve as a tool to evaluate benchmarks for care (e.g., time from OR arrival to induction of anesthesia, appropriateness of blood product administration, etc.). We believe that a checklist such as this can serve as a starting point for that discussion. ■■

RECUSE NOTE

Michael J. Murray is the Section Editor for Critical Care, Trauma, and Resuscitation for *Anesthesia & Analgesia*. This manuscript was handled by Steve Shafer, Editor-in-Chief, and Dr. Murray was not involved in any way with the editorial process or decision.

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