Anesthesia During Resuscitation: Panacea or Poison?

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Date for publication: January 16, 2016

Resuscitation is the restoration of normal tissue perfusion: the reversal of shock. Resuscitation includes maneuvers to ensure oxygen content in the blood as well as adequate flow to the tissues that need it. Perfusion of vulnerable tissue beds is seldom directly measured, but can be inferred from blood pressure, skin color, core temperature, changes in serum lactate, and mixed venous oxygenation. Assessment of perfusion is further confounded by the knowledge that vascular beds vary widely in tolerance for ischemia; organ failure occurs within 3-5 minutes after the loss of oxygen delivery to the brain or heart, whereas isolated extremities can tolerate interruption of perfusion by a tourniquet for hours at a time. The restoration of blood flow to ischemic tissues is the primary goal of the trauma anesthesiologist.

Aiding in reperfusion are the direct and indirect effects of the anesthetic medications we administer to achieve amnesia and analgesia. Amnestic agents such as midazolam, propofol, and volatile anesthetics are vasodilators and negative inotropes that cause hypotension, even in euvolemic patients presenting for elective surgery; in hypovolemic and vasoconstricted trauma patients these effects can be profoundly exaggerated. Johnson, et al. at the University of Utah have demonstrated in a series of elegant animal studies that propofol – among other medications – is several times more potent in the presence of hemorrhagic shock; a much smaller dose produces the same level of sedation.[1] Moreover, the few anesthetic agents with minimal direct hemodynamic effects – narcotics, etomidate, ketamine – can produce profound hypotension in trauma patients through indirect effects on pain and sympathetic stimulation. Any activity that lowers the patient's catecholamine level, by reducing pain, stimulation, or consciousness, has the potential to reverse compensatory vasoconstriction and decrease the blood pressure. Every trauma anesthesiologist has experienced the exaggerated sedative and hemodynamic response that even 50 mcg of fentanyl can produce in an exsanguinated patient.

Fear of hemodynamic collapse has led to the common practice of limiting anesthesia to trauma patients, especially during early resuscitation. It is common – although seldom discussed in public – to see a young, previously healthy patient anesthetized with no more than scopolamine and rocuronium during the early stages of an emergency exploratory laparotomy. Fluids are restricted, as a strategy to achieve deliberate hypotension. The patient will not move or remember while the surgeons are working, and bleeding will be limited by hypotension, but is this an optimal anesthetic?

Assuming the patient presented in stage 3 or 4 hemorrhagic shock, they might be functioning with as little as 3 liters of total blood volume, out of the normal 5. This implies a state of intense vasoconstriction. Much of the body will be experiencing profound ischemia, an ongoing inflammatory response, and a corresponding risk for organ injury or failure. Compare this physiology to the elective surgical patient who is equally hypotensive, but euvolemic with a full MAC of anesthetic agents circulating. The systolic blood pressure may be identical but that is where the similarities end. The elective patient is in a high-flow, low-pressure state with normal perfusion and a normal pH. Oxygen delivery throughout the body is preserved, as evidenced by continued function of the pulse oximeter on a distal extremity. In contrast, the trauma

patient is cold and acidotic. They have a rising serum lactate level and an increased risk for organ failure. It should be clear which state is preferable.

I hypothesize that optimal resuscitation should include early, aggressive administration of anesthetic agents, titrated with liberal administration of blood products to prevent critical hypotension.[2] Rather than restricting fluids to limit bleeding, I propose restricting blood pressure with anesthetics by relaxing the vasculature while volume is given. I have advocated this approach for years based on the theoretical arguments above and on my anecdotal experience. However, is there existing evidence that early deep anesthesia is better?

Prospective randomized studies of light versus deep anesthesia during resuscitation do not exist, and retrospective reviews are confounded by the heterogeneity of trauma patient comorbidities and injuries. The animal literature is not applicable because of difficulty establishing a truly comparable control group. The study would be logistically difficult and it is unethical to induce hemorrhagic shock in un-anesthetized animals. In fact, close reading of the hundreds of animal trials of deliberate hypotensive resuscitation suggests that in the vast majority of these studies the animals were receiving 1 MAC equivalent of anesthesia throughout the protocol – something which might have contributed to the degree of benefit demonstrated.[3]

There is good human literature to suggest that better outcomes are associated with more rapid clearance of serum lactate.[4] There is retrospective evidence that elective – and already anesthetized – surgical or obstetric patients who hemorrhage and require transfusion have better survival than trauma patients who end up receiving the same quantities of blood; i.e. a trauma patient receiving 10 units of RBCs and reaching the ICU has a substantially higher risk of organ failure and subsequent death than an elective surgical patient who receives the same amount of blood. Mortality in seriously bleeding traumatically injured patients was about 15% in both CRASH-2,[5] and the more recent PROPPR trial,[6] but runs about 3% in obstetric patients with severe hemorrhage.[7]

Establishing the benefit of early deep anesthesia in trauma patients may be possible in a prospective human trial, but a substantial number of patients (and substantial research infrastructure) would be required. Further questions will arise, such as; how do we select patients for study? Which is the best anesthetic to use? Some have advocated for a high-dose narcotic approach; the advantage is no direct cardiac depression or vasodilation, but the disadvantage is a prolonged period of unresponsiveness that may make it hard to assess neurologic function. Other clinicians prefer to use volatile anesthetics or a balanced technique. The cardiac depression and vasodilation will be more pronounced, but minute-to-minute titration is easier and the anesthetic can be more readily reversed.

Whatever the approach to anesthesia, early administration to hemorrhaging trauma patients requires careful titration by an experienced clinician with the support of reliable monitors, a ready supply of blood products, and all the other components of modern hemostatic resuscitation.[2] In this way, hypotensive resuscitation can produce a physiologic benefit. However, when misused, it can be a weapon. Future research will tell us how the costs and benefits truly balance.

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