Journal of Critical Care xxx (2013) xxx–xxx

Contents lists available at ScienceDirect

Journal of Critical Care

journal homepage: www.jccjournal.org

Hypotensive resuscitation in a head-injured multi-trauma patient ☆

Joshua M. Tobin, MD [a,*], Richard P. Dutton, MD, MBA [b], Jean-Francois Pittet, MD [c], Deepak Sharma, MBBS, MD, DM [d]

[a] David Geffen School of Medicine at UCLA, Department of Anesthesiology/Division of Critical Care, Los Angeles, CA 90095-7403, USA
[b] Clinical Associate, Anesthesia Quality Institute, American Society of Anesthesiologists, Department of Anesthesia & Critical Care, University of Chicago, Chicago, IL, USA
[c] Director of the Division of Critical Care Anesthesiology, University of Alabama at Birmingham, Birmingham, AL, USA
[d] Chief of the Division of Neuroanesthesiology and Perioperative Neurosciences, University of Washington, Seattle, WA, USA

ARTICLE INFO

Keywords:
Resuscitation
Trauma Care
Traumatic Brain Injury
Hypotension

ABSTRACT

The concept of permissive hypotension is a controversial topic in trauma care. While driving blood pressure to "normal" levels with large volume crystalloid infusions is not appropriate, definitive data on the target blood pressure for hypotensive resuscitation are lacking. Indeed, the concept of systolic blood pressure as a marker for resuscitation is arguable. In this case presentation, a panel of experts in trauma resuscitation discusses the merits and limitations of hypotensive resuscitation in the context of a patient who has sustained multiple injuries, including a head injury.

The controversies highlighted herein call attention to the role of the intensivist in managing a continuing resuscitation while coordinating the care of other physicians whose therapies can run at cross-purposes to one another. The challenges of the practice of critical care in the 21st century are no more apparent than in the care of a complex trauma patient.

A 17-year-old male adolescent is the unrestrained driver in a single car crash in which he veered off the road and hit a bridge abutment. Paramedics initiated a 16-gauge intravenous (IV) line at the scene and have begun infusing one liter of normal saline. The pre-arrival report states that the patient is disoriented and has a blood pressure of 100/palpation with a heart rate of 120 beats per minute (bpm). He has lacerations to the head and face and does not have any obvious extremity deformities. Paramedics have been unable to assess the patient's abdomen due to agitation and non-compliance. He is noted at the scene to be moving all four extremities spontaneously. They have placed a cervical collar and full spinal protections with a spine board.

Upon arrival in the trauma bay the patient has a blood pressure of 90/56 with a heart rate of 126 bpm. He has a Glasgow Coma Scale of 8 (eyes = 2, verbal = 3, motor = 3). He moves all 4 extremities but remains non-compliant with the remainder of the physical exam. The trauma team elects to intubate the patient's trachea for airway protection. He is induced via his in situ IV line with etomidate and succinylcholine. Manual in-line stabilization and cricoid pressure are applied as the anesthesiologist uses a Macintosh 3 laryngoscope blade to place a #8 endotracheal tube. End-tidal carbon dioxide is verified on the side-stream analyzer and breath sounds are confirmed in all lung fields. The epigastrium is silent.

After induction the blood pressure is 84/50 and the heart rate is 129. The endotracheal tube is secured and a focused assessment with sonography for trauma (FAST) is performed. The FAST results are equivocal and the patient is transported to the computerized tomography (CT) scanner. A CT scan of the head reveals no intracranial blood and open basal cisterns. There is a zygomatic arch fracture on the left. The CT scan shows no fracture or subluxation of the cervical spine. The abdominal CT scan reveals a significant liver laceration and free fluid in the abdomen. The imaging studies and physical exam findings are otherwise unremarkable.

The patient is transported back to the trauma bay where his blood pressure is 78/42 with a heart rate of 130. An infusion of two units of type "O" negative blood is initiated as the patient is emergently transported to the operating room (OR) for an exploratory laparotomy.

This case emphasizes a number of important concepts in the management of the trauma patient. Prompt arrival of emergency medical services is a vital first step in improving the survival of the injured patient. Paramedics initiated an IV line and infused a liter of normal saline en route to the hospital. While this remains part of the field management of trauma in many emergency medical services systems, evidence suggests that large volume crystalloid infusions may do more harm than good. More recent data further suggest that chloride rich solutions can worsen acute kidney injury in the intensive care unit [1]. If crystalloid infusions are to be used, it may be appropriate to use chloride-poor solutions (eg, lactated ringers, plasmalyte).

☆ Conflicts of Interest: None to disclose.

* Corresponding author. Tel.: +1 310 206 7496; fax: +1 310 825 2236.
E-mail addresses: jmtobin@mednet.ucla.edu, josh_tobin@hotmail.com (J.M. Tobin), r.dutton@asahq.org (R.P. Dutton), pittetj@uab.edu (J.-F. Pittet), dsharma@uw.edu (D. Sharma).

0883-9441/$ – see front matter © 2013 Published by Elsevier Inc.
http://dx.doi.org/10.1016/j.jcrc.2013.11.017

Upon arrival in the trauma bay the patient was noted to become increasingly obtunded and tracheal intubation was performed for airway protection. Rapid sequence induction and direct laryngoscopy are a safe and effective means for tracheal intubation in trauma patients [2]. This patient certainly has a mechanism of injury to suggest possible spinal cord injury and a cervical spine collar was appropriately placed by paramedics. Even in patients with documented vertebral body fractures and documented spinal cord injuries, orotracheal intubation remains a safe approach to airway management in trauma [3].

The initial CT scan revealed no cervical spine injury or traumatic brain injury (TBI). While this is reassuring, the patient's physical exam on presentation suggests a possible TBI and a follow-up CT scan of the head is warranted to evaluate for evolution of any intraparenchymal hematoma or other TBI. The patient is appropriately taken emergently to the OR for exploratory laparotomy due to his liver laceration.

The resuscitation in the OR will involve the administration of blood products. Data over the last ten years have demonstrated improved survival with plasma to red blood cell ratios approaching unity, however, the proper ratio of red blood cells to plasma remains a topic of investigation. The goal of resuscitation in the OR is also a subject of debate and on-going research. In hypotensive resuscitation a lower blood pressure is tolerated, with mean arterial pressures approaching 50 mm Hg. The idea is that lower blood pressures will not exacerbate blood loss in the acute/uncontrolled blood loss stage early in resuscitation. There is also a concern of "popping the clot" as larger resuscitation volumes produce higher pressures that overcome the hemostatic benefit of newly formed blood clots.

The anesthesiologist is responsible for trauma resuscitation and must manage the, sometimes competing, interests of the neurosurgical and trauma surgical therapies. At the same time the anesthetic must be conducted in parallel with resuscitation of a patient in extremis. To discuss the finer points of such a complex anesthetic/resuscitation a panel of anesthesiologists with expertise in trauma, critical care and head injury will offer their perspective in the management of this patient.

1. Dr Richard P. Dutton is the Director of the Anesthesia Quality Institute at the American Society of Anesthesiologists and is the former Chief of Anesthesiology at the R Adams Cowley Shock Trauma Center at the University of Maryland. Dr Dutton: What evidence is there to support hypotensive resuscitation in blunt trauma? Penetrating trauma?

This patient's greatest and most-immediate risk is exsanguination from the liver injury. Up to half of all mortality from trauma is due to hemorrhage, either early (about 33% of deaths) or later from the effects of shock and multiple organ system failure. Patients who bleed to death do so during the first three hours in the hospital [4], emphasizing the importance of early intervention. Foremost, of course, is anatomic control of the site of hemorrhage, either through surgery or angiographic embolization. Anesthesiologists play an important role in the logistics of moving patients to definitive care. During this intervention, however, the management of ongoing fluid resuscitation has a significant impact on outcomes. One widely accepted approach is resuscitation to a target blood pressure that is lower than normal for the patient, as a means to avoid the rebleeding associated with blood pressure spikes that wash away fragile extraluminal clots [5]. Deliberate hypotension is common in elective surgery, and is well supported in numerous animal models of uncontrolled hemorrhage [6].

At least three human trials have attempted to validate this approach. Most influential was the trial by Bickell et al in Houston in the early 1990s. [7] Hypotensive patients with penetrating torso trauma were randomized in the field to either customary fluid therapy or none at all; this approach was followed from prehospital transport through emergency department assessment to the operating room door. The no-fluid group had significantly improved survival (70% vs. 64%; $P = .04$). A similar protocol was conducted in Baltimore in the late 1990s, randomizing hypotensive patients (either blunt or penetrating) to blood pressure maintenance at 80 mm Hg systolic vs. > 100 mm Hg until definitive control of hemorrhage [8]. No difference in survival was found, despite a higher injury severity in the hypotensive group. Finally, another trial is underway now in Houston; a preliminary report suggests improved outcomes with hypotension [9].

Despite the heterogeneity of patients and injuries in these trials, and concerns about the underlying methodology, deliberate hypotension has been an accepted strategy in penetrating trauma in most major trauma centers since the year 2000. Controversy remains over the best approach to achieving hypotension: whether through fluid restriction (the original Bickell premise) or through simultaneous administration of fluid and anesthetic agents (titrating anesthetic-induced vasodilation against vascular filling) [10]. Although scientific evidence is scant, the latter approach is supported by both theories of pathophysiology—vasodilatory hypotension preserving tissue perfusion better than vasoconstricted hypotension—and some limited animal data [5].

A particular concern in this debate is the role of deliberate hypotension in patients who might be vulnerable to ischemic injury. This includes patients with traumatic brain injury (TBI) as well as older patients and those with known coronary artery disease. TBI is especially challenging, because of the well-documented association between episodes of hypotension and bad outcomes in patients with severe injury. It should be recognized, however, that this association is based on observational data and does not prove cause and effect. In fact, it may be that while simultaneous bleeding and TBI predict a bad outcome, the patients in this cohort that do best are the ones that stop bleeding fastest, and are thus able to complete resuscitation. In other words, deliberate hypotension might be MORE important in vulnerable patients. There are some animal data available to support this point of view [11], but definitive human trials are unlikely.

In summary, deliberate hypotension is an important tactic for limiting ongoing blood loss and speeding the time to complete resuscitation in patients with traumatic hemorrhage. While numerous questions of clinical application remain open, the core hypothesis that a lower blood pressure will lead to less blood loss has been well established in both pre-clinical and clinical trials. Hypotensive management remains an important tool to facilitate hemostasis and resuscitation in dying trauma patients.

2. Dr Jean-Francois Pittet is a Professor of Anesthesiology at the University of Alabama at Birmingham and the Director of the Division of Critical Care Anesthesiology. Dr Pittet: What are the advantages, if any, of hypotensive resuscitation in trauma?

The case presented above emphasizes a number of important concepts in management of the trauma patient. I will focus my comments on pre-hospital and hospital-based hypotensive fluid resuscitation and I will present evidence against the use of hypotensive fluid resuscitation for this particular patient. Recognition of when a trauma patient is bleeding can be difficult. Pulse and arterial blood pressure are neither sensitive nor specific for severe hemorrhage. Young patients may lose more than 30% of their blood volume with little change in their vital signs. Furthermore, the classical cut-off systolic blood pressure (SBP) of 90 mm Hg as a marker of hemorrhagic shock has been based on expert opinion and not on evidence-based data. In fact, a SBP below 110 mm Hg is associated with a significant increase in mortality in blunt major trauma patients with baseline pressure of 130 to 139 mm Hg. Importantly, the mortality rate doubled for a SBP <100 mm Hg, tripled at a SBP< 90 mm Hg and was 5- to 6-fold higher at a SBP <70 mm Hg [12]. In addition, single, isolated hypotensive SBP measurements of less than 105 mm Hg during trauma resuscitation should not be ignored or dismissed, as

Please cite this article as: Tobin JM, et al, Hypotensive resuscitation in a head-injured multi-trauma patient, J Crit Care (2013), http://dx.doi.org/10.1016/j.jcrc.2013.11.017