Trauma, Critical Care, and Emergency Care Anesthesiology: A New Paradigm for the "Acute Care" Anesthesiologist?

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In 2003, the American College of Surgeons began to evaluate the need for a specialized practice of acute care surgery (ACS), an evolving discipline with 3 essential components: trauma, critical care, and emergency surgery. In 2006, the Institute of Medicine subsequently identified a shortage of emergency and critical care on-call specialists.[1] ACS has matured as a specialty, partly in response to this deficiency. Over the past decade, the American College of Surgeons has documented the need for these services and a new training paradigm,[2,3] developed fellowship curricula,[3,4] and demonstrated a financial advantage for providing services for emergency surgical procedures.[5]

National data on demographics and outcomes after emergency operative procedures show that morbidity and mortality are higher for patients who require emergency surgery.[6] An overview of adverse events presented by the Anesthesia Quality Institute (AQI) also found that patients with ASA physical status >III and those over the age of 50 exhibit the highest serious adverse event rate.[7] The unscheduled nature of critical illness and injury, combined with the significant resources required to treat these diseases, challenges health care providers and health systems. Hospitals are experiencing an increase in the volume and acuity of acute care admissions, and the number of elderly patients with coexisting diseases, while simultaneously dealing with declining resources and high demands for improved clinical and financial efficiency and quality and patient satisfaction.[2] Yet, a paucity of literature informs the impact of anesthetic management of these patients from a systems approach. As perioperative partners with surgeons in trauma and intensive care management, and during emergency general surgery (EGS) cases, we propose a parallel practice for acute care anesthesiology modeled after the American College of Surgeons paradigm. The emphasis of acute care anesthesiology practice would be on the *time-sensitive* and *focused* resuscitation of trauma, and critically ill and emergency patients, based on the most up-to-date literature and practice management data.

EMERGENCY CARE

Although the percentage of emergency, trauma, and critically ill patients requiring anesthesiology care is not well documented, one 2005 report of operative experience at a tertiary academic, level I trauma center found that more than half of their operative procedures were nonelective: 40% were urgent, 11% were true emergency procedures, and 8% were trauma related.[8] A recent 2011 review of the National Surgical Quality Improvement Database found that many trauma cases typically occur during off-hours.[6]

In addition, due largely to the presence of shock, the physiology of trauma and emergency patients differs considerably from that of patients undergoing elective surgeries. As a result, anesthetic and resuscitation strategies for elective surgical cases differ markedly from those for emergency surgery.[9] In contrast to elective cases, in which large-volume blood loss and fluid shifts might be readily anticipated but not yet present, bleeding or infection in emergency surgery patients often results in substantial total body fluid deficit at the time of presentation to the trauma bay or operating room. This difference between trauma and elective patients is evident in 2 recent studies:

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A retrospective cohort study of over 12 million cases in the American Society of Anesthesiologists (ASA) Anesthesia Quality Institute's National Anesthesia Clinical Outcomes Registry (NACOR) from 2010 to 2014 found that 270,000 cases were emergent.[10] Patients undergoing emergency surgeries had a higher ASA physical status and longer case duration. The 3 most frequently performed emergency cases were intra-abdominal procedures—the precise cohort that manifests the highest incidence of serious adverse events.[7] The most common trauma case was orthopedic fixation of the lower extremity, and emergency cases were more likely to occur after 6:00 PM.[10] In another series of patients with soft tissue infections presenting emergently to the operating room (OR) for initial debridement, those in septic shock demonstrated a significantly higher mortality (34.8%) than a less sick cohort with the same disease (2.8%). Patients in shock had longer duration of surgery and higher blood loss, and required more fluids. They also received lower doses of anesthetics than the patients without septic shock.[11] Each of the above studies highlights the potential value of around-the-clock availability of anesthesiologists with expertise in the stabilization and resuscitation of critically ill patients with marginal physiological reserve. In most surgical practices, trauma surgeons have expanded their training and practice to care for EGS patients. It follows that outcomes for trauma and emergency surgery patient cohorts may therefore be similar, but one study suggested that morbidity is higher for ACS patients at trauma centers when compared with the same patients at nontrauma centers.[6] The authors concluded that improving the processes for trauma care may also improve outcomes in ACS patients.

The American Association for the Surgery of Trauma is currently developing quality indicators for hospital care of EGS patients. Their panel of experts has included recommendations on the preoperative workup and intraoperative monitoring that should be performed by anesthesiologists during emergency surgery cases. Of significance is that the expert panel includes only one anesthesiologist (MM). Thus, there is a critical opportunity for anesthesiologists to influence, measure, and define the value of our practice in the care of this high-risk patient population.

TRAUMA

Trauma is the leading cause of deaths in Americans under the age of 45 years, and the third leading cause of death in all ages in the United States. Most anesthesiologists will care for injured patients during their career—either after the initial trauma or for follow-up procedures. ASA data show that most trauma and emergency cases are performed at nonacademic, nonuniversity hospitals.[10] Trauma is a distinct disease process, and although the science of resuscitation has advanced rapidly over the past several years, many unanswered questions remain. For example, the concept of "damage control" resuscitation includes a conservative fluid administration to achieve a systolic blood pressure (SBP) of 80 mm Hg and administration of a 1:1:1 red blood cells/plasma/platelets ratio.[12] Although early studies in both military and civilian cohorts suggest a survival benefit, it is not clear whether it is the targeted hypotension—which is intended to decrease blood loss until hemorrhage control—the "whole" blood transfusion, or some other variable that is associated with decreased mortality. Data are conflicting, as the following articles suggest:

1. Deliberate hypotension, maintained until control of hemorrhage, is associated with a decrease in mortality in penetrating trauma but an increase in mortality in blunt trauma.[13–15]
2. Prehospital fluid administration is associated with improved survival.[16]
3. Restrictive resuscitation (<150 mL) demonstrated a survival advantage compared with "standard" resuscitation.[17]

These recommendations must be considered in the context of each other and also with coexisting injuries. For example, hypotensive resuscitation is not an option in patients with suspected traumatic brain or spinal cord injury. In patients with traumatic brain injury, the odds of death are 1.5 times greater at SBP < 120 mm Hg, double at <100 mm Hg, triple at <90 mm Hg, and 6 times greater at SBP <70 mm Hg.[18] Balancing cerebral perfusion pressure targets with the goal of decreasing bleeding until definitive hemorrhage control in these patients is a challenge for the most experienced trauma anesthesiologist. The practice of pharmacologic resuscitation is also advancing rapidly and may include antifibrinolytics,[19] procoagulants,[20] replacement of endogenous vasopressin,[21] and correcting hypocalcemia.[22] The complexity of these examples indicates that trauma anesthesiology has become an anesthesia subspecialty that requires additional training, either through longer exposure during residency or during a specialized fellowship.

Continuing research and controversy regarding resuscitation strategies after trauma will undoubtedly change current management paradigms. The need to maintain up-to-date knowledge and clinical excellence also suggests the need for specialization and expertise in trauma anesthesia. The American College of Surgeons sixth edition of "Resources for Optimal Care of the Injured Patient" published this year has defined the role of anesthesiology departments at level I and level II trauma centers, including 24-hour in-house availability. The American College of Surgeons believes that our work is critical in the time-sensitive management of these patients, and the authors' belief is that anesthesiologists should self-determine and define the value they bring to their patients.

CRITICAL CARE

The American Board of Anesthesiology was one of the first specialty boards to sponsor training and certification in critical care, recognizing the subspecialty in 1986. Despite this early leadership role, the number of accredited fellowship programs in critical care anesthesiology has decreased in the past decade. Yet, the demand for intensive care unit (ICU) services is projected to grow rapidly during the next decade, as the average acuity of hospitalized patients rises with the growth in the elderly population. The proportion of the population aged >65 years is estimated to increase exponentially after 2010, adding to the already overtaxed need for critical care resources.[23] As the average life expectancy lengthens, the number of surgical procedures performed on these patients will also likely increase,[24] which may present an opportunity for anesthesiologists to expand our scope of care for these patients. Patients with intra-abdominal sepsis,

soft tissue infection, acute abdominal pathology, and acute hemorrhage are more likely to require urgent or emergent evaluation and operative intervention, with subsequent admission to the ICU.[25] When the elderly patient presents for an emergency operation, the preoperative workup is often less comprehensive owing to the need for urgent operative intervention, placing the patient at increased risk for perioperative morbidity and mortality.

The American College of Surgeons model has incorporated "critical care" into the surgical training program in acute care (trauma, EGS, and critical care). Similarly, critical care anesthesiology involves the postoperative care of the most critically ill and injured surgical patients, particularly those with significant preexisting comorbidities, and could also incorporate trauma training. During the 1-year ICU fellowship, 3 months' elective time would then allow the trainee to develop skills other than ICU care: more experience in the intra- or preoperative management of trauma and emergency cases, ATLS® certification, rotations on the trauma team, EGS service, or with the echocardiography service. These experiences should enhance the clinician's career regardless of whether he or she chooses to practice acute care anesthesiology in an academic or private practice setting. An acute care anesthesiology fellowship would extend the management of medical comorbidities and the science of resuscitation skills forward into the emergency department, trauma bay, and OR, where resuscitation care may differ from the postoperative care. An anesthesiologist trained in acute care could then staff an OR for emergency and trauma cases or an ICU for critical care or, where the model exists, could participate in emergency department airway, access, and resuscitation efforts and contribute to the education of emergency medicine residents.

A PROPOSED TRAINING PARADIGM FOR AN ACUTE CARE ANESTHESIOLOGY FELLOWSHIP

The Accreditation Council of Graduate Medical Education (ACGME) requires that anesthesiology residents provide care for only 20 patients with "life-threatening" pathology during their training. Because the Residency Review Committee for anesthesiology makes their residency-case data available only to program directors, we were unable to obtain information on the number of trauma or emergency cases residents complete during their training.

From the independent "Residency Place" website (https://www.residencyplace.com/PathFinder/ProgramList.aspx?ListType=0&Specialty=Anesthesiology), however, we identified 7 of 123 anesthesiology programs in this database that reported resident case log data (Duke University, Johns Hopkins University, University of Alabama, University of Florida, University of Kentucky, University of North Carolina Chapel Hill, and the University of Tennessee). Of these, 4 programs list average trauma case numbers for residents with a range of 28 to 160 (Table 1) and no programs reported emergency/ACS cases. Subspecialty rotations during residency do ensure a broad exposure to the pathophysiology and anesthetic requirements of managing patients with cardiac, thoracic, vascular, and neurologic diseases, but most of these cases are elective (i.e., thoracotomy for resection of mass, video-assisted thoracic surgery (VATS), thoracic or aortic endovascular repair, or hepatectomy). An emergent trauma patient may have injuries to each of the above body systems, requiring competing goals in resuscitation.

Table 1. Publically Available Trauma Case Numbers for Anesthesiology Residents

Program	Average trauma case per resident
Johns Hopkins University	48.8
University of Alabama	89
University of Florida	28
University of Tennessee (University of Tennessee Graduate School of Medicine)	160
University of Tennessee Medical Center	45

At busy trauma centers, residents may be exposed to a high volume of trauma cases over several months. However, most emergency surgery cases actually occur at medium community hospitals, with less opportunity for resident participation and training.[10] This variability in exposure to trauma and emergency surgery cases during training suggests a need for a standardized approach to preparing the consultant anesthesiologist for an acute care anesthesiology practice. Although graduate medical education and hospital training programs may be moving away from increased trainee funding and prolonged fellowships, anesthesiology has seen a progressive *increase* in subspecialty development due to advancing knowledge, techniques, interests of trainees, and expanding opportunities for the perioperative physician. Areas such as pediatrics, obstetrics, and pain management are well-established domains involving greater training and recognized expertise, but newer disciplines such as regional, offsite, outpatient, and quality improvement/patient safety subspecialties are growing. Training in these new areas does not mean that, as in cardiac, only a subspecialty-trained anesthesiologist would be expected to care for these cases. Rather, this trend demonstrates the breadth and depth of our advancing practice. An acute care anesthesiologist, as with other fellowship-trained physicians, could also serve as a resource for colleagues in managing trauma or EGS cases throughout the perioperative spectrum, assisting in the management of the ill or injured before and after the operating room. By didactic education and the development of protocols, experts from academic training centers could then translate improvements in clinical care to the community and private hospitals.

Recently, proposals to restructure anesthesiology training have included subspecialty focus in critical care or pain medicine during the clinical anesthesia year 3.[26,27] One stated goal of such initiatives would be to "restructure the training curriculum into clearly defined basic and advanced components…"[27] A related proposal is to require that anesthesiology trainees complete 2 additional years of training after the clinical anesthesia year 3, possibly creating programs in hospital medicine or emergency medicine in combination with anesthesiology.[26] Each of these positions recognizes the value of, and the need for, additional exposure to the physiology and management of critical and emergency care. We suggest that training in "acute care" anesthesiology (trauma, critical care, and emergencies) is only logical, given the increase in the number of these cases.

Table 2. Suggested Components of the Educational Curriculum for Acute Care Anesthesiology Fellowship Training[a]

Core principles of trauma and emergency care	Anesthetic considerations for patients with the following blunt or penetrating injuries	Anesthetic management plan for the following special populations
Develop necessary attitude and mastery in interdisciplinary leadership, communication, and organization and teamwork skills	Airway injury	Burn trauma patients
Trauma epidemiology, mechanisms of injury, prehospital care and transfer	Traumatic brain injury	Pediatric trauma patients
Initial evaluation and management, team approach, triage, surgical priorities and mass casualty, disaster management	Spine trauma	Geriatric trauma patients
Shock resuscitation and fluid therapy, damage control resuscitation, goal-directed therapy	Ocular and maxillofacial trauma	Pregnant trauma patients
Septic shock physiology/drug requirements	Chest trauma, bronchial disruption, role of ECMO	New endovascular techniques for aortic injury/hemorrhage control (e.g., Retrograde Balloon Occlusion of the Aorta [REBOA])
Blood component therapy and	Abdominal trauma	Septic shock
Trauma-induced coagulopathy (role of inflammation), massive transfusion protocols	Major pelvic and limb trauma	Massive fluid shifts
Ultrasound and echocardiography in trauma	Major burn, soft tissue, and vascular trauma	Extensive soft tissue debridement
Postoperative care of the trauma patient		
Biologic, chemical, and radiation exposures in trauma		
Emergency preparedness		

ECMO = extracorporeal membrane oxygenation.
[a]In addition to standard critical care curriculum if fellow or program opts for this option.

PROPOSED CURRICULUM

We believe that a 1-year critical care fellowship (ACGME accredited) accompanied by a 1-year non-ACGME accredited acute care anesthesiology fellowship, similar to the American College of Surgeons training paradigm, is the optimal model. However, we could not reach consensus on endorsing a 1- or a 2-year program and therefore suggest several models: completing a 1-year acute care fellowship only, *or* incorporating the acute care component into the 3-month elective rotations during a 1-year critical care fellowship. We recommend that the specific choice of this training be determined by the anesthesiology department offering the fellowship. The content should expand areas not commonly addressed in a core residency program, such as those delineated in Table 2. The fellowship is not meant to identify other practitioners as less trained, but to allow physician anesthesiologists to expand the scope of their practice into other areas such as prehospital care, trauma resuscitation, and out-of-OR anesthesia. Graduates of an acute care anesthesiology fellowship would serve as a resource for anesthesiologists with less training or experience in more detailed aspects of trauma and emergency care.

We agree that a portion of the curriculum should be devoted to understanding and participating in the continuum of care, from entry into the system through return to normal function. This includes time spent in participatory learning focused on care coordination and systems-based quality improvement projects. Those with an interest in research could follow the "physician scientist" model to tackle the most complex systematic challenges, which would further define the role of the acute care anesthesiologist and the need for training, staffing, and patient management, as proposed by the ASA and the perioperative surgical home model.

CONCLUSIONS

Anesthesiologists have an opportunity to meet the growing needs of hospitals in providing care to critically ill, injured, or emergency care surgical patients. Acute care anesthesiology would encompass pre-, intra-, and postoperative care of the critically ill surgical patient, expand the scope of anesthesiology, and contribute to improving the safety and quality of patient care. Although no data currently examine the influence of the acute care anesthesiologist on outcomes in this patient population, it is not unreasonable to believe that a model similar to that for the acute care surgeon would contribute to better patient care. The most recent data suggest that ACS is a independent predictor of death and major complications when compared with non–acute care surgery cases with a similar case mix.[28] Thus, we need to explore the added value of anesthesiologists: Would an acute care anesthesiologist contribute to better patient outcomes? The specialty of anesthesiology should explore the value of the trained acute care anesthesiologist in this model, possibly using data from the AQI NACOR registry. In our opinion, the acute care anesthesiologist model represents an opportunity for further expansion of the role of anesthesiologists into the "perioperative surgical home care" model of patients hospitalized for nonelective surgical procedures.

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