Acute provider stress in high stakes medical care: Implications for trauma surgeons

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Acute stress has marked effects on cognitive decision making, memory, technical performance, and teamwork. These known effects of acute stress may lead to increased medical errors, particularly in high stakes, high stress fields, like emergency care and surgery. A growing body of surgical literature has described these detrimental effects of stress on technical performance in the operating room.[1–4] Interest is, therefore, increasing in targeting acute stress as a modifiable risk factor for human error, particularly within these fields. Trauma care, comprised of rescue, initial evaluation, resuscitation, surgery, and critical care, is a surgical discipline that may be even more susceptible to error secondary to maladaptive stress responses. Potential contributing factors to stress-induced error in trauma care include high acuity, high-stakes decisions, and suboptimal surgical conditions with numerous inherent unknowns. Despite the risk for acute stress and impact of stress within trauma care, existing reviews and studies have rarely focused specifically on the effects of acute caregiver stress during the spectrum of trauma management. The goal of this narrative review is to provide an overview of existing literature and identify lessons learned from other high stakes medical fields that can reasonably be applied to trauma care, as well as identifying knowledge gaps with regard to acute stress in trauma care.

Recently, stress has become the topic of increased focus in health care and in the general public. The term "stress" is subject to myriad interpretations and lacks a unifying scientific or psychological definition. It is clear that acute and chronic stress—however defined—are interrelated. Repeated or unmitigated episodes of acute stress lead to chronic stress and its attendant health and wellness consequences. But the use of a single word to explain the chaotic motion of a panicking drowning victim and the prolonged burnout of a busy trauma nurse likely masks important differences leading to divergent strategies.

Chronic stress in trauma care is widely accepted and relatively well studied. Trauma surgeons work long hours, endure numerous call shifts, and are routinely exposed to injury and suffering.[5–7] Prior work has demonstrated a clear correlation between both hours worked and nights on call with burnout.[5] Sleep patterns are disrupted for 3 nights after a call shift, delaying psychologic and physiologic recovery[8] Further, the patient population encountered by trauma caregivers places increased psychological stress on surgeons with 15% to 22% of surgeons meeting diagnostic criteria for posttraumatic stress disorder.[7,9] These chronic stressors results in trauma surgeons having the highest rate of burnout of all surgical subspecialties (51.6%) and a quality of life survey score that is half a standard deviation below the population norm.[6,10]

In contrast to chronic stress, whose costs are paid over months and years, relatively little evidence exists in the surgical literature regarding the acute stress response at the moment of care, and its impact on performance in the OR and trauma bay. Following the lead of other mission-focused environments—military, performance, athletic, and so on—this review attempts to summarize existing evidence related to acute caregiver stress in the care of injured patients.

There are a number of factors that make management of acute stress particularly important to trauma team members. Relative to other surgical services, trauma surgeons are more likely to encounter acute, life-threatening disease processes in their patients. Trauma teams often have little control over their workday, and often, must manage simultaneous critical events. Trauma care is a multidisciplinary effort with a team consisting of paramedics, nurses, trainees, and specialists that must be coordinated in order to rapidly evaluate, resuscitate and stabilize patients brought in from the field. Trauma patients may need to be emergently treated before they are medically optimized, and there is often not time to plan complex operations before the first incision. This lack of control, high prevalence of unknowns, and demand for quick action is challenging for most practitioners and may be crippling for some. The unique trauma environment may put practitioners at higher risk for acute stress and may make the effects of stress, such as heightened distractibility, decreased working memory, and impaired communication/teamwork, more likely to cause error and patient harm.

Other disciplines, such as internal medicine (IM) and emergency medicine (EM), emergency medical services (EMS), and general surgery, have developed a sizable literature on the effects of stress in their fields, including strategies for stress mitigation.

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After first outlining models of stress psychology and measurements of stress, this article will discuss relevant contributions from other high stakes fields. We hypothesize that we will be able to apply lessons learned from these fields to trauma care and identify knowledge gaps with regard to trauma-specific acute stress and mitigation techniques.

DESCRIPTIVE MODELS OF STRESS PSYCHOLOGY: COGNITIVE AND PHYSIOLOGICAL AROUSAL

Models describing the interplay between stress and human performance are founded on the Yerkes-Dodson curve of physiological arousal (stress) and performance.[11] Under this construct, performance improves with increasing physiological arousal up to a point, after which it decreases dramatically (Supplemental Digital Content 1, Appendix 1, http://links.lww.com/TA/B536).[12,13] Using the Yerkes-Dodson curve, Hanin described the "zone of optimal functioning" as an individual's ideal anxiety level for optimal performance. Multidimensional anxiety theory added cognitive anxiety as another independent variable to the arousal performance Yerkes-Dodson curve to better approximate changes in performance when cognitive anxiety is high.[12] Similarly, Hardy and Fazey developed the catastrophe anxiety model to demonstrate how cognitive anxiety and arousal interacted to produce changes in performance (Supplemental Digital Content 2, Appendix 2, http://links.lww.com/TA/B538).[14] In this last model, physiological arousal is not detrimental to performance at levels of low cognitive anxiety but results in a catastrophic decrease in performance when both arousal and cognitive anxiety are high.[12] In turn, high cognitive anxiety is always detrimental to performance but has a significantly bigger impact at high physiological arousal.[14]

In a different approach, the cognitive appraisal anxiety theory posits that the psychological and physiological manifestations of stress are dependent on an individual's assessment, termed *cognitive appraisal*, of whether the available resources are adequate to meet the demands of a situation.[2,3] A *challenge* or assessment that resources are adequate to meet demands, engenders *eustress,* and instigates mild sympathetic nervous system activation without hypothalamic-pituitary-adrenal axis activation. In other words, individuals who feel challenged demonstrate an increase in heart rate without significant changes to circulating cortisol levels and typically demonstrate improved performance with heightened concentration and vigilance. Conversely, a *threat*, or assessment that resources are incommensurate to demands, engenders *distress,* and causes cognitive anxiety, sympathetic nervous system activation, and hypothalamic-pituitary-adrenal axis activation. Thus, threatened individuals experience subjective anxiety, increased heart rates, elevations in circulating cortisol levels, and exhibit poor performance. This poor performance may be characterized by hypervigilance, high distractibility, decreased working memory, defective teamwork, and poor decision making.[2,4] Threat appraisals occur more frequently when individuals perceive stress as socioevaluative, that is, that peers or superiors are judging their performance, or as uncontrollable, that is, beyond the scope of their abilities or training.[2] Interestingly, the cognitive appraisal anxiety theory, multidimensional anxiety theory, and catastrophe anxiety model have each demonstrated that individuals with high self-confidence and the belief that they can control a situation's outcomes are more likely to exhibit performance enhancement under stressful conditions.[1,2,15] Cognitive and physiological arousal appear to be commingled in a complex manner and likely cannot be easily isolated. Measurements of both cognitive anxiety and physiological arousal ought to be incorporated into further study on acute stress to improve our understanding of how these variables affect performance.

MEASURING ACUTE STRESS: SUBJECTIVE VERSUS OBJECTIVE

In experimental settings, stress can be measured both subjectively and objectively. Typically, subjective measures capture self-perceived levels of stress through questionnaires, whereas physiological measures identify objective effects of the stress response. It is not clear which type of measurement—subjective or biometric—should serve as the gold standard when both are used. The theoretical interplay between cognitive and physiological arousal further complicates real-time stress measurement. Descriptive models typically treat cognitive and physiologic arousal as separate variables, but biometric stress measurements are typically validated against subjective cognitive measures, suggesting that they are viewed as measuring the same phenomenon. The limited success of these efforts at subjective/physiologic correlation lends credence to the premise of more descriptive models; namely, that 2 separate but related variables are being assessed.[9,16,17] In stress research among trauma teams, these conceptual hurdles are compounded by practical considerations of portability, sterility, privacy, and accuracy in self-reporting. Physiological measurements are also notoriously confounded by activity, fatigue, medications, caffeine, and even speech.[12] Lengthy surveys are impossible and unethical during high-stakes decision making. Understanding the trauma-specific pros and cons of common subjective and objective measurements of stress is important in designing stress research and evaluating the applicability of previous research on stress to trauma care.

The 2 most commonly used subjective measures of acute stress are the State Trait Anxiety Inventory (STAI) and the Subjective Units of Distress scale. The STAI is traditionally a 40-question inventory evaluating self-perceived stress, but has been abbreviated to a 6-question format to be used in surgical studies.[16,18,19] The Subjective Units of Distress scale consists of a 1-question measurement of self-perceived stress ranging from 0 to 100.[20–23] Subjective measures of stress are vulnerable to reporter bias, and survey collection methods may disrupt surgical workflow, especially during time-critical events where stress is more likely. These difficulties might be avoided in the future with the validation of a physiological measurement of stress correlated to subjective measures of stress.

Physiological measures used to evaluate stress include salivary and serum cortisol levels, skin conductance testing, heart rate variability (HRV), inflammatory markers, facial heat mapping, and blood pulse waveform.[2,12,16,17,20,24–29] Although it has not yet been conclusively validated, HRV is among the most promising methods for physiological monitoring due to its high precision in real-time and unobtrusive, noninvasive monitoring.[16,17] Even among investigators using HRV, there is wide variance in how the data is analyzed and applied, ranging from the standard deviation of beat to beat intervals to complex analysis using nonlinear mathematics.[17] Future studies of stress measurement in trauma care will likely require development of both physiologic and subjective/cognitive metrics, which are accurate and feasible in the trauma setting.

CAREGIVER STRESS DURING EMERGENT INPATIENT CARE

There is little data on acute stress during initial hospital evaluation of injured patients. However, as both require efficient triage, diagnosis and provision of acute care, the experience of EM residents and IM residents on emergency department (ED) rotations may be comparable to some aspects of the experience of surgeons participating in trauma care. In a study by Gonzalez-Cabrera et al. in Granada, IM residents in the ED had significant elevations in salivary cortisol, with the greatest relative increase in cortisol occurring 4 hours prior to the start of their shift.[30] The anticipatory stress demonstrated by that rise in salivary cortisol may have marked effects on patient outcomes in the hospital. Arnetz et al.[31] illustrated the correlation between EM residents' expectation of their stress level in an upcoming shift and the number of reported near-miss events they had during that shift. Anticipatory stress may also affect trauma care providers, and future studies focused on management of preshift stress have the potential to reduce near-miss events and improve trauma patient outcomes.

Besides the timing of stress with regard to emergency shifts, the other body of research looking at stress in IM residents providing emergency care studies the effect of level of experience on stress. There is conflicting evidence as to whether the stress response is modulated by level of training among nonsurgical residents providing emergent care. The IM residents working in an ED do not demonstrate any relationship between cortisol response and years of residency training.[29] This is in contrast to other research which indicates that resident or physician experience decreases the association of elevated heart rate, systolic blood pressure response, and diastolic blood pressure response with emergencies and 24-hour shifts.[32,33] These studies offer interesting insight that experience may not be enough to mitigate stress responses and that even the most seasoned trauma practitioner may benefit from recognizing stress and actively managing it.

ACUTE STRESS AND EMERGENT PREHOSPITAL CARE

The EMS providers provide care under conditions that in many cases are analogous to other trauma practitioners. The EMS providers may be required to make critical triage decisions, perform rapid evaluation with limited information, and are subject to extensive distractions. In an early study on the effects of stress in prehospital emergency care in 2005, LeBlanc et al.[34] demonstrated increased drug dose calculation errors by paramedics after a high stress resuscitation simulation. Although senior paramedics made fewer dosage errors than novice paramedics, both groups performed worse following the high stress scenario.[34] A simulation study of highly experienced paramedics conducted in Norway found that the addition of socioemotional stress in the form of a distraught bystander increased participants' perception of effort, mental strain, and frustration, but did not result in a qualitative impact on their cardiopulmonary resuscitation (CPR), a basic technical skill.[35] In a later simulation study with high and low stress scenarios, LeBlanc et al.[36] demonstrated that paramedics performed worse under high stress conditions; participants also demonstrated significant elevations in salivary cortisol and subjective anxiety in response to the high stress scenario. Following the high-stress scenario, paramedics were more likely to document additional actions or information that did not occur in the simulation, that is, errors of commission, compared with documentation following the low-stress simulation.[36]

Given the similar roles of paramedics and trauma caregivers, it is likely that the latter are also vulnerable to these effects of high stress, including calculation mistakes, perceived mental strain, or errors of commission. It is notable that the calculation and documentation errors were demonstrated after the stressful scenario, implying that a stressful event may have repercussions for patient care even after it has been resolved. Further research should better elucidate these effects in trauma care and help trauma care providers to manage or avoid them, especially as errors of commission during sign-out or real-time documentation may have significant impact on patient care. In the interim, trauma providers should be aware of the potential risk of mental errors during and after exposure to stressful situations.

INTRAOPERATIVE STRESS

Since Arora et al.'s call for further research on stress in surgery in 2010, numerous studies on the effects of intraoperative stress have been published. In the last 2 years, systematic reviews on quantification of stress in surgery, a framework for the effects of intraoperative stress on patient outcomes, and applications for mental skills training in surgery have been published.[37–39] In terms of technical performance, acute stress has greater impact on surgical trainees than experienced surgeons, and induces worse performance in laparoscopic procedures compared with open surgeries.[40] Furthermore, acute stress impairs resident learning and acquisition of technical skills.[29,40] In a recent article, Pavlidis et al. demonstrated improved time to skill acquisition in microvascular surgical techniques when novices were trained under deliberately low-stress conditions[29]

Intraoperative stress also undermines nontechnical skills, such as communication, teamwork, situational awareness, and decision making, which can result in adverse outcomes.[37,41] Comprehensive mental skills training (CMST) encompasses techniques for stress management and performance enhancement and has been widely incorporated into military, aviation and professional athlete training programs.[2,39,42] The CMST includes a variety of approaches such as visualization, preperformance routines, positive self-talk, and energy management. Currently, mental skills training curricula for surgeons focus more on visualization for intraoperative skills rather than stress modulation techniques such as energy management.[39] Although acquiring technical proficiency in surgical procedures is the critical component of surgical training, nontechnical skills are also fundamental to success as a surgeon.[41] Given the importance of communication, decision making, and teamwork to the delivery of trauma care, incorporation of CMST may be particularly beneficial in this setting.

STRESS IN TRAUMA CARE

Although trauma-specific acute stress literature is limited, a few studies have established the physiological and psychological effects of acute stress in trauma. In a pilot study of high- and low-stress trauma simulations using general surgery and EM residents, Harvey et al.[43] demonstrated a positive correlation between cortisol levels and STAI scores in residents who perceived scenarios as a "threat." In a separate analysis, Harvey et al.[44] also showed reductions in residents' simulation checklist performance scores and postscenario recall consistent with the distractibility, hypervigilance and decreased working memory expected in persons experiencing acute stress. By contrast, Joseph et al.[9] measured stress in real time during trauma activations and emergency surgeries for 22 attending trauma surgeons and general surgery residents using HRV monitoring and the STAI. Objectively, they found that all participants had increased stress during trauma activations and emergency surgery, although attending surgeons demonstrated significantly lower stress than residents. Subjective STAI scores, however, did not correlate with stress measured by HRV monitoring. This seeming disconnect led Joseph et al.[9] to posit that trauma surgeons and surgical trainees may regularly mischaracterize or discount the stress they experience in the hospital. These studies demonstrate the presence of acute stress in trauma simulations and evidence of increased physiological arousal during trauma shifts as well as theoretical increased error.

A few studies in trauma care have examined the effects of stress management interventions in surgical training programs on performance and perceived mental strain. Maher et al.[45] published a pilot study in which a brief educational intervention on stress management preceded a high stress trauma simulation. Although STAI and salivary cortisol measurements of stress remained consistent between the intervention group and controls, residents who received the stress management training reportedly found the intervention valuable and highly relevant to their future practice.[45] While the follow up study by Goldberg et al.[46] remained underpowered, residents who participated in the intervention showed significantly improved time to accurate diagnosis and improved technical performance for emergency procedures. Similarly, Lorello et al.[47] studied the application of mental practice on teamwork in trauma resuscitations. Paired trauma team leaders (general surgery residents) and trauma team members (anesthesia and EM residents) who underwent a 20-minute mental practice session prior to a trauma simulation scored higher on the Mayo High Performance Teamwork Scale than control pairs who received 20 minutes of Advanced Trauma Life Support (ATLS) instruction.[47]

Recently, acute stress management has been bundled with other related competencies under the rubric of "mental skills." This approach recognizes that masterful performance in high-stakes environments requires a number of trainable skills and behaviors before, during, and after performance. Many of these skills pertain to the management of acute stress. In mental skills training, stress mitigations strategies are often borrowed from diverse sources and may include preevent visualization, mindfulness, positive self-talk, breathing techniques, refocusing, and tactical pauses.[48,49] These approaches and others have been studied to a limited extent in surgical settings.[50]

Although the trauma-specific acute stress literature is small, these studies demonstrate the presence and detrimental effects of uncontrolled stress during trauma and suggest future directions for integrating stress mitigation skills into surgical training. As with other clinical skills, there is an incomplete understanding of the relative utility of simulation versus real-world training in acquisition of stress management expertise. Many dimensions likely contribute to the success of simulation training.[51] Fidelity and realism are intuitively important, but may be hard to define or achieve.[52] Because acute stress is explicitly an emotional phenomenon, high-fidelity simulation or even real-world training may have increased importance.

CONCLUSION

Stress is ubiquitous in medicine, and trauma surgeons in particular experience volatile conditions with frequent periods of high stress. Based on psychological models of stress, such as the Yerkes-Dodson curve, multidimensional anxiety theory, and the threat versus challenge hypothesis, further study on acute stress and performance in medicine should incorporate measurements of both cognitive anxiety and physiological arousal to improve our understanding of how these variables affect performance in high stakes medical care. As our understanding of the effects of stress on technical and nontechnical skill improves, so too does the importance of research into how to mitigate this stress. Future work should thoroughly quantify acute stress in trauma care, and characterize its effects on medical errors, patient outcomes, surgeon wellness, and surgical education. Tools developed by allied fields—in medicine, military, athletics, and beyond—should not be ignored.

AUTHORSHIP

J.K. participated in the review design, the literature search, the writing of the original text, and the critical revision of this article. M.T. participated in the review design, the literature search, the writing of the original text, and the critical revision of this article. A.F. participated in the critical revision of this article. S.F. participated in the review design and the critical revision of this article. E.H. participated in the review design, the literature search, the writing of the original text, and the critical revision of this article. J.S. participated in the review design, the literature search, the writing of the original text, and the critical revision of this article.

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