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WELLNESS FOR THE TRAUMA SURGEON (J HARTWELL AND T ANAND, SECTION EDITORS)

Sleep Deprivation, Burnout, and Acute Care Surgery

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Abstract

Purpose of Review To define what sleep deprivation is, how it relates to the growing problem of burnout within surgeons, and what can be done to mitigate its effects.

Recent Findings There is a growing awareness that sleep deprivation, in both its acute and chronic manifestations, plays an immense role in burnout. The physical and mental manifestations of sleep deprivation are manifold, effecting nearly every physiologic system. Studies evaluating strategies at mitigating the effects of sleep deprivation are promising, including work done with napping, stimulant use, and service restructuring, but are fundamentally limited by generalizability, scale, and scope.

Summary The overwhelming majority of data published on sleep deprivation is limited by size, scope, and generalizability. Within acute care surgery, there is a dearth of studies that adequately define and describe sleep deprivation as it pertains to high-performance professions. Given the growing issue of burnout amongst surgeons paired with a growing patient population that is older and more complex, strategies to combat sleep deprivation are paramount for surgeon retention and wellbeing.

Keywords Acute care surgery · Trauma surgery · Sleep deprivation · Burnout

Introduction: What Is Sleep Deprivation?

Burnout affects approximately 50% of physicians and encompasses a multifaceted and multifactorial psycho- and physiological phenomenon that is deleterious to personal well-being [1•]. The phrase "burnout" dates to the 1970s and describes the response to workplace stressors via three domains: depersonalization, emotional exhaustion, and reduced personal accomplishment [2•, 3•]. These risk factors can be measured using the Maslach Burnout Inventory, created by Dr. Christina Maslach, to evaluate the presence and/or degree of burnout one is experiencing [3•]. Terms synonymous with burnout, such as "moral injury" or "moral distress," expand upon the experience to include its psychological and interpersonal effects. Burnout is part of a tripartite feedback mechanism which involves health conditions and sleep disturbances. Sleep loss can worsen mental and physical wellbeing through stress, anxiety, depression, and decreased cognition. These in turn form a feedback loop which in turn can worsen sleep loss. This creates a negative cycle involving poor sleep, worsening health conditions, and increased feelings of burnout as deftly demonstrated by Stewart et al. (Fig. 1 adapted from their referenced work) [4].

The symptomatology of burnout, including overwhelming exhaustion, detachment from or cynicism about reality, and difficulty accomplishing tasks, overlaps with somatic causes of burnout (e.g., sleep deprivation) [4]. Sleep deprivation itself has similar health effects in which exhaustion, waning empathy, and apathy are all implicit [4]. Moreover, the timeline of sleep deprivation varies with its chronicity: acute sleep deprivation being no sleep for a time period of greater than 24 h, and chronic sleep deprivation typically defined as lack of or poor quality sleep over at least 6 nights

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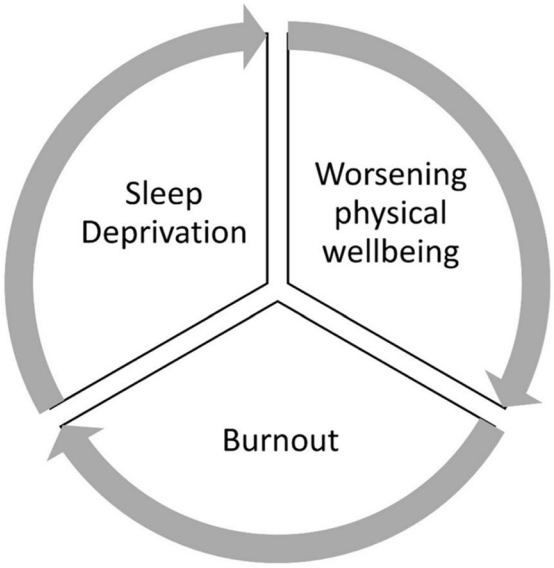

Fig. 1 Negative cycle involving poor sleep, worsening health conditions, and increased feelings of burnout. Adapted from Stewart et al. [4]

[5]. Lack of sleep causes physiologic distress that deranges cardiovascular, neurocognitive, metabolic, and immunologic processes. Disruption of these mechanisms can manifest in disturbances of emotional states including mood changes and irritability. Moreover, sleep deprivation can manifest somatic disturbances including changes in appetite, sleepiness, and paradoxically insomnia [2•]. Perhaps most troubling, poor sleep can have profound consequences on concentration, memory, and task performance—domains utterly germane to acute care surgeons dealing with highly complex and high-acuity patient populations [6, 7•].

In the short term, acute sleep loss is associated with impaired executive functioning and psychomotor responses to varying degrees [5, 7•, 8]. In a 1972 study on the effects of stress in surgical performance, Goldman et al. assess sleep-deprived residents in multiple areas of task performance in the operating room [8]. Eighty percent of residents demonstrated physiological derangements with acute sleep deprivation (i.e., tachycardia above baseline) as well as diminished operative efficiency and poor execution of planned maneuvers. In addition to the physiologic burden, sleep deprivation imbues on healthcare workers, procedural proficiency may also be at risk [7•, 9].

Chronically, the effects of sleep loss accumulate over time, affecting higher-level cognitive functioning and inducing a state of chronic stress which can cause wide-ranging physiologic effects including hypertension, hyperglycemia, and immune response suppression via disruption of the hypothalamic-pituitary-adrenocortical axis (HPA) and the sympathetic-adrenal-medullary system [7•, 10, 11]. One study on sleep deprivation and cortisol levels found an elevation in serum cortisol levels after a single night without sleep to 9.6 µg/dL from a baseline 8.4 µg/dL indicative of HPA disruption [11]. The psychological effects of chronic sleep deprivation can include negative self-perception, decreased ability to concentrate or make appropriate judgments, and increased anger and irritability [2•].

Sleep deprivation has a clear association with burnout, even among trainees, and can affect the personal life of surgeons [3•, 4, 12]. Sleep deprivation can potentiate hyperarousal stress states and burnout can lead to increased insomnia and changes in the architecture of sleep, creating a negative cycle of decreasing sleep quality [4]. High rates of depression, substance and alcohol abuse, divorce, and suicidality can further compound in a specialty which is already plagued by a high divorce rate and a 150-to-300% increased suicide rate compared to the general population [2•, 4, 7•]. Poor sleep health has been linked to increased pregnancy complications, somatic complaints, and increased rates of motor vehicle crashes [7•].

Disengagement and lack of empathy caused by sleep deprivation can lead to decreased attention and care for patients. Notably for surgeons, sleep deprivation has been associated with longer operative times due to inefficiency and increased error rates [2•, 7•]. A national survey in 2010 found that 9% of surgeons made a major medical error within the past 3 months and these errors were strongly associated with symptoms of burnout and depression [9]. While there also appears to be an association between increased levels of burnout and decreased patient outcomes, causality remains to be determined [13].

Beyond the effects of sleep deprivation on individuals, the impact of poor sleep health on economic and health systems outcomes cannot be understated. With an affected workforce, employers can experience a decrease in employee retention, higher medical errors driving up financial costs, and decreased productivity [2•, 3•]. Physicians experiencing burnout have a higher risk of voluntary reduction in work hours due to exhaustion. When viewed at a national level, the lost productivity equals that of over 1000 full-time physicians [13]. With ongoing surgeon shortages and in the wake of an ongoing pandemic, reductions in efficient healthcare workforce can provoke crisis [14••].

Factors Effecting Burnout and Sleep Deprivation

Sleep deprivation is syndromic of systemic issues including available surgeon supply, patient volume and complexity, and the need to provide 24/7/365 hospital coverage [15, 16]. Sparse literature exists on solutions to sleep deprivation

and finding a one-size fits all solution to the issue of sleep health is likely untenable as differing hospitals, practices, and systems have different needs. Instead, discussing the key factors contributory toward sleep deprivation and influential on burnout will yield more avenues for the development and implementation of meaningful solutions. We feel from an organizational perspective that ambiguity in the definition of what an acute care surgeon and the growing surgeon shortage play immense roles in surgeon attrition (Table 1). Both of these areas directly contribute to surgeon clinical workload and to the scope of practice acute care surgeons can accomplish [17]. As such, their addressal is required to better understand the milieu in which any strategy to combat sleep deprivation is derived.

Defining a Full-Time Equivalent

Discussion on a national level is needed on what acute care surgery is as a specialty, what its needs are, and what constitutes a standard full-time equivalent (FTE). Without a generalizable, consensus-based standard on what an acute care surgeon does, it is difficult to determine what constitutes fair and equitable workloads. Defining a standard for acute care surgery is difficult, and the debate on what acute care surgery *is* has been ongoing for nearly 20 years [18]. Among their many findings, Esposito et al. demonstrated through a questionnaire distributed through the Eastern Association for the Surgery of Trauma membership that there was little consensus in practice or and sparing agreement in on the breadth and depth of acute car surgery. More recently, Murphy et al. performed a national survey of trauma surgeons across the USA inquiring about a range of different metrics including call loads, compensation, distribution of service coverage, and frustrations in balancing academic and administrative responsibilities [19••]. Across a variety of academic and non-academic institutions, there was a wide range of responses with deep heterogeneity across nearly all queried metrics. Of the several findings, perhaps the most illuminating was the differing service models across like institutions. For instance, in the level I contingent few centers had similar FTEs available for staffing, and both the call burden and type of call (home vs in-house) ranged significantly. Between level I and III centers, these differences only widen. Just as all politics are local, we infer these findings as indicative that individual institutions develop in a manner to meet their needs, and likely do so under the financial and resource constraints imposed upon them by geographic and administrative factors (where your center is located and how is it viewed by hospital administration). The authors appropriately conclude that "defining FTE for an ACS…is nuanced and depends on a multiple of factors…."

Surgeon Supply

Surgeon supply can significantly impact both burnout and sleep deprivation. In-house call requirements, service staffing, and administrative time are bottlenecked by the number of available surgeons to share the workload. Surgeon shortage is a large issue and influenced by innumerable factors but can directly impact patient care and physician wellbeing [20–22]. High-stakes decisions and routine exposure to patient suffering culminate with acute care surgeons having the highest rate of burnout across surgical subspecialties [23]. Many surgeons feel lack of control on individual, group, and organizational levels and lack in agency in work-life balance all contribute to burnout [19••, 24••, 25]. While little work has been done to show the impact of work hours and call burden on physiologic stress, recent work has suggested that the effects of sleep deprivation are both prevalent and long-lasting [26••].

To that end, service model makeup including call burden and call distribution is inexorably linked to surgeon retention. In their prospective, single-center study of trauma surgeons at a level I trauma center, Jones et al. changed service models from 24-h in-house call to 7 days of 12-h shifts. Through survey of both surgeons and friends/family, they demonstrated reductions in emotional exhaustion, depersonalization, and diminished sense of personal accomplishment without requiring extra resources or reducing clinical productivity [27••].

Table 1 Factors affecting burnout and sleep deprivation

Factor	Implications
Variable FTE	Lack of standardization makes it difficult to establish national best practices Without a standard definition, difficult to weigh physician well-being against demands of 24/7/365 coverage
Surgeon shortage	Imbalances between an increasingly older and complex patient population and burgeoning surgeon shortages will likely potentiate increased burnout Academic and administrative workloads may not necessarily adjust despite more clinical work for less surgeons
Poor Retention	Poor surgeon retention due to burnout will likely only exacerbate stressors already imposed on physicians
Pandemic	Inflexible staffing models respond poorly to unintended stressors (e.g., the COVID-19 pandemic) contributing to burnout

FTE full-time equivalent

The Unseen and Unplanned Stressors

Many of the factors that place physicians at risk of burnout such as increased workload, decreased perceptions of control, limitations in resources and supplies, disruptions to sleep and work-life balance, and diminished sense of reward had increased prevalence during the COVID-19 pandemic and led to a surge in burnout of health care workers [28]. While data regarding the effects of the pandemic on burnout, sleep deprivation, and overall surgeon wellbeing are either yet in their infancy or non-existent, unseen and unplanned stressors likely have detrimental effects on all aspects of care.

Sleep Deprivation Strategies

Focus on using evidence-based strategies targeted to combat sleep deprivation can be impactful and tailored to the needs of individuated systems. Or more plainly, when you are up at 3am, what can be done to lessen the physiologic and psychologic toll by lack of sleep? The induction of work-hour restrictions in 2003 led to a proliferation in changes of service models including the induction of night float systems [29]. But data evaluating strategies to mitigate the impact of work schedules necessitating a flip in the circadian rhythm are sparse, and most of these studies center on graduate medical education trainees with large heterogeneity in specialty. Nevertheless, most research focuses on three areas: napping strategies, stimulants such as caffeine and modafinil, and melatonin.

Napping holds an intuitive advantage over other modalities as it engages natural restorative processes through which even minor increases in sleep accrual diminish the negative impacts of sleep deprivation [30]. This is so much so that the American Academy of Sleep recommends endorses napping for physicians-in-training to reduce fatigue. Within resident training, Arora et al. demonstrated that interns working 30-h shifts reported less fatigue both during call shifts and post-call with an average nap duration of 41 min [31]. When patient responsibility was transitioned to colleagues during a scheduled nap, the average nap duration increased to 68 min. Moreover, uninterrupted naps lead to less sleep disturbances and better sleep quality as anticipation of interruption has been shown to lead to sleep fragmentation [32]. In drivers, napping may have comparable effects to caffeine in reductions of fatigue and sleepiness, and a wealth of research in the transportation industry suggests napping is an effect means of alleviating fatigue [33–35]. In one of the few randomized trials evaluating the effectiveness of napping on task performance, Tempesta et al. conducted a prospective quasi-experimental trial on napping during night shift [36]. Their trial demonstrated that for interns with 2-h naps compared to no naps on shift, the 2-h napping group had better task switching, improved performance speed, and less need for post-call sleep duration for recovery. In a randomized, controlled interventional trial of emergency medicine residents and registered nurses, Smith-Coggins et al. reported that even a 40-min nap showed improvements in several objective and self-reported metrics including reaction times, measures of fatigue, and memory [37]. This aligns with data equating acute sleep deprivation to being intoxicated with alcohol [38•].

Supplementation with melatonin has been sought to reset the circadian rhythm and darkness-related activities including sleep propensity [39]. A recent meta-analysis of melatonin use in patients with insomnia demonstrated reductions in time to sleep with exogenous supplementation of melatonin compared to placebo [40]. This has similarly been demonstrated in other sleep disorders such as sleep–wake phase disorders where melatonin supplementation reduced REM latency [41]. In healthcare workers, however, data on melatonin supplementation is sparse. To date, two randomized trials have been performed evaluating the effects of 1-mg oral melatonin and 3-mg oral melatonin in emergency medicine and pediatric medicine residents, respectively. In the former, 19 EM residents were given 1-mg oral melatonin after 3 consecutive night float shifts after which self-reported metrics on sleep duration, recovery, alertness, and mood were assessed [42]. The authors reported no beneficial effects with supplementation of 1-mg melatonin. In a separate study, Cavallo et al. evaluated whether a 3-mg dose of melatonin positively affected similar metrics, but only demonstrated a significant reduction in omission errors with no significant effect on sleep duration, mood, or other measures of attention [43]. *En masse* the available data does not appear to defend melatonin use for the treatment of sleep deprivation, and what data exists is insufficient to be generalized to surgeons.

Stimulant use to combat sleep deprivation has been studied at length for its potent antagonism of the adenosine receptor which has been identified as a key regulatory neurotransmitter in sleep promotion [44]. In mice, caffeine use has been demonstrated to block the A_{2A} subtype of the adenosine receptor and promote wakefulness, and genetic deletion studies of the A_{2A} receptor resulted in blocking caffeine-induced wakefulness [45•, 46]. Human studies of the effects of caffeine administration on sleep suggest that caffeine increases sleep latency and promotes alertness, but variable dosing, chronicity of caffeine administration, and confounding effects of test subject lifestyle choices make it difficult to codify these results. Chronic administration of caffeine may result in tolerance of the caffeine-induced antagonism of the A_1 and A_{2A} receptors making the synthesis of data on caffeine use for sleep deprivation in chronic users difficult [47, 48]. Work on the subjective effects of caffeine suggests that caffeine intake after abstinence of caffeine for > 24 h may alleviate sleep pressure during sleep

deprivation, but chronic caffeine use may mitigate the effectiveness of sleep pressure reduction [49, 50]. The effects of caffeine in healthcare workers have not been well characterized. A single randomized trial performed by Huffmyer et al. analyzed the effects of 160 mg of caffeine on post-night-float stretch (6 nights) anesthesia residents compared to a non-caffeinated drink and conducted controlled driving performance tests [51]. Their results demonstrated caffeinated subjects had improved driving performance and reaction times compared to placebo, but only after prolonged driving (> 10 min) suggesting complex and prolonged task performance may benefit but there is an on-boarding time where caffeine may not demonstrate effect.

The crux of these trials lies in their generalizability. In a 2020 review of works on optimizing sleep performance during night float for graduate medical education, Sholtes et al. screened 2818 references of which only 5 original works met their inclusion criteria of being specific to trainees working in night-shift systems and had either a pharmacological or non-pharmacological intervention to effect sleep deprivation [52••]. Of those 5 studies, only 3 were conducted in the USA, one in Italy, and one in the UK and the specialties examined were similarly limited. The authors conclude "without good data, it is not surprising that there is insufficient evidence for interventions to guide graduate training programmes to help GME trainees navigate working night float shifts." In our opinion, this sentiment is germane to any evaluation of sleep deprivation and its mitigation thereof in acute care surgeons. The gravity of burnout along with the synergistic parasitism inadequate sleep has with it on physician wellbeing underlies a dire need for further studies on the amelioration of sleep deprivation.

Conclusions

Sleep deprivation and burnout are distinct, yet intimately associated manifestations of a healthcare system designed for the wellbeing of patients but not necessarily surgeons. It is in our opinion that the current body of academic literature about sleep deprivation in the context of acute care surgery is wholly inadequate to address the negative cycle of burnout, sleep loss, and health disparity growing within acute care surgery. Ongoing national discussions regarding the standardization of FTEs are promising and needed, and there is equipoise within existing data that service model variation is a viable area of study for the wellbeing of trauma center and surgeon alike. As the population grows in age and complexity and as surgeon shortages loom in the wake of an alarming epidemic of burnout amongst providers, work into the amelioration of sleep deprivation and burnout is paramount for the viability of the profession of trauma surgery in isolation and the healthcare system at large.

Declarations

Conflict of Interest The authors declare no competing interests.

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