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Surgeons' and surgical trainees' acute stress in real operations or simulation: A systematic review

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ABSTRACT

Background and purpose: Acute stress in surgery is ubiquitous and has an immediate impact on surgical performance and patient safety. Surgeons react with several coping strategies; however, they recognise the necessity of formal stress management training. Thus, stress assessment is a direct need. Surgical simulation is a validated standardised training milieu designed to replicate real-life situations. It replicates stress, prevents biases, and provides objective metrics. The complexity of stress mechanisms makes stress measurement difficult to quantify and interpret. This systematic review aims to identify studies that have used acute stress estimation measurements in surgeons or surgical trainees during real operations or surgical simulation, and to collectively present the rationale of these tools, with special emphasis in salivary markers.

Methods: A search strategy was implemented to retrieve relevant articles from MEDLINE and SCOPUS databases. The 738 articles retrieved were reviewed for further evaluation according to the predetermined inclusion/exclusion criteria.

Results: Thirty-three studies were included in this systematic review. The methods for acute stress assessment varied greatly among studies with the non-invasive techniques being the most commonly used. Subjective and objective tests for surgeons' acute stress assessment are being presented.

Conclusion: There is a broad spectrum of acute mental stress assessment tools in the surgical field and simulation and salivary biomarkers have recently gained popularity. There is a need to maintain a consistent methodology in future research, towards a deeper understanding of acute stress in the surgical field.

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Introduction

Stress can be defined as a stability imbalance that occurs when an individual is emotionally activated and perceives that cognitive and/or performance requirements outweigh the available resources[1] or as a physiological arousal, which represents an always present mechanism of coping with perceived or real threats or challenges.[2] Stress is believed that greatly contributes in performance and task execution.[3]

It is well known that surgeons work in a stressful environment due to the abundant surgical challenges, the technical requirements, and the time pressure they face every day. It is also known that acute stress has a direct impact on surgical performance and patient safety.[4,5] Moreover, surgical teams frequently encounter highly complex crisis situations, which can cause considerable stress and can, in turn, directly contribute to patient outcomes.[6,7] Moreover, due to the evolving nature of surgical techniques, surgeons will continue to experience increasing acute stress, thus, making stress assessment more relevant and necessary than before.

Án in-depth understanding of how surgeons perceive operative stress is still missing.[8] Several factors have been suggested to affect surgeons' operative practice including mental and environmental stressors[9] such as bad perioperative sleep quality,[10] engagement levels and emotional exhaustion,[11] complex or rarely performed cases, lack of experience in the performance of new surgical procedures, such as laparoscopy,[12] and poor assistance.[5] Therefore the ability to implement a coping strategy to deal with stress seems to be important for enhancing performance.[13] In order to address these issues, formal intraoperative stress management training becomes a necessity.[5,14]

In contrast to real surgery ever changing cases, simulators provide a standardised milieu that allows inter- and intra-individual comparisons among participants. Furthermore, simulation training is a well-established method for improving technical and non-technical skills in a controlled and quantitative manner.[15] It is assumed that a high-fidelity simulator can replicate real psychological challenges and stress[9] and yet it can facilitate lower stress loads in real environments.[16,17] A simulation based study showed that surgeons with insufficient stress-coping strategies demonstrated poor performance in virtual laparoscopic procedures.[18]

Among the several methods proposed to measure and assess a trainee's competence in a simulated environment, it is evident that technology-based measures can avoid bias and should be preferred to quantify performance and provide objective metrics.[19] Today, various performance parameters derived from technology-based assessment tools have been proposed and used, such as motion tracking, visual attention, stress responses, and video analysis. Each one of them has advantages and disadvantages and corresponds to a specific objective interpretation of performance.[20] The complexity of stress mechanisms and the involved factors make acute stress estimation and measurements difficult to interpret.

However, only limited data exist in the literature regarding surgeons' acute mental strain measurement methods in the surgical operating and simulation field, while several stress-measuring tools, including subjective and objective methods, have been used for this purpose.

Subjective assessment tests

Subjective assessment tests involve self-assessment of the subject through report forms or structured questionnaires. The Spielberger State-Trait Anxiety Inventory (STAI)[21] is the most commonly used subjective test. The STAI is a validated tool for quantifying emotional, physical, and cognitive aspects of stress experienced. It consists of 40 self-report items pertaining to anxiety effect. A-Trait scale and A-State scale are composed of 20 items each and are scored on 4-point Likert-type response scales. Higher scores correspond to higher level of stress. It is usually completed before and immediately after each operative procedure or simulation task. Recently, the Imperial Stress Assessment Tool (ISAT) was created by the combination of STAI with objective physiological variables (heart rate and salivary cortisol levels), as another improvement in the evaluation of acute surgical stress.[22] Rarely, another subjective acute stress assessment tool used is the observer rating, which incorporates an analogue scale to quantify the surgeons' acute mental strain through an observer.

Objective assessment tests

Heart rate (HR) and heart rate variability (HRV)
Acute stress affects the autonomic nervous system (ANS) that modulates HR. HRV corresponds to the beat-to-beat changes in heart rate[23] and is a non-invasive tool to estimate heart rate modulation by the ANS in a variety of settings including stress.[24,25] Thus, intraoperative acute surgeons' stress causes acute changes in the ANS that are reflected by HRV. HRV is calculated by digital processing of electrocardiograms (ECGs). Several HRV parameters are computed using time-domain, frequency-domain, and nonlinear methods.[26,27] In the frequency domain evaluation, the high frequency (HF) component represents the parasympathetic activity, and the low frequency/HF ratio represents the sympathetic activity.[28] Also, ANS activity is quantified by time domain analysis of R–R interval variability.[29]

Electrodermal activity (EDA) or galvanic skin response (GSR) or skin conductance (SC)
One of the three types of sweat glands are the eccrine glands. Apart of their presence on hairy skin, they can also be found on the skin of the palm and sole, where they are activated by deep respiration, mental stress, and local tactile stimulation. These glands exhibit the phenomenon known as "emotional sweating". The limbic system appears to play a role in emotional sweating; therefore, the measurement of sweat output in these regions may be a tool for assessing sympathetic function and limbic activity.[30] As the skin eccrine glands of the palm and sole excrete sweat in response to autonomic stimuli, they cause fluctuations in electrical conductivity, enabling the GSR to be measured.

Thermal activity (TA)
Under acute stress, sympathetically mediated vasoconstriction occurs and together with stress-induced thermogenesis they

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