The impact of heat stress on operative performance and cognitive function during simulated laparoscopic operative tasks

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Background. *Increasing ambient temperature to prevent intraoperative patient hypothermia remains widely advocated despite unconvincing evidence of efficacy. Heat stress is associated with decreased cognitive and psychomotor performance across multiple tasks but remains unexamined in an operative context. We assessed the impact of increased ambient temperature on laparoscopic operative performance and surgeon cognitive stress.*

Study design. *Forty-two performance measures were obtained from 21 surgery trainees participating in the counter-balanced, within-subjects study protocol. Operative performance was evaluated with adaptations of the validated, peg-transfer, and intracorporeal knot-tying tasks from the Fundamentals of Laparoscopic Surgery program. Participants trained to proficiency before enrollment. Task performance was measured at two ambient temperatures, 19 and 26°C (66 and 79°F). Participants were randomly counterbalanced to initial hot or cold exposure before crossing over to the alternate environment. Cognitive stress was measured using the validated Surgical Task Load Index (SURG-TLX).*

Results. *No differences in performance of the peg-transfer and intracorporeal knot-tying tasks were seen across ambient conditions. Assessed via use of the six bipolar scales of the SURG-TLX, we found differences in task workload between the hot and cold conditions in the areas of physical demands (hot 10 [3–12], cold 5 [2.5–9],* P = *.013) and distractions (hot 8 [3.5–15.5], cold 3 [1.5–5.5],* P = *.001). Participant perception of distraction remained greater in the hot condition on full scoring of the SURG-TLX.*

Conclusion. *Increasing ambient temperature to levels advocated for prevention of intraoperative hypothermia does not greatly decrease technical performance in short operative tasks. Surgeons, however, do report increased perceptions of distraction and physical demand. The impact of these findings on performance and outcomes during longer operative procedures remains unclear. (Surgery 2015;157:87-95.)*

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Perioperative hypothermia, a multifactorial consequence of anesthetic-mediated disturbance of thermoregulation, infusion of lower-than-body-temperature intravenous fluids, prolonged exposure to ambient temperatures, and heat loss via cavitary exploration, is responsible for substantial morbidity in patients undergoing operation.[1-3] Increasing ambient operating room (OR) temperature in an attempt to mitigate intraoperative patient heat loss, a strategy assumed both efficacious and risk-free, remains widely advocated despite lack of strong support in the literature. The authors of a recent prospective analysis of patients undergoing emergent operation found no association between ambient OR and patient core temperature and questioned the legitimacy of this practice.[4]

Lack of efficacy is not the only potential problem, because increasing OR temperature may not

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be a completely benign intervention. The greater temperatures advocated for patient normothermia are associated with considerable discomfort in OR personnel, may increase syncope incidence, and also may result in greater rates of operative field contamination by sweating surgeons.[5-7] A substantial body of evidence from the psychological and human performance literature also suggests ambient or core temperatures beyond a specific tolerated range are detrimental to task-performance across a wide range of activities.[8-11] Identification of environmental factors negatively impacting operative performance has important patient safety implications, but the effects of heat stress remain largely unexplored in the medical literature. The current study is the first examination of the effects of heat stress secondary to increased ambient temperature on surgeon technical performance and cognitive function.

METHODS

Basic protocol and outcome measures. This experimental trial was conducted at the University of Southern California (USC) Keck School of Medicine Surgical Skills Center from February 1–28, 2012, using a within-subjects, counterbalanced protocol to test the hypothesis that increased ambient temperature negatively impacts performance during simulated laparoscopic surgical tasks. After approval from the institutional research board, volunteer surgery residents from the USC Keck School of Medicine and clinical fellows from the Los Angeles County Hospital USC Division of Acute Care Surgery were enrolled. All training and testing sessions were conducted in the USC Keck School of Medicine Surgical Skills laboratory. Study participation was solicited and consent obtained using a standardized information and consent form approved by the institutional review board and specially developed for this project. After providing informed consent, participants completed an inventory detailing basic demographic details, their training level, specialty program, estimated past laparoscopic case volume, and participation in the Fundamentals of Laparoscopic Surgery (FLS) program, as well as Likert-scaled ratings of their comfort with laparoscopy and laparoscopic simulators and their interest in pursuing advanced training in this technique.

The study protocol used two validated sets of outcomes measures: a technical performance measure and a measure of cognitive workload. Technical performance assessment used two previously validated simulated laparoscopic operative tasks, one "simple" (peg transfer) and one "complex" (intracorporeal knot tying), used with permission from the FLS, itself derived from the McGill Inanimate System for Training and Evaluation of Laparoscopic Skills.[12-15] These tasks were performed in two ambient conditions, 19 and 26°C (66 and 79°F). The greatest temperature was chosen because it replicated the greatest temperature advocated in the literature for prevention of intraoperative hypothermia; the lesser temperature was selected because it had been associated with acceptable levels of surgeon comfort in a landmark early study of thermal stress in the OR.[5,16] Potential "practice effects" were reduced through both random counterbalancing of participants to the initial ambient temperature as well as incorporation of a "training to proficiency" and "prepractice" period.

Participant cognitive perception of task difficulty and performance was measured using the Surgical Task Load Index (SURG-TLX).[17] The SURG-TLX is a validated instrument designed to measure cognitive and affective perceptions of workload during surgical tasks. The instrument measures response across six self-assessed dimensions: mental demands, physical demands, temporal demands, task complexity, situational stress, and distraction. The SURG-TLX is derived from the National Aeronautics and Space Administration Task Load Index, which has been validated across a wide variety of human performance studies, including use in surgical settings.[18-24] The first part of the instrument involves rating the six cognitive domains along a bipolar scale (range 1 low to 20 high), to determine the amount of stress perceived for each dimension. The second part of the instrument involves calculating the weights of these six dimensions. Participants rank the relative importance of each domain (relative to their experience of the task) through selection of 15-paired comparisons resulting in a ranking (from 0 to 5). The score given by a participant for each domain on the bipolar scale is then multiplied by the ranking assigned to that domain, producing a final score for each cognitive dimension.

For the purpose of this study, we examined both the full instrument as well as the component bipolar scale for each cognitive domain. The rationale for our particular interest in the bipolar scale was that the pairwise comparison portion of the full instrument forces participants to choose one of two types of stress (ie, mental demands or task difficulty) and does not allow the learner to indicate that they felt no stress at all. The forced