



Effectiveness of a comprehensive mental skills curriculum in enhancing surgical performance: Results of a randomized controlled trial



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ARTICLE INFO

Article history:

Received 16 April 2016

Received in revised form

7 October 2016

Accepted 20 October 2016

Keywords:

Surgery
Simulation
Skills training
Skill retention
Mental skills
Stress management
Performance enhancement

ABSTRACT

Introduction: We hypothesized that the implementation of a novel mental skills curriculum (MSC) during laparoscopic simulator training would improve mental skills and performance, and decrease stress.

Methods: Sixty volunteer novices were randomized into intervention and control groups. All participants received FLS training while the intervention group also participated in the MSC. Skill transfer and retention were assessed on a live porcine model after training and 2 months later, respectively. Performance was assessed using the Test of Performance Strategies-2 (TOPS-2) for mental skills, FLS metrics for laparoscopic performance, and the State Trait Anxiety Inventory (STAI-6) and heart rate (HR) for stress.

Results: Fifty-five participants (92%) completed training and the transfer test, and 46 (77%) the retention test. There were no significant differences between groups at baseline. Compared to controls the intervention group significantly improved their mental skill use, demonstrated higher laparoscopic skill improvement during retention, and reported less stress during the transfer test.

Conclusions: The MSC implemented in this study effectively enhanced participants' mental skill use, reduced cognitive stress in the operating room with a small impact on laparoscopic performance.

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1. Introduction

The inherent cognitive demands of surgery, including the need to execute elaborate technical procedures flawlessly, maintain focus for extensive periods of time amidst several distractions, sustain sound clinical judgment and situational awareness, and balance attention between several intraoperative considerations (e.g., patient condition, performance of the surgical team, etc.), may exceed surgeons' stress-management abilities and lead to catastrophic errors that jeopardize patient safety.^{1–3} It has been postulated that there is a dynamic, cascading relationship between adverse factors that contribute to surgeons' stress levels.⁴ That is,

increased intraoperative workload can contribute to heightened cognitive demand, which can eventually surpass the surgeon or team's stress-coping ability, ultimately leading to excessive stress. In a recent survey of surgeons' experience managing intraoperative stressors, we found that 40% of responding surgeons had witnessed a technical complication resulting from the primary surgeon experiencing heightened stress.⁵ The vast majority of respondents (82%) indicated that stress management training would be valuable to surgeons.

Helping surgeons cope with intraoperative stress effectively may thus be critical to enhance surgical performance particularly for inexperienced surgeons. The literature suggests that surgical trainees are more vulnerable than experienced surgeons to succumb to overwhelming intraoperative stress due to their relative inexperience in the operating room, and their associated lack of developed stress management strategies.¹ In prior studies we have demonstrated that despite achieving proficiency on laparoscopic

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surgery simulators in a stress-free environment, surgical novices cannot fully transfer simulator-acquired surgical skill to the clinical environment in part due to overwhelming stress.^{6–8} Further, laparoscopic skills acquired on simulators may deteriorate significantly over periods of inactivity.^{6–10} Thus, there is a need to develop reliable methods to reduce learner stress in the operating room and maximize simulator-acquired skill transfer and retention.

Mental skills, which are psychological strategies intended to help performers reliably achieve their ideal mental state for performance,¹¹ may be able to help surgical novices reduce stress and enhance their transfer of simulator-acquired skills to the operating room. Mental skills training curricula have proved effective at enhancing the performance of several groups who have to perform under high stress conditions such as military pilots,¹² US Navy SEALs,¹³ members of police special forces,¹⁴ and elite athletes.¹⁵ Compared to the more comprehensive application of mental skills in other high-stress fields though, mental imagery (i.e., synonymous with mental rehearsal and mental practice) has been the primary mental skill implemented in surgical research. A recent meta-analysis of randomized controlled trials that implemented mental imagery as a surgical training intervention found that it was effective at enhancing surgical skill acquisition.¹⁶ However, there are several additional mental skills that may be effective at reducing surgical novices' stress and enhancing their performance.

We recently developed a novel, comprehensive, mental skills curriculum (MSC) and have examined its preliminary effectiveness when applied during simulator training of surgical novices. This curriculum consists of several performance enhancing strategies including goal setting, energy management (relaxation or increasing energy), attention and thought management, mental imagery, refocusing strategies, and pre-performance routines. In an initial prospective study novice participants that underwent mental skills training using this curriculum displayed significantly better transfer of simulator-acquired laparoscopic skill to the operating room compared with historical controls.¹⁷ Our objective in the current prospective randomized controlled study was to assess whether training using our novel mental skills curriculum would lead to application of these skills in clinical situations, reduction in participant stress under challenging conditions, and improvements in surgical skill transfer to the clinical environment and retention. We hypothesized that novices who concurrently trained in laparoscopic suturing and mental skills would demonstrate improved laparoscopic skill transfer and retention in the clinical environment compared with a control group that trained in laparoscopic suturing only.

2. Methods

After Institutional Review Board-approval, volunteer surgical novices ($n = 60$, premedical students) were enrolled in this single blinded randomized controlled trial. Participants completed a questionnaire detailing demographics and prior laparoscopic and simulator experience, and had a baseline assessment on the Fundamentals of Laparoscopic Surgery (FLS) peg transfer and intracorporeal suturing,¹⁸ and mental skills use. For the latter the Test of Performance Strategies Version 2 (TOPS-2) was used, which is a 68-item self-report instrument that measures a comprehensive range of psychological skills that have been shown to impact successful athletic performance: goal-setting, imagery, self-talk, relaxation, activation, emotional control, and automaticity.¹⁹ The instrument assesses the frequency of participants' use of these skills in practice and performance situations. Example items from the TOPS-2 include: "I set realistic but challenging goals for practice", "I rehearse my performance in my mind before practice", and "I talk positively to myself to get the most out of my performance during a

procedure". Responses range from: 1-"Never" to 5-"Always". The TOPS-2 has been shown to discriminate between elite and high-level performers in non-competition performance settings, and has been shown to be reliable and valid. The non-normed fit index (NNFI) and comparative fit index (CFI) are excellent for both the competition and practice subscales, (0.97 and 0.97, and 0.96 and 0.96, respectively).¹⁹ This instrument was modified by the authors with permission for use with surgeons by replacing any reference to "competition" with "procedure" as appropriate. For example, one statement from the original instrument read "I evaluate whether I achieve my competition goals" was modified to read "I evaluate whether I achieve my procedure goals".

Participants were stratified according to FLS performance and TOPS-2 scores and randomized into intervention and control groups. The intervention group participants received FLS peg transfer and intracorporeal suturing training during nine training sessions and mental skills training using the novel comprehensive MSC. The control group did not receive mental skills training but followed the same laparoscopic skills curriculum. Skill transfer and retention 2 months after training completion were assessed on a live porcine fundoplication model.

2.1. Training

Participants in both groups attended 9 biweekly, small group ($n = 2$ or 3) training sessions over a period of approximately 5 months. During each session both groups received 45 min of FLS proficiency-based simulation training on peg transfer during the first 3 sessions followed by training in intracorporeal suturing in the remaining 6 sessions. To reach proficiency, participants had to meet previously published expert levels (i.e. 48 s without errors for the PEG transfer and 112 s with no errors of accuracy or knot security for intracorporeal suturing and knot tying)²⁰ on 2 consecutive and 10 additional repetitions. All participants were transitioned to intracorporeal suturing on session 4 or earlier once they had achieved PEG transfer proficiency.

The comprehensive MSC implemented in this study included several mental skills such as action plans (i.e., goal setting), energy management (i.e., relaxation and strategies to increase energy), attention and thought management techniques (i.e., helping participants maintain attention on target and effectively counter negative thoughts), mental imagery, refocusing techniques, and performance routines and has been described in more detail elsewhere.²¹ The MSC group participated in eight biweekly 45-min mental skills education sessions with a mental performance coach, just before their laparoscopic training session. Each session required participants to observe video modules to educate them on specific mental skills and how they may be implemented to optimize surgical performance, complete exercises in an accompanying workbook to crystalize how learners planned to implement each mental skill during surgical simulation training and eventual surgical performance, and practice each skill during the subsequent FLS training session under the supervision and guidance of the mental performance coach to facilitate participants' development of mental skills as habits for performance. Following the 9 session training period, participants were retested according to the same protocol as the baseline assessment.

2.2. Transfer and retention tests

Three weeks after the conclusion of training, participants took part in a transfer test that required to put three gastrogastic sutures on a live, anesthetized porcine model to complete a fundoplication. An expert laparoscopic surgeon (DS) readied and standardized the porcine models for testing as has been described

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