The American Journal of Surgery 213 (2017) 652–655

Contents lists available at ScienceDirect

The American Journal of Surgery

journal homepage: www.americanjournalofsurgery.com

Do errors and critical events relate to hernia repair outcomes?

Katherine Law Forsyth [a], Shannon M. DiMarco [b], Caitlin G. Jenewein [b], Rebecca D. Ray [b], Anne-Lise D. D'Angelo [b], Elaine R. Cohen [b], Douglas A. Wiegmann [a], Carla M. Pugh [a, b, *]

[a] University of Wisconsin-Madison, School of Engineering, Department of Industrial and Systems Engineering, 3214 Mechanical Engineering Building, 1513 University Avenue, Madison, WI, 53706, USA
[b] University of Wisconsin-Madison, School of Medicine and Public Health, Department of Surgery, 600 Highland Avenue, Clinical Science Center, K6/100, Madison, WI, 53792, USA

ARTICLE INFO

Article history:
Received 1 July 2016
Accepted 16 November 2016

Keywords:
Surgical error
Decision-making
Assessment
Laparoscopy
Simulation
Surgical education

ABSTRACT

Background: The study aimed to validate an error checklist for simulated laparoscopic ventral hernia (LVH) repair procedures. We hypothesize that residents' errors can be assessed with a structured checklist and the results will correlate significantly with procedural outcomes.
Methods: Senior residents' (N = 7) performance on a LVH simulator were video-recorded and analyzed using a human error checklist. Junior residents (N = 38) performed two steps of the same simulated LVH procedure. Performance was evaluated using the error checklist and repair quality scores.
Results: There were no significant differences between senior and junior residents' checklist errors ($p > 0.1$). Junior residents' errors correlated with hernia repair quality ($p = 0.05$).
Conclusions: The newly developed assessment tool showed significant correlations between performance errors, critical events, and hernia repair quality. These results provide validity evidence for the use of errors in performance assessments.
Summary: This study validated an error checklist for simulated laparoscopic ventral hernia (LVH) repair procedures. The checklist was designed based on errors committed by chief surgery residents during LVH repairs. In a separate data collection, junior residents were evaluated using the checklist. Hernia repair quality was also assessed. Errors significantly correlated with hernia repair quality ($p = 0.05$).

1. Introduction

Residents' lack of readiness for operative independence generated national debate over how to best educate future surgeons.[1] Surgical faculty,[2] program directors,[3,4] and senior surgeons from the American College of Surgeons[5] all perceive graduating residents as less competent than their predecessors. Further, residents are concerned about performing advanced procedures,[2] suggesting they feel ill prepared for surgical autonomy.

Commonly performed assessments of surgical residents focus on technical skill, and include the Objective Structured Assessment of Technical Skills (OSATS),[6] McGill Inanimate System for Training and Evaluation of Laparoscopic Skills (MISTELS),[7] and procedure-specific checklists.[8,9] Each assesses a different construct: OSATS for global skills, MISTELS for task completion, and procedure-specific checklists for procedural step completion. Although technical skill is essential in surgical performance, surgical judgment and decision-making are also necessary.

Incorporating surgical judgement and decision-making into evaluation may be one method to improve resident readiness.[10] Our previous work used Rasmussen's model of human performance to guide the assessment of resident decision-making during a simulated laparoscopic ventral hernia (LVH) repair procedure.[11,12] The Rasmussen model categorizes performance into skill-, rule-, and knowledge-based behavior.[12] It defines skill-based behavior as a subconscious, automated behavior such as surgical dexterity or fine motor skills like suturing or knot-tying. Rule-based behavior is driven by goals set by existing rules or procedures. Knowledge-based behavior occurs in unfamiliar situations where there are no corresponding rules, and goals are determined by the specific situation.

In our previous work, we found that a majority of chief residents failed to prepare the mesh correctly before insertion and inappropriate tissue handling when performing an LVH repair. These

* Corresponding author. Department of Surgery, University of Wisconsin Hospital and Clinics, 600 Highland Ave., K6/135 CSC, Madison, WI, 53792, USA.
E-mail address: pugh@surgery.wisc.edu (C.M. Pugh).

http://dx.doi.org/10.1016/j.amjsurg.2016.11.020
0002-9610/

results are in line with prior research and add to the apprehensions over residents' ability to perform laparoscopic procedures independently.[2] Surgical judgment and decision-making studies are sparse,[11,13,14] and existing opportunities that challenge residents in this context are both limited and resource intensive.[15,16] Our goal was to develop an assessment incorporating both technical and decision-making skill for surgical residents. We aimed to design and validate a checklist for the LVH repair procedure that explicitly translates to the Rasmussen model. The goal is to develop competency metrics that positively affect procedural outcomes.

2. Methods

2.1. Design of the critical events checklist

As part of a previous study, a video-database was created using data collected over a two-day conference on advanced laparoscopic hernia repairs. Seven chief general surgery residents (Post Graduate Year [PGY] 4–5) performed an LVH repair procedure on a previously validated simulator.[11,17] Residents were expected to complete the procedure from port insertion to mesh tacking within 30 min. Residents were provided all necessary surgical equipment to perform the repair, excluding cautery. Each performance was video- and audio-recorded using a scene camera and an endoscopic camera.

Recently, a multidisciplinary (education/assessment, surgery, human factors engineering) team of researchers (KL, AD, EC) received a grant to review the videos for errors using a human error classification system.[18–20] Error frequency was calculated to help understand the distribution and prevalence of errors. This information was used in the current study to develop a critical events checklist.

To better understand and validate the utility of the newly developed checklist, junior general surgery residents (N = 38; PGY 1 = 3, PGY 2 = 15, PGY 3 = 20) performed only two steps of the LVH procedure within 15 min: 1) mesh securing and 2) mesh tacking. For the two procedural steps, the following common critical events were identified from the video-database: (1) skin not cut prior to inserting suture passer; (2) two sutures brought up with suture passer concurrently; (3) same hole in peritoneum used to bring up second suture; (4) failed to tie down sutures before tacking; (5) mesh not flat prior to tacking; (6) lack of counter pressure during tacking; (7) tacker slips on mesh; (8) drops tool; (9) does not complete procedure in time. These common errors were then formatted into a checklist for use in the current study (Table 1).

2.2. Rasmussen's model of human performance

Seven of the eight errors and events corresponded to a category within Rasmussen's Skills, Rules, and Knowledge model (Table 2). Skills-based behaviors were identified by: (1) when a resident dropped a tool, or (2) the tacker slipped while attempting to tack. Rule-based behaviors were identified by: (3) does not cut skin prior to inserting suture passer, (4) two sutures brought up with suture passer concurrently, (5) second suture brought up using same hole in fascia, (6) fails to secure sutures before tacking, and (7) does not apply counter pressure when tacking. Because of the simplified scenario presented to residents and the type of errors identified from the error database, no errors or events corresponded to the knowledge-based behavior level.

2.3. Identifying critical events

In the scenario presented to the junior residents (N = 38) laparoscopic ports were placed in advance, the hernia was already measured, and mesh was appropriately sized and inserted. Two of four transfascial suture sets fastened to the mesh were already secured to the abdomen. Because of the technically advanced nature of the LVH repair procedure, junior residents were presented with this simplified scenario to increase the chances of success. The goal was to complete the procedure by bringing up the remaining two suture sets to secure the mesh and by placing five tacks.

Each performance was video- and audio-recorded using a scene camera and an endoscopic camera. Following the data collections, the resident performance videos were evaluated using the error checklist and final product analyses were performed to assess the quality of each hernia repair.[21]

2.4. Statistical analysis

Chi-square tests for categorical data and t-tests for continuous data were used to identify differences between the resident groups on the last two steps of the procedure. T-tests were performed for the items: 'does not cut skin', 'second suture brought up using same hole', and 'two sutures brought up concurrently'. Pearson correlations were performed to determine if there were significant correlations between common errors and hernia quality scores. All analyses were performed using IBM SPSS Statistics Version 23 (IBM Corp, Armonk, NY).

3. Results

Video-recordings of 38 LVH repair procedures were analyzed. Twenty-nine (76.3%) residents completed the procedure in the allotted time. Residents committed 103 errors in total (M = 2.71, SD = 1.80) for the mesh securing and mesh tacking stages of the procedure.

3.1. Prevalence of errors and critical events

Commonly committed errors by the junior residents included: failing to cut the skin prior to inserting the suture passer (52.6%),

Table 1
Errors and critical events checklist.

Event#		Common events that can occur							
		Skin not cut prior to inserting suture passer	Two sutures brought up with suture passer concurrently	Uses same hole to pull up 2nd suture	Fails to secure sutures before tacking	No counter pressure with tacking	Tacker slips on mesh	Drops tool	Does not complete procedure in time
Number of times event occurs	1								
	2								
	3								
	4								
	5								
	6								