Measuring Error Identification and Recovery Skills in Surgical Residents

Joel M. Sternbach, MD, Kevin Wang, BS, Rym El Khoury, MD, Ezra N. Teitelbaum, MD, and Shari L. Meyerson, MD

Department of Surgery, Northwestern University, Chicago, Illinois

Background. **Although error identification and recovery skills are essential for the safe practice of surgery, they have not traditionally been taught or evaluated in residency training. This study validates a method for assessing error identification and recovery skills in surgical residents using a thoracoscopic lobectomy simulator.**

Methods. **We developed a 5-station, simulator-based examination containing the most commonly encountered cognitive and technical errors occurring during division of the superior pulmonary vein for left upper lobectomy. Successful completion of each station requires identification and correction of these errors. Examinations were video recorded and scored in a blinded fashion using an examination-specific rating instrument evaluating task performance as well as error identification and recovery skills. Evidence of validity was collected in the categories of content, response process, internal structure, and relationship to other variables.**

Results. **Fifteen general surgical residents (9 interns and 6 third-year residents) completed the examination. Interrater reliability was high, with an intraclass correlation coefficient of 0.78 between 4 trained raters. Station scores ranged from 64% to 84% correct. All stations adequately discriminated between high- and low-performing residents, with discrimination ranging from 0.35 to 0.65. The overall examination score was significantly higher for intermediate residents than for interns (mean, 74 versus 64 of 90 possible; $p = 0.03$).**

Conclusions. **The described simulator-based examination with embedded errors and its accompanying assessment tool can be used to measure error identification and recovery skills in surgical residents. This examination provides a valid method for comparing teaching strategies designed to improve error recognition and recovery to enhance patient safety.**

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A large part of patient safety is the prevention and management of errors [1]. Although error prevention is the ideal goal, any system involving humans can never be made completely error free. Therefore when training residents, error identification and recovery are at least as important as error prevention, potentially more so. The ability to rapidly identify and recover from errors can mitigate the impact of those errors on patients. One glaring weakness in current surgical training is error identification and recovery [2]. Surgical residents are taught the correct way to do a procedure, which they then practice repetitively each time they encounter the opportunity during their residency. Faculty members focus on teaching the correct steps and often do not explicitly teach about errors and error recovery [3]. Tang and colleagues [4] demonstrated that trainees make far more mistakes when allowed autonomy on a simulator than they do in the operating room. Close supervision in the operating room prevents the vast majority of consequential errors; therefore, resident exposure to errors during training is random, and each resident does not necessarily see a sufficient variety of errors to obtain important error recovery skills [4]. In fact, when residents do encounter difficulties in the operating room, it is usually a trigger for the faculty to take over the case and solve the problem in the interest of patient safety. Therefore, residents rarely, if ever, get the opportunity to recover from errors in the operating room.

Rather than relying on random chance to decide if a resident learns to manage errors adequately, we need to formally include error identification and recovery in residency training [2]. If we are to develop such educational modules, we must be able to assess operative problem solving in a reliable and valid manner. To this end, we have developed a novel simulator-based assessment—the Error Recognition, Avoidance, and Recovery (ERAR) examination, which embeds cognitive and technical errors into an operative procedure in progress. The goal of this study is to provide evidence of the validity of the scores obtained on the ERAR examination in accordance with the 5-category framework (content, response process, internal structure, relationship to other variables, and consequences) set out

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Address correspondence to Dr Meyerson, Division of Thoracic Surgery, Northwestern University Feinberg School of Medicine, 676 N Saint Clair St, Ste 650, Chicago, IL 60611; email: smeyerso@nm.org.

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by the American Educational Research Association [5]. If there is sufficient evidence supporting the validity of scores obtained on this assessment, it can be used to provide formative and summative feedback to residents in training and can be extended to other procedures and used to evaluate curricula for teaching error identification and management.

Material and Methods

Participants

Two groups of surgical residents at a single tertiary-care academic medical center were recruited into the study. Group 1 consisted of interns at the end of their intern year. The second group contained intermediate residents at the end of their third year who spent at least 2 months on the thoracic surgery service and participated in the operation modeled in this simulation in a clinical setting. Power analysis showed that to detect a difference of 10 points on the ERAR examination between the 2 groups, which is the minimum that would be considered clinically significant, if the SD is 6 points with alpha = 0.05 and power = 0.80, a sample size of 6 in each group is required. Informed consent for this study was obtained from all participants, and the study protocol was reviewed and approved by the institutional review board of our institution.

Simulation

The operative task chosen for this study is thoracoscopic division of the superior pulmonary vein. The simulator consists of a previously described porcine heart lung block (Animal Technologies Inc, Tyler, Texas) with the pulmonary artery and veins distended with a blood-substitute fluid. Using this platform, an entire left upper lobectomy can be simulated and generally requires between 20 and 60 minutes to perform [6]. To allow multiple iterations with different errors in a reasonable time frame, the task chosen for this study is limited to the first major step only. Despite this being only the first step of a more complex procedure, there are numerous errors that can be simulated; therefore, it was believed that this was an appropriate task to pilot the concept of a combined simulator-based assessment.

Thoracoscopic division of the left superior pulmonary vein can be divided into 6 steps: (1) identifying the correct lobe, (2) establishing exposure of the superior pulmonary vein, (3) dissecting entry and exit sites for the stapler, (4) selecting an instrument and approach for encircling the vein, (5) encircling the vein, and (6) stapling the vein. To teach the operative task, we developed a training video that was reviewed by the residents during their practice time on the simulator. The video begins by presenting the goals of the task and the relevant anatomy. The entire task is then shown start to finish, with a narrated description of the steps and possible errors and pitfalls.

As the residents reviewed each step, they paused the video and practiced the step on the simulator. Finally, they had an additional fresh tissue block to practice the entire task. A trained research assistant acted as camera driver throughout the practice time and examination but did not provide verbal or manual instruction at any point. When the resident felt comfortable with the task, they notified the research assistant and proceeded to the examination.

ERAR Examination

The ERAR examination consists of 5 stations (Fig 1). Each station represents a different operating room. In each room, another surgeon has started a thoracoscopic left upper lobectomy but is not feeling well and had to emergently leave the room. That surgeon has asked the examinee to take over, identify if any errors had been made by the previous surgeon, correct any such errors, and correctly complete the procedure. Stations were presented in random order, and the thoracoscopic video feed of each station was recorded for subsequent analysis.

Station 1 starts with the camera in place, but no dissection or exposure has been performed. The resident must recognize that no errors have been made and complete the task correctly from start to finish. Station 2 starts with the vein completely dissected and a clamp positioned around the vein ready to be replaced with a stapler for vein division. There are 2 embedded errors in this station. The clamp is around only a distal branch rather than the entire superior pulmonary vein, and the retractor is poorly placed, making it look like that is the only vein branch. The resident must recognize the error, correct the exposure, dissect the correct exit point, and encircle the entire vein. This specific error was the most common error made by residents in previous studies of this task [7]. This error is often seen in combination with the exposure error, which leads to the visual illusion that all branches have been included. Station 3 presents a partially completed dissection, but in the correct location. The resident must recognize that the dissection is correct so far and continue the procedure by encircling and dividing the vein. Station 4 begins with the retractors in place but no dissection started. The embedded error in this station is that the retractor is positioned to expose only the upper division vein making it easy to miss the lingular vein branch. The resident must correct the exposure and dissect the correct entry and exit sites to get around the entire superior pulmonary vein. This station again tests the most common error of anatomical misidentification but focuses on exposure, which creates the visual illusion that the upper division branch is the entire vein. Station 5 begins with the procedure nearly complete. The vein is fully dissected, with the clamp around the correct branches. The assistant hands the resident a stapler that has been angulated in the wrong direction so that it cannot be passed around the vein without causing undue tension. The resident must recognize the error and correct the stapler angulation before passing it behind the vein. Incorrect angulation of the stapler is 1 of the most common technical errors on this step of the operation [7].