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Development of a train-to-proficiency curriculum for the technical skills component of the fundamentals of endoscopic surgery exam

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Abstract

Background The demonstration of competency in endoscopy is required prior to obtaining American Board of Surgery Certification. To demonstrate competency, the resident must pass a national high-stakes cognitive test and a technical skills exam on a virtual reality simulator. The purpose of this preliminary study was to design a proficiency-based endoscopy simulation curriculum to meet this competency requirement.

Methods This is a mixed methods prospective cohort study at a single academic medical institution. Prior to taking the national exam, surgery residents were required to participate in a skills lab and demonstrate proficiency on 10 simulation tasks. Proficiency was based on time and percent of objects targeted/mucosa seen. Simulation practice time, number of task repetitions to proficiency, and prior endoscopic experience were recorded. Resident's self-reported confidence scores in endoscopic skills prior to and following simulation lab training were obtained.

Results From January 1, 2016 through August 1, 2017, 20 surgical residents (8 PGY2, 8 PGY3, 4 PGY4) completed both a faculty-supervised endoscopy skills lab and independent learning with train-to-proficiency simulation tasks. Median overall simulator time per resident was 306 min (IQR: 247–405 min). Median overall time to proficiency in all tasks was 235 min (IQR: 208–283 min). The median time to proficiency decreased with increasing PGY status ($r=0.4$, $P=0.05$). There was no correlation between prior real-time endoscopic experience and time to proficiency. Reported confidence in endoscopic skills increased significantly from mean of 5.75 prior to 7.30 following the faculty-supervised endoscopy skills lab ($P=0.0002$). All 20 residents passed the national exam.

Conclusions In this preliminary study, a train-to-proficiency curriculum in endoscopy improved surgical resident's confidence in their endoscopic skills and 100% of residents passed the FES technical skills test on their first attempt. Our findings also indicate that uniform proficiency was not achieved by real-time experience alone.

Keywords FES · Simulation · Proficiency-based training · Endoscopy

In 2018, demonstration of competency in surgical endoscopy will be required in order to obtain American Board of Surgery (ABS) Certification. This is a new educational goal of which the objectives have been outlined in the Fundamentals

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of Endoscopic Surgery (FES), the ABS Flexible Endoscopy Curriculum (FEC), and within the Surgical Council on Resident Education (SCORE) curriculum [1–3]. To demonstrate competency in FES, the surgical resident must complete a cognitive exam and a technical skills exam on the virtual reality simulator, Simbionix GI Mentor II. FES is a high-stakes exam that has been validated for assessing knowledge and skill in flexible endoscopy [3, 4]. The reported failure rate among surgical residents prior to the introduction of any formal endoscopic curriculum has been as high as 30% [5].

An online didactic component created by the national FES committee has been provided to help trainees prepare for the cognitive component of the FES exam [4]. However, at our institution, there was no specific curriculum designed to assist the trainee in flexible endoscopy skills acquisition for the technical components of the FES exam. Content of the national technical skills exam includes the following: (1) scope navigation, (2) loop reduction, (3) retroflexion, (4) mucosal evaluation, and (5) targeting a lesion. Scoring of technical performance includes time as well as percent of lesions targeted for successful completion [3]. The available endoscopic tasks designed for the Simbionix GI Mentor II simulator have been evaluated and shown to be effective for learning endoscopic skills [3, 6]. The purpose of this study was to develop a proficiency-based curriculum which emphasizes the same measures of performance as the FES exam to efficiently maximize individual learning so that 100% of residents pass the national FES skill component on their first attempt. This proficiency-based curriculum would also support trainees in meeting the objectives of SCORE and FEC curriculum.

Materials and methods

Simulation models

Simbionix GI Mentor II

The Simbionix GI Mentor II simulator provides a fundamental skills package designed to assist the learner in gaining proficiency. The fundamental skill package available at the time of this study included 2 modules on basic scope navigation and 3 modules on basic mucosal evaluation. The fundamentals package does not include proficiency definitions for the individual tasks. The basic scope navigation modules require the learner to use skills such as torque, tip deflection, and backward and forward movements to fit targets into the endoscope view. The mucosal evaluation modules require the user to withdraw the scope through a simulated lumen while keeping the scope centered and circumferentially assessing the lumen surface. The simulator allows for real-time performance metrics to be recorded for each learner who logs on with their own personalized login. The real-time performance measures on most tasks include time to completion, time to cecum, percent lesions targeted, number of wall hits, and number of excessive loops formed. The simulator also allows for the program administrator to assign tasks and set proficiency metrics for these tasks. Proficiencies were set for each task on the Simbionix GI Mentor II and the surgical resident was notified by the simulator when he or she met the proficiency metrics or failed to meet the proficiency metrics (Fig. 1).

Endoscopic simulation labs

Endoscopic simulation labs were also designed and facilitated by three experienced endoscopists who perform more than 200 endoscopic procedures a year. Endoscopic simulation labs included the following materials: (1) 3 Olympus colonoscopes with processor, (2) 1 Olympus Esophagogastroduodenoscope (EGD) with processor, (3) Olympus disposable jumbo biopsy forceps, (4) Olympus endoscopic rotatable easy-clip single use device, (5) Olympus endoscopic injection needle (6) harvested fresh frozen porcine stomachs, (7) 2–0 silk suture to create polyps within the porcine stomach, (8) India ink, and (9) homemade box trainer with styrofoam bowel and thumbtacks attached to a buzzer (see image 1). A total of 6 endoscopy lab sessions of

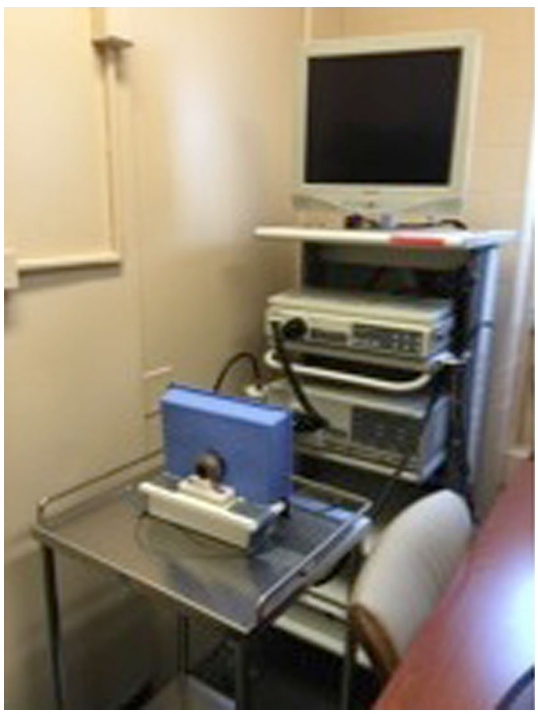

Fig. 1 Boxtrainer for simulation of retroflexion. The trainee places the scope through the opening in the blue panel and upon retroflexion, visualizes the sphere of labeled tacks

150 min each were assimilated. Attendance at one simulation lab was required for each surgical resident.

Development of proficiency scoring (tasks and metrics)

Three experienced endoscopists aided in the development of this curriculum. One experienced endoscopist (author SG) performed all fundamental skills tasks and 75% of the case modules currently available on the GI Mentor II and took the national FES examination and received a passing score. The other two expert endoscopists (authors MM, SN) had extensive simulation experience and performed all tasks outlined in this study to provide additional guidance on creation of the simulation task metrics. Along with the knowledge of the structure of the exam, experience in teaching endoscopy, and careful review of existing literature, initial proficiency standards (as outlined below) were created for each 5 skills tested on the FES exam (see Table 1) [6]. The definition of proficiency for each task on the simulator was assigned after agreement from all three experts.

(1) *Scope navigation* To complete the endoscopy lab, the surgical resident was required to list the parts and function of the Olympus colonoscope and assemble correctly. This was a pass or fail exercise and number of attempts or total time was not recorded. On the Simbionix GI Mentor II simulator, the surgical resident was required to complete the Fundamental Modules Task 1 "Basic Scope Navigation" and 2 "Advanced Scope Navigation" to the proficiency as described in Table 1.
(2) *Loop reduction* On the Simbionix GI Mentor II simulator, the surgical resident was required to complete the Colonoscopy Module 1, case 2 and 3 and Colonoscopy Module 2, case 5 to the proficiency as described in Table 1.
(3) *Retroflexion* In the simulation lab, the surgical resident was required to retroflex a colonoscope in the boxtrainer and identify different numbers or targets in retrolexion. This was a pass or fail exercise and total time was not recorded.
(4) *Mucosal evaluation* In the simulation lab, the surgical resident was required to insert an EGD scope into porcine stomach and identify all lesions and biopsy or clip a lesion. On the Simbionix GI Mentor II simulator, the surgical resident was required to complete the Fundamentals Module Tasks 3 "Basic Mucosal Evaluation," Task 4 "Advanced Mucosal Evaluation I," and Task 5 "Advanced Mucosal Evaluation II" to the proficiency level described in Table 1.
(5) *Targeting a lesion* In the simulation lab, the surgical resident was required to retroflex a colonoscope in the boxtrainer and then target 8 numbered thumbtacks in consecutive order in less than 3 min. On the Simbionix GI Mentor II simulator, the surgical resident was required to perform the endobubble case 2 to the proficiency described in Table 1.

Participants

Participants in this study included 20 postgraduate year (PGY) 2–4 general surgery residents. All participating general surgery residents were required to complete all tasks in the endoscopy lab under faculty observation and the additional assigned tasks on the GI Mentor II simulator independently to proficiency. All participants attended their assigned endoscopy lab during a clinical rotation in surgical endoscopy during their 2nd, 3rd, or 4th PGY. The numbers of upper and lower endoscopies performed during

Table 1 Description of the simulation tasks

Equipment/simulation task	Proficiency
1. Boxtrainer task—retroflexion and targeting	100% items targeted, < 3 min
2. GI Mentor II Fundamentals Task 1—basic scope navigation	100% items targeted, < 5 min
3. GI Mentor II Fundamentals Task 2—advanced scope navigation	100% items targets, < 5 min
4. GI Mentor II Fundamentals Task 3—basic mucosal evaluation	85% mucosal visualization, < 3 min
5. GI Mentor II Fundamentals Task 4—advanced mucosal evaluation I	85% mucosal visualization, 100% lesions targeted, < 10 min
6. GI MENTOR II Fundamentals Task 5—advanced mucosal evaluation II	> 95% lesions targeted, < 3 min
7. GI Mentor II endobubble case 2—lesion targeting	> 80% bubbles targeted < 5 min
8. GI Mentor II Colonoscopy Module 1, case 2—loop reduction and mucosal evaluation	Successful cecal intubation < 5 min, no excessive loop, 90% mucosa visualized
9. GI Mentor II Colonoscopy Module 1, case 3—Loop reduction and mucosal evaluation	Successful cecal intubation < 5 min, no excessive loop, 90% mucosa visualized
10. GI Mentor II Colonoscopy Module 2, case 5—loop reduction and mucosal evaluation	Successful cecal intubation < 5 min, no excessive loop, 90% mucosa visualized

their previous clinical rotations and prior to completing the Simbionix GI Mentor II simulation tasks were recorded.

Data analysis

Surgery residents were asked to indicate on a Likert scale their confidence level in the skills required to perform endoscopy prior and following the endoscopy lab. Analysis of this assessment included a comparison of reported confidence scores on a scale of 1–10 with 1 being the least confident. All surgical residents who completed both the endoscopy labs and the Simbionix GI Mentor II simulation tasks as well as the technical skill component of the FES national exam were asked to indicate the overall usefulness of the endoscopic curriculum as either not helpful, somewhat helpful, helpful, or very helpful in preparing them for the technical component of the FES exam. Furthermore, the surgical residents were asked to indicate which of the 5 skills (scope navigation, loop reduction, retroflexion, mucosal evaluation, targeting a lesion) they were confident performing and which skills they lacked confidence in performing following the simulation exercises.

Quantitative assessments included the following variables from the GI Mentor simulator: overall simulation time, time to proficiency, individual task time, overall number of task repetitions, and number of task repetitions to proficiency. Other quantitative data included PGY status, prior endoscopic experience indicated by the number of real-time upper and lower endoscopies performed by the resident, and FES examination results (Pass/Fail).

Statistical analyses were performed using STATA® version 14 software (StataCorp, College Station, TX, USA). Paired *t* test for differences in means, and Mann–Whitney *U* test for medians were used for all comparisons of simulation times in all tasks, and prior endoscopic experience. While a paired *t* test was used to compare level of confidence prior to and following the education periods for the entire group, a mixed between-and-within-group analysis of variance was performed to identify differences in the scores. Pairwise comparison was used to analyze linear trends using Pearson's statistic. Analysis of qualitative assessments was through thematic analysis of content. All statistical significance was set at ≤ 0.05 in a two-tailed test with corresponding 95% confidence intervals.

Results

From January 2016 till August 2017, 20 residents (14 male) completed at least one endoscopy lab and 18 residents completed the simulation exercises to proficiency. Two residents did not complete one task. All of these 20 surgical trainees passed the national FES test on their first attempt. The 20 surgical residents included 8 PGY II, 8 PGY III, and 4 PGY IV. The median number of upper and lower endoscopies performed increased with increasing PGY status for both upper and lower endoscopies.

The median total time spent on the Simbionix GI Mentor simulator (tasks 2–10) by the 20 trainees was 306 min (IQR: 247–405 min). The median time to proficiency in all tasks on the simulator for the 20 trainees was 235 min (IQR: 208–283 min). Table 2 demonstrates the number of endoscopic procedures performed, the total practice time, time to task proficiency, and additional time by PGY status. There was no significant correlation noted between median time to proficiency and prior endoscopic experience ($r = 0.17$, $P = 0.45$). However, median time to proficiency decreased with increasing PGY status ($r = 0.4$, $P = 0.05$). It is interesting to note that at each PGY level, surgical residents continued to practice on the simulator even when the proficiency-based competencies were met.

The median time and repetitions spent on the Simbionix GI Mentor simulator tasks by the surgical trainee are demonstrated in Table 3. The greatest median number of repetitions needed for proficiency was for task 2 (9.5 reps) with the least median number of repetitions needed for task 8 (1.5 reps). Task 4 required the most time to complete to proficiency as the task allotted the most time and required a median number of 8.5 repetitions.

Within this group of trainees, reported confidence in endoscopic skills increased significantly from mean of 5.75 prior to 7.30 (mean diff 1.55 ± 1.5, $P = 0.0002$) following the endoscopy lab. All trainees reported that the simulation tasks were "very helpful" or "helpful" in preparing for the FES technical exam. Similarly, these trainees felt that the simulation exercises improved their endoscopic skills. The task the trainees felt best prepared for was "mucosal evaluation" and the task the trainees felt least prepared for was "loop reduction." Many surgical residents commented that the proficiency mark for the endobubble task was "not helpful."

Table 2 Endoscopy experience, total time, time to proficiency, and additional time for each surgical trainee stratified by PGY status

PGY level (*n*)	Colon (median *N*)	EGD (median *N*)	Practice time total (min)	Time to proficiency (min)	Additional practice time (min)
II (8)	48	37	352	283	64
III (8)	59	59	287	241	46
IV (4)	67	69	350	254	96

Table 3 Median repetitions and time need to complete each simulation task

Task and time allowed	Median total repetitions	Median repetitions to proficiency	Median total time (min)	Median time to proficiency (min)
Boxtrainer (3 min)	NA	NA	NA	NA
Task 1. Basic scope navigation (5 min)	2.5	2	13	5
Task 2. Advanced scope navigation (5 min)	10	9.5	67	48
Task 3. Basic mucosal evaluation (3 min)	3.5	3	15	9
Task 4. Advanced mucosal evaluation I (10 min)	9.5	8.5	82	72
Task 5. Advanced mucosal evaluation II (3 min)	6	6	23	20
Task 6. Lesion targeting (5 min)	7	6	11	9
Task 7. Loop reduction and mucosal evaluation (5 min)	5	5	55	32
Task 8. Loop reduction and mucosal evaluation (5 min)	2	1.5	18	16
Task 9. Loop reduction and mucosal evaluation (5 min)	2	2	23	16

Discussion

Despite being leaders in the development of the field of endoscopy, many surgeons have not learned or maintained skills in gastrointestinal endoscopy. In a national survey of rural and urban surgeons, Heneghan et al. [7] demonstrated that rural surgeons performed three times as many colonoscopies as urban surgeons. He concluded that endoscopy is essential to general surgery training so that rural surgeons feel equipped to provide this skill upon completion of their training. Furthermore, the natural progression of minimally invasive surgery is to move toward the use of the flexible laparoscope. Training in surgical endoscopy is a necessity for the development of newer skill sets in minimally invasive surgery.

Proficiency-based training, as defined by Stoller et al. [8] sets specific performance goals for a task that "motivates the trainees with a diverse set of baseline skills to engage in a personalized fashion of deliberate practice to attain a uniform proficiency standard." Motivation is facilitated by the feedback on progress that the trainee is given. Willis et al. [9] demonstrated with a randomized trial of 3 different pedagogical approaches that proficiency-based training in simulation leads to more uniform results and at a higher level. Simulation in surgery lends itself to proficiency-based training as a validated method and is gaining in popularity [10, 11]. In this study, we developed a simulation-based curriculum that included proficiency-based performance goals to train surgical residents in surgical endoscopy. We found that this curriculum resulted in 100% first-time pass rate on the FES exam and a significant increase in confidence about endoscopy skills in all trainees.

Few studies have examined the use of proficiency-based testing in FES. Hashimoto et al. compared proficiency-based curriculum with task repetitions on the GI Mentor VR simulator among matched paired trainees and found that proficiency-based curriculum required less time to achieve significantly higher scores on the FES technical skills exam [12]. In this study, the authors chose to use selected case modules available on the Simbionix GI Mentor simulator. We found that the individual case modules were long and therefore required more time for repetitions. This may account for why time to proficiency took longer in Hashimoto's study than in our study (4.9 vs. 3.9 h).

We chose to examine both practice time and time to proficiency on each simulation task on the GI mentor simulator because of the novelty of this test and to further understand in what areas the learner may seek additional practice beyond achieving proficiencies. Our findings, although preliminary, suggest that additional simulation practice beyond initial achievement of the proficiency was sought by all surgical trainees regardless of PGY status and prior real-time endoscopic experience. We also noted that uniform proficiency standards on the GI Mentor simulator were not achieved more readily by those surgical trainees with more endoscopic experience, but can be obtained at a similar rate regardless of prior endoscopic experience.

The relationship between actual endoscopic experience and FES examination results has been previously demonstrated by Gardner et al. [5] These authors concluded that a minimal number of total endoscopic cases associated with passing the FES technical exam was 103 [5]. Mueller et al. [13] demonstrated that obtaining a Global Assessment of Gastrointestinal Endoscopic (GAGES) score of 15 or greater on an observed real-time endoscopy was associated with an initial passing score on the FES technical exam. Also, Van Sickle et al. examined the simulation time and task repetition to proficiency; however, no correlation was made to previous endoscopic experience [6].

Feedback from the surgical trainees regarding the use of a proficiency-based simulation exercise for training in endoscopic surgery was invaluable. Trainees recommended the

endobubble task and loop reduction on colonoscopy tasks be removed or modified. The endobubble is the only task with proficiency testing performed previously by Van Sickle et al. [6]. According to his work, the task setting on our simulation exercise was "high proficiency." To this end, Kishiki et al. [14] demonstrated that setting average level task goals for proficiencies as compared to high level proficiency or no goals resulted in improved task performance and confidence among medical students. Another option for training in loop reduction includes the Scopeguide® by Olympus. This technology allows you to view where your scope is in the intestinal tract during real-time endoscopy and has been found to be most helpful with loop reduction [15].

There are several limitations to this study. The most notable limitation is the number of experts in designing the simulation curriculum and the number of participants. Further, there was no comparison group without any proficiency-based simulation practice. Although endoscopic technology has existed for many years, there is also a paucity of data regarding the establishment of proficiency standards in endoscopic simulation. Therefore, the authors feel that this preliminary study will help guide others in the development of their own endoscopic curriculum. Furthermore, the authors only have knowledge of the pass–fail rates on the FES exam and do not have detailed task-specific data. As part of our internal review process, it was felt that releasing of exam scores from the surgical residents should be considered optional and therefore, only pass or fail rates were recorded. Obtaining detailed exam results may assist educators in building an efficient surgical endoscopy curriculum.

Conclusion

Proficiency-based training and assessment, especially for technical and procedural skills, results in consistently high performance. Learners will practice on simulators that have the capacity to provide feedback on the attainment of proficiency, including economy of action, errors, and time to completion. Surgeons in training value the structure and feedback and may continue to practice beyond attainment of proficiency. The proficiency training model, especially with simulation, will play an increasing role in surgical education.

Compliance with ethical standards

Disclosures Drs. Susan Gearhart, Michael Marohn, Saowanee Ngamruengphong, Gina Adrales, Oluwafemi Owodunni, Kim Duncan, Emil Petrusa, and Pamela Lipsett have no conflicts of interest or financial ties to disclose.

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