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Simulation Training Improves Trainee Technical Skill and Procedural Attitudes in Endoscopic Gastrostomy Tube Placement

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Simulation Training Improves Trainee Technical Skill and Procedural Attitudes in Endoscopic Gastrostomy Tube Placement

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Introduction: Percutaneous endoscopic gastrostomy (PEG) tube placement remains a core competency of gastroenterology fellowship, although this procedure is performed infrequently. Some training programs lack sufficient procedural volume for trainees to develop confidence and competence in this procedure. We aimed to determine the impact of a simulation-based educational intervention on trainee technical skill and procedural attitudes in simulated PEG tube placement.

Methods: Gastroenterology fellows were invited to participate in the study. Baseline procedural attitudes toward PEG tube placement (self-confidence, perceived skill level, perceived level of required supervision) were assessed before simulation training using a Likert scale. Baseline technical skills were assessed by video recording–simulated PEG tube placement on a PEG tube simulator with scoring using a procedural checklist. Fellows next underwent individualized simulation training and repeated simulated PEG tube placement until greater than 90% of checklist items were achieved. Procedural attitudes were reassessed directly after the simulation. Technical skill and procedural attitudes were then reassessed 6 to 12 weeks later (delayed posttraining).

Results: Twelve fellows completed the study. Simulation training led to significant improvement in technical skill at delayed reassessment (52.9 ± 14.3% vs. 78.0 ± 8.9% correct, $P = 0.0002$). Simulation training also led to significant immediate improvements in self-confidence (2.1 ± 0.7 vs. 3.1 ± 0.3, $P = 0.001$), perceived skill level (2.2 ± 1.0 vs. 4 ± 1.1, $P < 0.001$), and perceived level of required supervision (2.2 ± 0.9 vs. 3.2 ± 0.6, $P = 0.003$).

Conclusions: Simulation training led to sustained improvements in gastroenterology fellows' technical skill and procedural attitudes in PEG tube placement. Incorporation of simulation curricula in gastroenterology fellowships for this infrequently performed procedure should be considered. (*Sim Healthcare* 00:00–00, 2021)

Key Words: Percutaneous gastrostomy tube, simulation training, gastroenterology fellowship.

Percutaneous endoscopic gastrostomy (PEG) tube placement is performed infrequently, occurring approximately once in every 60 endoscopic procedures in the United States.[1] This procedure is performed primarily by gastroenterologists, and competence is a requirement of US gastroenterology fellowship program graduates by the Accreditation Council for Graduate Medical Education. Because of the low frequency of this procedure and institutional variations in practice patterns, some training programs may lack sufficient procedural volume for gastroenterology fellows to develop confidence and competence in this procedure with clinical experience alone.

Simulation training has been shown to improve performance in various internal medicine procedures, such as central venous catheter placement and thoracentesis.[2,3] Incorporating simulation into gastroenterology fellowship training has been advocated by both the Accreditation Council for Graduate Medical Education and major gastroenterology societies. A recent survey of gastroenterology fellowship program directors found that most directors felt that endoscopic simulators are easy to use (76%) and are a good educational tool (65%); however, only 42% had simulators at their institutions.[4] The primary perceived barriers to simulation were high cost (72%) and accessibility of equipment (69%).[4] Endoscopic simulation training has historically involved the use of high-fidelity computerized simulators using expensive equipment that may not be feasible for purchase by fellowship programs, with most commercially available computerized endoscopic simulators costing greater than US $100,000.[4]

Low-fidelity simulators have the advantage of reduced cost and have recently been explored in endoscopic training.[5] Several studies have demonstrated similar efficacy of low- compared with high-fidelity simulation in procedural skill training.[6,7] As a result, low-fidelity simulators may offer a similarly efficacious, less expensive, and more accessible training platform for endoscopic procedures.

To our knowledge, there are no commercially available simulation platforms for PEG tube placement. Our aims were to design an inexpensive low-fidelity simulator of PEG tube placement and to assess the impact of simulation training on GI fellows' technical skill and procedural attitudes.

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METHODS

Participants

Study participants were gastroenterology fellows (first through third year) at the University of Michigan Health System from September 2016 to March 2017. Participation was optional, and participants were recruited through e-mail with no incentive. The University of Michigan Institutional Review Board determined that the study met exempt status (HUM00118687).

Study Design

A pretest-posttest design without a control group with a simulation-based educational intervention was used. Baseline demographic data including year in fellowship training, number of PEG tube placements observed, and number of PEG tube placements performed were obtained. Technical skill was assessed before simulation training (baseline) and 6 to 12 weeks after simulation training (delayed posttraining). Procedural attitudes were assessed before simulation training (baseline), immediately after simulation training (posttraining), and 6 to 12 weeks after simulation training (delayed posttraining). Testing and training sessions occurred in the University of Michigan Clinical Simulation Center and were video recorded.

Percutaneous Endoscopic Gastrostomy Tube Simulator

A low-fidelity PEG tube simulator was constructed using materials obtained from a home improvement store (Figs. 1A, B). The total cost of materials for the simulator was less than US $75. The frame of the simulator was built from wood (2 × 4-inch boards and 0.5-inch plywood). The simulated esophagus consisted of polyvinyl chrloride (PVC) electrical conduit and pipe cut such that the distance from simulated mouth to gastroesophageal junction was 40 cm. The PVC piping was secured using electrical conduit clamps to a wood support structure. We used a drill and handsaw to create a 12 (30.4 cm) × 8-inch (20.3 cm) opening in the plywood and affixed 2 × 4-inch cut board at the border of the opening to create a 12 (30.4 cm) × 8 (20.3 cm) × 4.5-inch (11.4 cm) space that simulated the stomach. Stomach lining was simulated using silicone caulk that was colored using pink acrylic paint and affixed to the wood frame. Clear vinyl sheets coated on one side with a layer of silicone caulk colored pink and on the other side with layer of silicone caulk colored cream were used to simulate the anterior gastric wall and external body wall. The thickness of caulking layer was 3 cm to simulate typical body wall thickness in patients undergoing gastrostomy tube placement. These sheets were attached to the wood frame using wing nuts, washers, and bolts. The sheets were easily replaced when there was demonstrable wear after repeated simulations. Construction required a handsaw, an electric drill, a standard drill bit set, a wood boring bit, and wood screws.

A simulated endoscope was constructed using a 5.5-mm flexible borescope (Shekar Direct) that was fixed to vinyl tubing (0.17-inch inner diameter), which served as the instrument channel. This device connected to a laptop computer using a USB cable and projected real-time video on the screen. The proximal end of the device could be manipulated by torquing the shaft similar to a conventional endoscope. The cost of the simulated endoscope was US $20. A Boston Scientific (Natick, MA) EndoVive Safety PEG Pull 20 Fr Kit was used for simulations. This PEG kit was reused during approximately 45 simulation sessions with minimal wear and did not require replacement during the study.

The first step in PEG tube placement requires performance of an upper endoscopy. Our use of an inexpensive borescope along with a 15.7-inch (40 cm) PVC simulated esophagus and a 12 (30.4 cm) × 8 (20.3 cm) × 4.5-inch (11.4 cm) working space simulated stomach accurately mimics the basic components of a limited upper endoscopy. Identifying an appropriate site selection for tube placement in the anterior gastric wall is effectively simulated using the silicone-coated vinyl sheets that allow for demonstration of both transillumination and one-to-one palpation. Subsequent steps that involve sterilization of body wall, drape placement, anesthetization of selected tract, trochar placement, wire advancement, and incision at tract site are all effectively simulated with the anatomically accurate 3-cm thickness silicone-coated vinyl sheets. Subsequent steps of snaring the guide wire advanced through the trochar and removal through the mouth are simulated with the borescope with attached working channel. The final pull-through step where the PEG tube is pulled through the mouth and through the anterior body wall requires a similar amount of force in a real patient because of the thickness of silicone and vinyl sheet and a similar distance to be pulled given the anatomically accurate lengths of simulated esophagus and stomach.

Representative simulation videos of study participants were reviewed by 2 experienced gastroenterologists who have performed more than 50 PEG tube placements and were not otherwise involved in the study. The independent reviewers both agreed that the simulator accurately reflects anatomy and allows for replication of all of the steps required for PEG tube placement.

Procedural Technical Skill Assessment

Participants were videotaped performing simulated PEG tube placement using the simulator at 2 time points: (1) before simulation training (baseline) and (2) 6 to 12 weeks after simulation training (delayed posttraining). Technical skill was assessed using a 34-item procedure checklist. The procedural checklist was developed by 1 author (A.P.W.) using relevant sources and was reviewed by 2 others with expertise in PEG tube placement (A.P., R.S.R.; see Table, Supplemental Digital Content 1, http://links.lww.com/SIH/A687, which provides stepwise checklist for trainee assessment of PEG tube placement).[8,9] Items were formally scored as either 0 (not done/incorrectly performed) or 1 (correctly performed) by 2 reviewers who were trained in grading of performance but were not involved in the simulation training (J.P.F. and S.S.).

Procedural Attitude Assessment

Participants completed electronic surveys assessing self-confidence, perceived level of required supervision, and perceived skill level related to PEG tube placement at 3 time points: (1) before simulation training (baseline), (2) immediately after simulation training (posttraining), and (3) 6 to 12 weeks after simulation training (delayed posttraining). Attitudes regarding the simulation training session were assessed

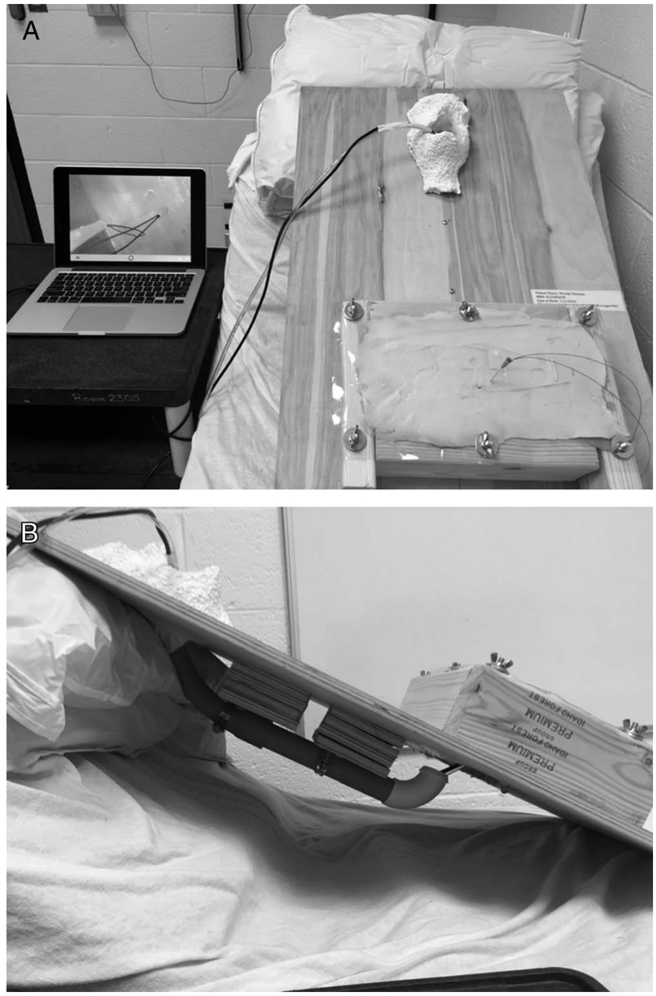

FIGURE 1. A, Image of endoscopic simulator with simulated endoscope attached to laptop computer at stage of snare capture of wire. B, Side view of endoscopic simulator demonstrating simulated esophagus and stomach.

immediately after simulation training. Responses were assessed using a Likert scale. Self-confidence was recorded as 1 = very low, 2 = low, 3 = moderate, 4 = high, and 5 = very high. Perceived level of required supervision was recorded as 1 = no experience, 2 = significant supervision, 3 = moderate supervision, 4 = minimal supervision, and 5 = ready for independent practice. Perceived skill level was recorded as 1 = lowest skill level and 7 = highest skill level. Responses to questions regarding the simulation training were recorded as 1 = strongly disagree, 2 = disagree, 3 = neither agree/disagree, 4 = agree, and 5 = strongly agree.

Educational Intervention

After participants completed the procedural attitude assessment and baseline testing using the simulator, they then underwent simulation training. Performance on baseline testing was immediately reviewed with the participant to identify procedural items that were either not completed or performed incorrectly. Participants were given the opportunity to ask questions about procedural steps and then underwent a brief didactic teaching session. Each subject subsequently performed deliberate practice and repeated the simulation with structured feedback after each attempt until they achieved more than 90% checklist items correct. This approach allowed the intervention to be tailored to the learner based on individual skill level. The total duration of the educational intervention varied by participant ranging from approximately 45 to 90 minutes and was carried out by a single instructor (A.P.W.).

Statistical Analysis

Data were analyzed using SAS statistical software (SAS Institute, Cary, NC). Procedural attitudes and technical skill were compared at different time points using 2-tailed paired t test, significance determined at $P < 0.05$, unless otherwise specified. Procedural checklist score reliability was estimated by calculating interrater reliability using the κ coefficient. Measures are reported as mean ± standard deviation, unless otherwise indicated.

RESULTS

Demographics

Twelve fellows completed all aspects of the study including 3 first-year fellows, 6 second-year fellows, and 3 third-year fellows (60% response rate). The participants' past experience with PEG tube placement was limited with the median number of PEG tube placements performed of 1 (range = 0–3). The total number of PEG tube placements observed was similarly low with a median of 1 (range = 0–5). Delayed posttraining assessments occurred at an average of 8.5 ± 2.5 weeks after simulation training. Only 1 participant performed a single PEG tube placement in the interval between baseline assessment and delayed posttraining assessment.

Procedural Technical Skill

On baseline testing, participants performed an average of 52.9 ± 14.3% of procedural checklist items correctly. At the time of delayed posttraining assessment, the average percent correct items increased significantly to 78.0 ± 8.9% ($P = 0.0002$; Fig. 2). The interrater reliability across the 34-item checklist was very high with a κ coefficient of 0.87.

We further analyzed the performance on individual checklist items and found that the measures of preprocedural administration of antibiotics (16.6% vs. 100%, $P = 0.0004$), performing a timeout (8.3% vs. 50%, $P = 0.017$), marking the puncture site (33.3% vs. 83.3%, $P = 0.026$), switching from 19 gauge filter needle to 22 gauge injection needle for lidocaine injection (33.3% vs. 91.6%, $P = 0.011$), and description of cutting the PEG tube with application of both the clamp and connector (25% vs. 75%, $P = 0.026$) had significantly improved in the delayed assessment after the educational intervention.

Procedural Attitudes

Before simulation training, participants reported low self-confidence in PEG tube placement, low skill in PEG tube placement, and high perceived level of required supervision (Fig. 3). Simulation training led to significant immediate improvements in self-confidence (2.1 ± 0.7 vs. 3.1 ± 0.3, $P = 0.001$), perceived skill level (2.2 ± 1.0 vs. 4 ± 1.1, $P < 0.001$), and perceived level of required supervision (2.2 ± 0.9 vs. 3.2 ± 0.6, $P = 0.003$). The significant improvements in perceived skill and supervision level but not self-confidence ($P = 0.052$) were sustained at the delayed posttraining assessment.

Trainee Impression of Simulation Training

Participant responses on a comprehensive evaluation of the simulation model and training session were uniformly positive (Table 1). Participants agreed that the simulation training accurately reflected actual PEG tube placement, was a valuable learning experience, and should be a required component of fellowship training. Participants felt that use of this low-fidelity model was not inferior to the use of a more high-fidelity approach using animal tissue.

DISCUSSION

In this study, we developed a low-cost and readily accessible simulator of PEG tube placement that requires no separate endoscopic equipment and can be set up in any location. We demonstrated that one period of training with this simulator significantly improved fellows' technical skill (52.9 ± 14.3% vs. 78.0 ± 8.9% correct, $P = 0.0002$) and procedural attitudes in PEG tube placement, which were sustained for at least 6 weeks after simulation training. Furthermore, several checklist items where significant improvements were noted have important safety implications for patients including the administration of preprocedural antibiotics. These findings bolster the value of including simulation for infrequently performed procedures during medical training.

At our institution, most fellows had limited experience with PEG tube placement even by the third year in training, which we suspect is related to referral practices for interventional radiology-guided gastrostomy tube placement as well as procedures performed without fellow involvement. Although we observed a highly significant increase in technical skill in PEG tube placement after simulation training, this benefit may not extend to individuals with greater experience with this procedure. Furthermore, despite all fellows achieving more than 90% correct items before completing the simulation training, only 2 individuals met this threshold at the time of delayed reassessment. Thus, a single simulation training session alone does not seem sufficient to ensure competence in this procedure. This finding is notable and may have implications for other gastrointestinal simulation-based training. All fellows agreed that this training should be a required component of fellowship training, and given the limited time required to set up and complete the simulation, regular practice would be very feasible. We suggest considering intervals of every 3 to

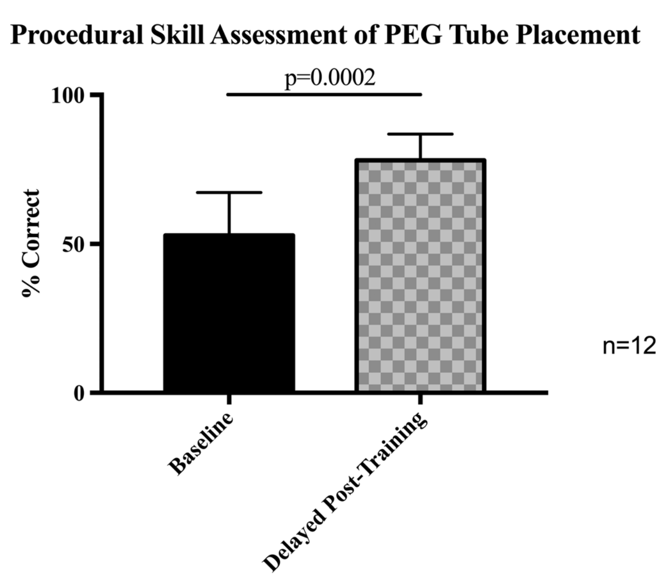

FIGURE 2. Delayed reassessment occurred 6 to 12 weeks after initial simulation training.

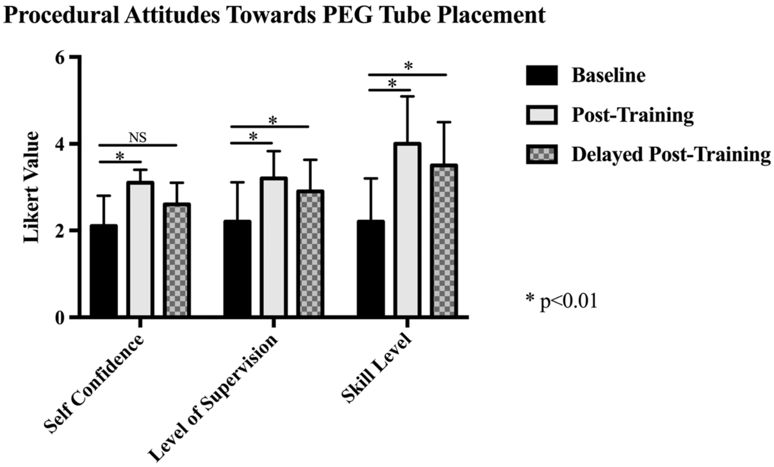

FIGURE 3. Self-confidence: 1 = very low, 2 = low, 3 = moderate, 4 = high, 5 = very high. Perceived level of required supervision: 1 = no experience, 2 = significant supervision, 3 = moderate supervision, 4 = minimal supervision, 5 = ready for independent practice. Perceived skill level: 1 = lowest skill level, 7 = highest skill level.

6 months in programs with low volume of PEG tube placements or among trainees undergoing extended periods of research training.

There are several important limitations to our study. This study was performed at a single institution where limited training in PEG tube placement for gastroenterology fellows occurs. The generalizability to trainees in other programs (gastroenterology, critical care, general surgery) and institutions with greater baseline experience in PEG tube placement is thus unknown. The study design allowed for assessment for completion of specific tasks related to successful PEG tube placement using a checklist. Although completion of these tasks is essential for successful placement, the model does not otherwise allow for assessment on whether trainees possess the technical skill in endoscopy to perform PEG tube placement or choose the correct location of PEG tube placement when confronted with scenarios where large bowel, liver, or ribs may be located between portions of the stomach and anterior abdominal wall. Other common clinical scenarios that endoscopists might encounter in PEG tube placement like altered anatomy, esophageal narrowing, procedure related bleeding, and sedation management could not be replicated with this model.

In conclusion, we demonstrate that use of an inexpensive low-fidelity simulator of PEG tube placement enhances gastroenterology fellows' technical skill and procedural attitudes. Although some limitations exist, the incorporation of simulation curricula in GI fellowships for this infrequently performed procedure should be considered at regular intervals in the context of a broad objective simulation curriculum.

TABLE 1. Trainee Evaluation of PEG Simulation Model

The PEG Tube Simulation Model:	Mean (SD)
Accurately Simulates Steps in PEG Tube Placement	4.7 (0.5)
Improved My Understanding of Steps Involved in PEG Tube Placement	4.8 (0.4)
Improved My Confidence in My Ability to Perform PEG Tube Placement	4.7 (0.5)
Was a Valuable Learning Experience	4.8 (0.4)
Boosted my Skill to Perform PEG Tube Placement	4.8 (0.4)
Should be a Required Component of Fellowship Training	4.4 (0.7)
Has Prepared Me Better Than Clinical Experience Alone	4.4 (0.8)
Was Inferior to Use of Animal Tissue	2.6 (0.5)

Likert values: 1 = strongly disagree, 2 = disagree, 3 = neither agree/disagree, 4 = agree, 5 = strongly agree.

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