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Esophageal Manometry Competency Program Improves Gastroenterology Fellow Performance in Motility Interpretation

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Abstract

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CONFLICTS OF INTEREST

Potential competing interests: A.K.: Consultant for Medtronic. J.E.P.: Consultant for Medtronic, Crospon, Diversatek, Torax, Ironwood, Impleo. Pharmaceuticals. C.P.G.: Consultant for Medtronic, Diversatek, Ironwood. D.A.C: Consultant and speaker for Medtronic and has a licensing agreement with Medtronic. The remaining authors have no conflicts of interest to disclose.

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SUPPLEMENTARY MATERIAL accompanies this paper at http://links.lww.com/AJG/B508, http://links.lww.com/AJG/B509

INTRODUCTION: Competency-based medical education (CBME) for interpretation of esophageal manometry is lacking; therefore, motility experts and instructional designers developed the esophageal manometry competency (EMC) program: a personalized, adaptive learning program for interpretation of esophageal manometry. The aim of this study was to implement EMC among Gastroenterology (GI) trainees and assess the impact of EMC on competency in manometry interpretation.

METHODS: GI fellows across 14 fellowship programs were invited to complete EMC from February 2018 to October 2018. EMC includes an introductory video, baseline assessment of manometry interpretation, individualized learning pathways, and final assessment of manometry interpretation. The primary outcome was competency for interpretation in 7 individual skill sets.

RESULTS: Forty-four GI trainees completed EMC. Participants completed 30 cases, each including 7 skill sets. At baseline, 4 (9%) participants achieved competency for all 7 skills compared with 24 (55%) at final assessment ($P < 0.001$). Competency in individual skills increased from a median of 4 skills at baseline to 7 at final assessment ($P < 0.001$). The greatest increase in skill competency was for diagnosis (Baseline: 11% vs Final: 68%; $P < 0.001$). Accuracy improved for distinguishing between 5 diagnostic groups and was highest for the Outflow obstructive motility disorder (Baseline: 49% vs Final: 76%; $P < 0.001$) and Normal motor function (50% vs 80%; $P < 0.001$).

DISCUSSION: This prospective multicenter implementation study highlights that an adaptive web-based training platform is an effective tool to promote CBME. EMC completion was associated with significant improvement in identifying clinically relevant diagnoses, providing a model for integrating CBME into subspecialized areas of training.

INTRODUCTION

Competency-based medical education (CBME) is a paradigm shift in graduate medical education supported by the American College of Graduate Medical Education (ACGME) Next Accreditation System initially launched in 2013. This initiative stimulated the generation of entrustable professional activities (EPAs), which comprised objectively measurable clinical tasks to determine trainee competency and achievement in educational milestones (1,2). Within Gastroenterology (GI), there are 13 EPAs derived from the GI core curriculum, and EPA #3 focuses on the management of common gastrointestinal motility disorders (3). However, a formal curricula to help fellows achieve competency for the knowledge and skills related to gastrointestinal motility are variably present and, when present, frequently underdeveloped among the GI fellowship programs (4).

As part of the required skills listed in the EPA for gastrointestinal motility disorders, trainees must be able to order, interpret, and apply the results of diagnostic motility studies, such as high-resolution esophageal manometry (HRM) (5). In 2016, formally validated quality measures for performance and interpretation of HRM were identified, and in 2017, skill-specific benchmarks for competency in HRM interpretation were established using the Angoff standard setting method (6,7). To investigate trainee interpretation for HRM using these benchmarks, a prospective study evaluated interpretation of 50 HRM cases across 20 GI fellowship trainees (8). Using a web-based HRM training and competency assessment program, trainees interpreted 50 HRM studies. The results revealed a significant variation in learning curves for esophageal motility diagnosis and for individual interpretative skills. Strikingly, over half of trainees failed to achieve competency in esophageal motility interpretation.

In response to this competency deficit, motility experts and instructional designers developed the esophageal manometry competency (EMC) program, a personalized, adaptive learning software program aimed at teaching and assessing the basics of esophageal manometry interpretation. The aim of this study was to evaluate the change in competency in HRM interpretation among GI fellows after participation in EMC.

METHODS

Study design and setting

This was a prospective, multicenter implementation study performed over 6 months (February 2018 to October 2018) across 14 fellowship programs at 14 institutions. The institutions were selected based on the convenience sampling after the educators expressed interest in participation. The study was approved by the institutional review board (IRB) at the lead site, University of Colorado (IRB #: 18–1567).

Participants

Participants were adults enrolled in an ACGME-accredited adult GI training program in the United States in their second year or higher of GI training. First year fellows were excluded, given the typically high clinical burden in the first year of fellowship. Because cases embedded within EMC were acquired and analyzed with ManoView software, participants without access to a personal computer (PC) desktop or laptop or ManoView ESO software version 3.0 or 3.3 (Medtronic, Minneapolis, MN) were excluded. There were no incentives provided to fellows from the lead site for participation in the program.

Study protocol

After electronic informed consent, participants completed an electronic intake questionnaire to provide demographic information and details regarding previous training and exposure to HRM interpretation. Next, the participants participated in EMC. After completion of EMC, participants completed a final questionnaire to provide feedback on EMC.

EMC intervention

EMC is a web-based electronic program, as depicted in Figure 1. The general structure of EMC includes an introductory video, baseline assessment, personalized adaptive modular pathways, and final test. The introductory video is a 30-minute video reviewing basics of HRM interpretation, Chicago Classification v3.0 (9), and use of the ManoView software. The baseline test includes 10 manometry cases. For each case, the subject opens the case on ManoView, manually analyzes the baseline phase and 10 5-mL room temperature saline swallows performed in the supine position (10), and answers 7 questions about the case. Although the values for integrated relaxation pressure, distal latency, and distal contractile integral were provided with the ManoScan analysis for both the baseline and final cases, participants were instructed to manually analyze each swallow and interpret these numbers to provide a diagnosis. After completion of the 10 baseline cases, EMC autocalculates baseline competence for 7 individual skill sets (pressure inversion point, integrated relaxation pressure, distal contractile integral, distal latency, hiatal hernia, peristaltic integrity, and esophageal motility diagnosis) based on the previously published formal benchmark standards (6) (see Table 5, Supplementary Digital Content 1, http://links.lww.com/AJG/B508). Distribution of diagnoses for baseline cases included achalasia (3 cases), esophagogastric junction outflow obstruction (2), absent contractility (1), ineffective esophageal motility (1), distal esophageal spasm (1), and normal motor function (2). Distribution for final cases included achalasia (5), esophagogastric junction outflow obstruction (2), absent contractility (1), ineffective esophageal motility (3), fragmented peristalsis (1), distal esophageal spasm (2), hypercontractile esophagus (2), normal motor function (2), and technically limited (2). Depending on the baseline performance, EMC creates learning pathways individualized to the subject. Learning pathways direct the users to mandatory skill-specific modules. Modules start with learning objectives for the particular skill set and include video clips and interactive case vignettes. After completion of the individualized learning pathway, participants complete the final test which includes 20 manometry cases. Again, for each case, the subject opens the case on ManoView and answers 7 questions about the case. EMC again automatically assesses the final competence for 7 individual skills and generates a report card comparing subject's baseline and final competency with previously established competency benchmarks for trainees.

Data source and measurement

Data for all participants were collected in a uniform data set built into the EMC program. The following data were collected: name, user type (trainee, unsupervised practice, and master), affiliated institution, question answered correctly (yes or no: Y or N), individual skill set passed (Y or N), percentage score (%), module completed (Y or N), time taken for module completion (minutes), and total time for program completion (hours, minutes). Subject responses to intake questions and elective final feedback questions, described in the results section, were also collected in the data set.

Outcomes

The primary outcomes were the overall competency and skill-specific competency. Overall competency was measured on a continuous scale of 0–7 points, where a point was given for competency in each of 7 skills. Skill-specific competency was measured categorically as competent or not competent for the specific skills. Secondary outcomes included diagnostic accuracy for a diagnostic group of esophageal motility disorders categorized into 5 groups as follows: outflow obstructive motility disorder (achalasia types I, II, and III and esophagogastric junction outflow obstruction), absent contractility, spastic disorders (hypercontractile esophagus and distal esophageal spasm), minor motility disorders (ineffective esophageal motility and fragmented peristalsis), or normal motor function.

Data analysis

Complete case analyses were performed, and missing data were not imputed. All eligible cases during the study period were included without a predetermined sample size. Descriptive summaries of the measures are provided as a mean (SD) or median (interquartile range [IQR]) for continuous measures and as frequency (%) for categorical measures.

To address the primary aim, change in competency after EMC intervention, 2 analyses were performed. First, a nonparametric paired Wilcoxon signed-rank test compared overall competency between baseline and postintervention. Second, the change in skill-specific competency was assessed by comparing proportion competent at baseline vs final test per skill set using the McNemar test for paired binary data. Data were tested for normality with the Shapiro-Wilk test, and, if normally distributed, the composite score between baseline and post-training was compared with paired Student *t* tests; otherwise, the nonparametric paired Wilcoxon signed-rank test was used to determine if scores changed over the course of training.

A secondary analysis compared diagnostic accuracy for the 5 categories of the diagnostic groups at baseline and postintervention using the nonparametric paired Wilcoxon signed-rank test. As another secondary analysis, the associations between subject factors and overall baseline competency were examined via multivariable adjusted linear regression using generalized estimating equations with an independence working correlation structure with robust variance estimation for *P* values and confidence intervals.

For all analyses, *P* values less than 0.05 were considered statistically significant. All data analyses were conducted using R v3.5.1 (11).

RESULTS

Baseline characteristics

A total of 154 GI trainees were invited to participate, and 96 fellows across 14 centers enrolled in the program. Over the study period, 44 GI trainees across 12 centers completed the study. Of the 44 participants, 23 (52%) were men. Most, 28 participants (64%), were in their second year of GI fellowship, 15 (34%) in their third year, and 1 (2%) in a fourth (advanced) year (Table 1). Twenty-five (64%) had no previous esophageal manometry training, and 27 (69%) had interpreted 10 or fewer manometry cases over the course of their fellowship. Each subject completed 30 cases (10 baseline cases and 20 final cases) and provided responses to 7 skill sets, accounting for 9,240 total skill set data points. Participants completed EMC over a mean of 11.9 hours (SD 8.6).

Change in competency after EMC intervention (primary analyses)

Overall competency, or the number of skills with competency achieved, increased from a composite median score of 4 skills (IQR 3–5) at baseline to 7 skills (IQR 6–7) at the final assessment ($P < 0.001$, Figure 2). The proportion of participants with competency for a specific skill set increased from baseline to final assessment for all 7 skill sets including integrated relaxation pressure, pressure inversion point, hiatal hernia, distal contractile integral, distal latency, peristaltic integrity, and esophageal motility diagnosis (Table 2). The greatest increase in skill-specific competency was for diagnosis, for which a threshold for trainee competency was 75%. At baseline, 11% of participants met competency for diagnosis compared with 68% at the final assessment ($P < 0.001$). The number of participants achieving competency for all 7 skills increased from 4 (9%) to 24 (55%) ($P < 0.001$).

Change in diagnostic accuracy after EMC intervention (secondary analysis)

Accuracy in distinguishing between the 5 diagnostic groups improved across all diagnostic groups (Table 3). The final diagnostic group accuracy was highest for the outflow obstructive motility disorder (achalasia subtypes I, II, III and EGJ outflow obstruction; baseline: 49% vs final: 76%; $P < 0.001$) and normal motor function (50% vs 80%; $P < 0.001$) but also significantly improved in diagnoses of minor motility disorder (ineffective esophageal motility and fragmented peristalsis, 43% vs 74%; $P = 0.001$), and spastic esophageal disorder (hypercontractile esophagus and distal esophageal spasm, 43% vs 63%; $P = 0.01$).

Factors associated with overall competency (secondary analysis)

Table 4 depicts the association between subject level factors and baseline competency before EMC. Confidence was self-assessed before completion of EMC on a scale of 1 (not confident) to 10 (completely confident). Generally, baseline self-perceived confidence was a predictor of overall baseline competency, whereas other factors such as trainee year, previous formal esophageal manometry training, familiarity with the Chicago Classification or ManoView software, number of manometry cases previously interpreted, or intent to interpret HRM in independent practice were not significantly associated with baseline competency. In addition, time spent completing EMC was not associated with final competency. Of the 3 lowest scoring participants, all spent less than 11.9 hours on completing the program. The participant with reduced competency after completion of EMC (Figure 2) was a third year trainee, completed EMC in 3 hours, did not complete the educational modules when not required, and does not plan to interpret esophageal manometry in clinical practice.

Feedback after completion of EMC

Twenty-seven (61%) participants completed the postintervention feedback questionnaire. Sixteen (59%) planned to interpret manometry in clinical practice after completing EMC. Twenty-five (93%) would recommend EMC to GI fellows, and 23 (85%) would recommend EMC to physicians in practice.

DISCUSSION

Deficiencies in CBME in GI motility critically underprepare GI trainees for real-world unsupervised practice. Inadequate GI motility training risks misdiagnoses and can lead to inappropriate invasive treatments, such as surgery, delay to accurate diagnosis, and increased cost of repeated or additional procedures, and inappropriate medications. Although critically needed, establishing standardized motility training programs across institutions is challenging because of the variable expertise and limited resources of motility experts to educate trainees. A survey by Rao et al. Revealed that of the 171 GI fellowship training programs, only 25% of programs provide training in motility (4). Furthermore, previous methods of teaching esophageal manometry by apprenticeship and procedure volume are an outdated model for medical training (12,13). To address these concerns, the EMC program was created—a web-based, adaptive, personalized training and competency assessment program for high-resolution manometry used to augment comprehensive motility education. In this study, 44 senior GI trainees from 12 ACGME-accredited GI fellowship programs completed EMC. Overall competency and skill-specific competency in all domains for motility diagnostics improved after the EMC intervention.

The aim of EMC is to familiarize trainees with major patterns of esophageal dysmotility and identify diagnostic groups to direct future treatments. These skills are vital to providing quality patient care. The most compelling result highlighting the clinical relevance of EMC was the significant improvement in diagnostic accuracy for outflow obstructive motility disorders. Mean baseline performance for outflow obstruction disorders was 49% but increased to 76% after the completion of personalized pathways. Conversely, but equally critical, was the significant improvement in diagnosing normal motor function, changing from a mean score of 50%–79.5% after EMC. The ability to accurately distinguish between these disparate diagnostic groups alters the trajectory of patient care and protects patients from invasive interventions. Although diagnostic accuracy is essential in creating appropriate care pathways, previous studies have demonstrated that among GI trainees, diagnostic accuracy is variable and interrater agreement is poor (8,14,15). Given these deficiencies, there is clearly a role for competency-based assessment programs, such as EMC, to be added to a comprehensive motility curriculum. As a platform that incorporates individual learning curves into GI training, EMC recognizes learners' varying clinical backgrounds and exposure to esophageal motility (8,12,16–18).

Although competency scores improved from baseline to final performance, it is worth noting that the scores may be lower than expected after engaging in EMC and coupled with previous esophageal motility exposure in a training program. This could be attributed to multiple factors: lack of formalized education in esophageal motility disorders, variation in individual learning curves, absence of integration of clinical knowledge associated with manometry tracings, and inclusion of more nuanced diagnoses of minor motility disorders. In addition, the minimum cutoff scores for the trainee interpreter, previously determined via the modified Angoff method by 2 motility experts (6), may have been set too high for trainees new to esophageal manometry interpretation.

There are limitations of this study that guide future research on platforms such as EMC. First, the study lacks longitudinal data on the sustained impact of EMC on competency in esophageal manometry interpretation and, although adequately assessing competency, does not test clinical decision-making nor recognition of a poor-quality study. Future iterations of EMC could address the question of whether trainees can apply the concepts of manometry interpretation learned from EMC to clinical practice, which is more important than simply scoring well on the program's final assessment. As clear-cut phenotypes were used for manometry studies, pattern recognition may have biased the results and could explain why although only 11% of participants achieved competency in overall motility diagnosis at baseline, accuracy in distinguishing between motility diagnoses ranged from 43% to 73%. Next, this is a single arm study without a control arm for comparisons of EMC with other currently used methods of teaching esophageal manometry. The variability of motility education among GI fellowship programs would make a single control difficult to define, but this study presumes that baseline performance is a product of an institution's current motility curriculum. Similarly, a comparison between individual study of esophageal manometry using the same amount of time devoted to completion of EMC would provide useful information as well. Most fellows invited to participate and who completed the program came largely from institutions with established motility programs and increased trainee exposure to motility disorders, thus our results may not be representative of trainee performance across all fellowship programs. Finally, participation bias may have altered the results because nearly 60% of participants planned to interpret esophageal manometry in independent practice.

Nonetheless, the results of this study highlight the value of CBME platforms such as EMC in GI training, which in the future should be implemented across GI training programs. EMC can be used as an example platform to develop competency-based programs in other areas of GI. Assessment of clinical decision-making and long-term sustainability of competency will help delineate the clinical value of such programs.

In summary, EMC is a personalized, adaptive learning software program that provides GI trainees with vital, competency-based education in esophageal manometry interpretation. Its use among GI trainees improves diagnostic accuracy in esophageal motility disorders and supports the development of future competency-based educational tools in GI fellowship training.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Study Highlights

WHAT IS KNOWN

- CBME is a paradigm shift in graduate medical education.
- A formal curriculum with competency-based assessment for esophageal motility disorders in GI training programs is needed.

WHAT IS NEW HERE

- The EMC program is an adaptive, personalized program, designed to teach major patterns of esophageal dysmotility.
- Completion of EMC by GI trainees improved diagnostic accuracy for esophageal motility disorders.
- EMEMC can be used as an example platform for CBME in GI fellowship programs.

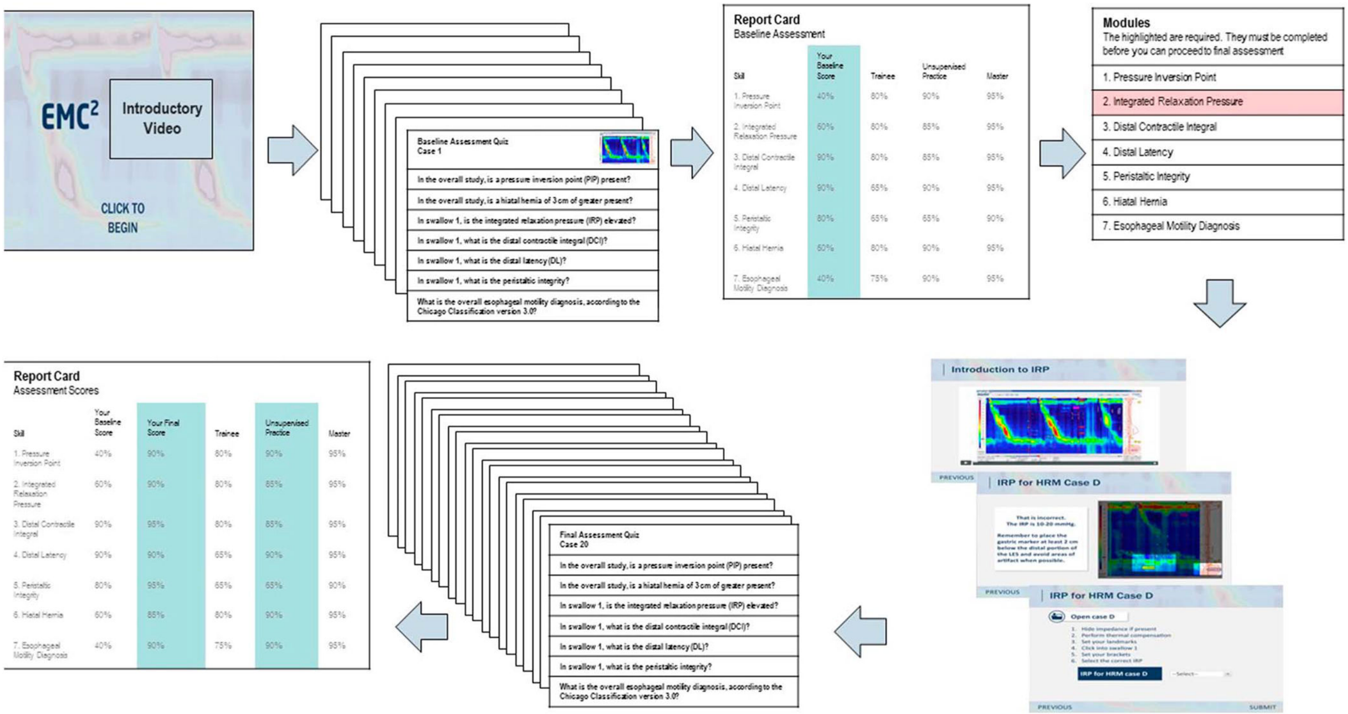

Figure 1.

Esophageal manometry competency (EMC) pathway. After program enrollment, participants watch an introductory video, followed by interpretation of 10 esophageal manometry cases. A report card is automatically generated after completion of the 10 baseline cases, and personalized learning pathways are created, individualized to the subject's baseline performance. After module completion, participants interpreted 20 final esophageal manometry cases, followed by the automatic creation of a final report card comparing baseline and final performance to established competency thresholds.

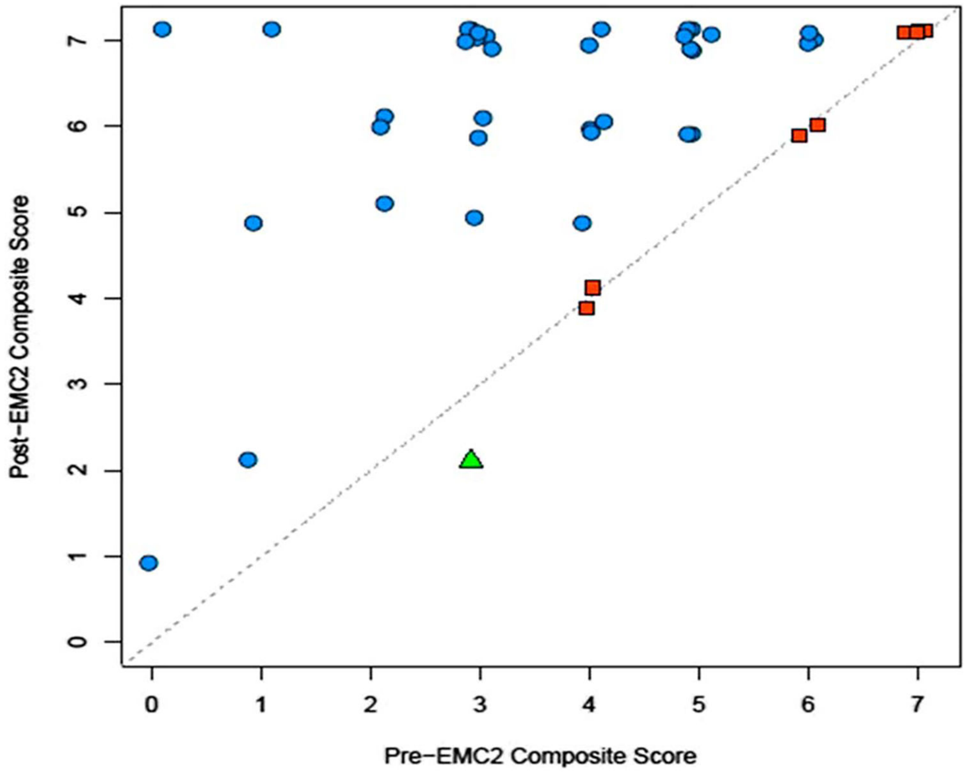

Figure 2.
Change in overall number of skills competent after EMC participation and completion. The blue circles (<image>) designate improved competency, the red squares (<image>) represent no change in competency, and the green triangles (<image>) indicate reduced competency after completion of EMC. Number of skills with competency achieved increased from a median of 4 skills at baseline to 7 skills at final assessment ($P < 0.001$). EMC, esophageal manometry competency.

Table 1.

Baseline characteristics of participants

Baseline characteristics	Participants
Female sex (n = 44)	21 (48%)
Trainee year (n = 44)	
2nd year	28 (63.6%)
3rd year	15 (34.1%)
4th year	1 (2.3%)
Institutional affiliation (n = 44)	
University of Colorado	6 (13.6%)
Washington University St. Louis	6 (13.6%)
University of Virginia	6 (13.6%)
Northwestern University	5 (11.4%)
Johns Hopkins MedicalCenter	5 (11.4%)
University of Utah	5 (11.4%)
University of Michigan	3 (6.8%)
Duke University	2 (4.5%)
University Hospitals Cleveland	2 (4.5%)
Brooke Army MedicalCenter	2 (4.5%)
University of California San Diego	1 (2.3%)
New York University	1 (2.3%)
Received previous esophagealmanometry training (n = 39)	14 (35.9%)
Familiar with ManoScan software (n = 39)	19 (48.7%)
Familiar with Chicago Classification (n = 39)	32 (82.1%)
Previous experience with unsupervised manometry interpretation (n = 39)	0 (0%)
Intend to practice esophagealmanometry in practice (n = 32)	21 (65.6%)
Previous no. of manometry cases interpreted (n = 39)	
0	15 (38.5%)
1–10	12 (30.7%)
11–50	9 (23.1%)
51–100	2 (5.1%)
>100	1 (2.6%)

Table 2.

Change in skill-specific competency

Skill set	Published threshold for trainee competency (8)	Competent at baseline assessment, n (%)	Competent at final assessment, n (%)	*P* value
Integrated relaxation pressure (IRP)	80%	13 (30)	39 (89)	<0.001
Pressure inversion point (PIP)	80%	32 (73)	41 (93)	0.03
Hiatalhernia >3 cm	80%	23 (52)	36 (82)	<0.01
Distalcontractile integral (DCI)	80%	36 (82)	40 (91)	0.34
Distallatency (DL)	65%	31 (71)	39 (89)	0.04
Peristaltic integrity (PI)	65%	32 (73)	42 (96)	0.01
Esophagealmotility diagnosis	75%	5 (11)	30 (68)	<0.001

Table 3.

Change in diagnostic accuracy

Esophageal motility diagnosis group	Percent accuracy at baseline, mean (SD)	Percent accuracy at final, mean (SD)	*P* value
Outflow obstructive motility disorder (achalasia types I, II, and III esophagogastric junction outflow obstruction)	49% (31.2)	76% (25.8)	<0.001
Normalmotor function	50% (35.8)	80% (27.1)	<0.001
Minor motility disorder (ineffective esophagealmotility and fragmented peristalsis)	43% (50.1)	74% (28.8)	<0.01
Spastic esophagealdisorder (hypercontractile esophagus and distal esophagealspasm)	43% (50.1)	63% (26.7)	0.01
Absent contractility	73% (45.1)	77% (42.4)	0.53

Table 4.

Adjusted regression assessing subject factor association with baseline competency

Subject factor	Estimate	95% confidence interval	*P* value
Trainee year 3 or higher	0.56	−0.51 to 1.63	0.31
Formaltraining received	−0.29	−1.61 to 1.03	0.67
Familiarwith ManoScan	−0.10	−1.23 to 1.03	0.86
Familiar with Chicago Classification	−0.46	−1.83 to 0.92	0.52
1–10 previous esophagealmanometry (EM) cases (vs 0)	−0.26	−1.35 to 0.82	0.63
>10 previous EM cases (vs 0)	−0.02	−1.36 to 1.33	0.98
Baseline confidence (scale of 1–10)	0.49	0.24 to 0.75	<0.001