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FELLOWS AND YOUNG GIS SECTION

# Impact of a Virtual Endoscopy Training Curriculum in Novice Endoscopists: First Experience in Argentina

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## Abstract

**Background** Virtual reality simulation in gastrointestinal endoscopy is an educational tool that allows repetitive instruction in a non-patient care environment.

**Aim** To determine the impact of a virtual endoscopy training curriculum applying an objective pre- and post-training analysis on trainee endoscopists.

**Methods** A before–after training study was carried out. Subjects were first year fellows of gastroenterology, who completed a questionnaire and then performed two pre-training simulated cases. The virtual endoscopy training curriculum consisted of an 8-h workday utilizing two GI MENTOR™ in a specialized clinical simulation center. After the training, all subjects completed the same two cases they did in the pre-training. Pre- and post-training results' comparisons were made by paired *t* test.

**Results** Totally, 126 subjects were included (mean age 30 years, 61% female). A significant improvement from pre- to post-training was observed in psychomotor skills (total time, percentage, and number of balloons exploded) and endoscopic skills (cecal intubation time, percentage of examined mucosa, and efficacy of screening). There was also an improvement in the quality of the endoscopic study; percentage of examined mucosa over 85% showed a significant improvement post-training with an adjusted OR of 2.72 (95% CI 1.51–4.89, $p = 0.001$).

**Conclusions** Virtual endoscopy training curriculum produces a significant improvement in the trainee endoscopists performance and their psychomotor skills and introduces the concept of a quality endoscopic study in a non-patient, risk-free environment.

**Keywords** Virtual simulator · Computer simulation · Endoscopy · Training · Education and competence

### Abbreviations

GI Gastrointestinal
VS Virtual simulator
VE Virtual endoscopy
NE Novice endoscopists
VR Virtual reality

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## Introduction

Traditional GI endoscopy learning model was taught from a senior endoscopist to a novice, in a clinical setting. This approach is limited by patient safety and comfort, time of the procedure, and decreased efficiency in the endoscopy unit [1]. Simulation-based training in endoscopy provides a learner-centered experience, allowing trainees to learn from mistakes in a low-risk environment. Two recent systematic reviews conclude that simulation-based training, prior to patient-based education, supplements traditional clinical training in endoscopy and is of greatest utility for novices [2, 3].

Prior studies have demonstrated that simply providing trainees with simulators does not ensure their effective use and that experts' feedback provided to trainees enhances acquisition of basic endoscopic skills [4, 5].

Tools that define competence in endoscopy indicate that three main domains are required: technical or psychomotor, cognitive, and integrative, where trainees can use learned skills to perform procedures in different clinical scenarios [6].

Since the first mechanical simulator in endoscopy was introduced, in 1969, these instruments have evolved and nowadays are complex computing devices. These devices consist of an endoscope with real dials and buttons, and a closed tip that contains forced feedback sensors. The trainees undergo the feeling of resistance as the endoscope is going through a mannequin. A computer displays pre-procedure clinical information; generates endoscopic images, including a variety of pathologic findings; and provides real-time feedback about looping and pressure. Users can work independently on these simulators and can view information about their performance and the pathology results.

There are few publications regarding the role of virtual simulators in educational programs of digestive endoscopy in Latin America.

The aim of the study is to determine the impact of the implementation of a virtual endoscopy training curriculum in novice endoscopists.

## Materials and Methods

### Participants

A study before–after was carried out. Physicians in the first year of the Gastroenterology Academic Program at the University of Buenos Aires, Argentina, since June 1, 2017, to December 31, 2019, were included. The study took place at SIMMER (Simulation Center, Roemmers) Buenos Aires, Argentina.

After signing the consent, the participants completed a questionnaire on demographics and their general medical and endoscopy experience: age, sex, hospital unit, experience in video games and/or use of musical instruments (guitar, piano), number of endoscopies performed in the last year, and quality criteria in endoscopy (percentage of arrival at the cecum and adenoma detection rate).

### Simulator

Two GI Mentor II simulators for flexible endoscopy (Simbionix Ltd., Israel; software version 2.7.3.0) were used in this study. The GI Mentor II provides hands-on training by various modules for training in basic psychomotor endoscopy skills as well as lower and upper flexible endoscopy procedures on a mannequin with a mouth and a rectal end. The endoscope used is a customized Pentax ECS-3840F endoscope (Pentax Corp., Tokyo, Japan). The steering and torque are controlled as in a real endoscope. Insufflation and suction also are available. The computer simulation program supplies visual and audio feedback, while the mannequin provides force feedback sensations, all corresponding to the selected training module and patient scenario. This VR endoscopy scenario varies in anatomy and pathology. The simulator provides objective measurements and statistics about each endoscopic study performance.

### Virtual Endoscopy Training Curriculum

The virtual endoscopy training curriculum consists of an 8-h workday, coordinated by an experienced instructor with a maximum of five trainees for each instructor. The participants received an introduction about the simulator and an explanation on how to operate the controls and steer the endoscope tip.

The training program included three items: A) The "Endobasket" module (level 1 and 2): The trainee had to navigate with the scope through a virtual pipe, picking up three balls with a virtual biopsy forceps and dropping them into a virtual basket nearby. The time taken and the number of correctly placed balls were registered. B) The "Endobubble" module: The trainees had to pierce 40 balloons using a virtual injection needle; the balloons fade away after a certain amount of time. The time taken and number of balloons are recorded, as well as how many times the mucosa was touched. C) Virtual endoscopy: There are 10 gastroscopy and 10 colonoscopy cases with a variety of pathologies. The software includes modules that describe different clinical scenarios, external view of the procedure to visualize the technical difficulty (such as loop formation) during the procedure. The virtual tunnel expands and collapses with the insufflation of air and suction, respectively. The virtual patient emits his discomfort audibly and even demands the suspension of the procedure when the insufflation is excessive. At the end of the procedure, the device shows a platform where the performance is evaluated according to different parameters: total time of the examination, recognition of pathological findings, degree of insufflation, discomfort of the patient, percentage of mucosa visualized, efficacy for screening, wall touches, time with loop, pain, and whether the air was removed at the end of the study.

During the training, the instructors explain and discuss aspects related to biosafety and equipment reprocessing, endoscope components, endoscopic technique, endoscopy quality criteria, instrument handling, indications, contraindications, and complications. All the simulated cases are discussed in a clinical scenario.

## Performance Assessment

The evaluation was carried out before and after the virtual endoscopy training curriculum by the instructors (experienced GI endoscopists trained in simulation). The trainees were informed about the parameters recorded by the simulator, and their scores were shown after each exercise. All the participants performed the tasks on the simulator single-handed without any scope assistance.

The evaluation included two exercises: (a) Endobubble II, for evaluation of psychomotor skills. The evaluator registered the total time, number and percentage of balloons exploded, and wall touches. (b) Colonoscopy (Case 1/Module 1) for evaluation of endoscopic skills: a basic colonoscopy with a low level of difficulty. The items evaluated by the virtual simulator software were: cecum arrival, time of arrival to the cecum (min), percentage of mucosa examined, efficacy for screening, percentage of time with clear vision, withdrawal time (greater than 6 min), photographs of the cecum, whether the air was removed when leaving, percentage of time with excessive pain and loop, and time with loop. The GI Mentor estimates the percentage of mucosa examined by dividing the colon wall into 2000 equal areas along its surface. Each area is considered screened only if it is visible on the screen for more than half a second. Time and percentage of mucosa screened are used to define the efficiency of screening.

## Statistical Analysis

Continuous data are presented as median, median difference with 95% CI, and interquartile range (IQR; from the 25th to the 75th percentile). Percentages were calculated for dichotomous variables. To compare continuous paired variables, Sign Rank test was applied. And to compare categorical variables Mc Nemar was used. $p$ value $< 0.05$ was considered statistically significant. Multivariate logistic regression analysis was performed to adjust for baseline differences (age over 30 years, sex, use of videogames, having performed more than 50 endoscopies). The statistical package Stata 14.0 (StataCorp, Texas, USA) was used for the analysis.

# Results

We analyzed the data of 126 trainees who completed the questionnaire and the entire virtual endoscopy training curriculum. The average age was 30 years (28–32), 61% were female. 69% had performed less than 50 endoscopic studies in the last year, 94% did not know their personal rate of adenoma detection, 81% did not know their cecal intubation rate, 71% did not play video games, and 21% played music instruments (Table 1).

## Psychomotor Skills

A statistically significant decrease between pre- and post-training was observed in execution time of the Endobubble II exercise and number of wall touches. A significant increase was observed in number and percentage of balloons exploded (Table 2; Fig. 1).

## Endoscopic Skills

The cecal intubation rate and percentage of mucosa examined improved significantly. The cecal intubation reaching, measured in minutes, decreased significantly. Likewise, the percentage of time with clear vision and the withdrawal time greater than 6 min showed a post-training improvement. There was also an improvement in the quantity of cecal photographs taken and the air suction when retrieving the scope (Table 2; Fig. 2).

**Table 1** Demographic data for 126 subjects

| | Students ($n = 126$) |
|---|---|
| Age (years) | 30 (28–32) |
| *Median (IQR)* | |
| Female sex $n$ (%) | 77 (61) |
| Perform more than 50 endoscopic procedures in the last year $n$ (%) | 39 (31) |
| Adenoma detection rate $n$ (%) | |
| Do not know | 119 (94) |
| Less than 20% | 3 (2) |
| Greater than 20% | 4 (3) |
| Cecal intubation rate $n$ (%) | |
| Do not know | 102 (81) |
| Less than 90% | 14 (11) |
| Greater than 90% | 10 (8) |
| Do you play musical instruments? $n$ (%) ($n = 100$) | |
| No | 76 (78.35) |
| Piano | 7 (7.22) |
| Guitar | 11 (11.34) |
| Other | 3 (3.09) |
| Do you play videogames? $n$ (%) | |
| No | 89 (70.63) |
| Daily | 2 (1.59) |
| Weekly | 14 (11.11) |
| Monthly | 21 (16.67) |

**Table 2** Performance data

| | Pretest ($n=126$) | Posttest ($n=126$) | Median difference (95% CI) | *P* |
|---|---|---|---|---|
| *Psychomotor skills (Endobubble 2)* | | | | |
| Execution time in minutes (median and IQR) | 2.2 (1.85–2.85) | 1.95 (1.7–2.28) | − 0.2 (− 0.32 to − 0.13) | 0.000* |
| Wall touches (median and IQR) | 2 (0–7) | 0 (0–3) | − 1 (−2 to 0) | 0.000* |
| Percentage of balloons exploded (median and IQR) | 20 (12–37) | 28.5 (15–47) | 8 (5 to 10) | 0.000* |
| Number of exploded balloons (median and IQR) | 8 (5–15) | 12 (7–18) | 3 (2 to 4) | 0.000* |
| *Endoscopic skills (Colonoscopy 1)* | | | | |
| Cecal intubation *n* (%) | 97 (76.98) | 124 (98.41) | | 0.000^ |
| Percentage of mucosa examined (median and IQR) | 74 (64–83) | 83 (77–88) | 7 (5 to 10) | 0.000* |
| Cecal intubation time in minutes (median and IQR) | 2.7 (1.95–4.3) | 2.38 (1.9–3.25) | − 0.5 (− 0.89 to − 0.32) | 0.000* |
| Efficacy for screening (median and IQR) | 79 (67–87) | 84 (78–89) | 4 (3 to 10.5) | 0.000* |
| Percentage of time with clear vision (median and IQR) | 95 (92–97) | 96 (94–97) | 1.5 (1 to 2) | 0.0001* |
| Percentage of time with pain (median and IQR) | 23 (10–39.5) | 7 (0–19) | − 15 (− 18.44 to − 9.56) | 0.000* |
| Time with loop (s) (median and IQR) | 0.33 (0.1–0.68) | 0 (0–0.005) | − 0.27 (− 0.33 to − 0.17) | 0.000* |
| Air is not removed when leaving *n* (%) | 88 (69.84) | 13 (10.32) | | 0.0021^ |
| Photographs of the cecum *n* (%) | 23 (17.42) | 109 (82.58) | | 0.000^ |
| Withdrawal time greater than 6 min *n* (%) | 22 (16.54) | 111 (83.46) | | 0.000^ |

*Signed-rank test, ^Mc Nemar

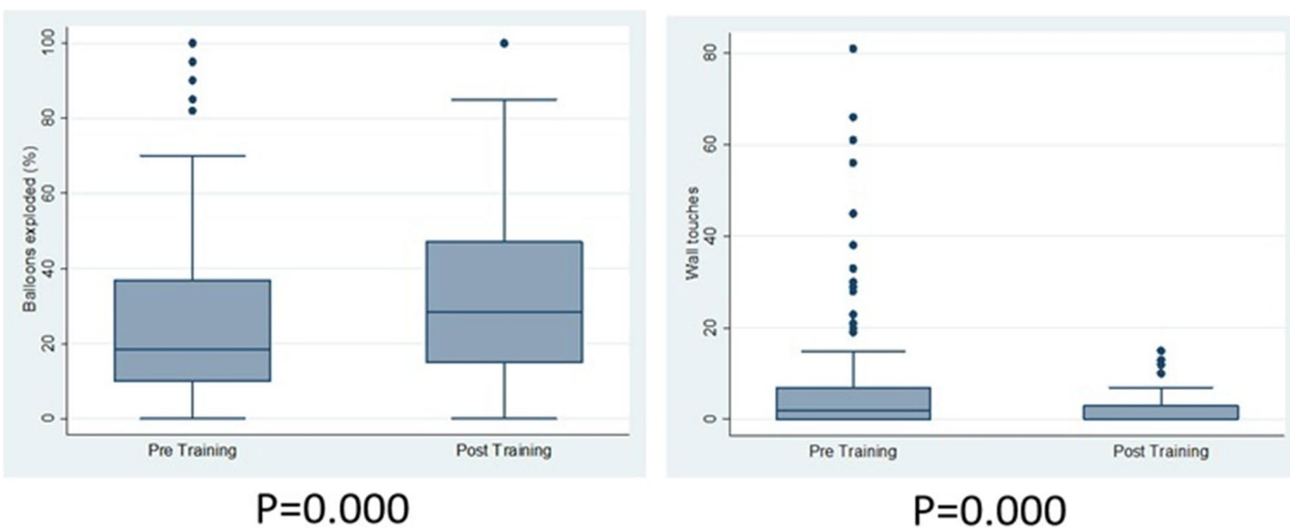


**Fig. 1** Psychomotor skills, Endobubble 2

## Procedure Quality Metrics

There was a significant improvement in the percentage of time with pain and loop after the virtual training (Table 2; Fig. 3). As for the colonic mucosa surface explored, examined mucosa over 85% showed a significant improvement post-training with an adjusted OR of 2.72 (95% CI 1.51–4.89, $p=0.001$).

## Discussion

The American Society of Gastrointestinal Endoscopy (ASGE) defines competence as "the minimal level of skill, knowledge and/or expertise derived through training and experience that is required to safely and proficiently perform a task or procedure" [1].

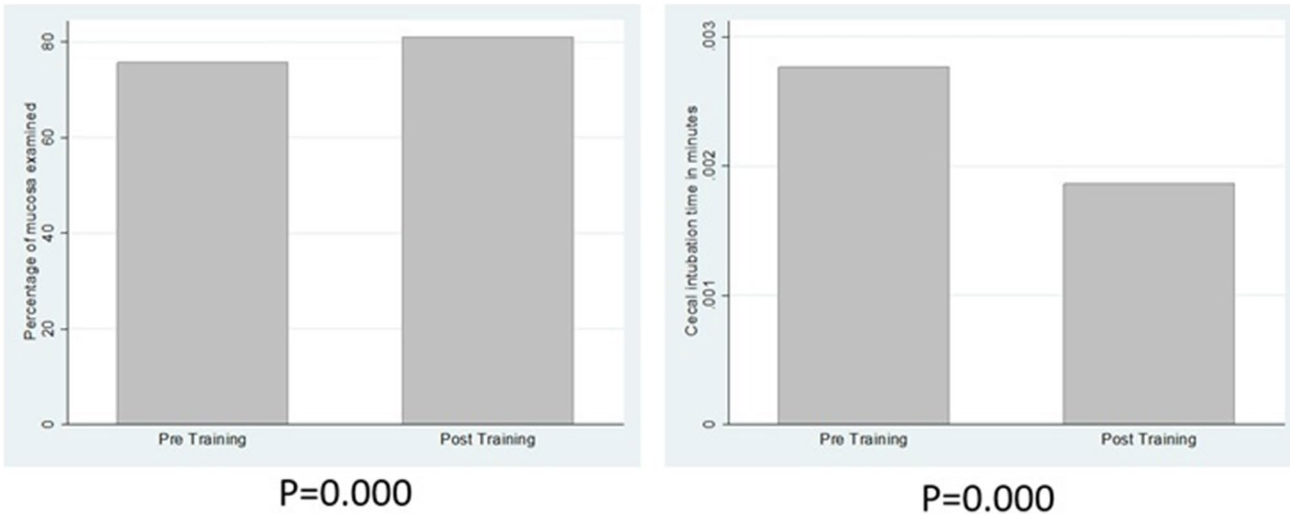


**Fig. 2** Endoscopic skills

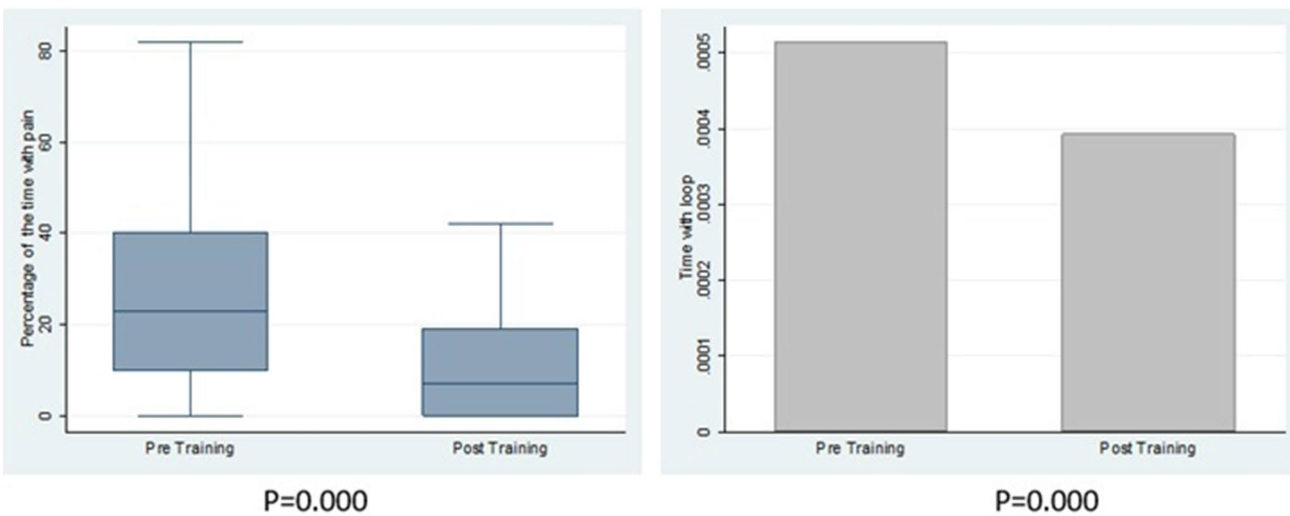


**Fig. 3** Procedure quality metrics

The improvement and standardization of training in endoscopy have become a major issue during the past few years. Problems have been noted primarily in teaching endoscopic novices, because newcomers to gastrointestinal endoscopy need many procedures to gain competency [7–9] and suffer from reduced time for individual learning. For more than 30 years, different types of simulators, including mechanical, animal, animal part, and computer-based models, have been developed to teach and learn endoscopic procedures. The goals of simulator-based teaching methods should be to shorten and improve the learning time in endoscopy for beginners, the maintenance of competency when endoscopic procedures are not regularly performed, and the testing and learning of new, mainly interventional methods, before the procedure is performed on the patient [2].

In this study, we demonstrated a significant improvement between pre- and post-training in the performance of novice endoscopists using the simulator. It was shown that novices improve psychomotor and endoscopic skills, as well as the procedure quality metrics. Published studies regarding virtual-based endoscopy training show different outcomes: the validation of the simulation, training in simulation and learning curves, and improved performance in patient-based assessment.

There are other studies that evaluate the role of virtual endoscopy training.

In a recent systematic review, twenty-three studies reported simulation training and learning curves, including 17 randomized control trials. Increased performance using virtual reality (VR) simulators was shown in all studies. All but one of these studies focused on the diagnostic aspects of forward viewing flexible endoscopy, for example intubation skills. Twenty studies reported on forward viewing flexible endoscopy (3 EGD, 3 sigmoidoscopy, and 14 colonoscopy). Unlike our study, all studies on flexible sigmoidoscopy and colonoscopy had a randomized design and compared simulator-based training groups versus controls. Acquired competence was evaluated using the same simulator. The most consistent outcome parameters demonstrating improved performance were on procedural times, cecal intubation rates (CIRs), and times in red-out, meaning that luminal view was lost. Six studies were carried out using the same Simbionix GI Mentor VR simulator that we used in this study for training and learning curve, and all of them demonstrated that simulator training improved the performance of novices. Due to the methodological heterogeneity of these studies, improved performance could not be expressed in terms of exact numbers. This systematic review concludes that the use of validated VR simulators in the early training setting accelerates the learning of practical skills [10].

In a multicenter trial performed in USA, significant improvements from pre- to post-training were seen in Endobubble tasks, cecal intubation time, total time, and screening efficiency [11]. In this trial, the same VR simulator was used, but unlike our study, postgraduate surgery residents were included in a non-mentored VR training.

In a trial that took place in the Netherlands, the novices improved their performance considerably on both VR colonoscopy I-3 and the Endobubble task [12]. Unlike our study, the training was non-mentored, and the training assignment was to visualize the cecum as quickly as possible without causing patient discomfort.

In a multicenter, randomized, controlled trial, significantly faster time to the cecum, total procedure time, and efficiency score were observed [13]. They included gastroenterology fellows without previous formal training in colonoscopy (< 10 cases), and their strength in comparison with our study is that the fellows were randomized into two groups (simulator training and no simulator training) and the VR training was longer and divided into five sessions.

In the second part of a randomized Denmark study, 20 novice endoscopists were included and randomized to a group who received psychomotor training (10 repetitions on the GI Mentor II of the Endobubble task) and a control group. Subjects who received psychomotor training performed the second virtual colonoscopy significantly faster than the control group. Furthermore, as in our study, the trained group achieved significantly greater improvement in percent of mucosa surface examined, efficiency of screening, time with clear view, pain experienced, time with pain, loop formation, time with loop, and excessive local pressure [14].

According to our knowledge, this is the first simulator study carried out in Latin America in such a large number of novice endoscopists. The limitations of the study were as follows: There was not control group and we did not extrapolate the impact of the VR training to the clinical practice. On the other hand, the training program consists of a single session, so it was not possible to evaluate the number of sessions until reaching the plateau in terms of the learning curve.

## Conclusion

This study showed that virtual simulation is an efficient endoscopic training and educational tool. This training method produces a significant improvement in the trainee's performance and their psychomotor skills, as well as introducing the concept of a quality endoscopic study in a non-patient, risk-free environment.

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## Compliance with Ethical Standards

**Conflict of interest** The authors declare that they have no conflict of interest.

## References


1. Faulx AL, Lightdale JR, Acosta RD, et al. Guidelines for privileging, credentialing, and proctoring to perform GI endoscopy. *Gastrointest Endosc*. 2017;85:273–281.
2. Ziv A, Ben-David S, Ziv M. Simulation based medical education: an opportunity to learn from errors. *Med Teachnol*. 2005;27:193–199.
3. Singh S, Sedlack RE, Cook DA. Effects of simulation-based training in gastrointestinal endoscopy: a systematic review and meta-analysis. *Clin Gastroenterol Hepatol*. 2014;12:1611–1623.
4. Kruglikova I, Grantcharov TP, Drewes AM, et al. The impact of constructive feedback on training in gastrointestinal endoscopy using high-fidelity virtual-reality simulation: a randomized controlled trial. *Gut*. 2010;59:181–185.
5. Walsh CM, Ling SC, Wang CS, et al. Concurrent versus terminal feedback: it may be better to wait. *Acad Med*. 2009;84:S54–S57.
6. Walsh CM, Ling SC, Khanna N, et al. Gastrointestinal endoscopy competency assessment tool: development of a procedure-specific assessment tool for colonoscopy. *Gastrointest Endosc*. 2014;79:798–807.
7. Bini EJ, Firoozi B, Choung RJ, Ali EM, Osman M, Weinshel EH. Systematic evaluation of complications related to endoscopy in a training setting: a prospective 30-day outcomes study. *Gastrointest Endosc*. 2003;57:8–16.
8. McCashland T, Brand R, Lyden E, de Garmo P. The time and financial impact of training fellows in endoscopy. CORI research project. Clinical outcomes research initiative. *Am J Gastroenterol*. 2000;95:3129–3132.

9. Desilets DJ, Banerjee S, Barth BA, et al. Endoscopic simulators. *Gastrointest Endosc*. 2011;73:861–867. https://doi.org/10.1016/j.gie.2011.01.063.
10. Ekkelenkamp VE, Koch AD, de Man RA, Kuipers J. Training and competence assessment in GI endoscopy: a systematic review. *Gut*. 2016;65:607–615.
11. Van Sickle KR, Buck L, Willis R, et al. A multicenter, simulation-based skills training collaborative using shared GI Mentor II systems: results from the Texas Association of Surgical Skills Laboratories (TASSL) flexible endoscopy curriculum. *Surg Endosc*. 2011;25:2980–2986. https://doi.org/10.1007/s00464-011-1656-7.
12. Buzink SN, Koch AD, Heemskerk J, et al. Acquiring basic endoscopy skills by training on the GI Mentor II. *Surg Endosc*. 2007;21:1996–2003. https://doi.org/10.1007/s00464-007-9297-6.
13. Cohen J, Cohen SA, Vora KC, et al. Multicenter, randomized, controlled trial of virtual-reality simulator training in acquisition of competency in colonoscopy. *Gastrointest Endosc*. 2006;64:361–368.
14. Eversbusch A, Grantcharov TP. Learning curves and impact of psycho-motor training on performance in simulated colonoscopy: a randomized trial using a virtual reality endoscopy trainer. *Surg Endosc*. 2004;18:1514–1518.