Title
The Promise of Virtual Training for Upper Endoscopy Skill Acquisition

Author
Nguyen, Tiffany

Publication Date
2021

Peer reviewed|Thesis/dissertation

UNIVERSITY OF CALIFORNIA,
IRVINE

The Promise of Virtual Training for Upper Endoscopy Skill Acquisition

THESIS

submitted in partial satisfaction of the requirements
for the degree of

MASTER OF SCIENCE

by

Thao-Uyen Tiffany Vu Nguyen

Thesis Committee:
Professor Sherrie Kaplan, UC Irvine, Chair
Assistant Professor In-Residence Robert Wilson, UC Irvine, Member
Professor Tonya Kaltenbach, UC San Francisco, Member
Professor Roy Soetikno, UC San Francisco, Mentor

2021

Table of Contents

List of Figures

Page

List of Tables

Page

Acknowledgements

Research Funding through

University of California San Francisco

Course Supplies through

Academy of Endoscopy

Abstract

Introduction

Endoscopy performance is highly variable among fellows and practicing physicians.[1,2] The field lacks a standard endoscopy training curriculum. Moreover, the traditional training under the apprenticeship model has proven to be a slow and ineffective method. Trainees who underwent a simulation-based mastery learning (SBML) curriculum accelerated their acquisition of clinical competency, 2.5x faster than trainees who received traditional training under the apprenticeship model.[3] During the COVID-19 pandemic, we adapted our SBML curriculum to train upper endoscopy (esophagogastroduodenoscopy [EGD]) to novice gastroenterology trainees through online virtual coaching. Herein, we performed a hypothesis-generating study to evaluate the effectiveness of SBML-based EGD training, comparing virtual to direct in-person coaching.

Methods

We conducted a 7-day virtual SBML course across 7 academic centers in the USA and Asia. A minimum passing standard was set for each topic. Theoretical material was delivered using Canvas, an online learning management system. For technical skills training, a virtual coach supervised hand-on training at scheduled intervals. At the end of training, an independent rater assessed the trainees skills using a validated scoring system. After the course, we assessed the trainees' clinical performance for the first 30 EGDs using the Assessment of Competency of Endoscopy (ACE) form. We compared the trainees' scores to that of our historical control cohort trained using in-person SBML training. Our primary outcomes were competence scores on the written exam, endoscope tip control, standard EGD. Our secondary outcome was clinical EGD evaluations. We used non-inferiority t-test statistics and Fisher's exact test.

Results

The virtual coaching group received similar scores as the direct coaching group for the written assessment (virtual coaching 81.9%+8.9% vs direct coaching 78.3%+8.2%, p=0.385).
For endoscope handling analysis, the trainees reached the MPS for competency after 31.4+29.1 attempts and mastery after 51.9+36.7 attempts, similar to the control cohort that had undergone the training with direct coaching (competency: 32.5+22.8, p=0.93; mastery: 38.2+31.1, p=0.42).
For Standard EGD, the mean scores for the general assessment of the UGI tract were similar between the intervention and control groups (4.6+0.6 vs 4.7+0.5, p=1.00). For clinical EGDs, there were no significant differences in scores for EGD 1-5, 11-15, 16-20, 21-25, and 26-30. For EGDs 6-10, the virtual coaching cohort performed significantly better than the direct coaching cohort (2.73+0.59 vs 1.65+0.59, p<0.001).

Discussion

The COVID-19 pandemic shifted the way we deliver endoscopy training. An SBML curriculum, delivered through virtual coaching, shows significant promise in effectively teaching novice GI trainees how to perform upper endoscopy. Moreover, SBML with virtual coaching allows trainees to learn from experts despite geographical constraints and other barriers to high-quality training. This program has the potential to improve patient safety and training efficiency compared to traditional apprentice-based training methods. We recommend a future randomized controlled trial, with a robust clinical evaluation strategy, to better understand the feasibility and effectiveness of virtual training.

Chapter 1. Introduction

Multiple studies have shown that endoscopy performance is highly variable among fellows and practicing physicians.[1,2] In gastroenterology fellowship, endoscopy training typically occurs directly at the patient bedside through the traditional apprenticeship model. However, this method of procedural training is often not standardized, which may lead to variable technical skills depending on the expertise of the supervising physician. Other surgical subspecialties (e.g. laparoscopy and cardiology) have progressed to more evidence-based training methods using simulations and structured curricula. Simulation-based learning can provide trainees the opportunity to develop their procedural skills safely and effectively before performing in patient settings. However, simulators are not commonly used in endoscopy.[4–6] The few existing simulation-based training programs focus on technical skills, without supporting educational curricula that emphasize competency and improvement in clinical practice.[7]

Studies show that simulation-based training coupled with the mastery learning pedagogy [simulation-based mastery learning (SBML)] improves clinical skills and reduces the risk of procedure-associated injury for a variety of procedural skills.[8–11] Mastery learning is a form of competency-based education in which learners are required to meet or exceed a predetermined level of skill before completion of training. Our research group has pioneered the use of SBML in endoscopy to facilitate the safe and efficient acquisition of basic and advanced procedural skills among practitioners and trainees.[12,13] We found that trainees who underwent the SBML training program reached competency for performing EGD in patients 2.5x faster than trainees who received traditional training under the apprenticeship model.[3]

Our goal was to increase accessibility to high-quality endoscopy training and to shift the teaching paradigm in endoscopy towards the use of an SBML training curriculum. Our project became even more timely during the COVID-19 pandemic, as many endoscopic procedures were rescheduled, and opportunities became limited for fellows to train their procedural skills though the apprenticeship model.[14]

We adapted our SBML curriculum to train upper endoscopy (esophagogastroduodenoscopy [EGD]) to novice fellows through online virtual coaching. Virtual coaching, sometimes referred to as telementoring, is a training system where remote instructors conduct training mainly through online teleteaching technologies.[15] It allowed for the widespread delivery of a standardized SBML curriculum across diverse settings in multiple institutions, while also improving the convenience for endoscopy education during the COVID-19 pandemic. Moreover, virtual coaching created an economy of scale that increases efficiency and improves access to high-quality procedural training.

Herein, we performed a hypothesis-generating study to evaluate the effectiveness of EGD training when delivered through virtual coaching versus direct in-person coaching. We reported changes in theoretical knowledge, simulation-based technical skills, and clinical performance after our training course.

Chapter 2. Background

Currently, upper endoscopy training is based on the traditional apprenticeship model in which fellows learn procedural skills by observing and practicing directly on patients. A recent multicenter study in the US revealed that there is a long learning curve for upper endoscopy: trainees achieve competency after more than two years of fellowship training.[16] Some trainees may not even reach competency by the end of their fellowship period, especially during the pandemic, when endoscopic procedure volume is limited. Simulation-based mastery learning is a stringent form of competency-based education that has been shown to accelerate the learning curve for upper endoscopy and other endoscopic interventions.[4–6] To improve the accessibility of the training system, we adapted our curriculum to be conducted primarily through virtual coaching.

There is minimal existing literature on studies evaluating the effectiveness of virtual coaching in endoscopy training, excluding those performed by our team. We have previously

described our experience conducting a SBML upper endoscopy course using a hybrid virtual coaching mechanism where trainees received asynchronous virtual training over 4 weeks and direct in-person instruction over 2 days.[17] However, there are no existing studies evaluating the effectiveness of endoscopy training conducted completely online. In surgery, Erridge et al recently published a systematic review of telementoring in surgeons and found that the majority of the articles provided low-quality evidence in evaluating the effectiveness of virtual coaching.[18] A randomized controlled trial in laparoscopy found that virtual video-based coaching significantly improved trainee performance in a porcine model.[19] However, clinical evidence supporting the intervention remains sparse. To support the use of virtual coaching for endoscopy training, there is a need to evaluate changes in trainee performance after virtual coaching.

Study Design and Methods

Research Aims

We aimed to evaluate the performance of the trainees undergoing the SBML curriculum and compare the skills of those who received virtual coaching versus direct coaching**.** Our results will provide the necessary information to assess the efficacy and value of virtual coaching in endoscopy for future randomized studies. This research will also provide feedback to identify areas of improvement in our training program and allow us to refine and optimize our course in order to expand our reach to more fellows, particularly those in rural or underserved areas who do not have access to high-quality endoscopy training.

Study Design

We conducted a longitudinal cohort study to observe the outcomes of trainees who underwent an EGD training program through virtual coaching compared to trainees who underwent the program through direct in-person coaching.

Sampling

We recruited all trainees who were in rotation at seven academic medical centers (US, Singapore, Indonesia, Thailand, Philippines) during the training period (n=22). We excluded trainees who were not fluent in English (n=1). Those who agreed to participate were included (n=21).

Intervention

Experimental Group

Our group conducted an EGD training program for first-year gastroenterology trainees (n=21) at seven academic medical centers (US, Singapore, Indonesia, Thailand, Philippines). The training program was conducted over one week (July 2020) through virtual coaching (VC) only. The trainees were relieved of their clinical duties and did not perform EGDs in patients for the duration of the training program. The trainees underwent the training program at their respective institutions, and all received remote instruction from a virtual trainer in San Francisco or Singapore.

Control Group

For the control group, we observed fellows (n=6) who had undergone the EGD training program with direct coaching (DC) one year before the intervention group (July 2019). We recruited all first-year gastroenterology trainees who were in rotation at 3 academic medical centers (US and Singapore) during the training period (n=6). The training was conducted in person at the San Francisco VA Medical Center (n=4) and Singapore General Hospital (n=2).

Course Curriculum

Two expert endoscopists determined the necessary elements to perform high-quality upper endoscopy: 1) appropriate diagnosis of common cancers and diseases, 2) adequate endoscope tip control (fine motor movements), and 3) thorough mucosal examination of the upper GI tract. Each training day consisted of a 8-hour session, during which at least one

remote instructor was available for assistance at any time. We began each session with a live large group lecture (Zoom, San Jose, CA, USA) and then dispersed into small groups (2-4 trainees) where the remote instructors provided more individualized guidance and feedback. The large group lectures were conducted over 1-2 hours and the small group sessions were conducted over 1-3 hours at a time. The trainees were able to view the instructor's endoscopy monitor and hands on the endoscope and vice versa (Figure 3.1). This set-up allowed the instructor to teach each technique, step-by-step, while monitoring the trainee's progress. At the end of each day, the trainees uploaded one video of themselves (of their choosing) performing the practice exercise, which allowed the instructors to monitor their progress.

Figure 3.1. Example of a Virtual Endoscopy Training Session using Zoom. The instructor and trainee have one camera showing their hands controlling the endoscope and the view of the endoscopy monitor

For the theoretical training, all students were given access to the course material on Canvas. The modules covered procedure hygiene, safety, endoscope handling, anatomy, mucosal biopsies, endoscopic findings, electrosurgery, clipping, and hemostasis. Trainees completed the online modules concurrently with their technical skills training. Trainees were

required to pass the written assessments prior to each stage of the technical skills training (Figure 3.2).

Figure 3.2. Course Timeline. Trainees are required to complete theoretical material on Canvas prior to attending the technical skills training. They learned endoscope tip control, standard EGD on a simulator model, and other basic interventions.

	6-Jul	7-Jul	8-Jul	9-Jul	10-Jul	11-Jul	12-Jul
Canvas Modules due before Training Session:	Module 1: Let's get ready to perform an upper endoscopy!	Module 2: Standardized EGD and Anatomy Module 3: When to take biopsies	Module 4: UGI Findings Module 5: Electrosurgery	Module 6: Endoscopic Presentation of UGI Diseases	Module 7: Clipping Module 8 Its a NVUGIB!		
Training session AM	- Endoscope Tip Control	- Endoscope Tip Control	- Electrosurgery	-Standard EGD	-Biopsy -Clipping	Introduction to Therapies -Foreign Body	
Training session PM	- Endoscope Tip Control	- Endoscope Tip Control	-Standard EGD	-Standard EGD -Photodocumentation -Distal Cap	Assessment and Feedback (Local)		

	13-Jul	14-Jul	15-Jul	16-Jul	17-Jul	18-Jul	19-Jul
Training session AM	Final Assessment (Independent Assessor)						
Training session PM							

First, the fellows were trained in endoscope tip control. We assessed their tip control skills using a previously validated simulator (Figure 3.3).[20] The tip control simulator was designed to facilitate rapid acquisition of fine tip control. Trainees were required to maneuver through stickers labelled “A-Z” using only one hand, with proper endoscope handling technique, and without torquing. The trainees had continuous access to the simulators and were given the opportunity to practice their skills at their own learning pace. Throughout the 7-day training period, we collected the amount of time it took for each trainee to complete the tip control simulator activity (completion time) and the amount of trials it took to reach competency (120 seconds) and mastery (100 seconds), which were based on the average speed of experienced endoscopists.[20]

Then, the fellows learned how to perform a standard EGD on a simulator model (Figure 3.2). The model represented the upper gastrointestinal tract, allowing the trainees to practice intubation and mucosal examination. We evaluated their EGD skills (thorough examination of

the upper GI tract) using a previously validated assessment tool (Appendix 1).[21] To meet competency for EGD, trainees were required to score at least a “4” (1- Very Poor to 6-Excellent) for the overall upper GI examination based on the values obtained from experienced endoscopists.[21] Two experienced endoscopists (9.5±6.4 mean years of practice), who were not involved in their training, performed the assessment.

Figure 3.3. Endoscope Tip Control Simulator (Left) and Standard EGD Simulator Model (Right). The trainees developed endoscope handling skills and fine motor movements using the tip control simulator. They learned how to perform thorough mucosal examination using the standard EGD simulation model.

Key Study Variables

Demographic information

We collected baseline demographic information including age, sex, training track, previous EGD experience, and dominant hand.

Written Assessment

On the last day of the course, the trainees took a written exam (20 multiple choice questions), which was created jointly by four experienced endoscopy educators. The 20 test questions were derived from their assigned articles, videos, lectures and quizzes, and covered topics including nomenclature, infection prevention, anatomy, endoscopic findings and treatment plan. The assessment was previously assessed for discriminant validity to determine

a significant difference among first-year trainees and second- and third- year trainees (56.5% vs 83.8%, $p<0.001$).[3] A score of 60% was required to pass the written exam.

Simulation-Based Technical Skills Assessments

We evaluated endoscope handling skills by observing the change in the endoscope tip control simulator completion time throughout the 7-day training period. A faster completion time for the simulator activity corresponded to better endoscope handling skills. We compared the intervention and control groups by analyzing completion time and the amount of trials it took to reach the minimum passing standard for competency (120 seconds) and mastery (100 seconds).[20]

On the final day of the course, the trainees took a final EGD assessment on their technical skills for intubation and examination using the simulator model. The minimum passing standard (MPS) was a score of at least "4" for the general assessment of the upper GI tract. Their performance was evaluated by an independent rater using the assessment tool described previously (Appendix 1). Both of the raters were experienced endoscopists and were not involved in their training. The raters underwent brief training to ensure that scoring was standardized between the two. We evaluated interrater agreement by having both raters assess a random sample of 10 trainee EGD videos. We calculated a kappa score for ordinal variables. We considered a kappa value of 0.60 to represent adequate reliability.

Feedback Survey

On the final day of the program, we administered a feedback survey regarding strengths and weaknesses of the virtual coaching technology, simulators, virtual instructors, and overall course. The survey had 24 items that were open ended or rated on a 10-point Likert scale. We also collected trainees' opinions regarding the feasibility and perceived effectiveness of the virtual coaching program.

Clinical EGD Assessment

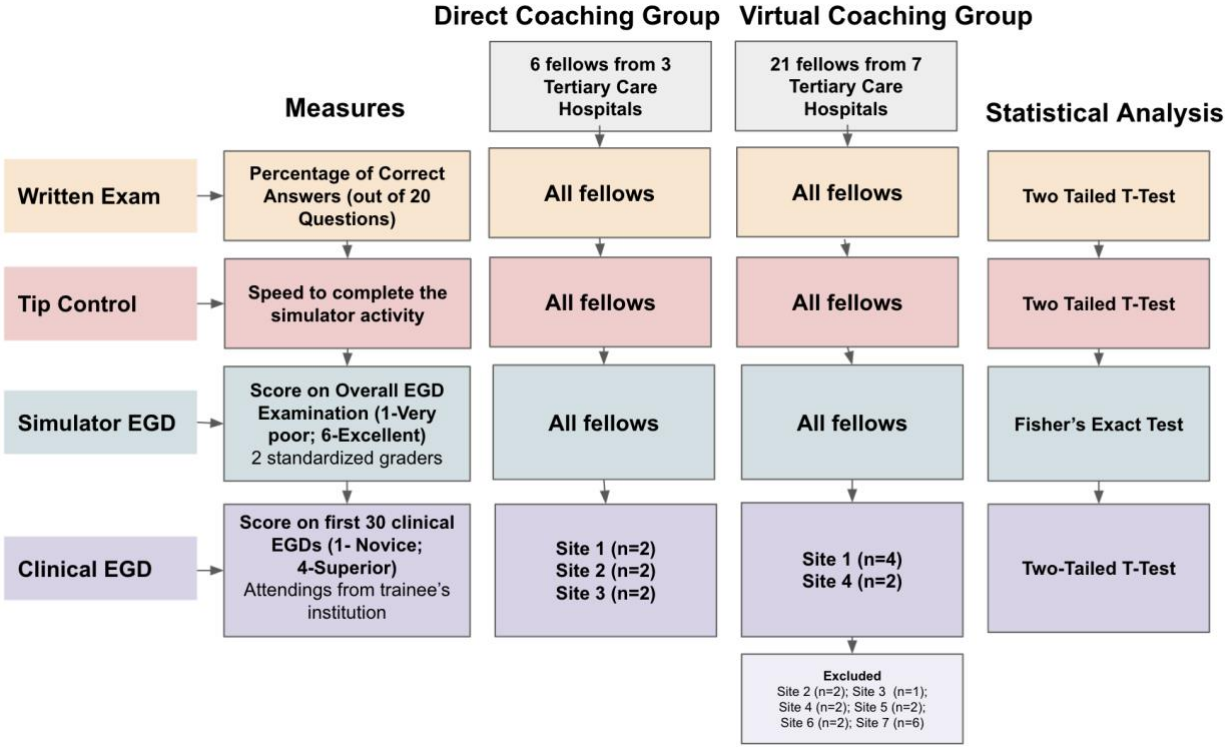
After completion of the program, we evaluated trainee's performance in clinical EGDs using the American Society of Gastrointestinal Endoscopy's Assessment of Competency in Endoscopy (ACE) tool (Appendix Figure 1). The ACE tool is a 9-item assessment tool used to evaluate cognitive and motor skills for EGD using a scale of 1 to 4 (1-Novice; 2-Intermediate; 3-Advanced; 4- Superior). We asked all trainees to collect the evaluation for each EGD they performed in clinical care. Supervising physicians at the trainee's respective institution assessed the trainee's skills for each clinical EGD performed. At the end of the procedure, the supervising physician completed the ACE tool online using Google Forms or on paper. If done on paper, the fellow took pictures of the completed forms and sent them to a research coordinator who recorded the scores to the database.

Statistical Analysis

We compared the scores of trainees who underwent the training through virtual coaching (n=21) to trainees who underwent the training through direct coaching (n=6)(Figure 3.4). The independent variable was the delivery method of training (virtual coaching vs direct coaching). The dependent variables were the scores on the written exam, tip control simulator, standard simulation-based EGD, and clinical EGDs. The primary outcomes were the scores on the written assessment, tip control simulator, and standard simulation-based EGD. The secondary outcome was the overall technical score on the clinical EGD evaluations. We conducted a two-tailed t-test for the written assessment and endoscope tip control analysis. To evaluate success in endoscope tip control, we used the average completion time of the last 5 attempts on the simulator. We performed a Fisher's exact test to compare standard EGD examination scores for the overall esophagus, stomach, duodenum and upper GI tract. We chose to use Fisher's exact test instead of a t-test because a majority of the scores were between 4 and 6. For the clinical EGD evaluations, we compared the mean scores of every 5 EGDs between the virtual coaching

and direct coaching groups using a two tailed t-test. We set the criteria for statistical significance as $p < 0.05$. We used SPSS statistics to perform the Fisher's exact test and two-tailed t-tests.

Figure 3.4 Evaluation strategy for the SBML EGD training program conducted through direct coaching and virtual coaching. To compare the intervention and control groups, we conducted two tailed t-tests for the written exam, tip control and clinical EGD evaluations and Fisher's exact test for the simulator EGD assessments.



Results

We enrolled 21 trainees (mean age-30.8±3.6; male-48%) in the virtual coaching training program (Table 4.1). We observed a historical cohort of 6 trainees (mean age 31.4±2.4; male-100%) who had undergone the program through direct in-person coaching. All trainees in the direct coaching group and 19 trainees (90.4%) in the virtual coaching group had never performed an EGD prior to the course.

Table 4.1. Participant Demographics. We collected participant demographics including age, gender, prior EGD experience, and dominant hand for each group.

	Virtual Coaching (n=21)	Direct Coaching (n=6)
Age	30.8±3.6 years	31.0±2.7 years

Gender		
Male	10 (47.6)	6 (100)
Female	11 (52.4)	0 (0)
Number of Prior EGDs		
0	19 (90.4)	6 (100)
<5	1 (4.8)	0 (0)
5-10	1 (4.8)	0 (0)
>10	0 (0)	0 (0)
Dominant Hand		
Right	17 (80.9)	5 (83.3)
Left	4 (19.1)	1 (16.7)

Written Assessment

The virtual coaching group received similar scores as the direct coaching group (virtual coaching 81.9%±8.9% vs direct coaching 78.3%±8.2%, p=0.385) (Table 4.2).

Simulation-Based Technical Skills Assessment

For endoscope handling analysis, we excluded four trainees in the virtual coaching cohort who had experience with the simulator prior to the training program. The trainees in the intervention group reached the minimum passing standard for competency after 31.4±29.1 attempts and mastery after 51.9±36.7 attempts, similar to the control cohort that had undergone the training with direct coaching (competency: 32.5±22.8, p=0.93; mastery: 38.2±31.1, p=0.42). The average scores for the last five attempts on the tip control simulator were also similar between the two groups (78±20 seconds vs 58±24 seconds, p=0.1754).

For Standard EGD, all of the trainees achieved mastery for the general assessment (score of 4 and above) after the first attempt. The mean scores for the general assessment of the UGI tract were similar between the virtual coaching group and direct coaching group

(4.6±0.6 vs 4.7±0.5, p=1.00). For the virtual coaching group, the lowest mean score was for overall duodenum examination (VC 4.5±0.78 vs DC 5.0± 0.89, p=0.52) while the lowest mean score for the direct coaching group was for the esophagus (VC 5.1±0.7 vs DC 4.8±0.8, p=1.00). The two groups received similar scores for overall stomach evaluation (VC 4.6±0.5 vs DC 5.2±0.8, p=0.06). We found that the raters had strong interrater reliability with a kappa score of 0.82.

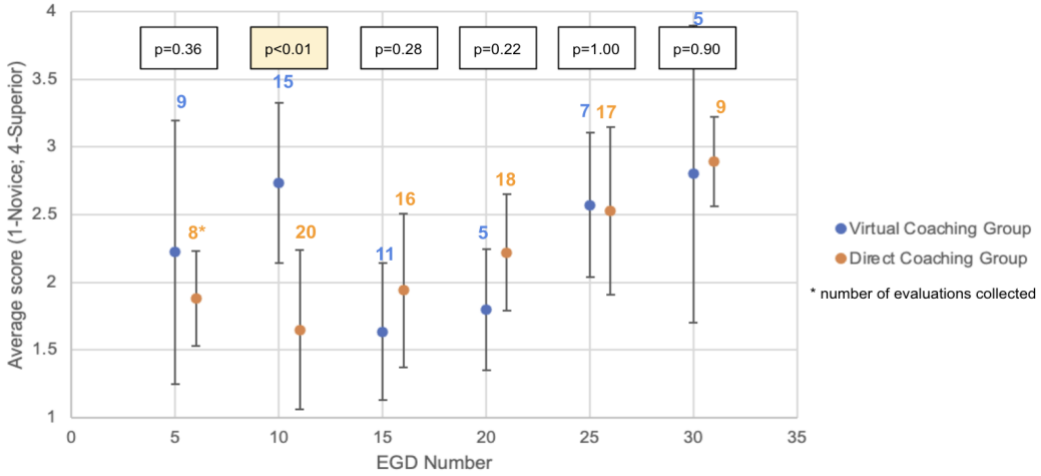
Table 4.2. Comparison of Simulation-Based Assessment Scores. We compared the scores of the virtual coaching and direct coaching groups using two-tailed t-tests for the written assessment and endoscope handling, and Fisher's exact test for the standard EGD assessment. There were no significant differences between the two groups (p>0.05).

	Virtual Coaching Group	Direct Coaching Group	p-value
Written Assessment	n=21	n=6	
Percent Correct out of 20 Questions	81.9%±8.9%	78.3%±8.2%	p=0.385
Endoscope Tip Control	n=17	n=6	
Attempts Needed to Reach MPS for Competency	31.4±29.1	51.9±36.7	p=0.93
Attempts Needed to Reach MPS for Mastery	32.5±22.8	38.2±31.1	p=0.42
Mean Completion Time for Last Five Attempts	78±20 seconds	58±24 seconds	p=0.18
Standard Simulation-Based EGD	n=21	n=6	
Overall Esophagus	5.1±0.7	4.8±0.8	p=1.00
Overall Stomach	4.6±0.5	5.2±0.8	p=0.06
Overall Duodenum	4.5±0.8	5.0± 0.9	p=0.52
General Assessment of Upper GI Tract	4.6±0.6	4.7±0.5	p=1.00

Clinical EGD Assessment

We asked all trainees in the virtual coaching group to collect clinical EGD evaluations. However, due to the reduced caseload and disruptions from the COVID-19 pandemic response, only 6 trainees (two sites) from the virtual coaching group were able to retrieve clinical EGD evaluations from their supervising physicians (Figure 3.4). We collected a total of 33 clinical EGD evaluations from 6 fellows (28.6%) in the virtual coaching group and 94 evaluations from 6 fellows (100%) from the direct coaching group (Figure 4.1). For the first 5 clinical EGDs, the trainees in the virtual coaching group received similar scores as the direct coaching group (2.22±0.97 vs 1.88±0.35, p=0.36, Figure 2). For EGD 6-10, the virtual coaching cohort performed significantly better than the direct coaching cohort (2.73±0.59 vs 1.65±0.59, p<0.001). There was no significant difference in scores for the remaining EGD groups (11-15, 16-20, 21-25, and 26-30). The mean scores for the first 30 EGDs were similar among trainees who received virtual coaching and trainees who received in-person coaching (mean ACE for 30 EGDs=2.3±0.8 vs. 2.2±0.7; p=0.25).

Figure 4.1. Comparison of clinical EGD evaluations between the virtual coaching group (intervention) and direct coaching (control) group. Trainees in the virtual coaching group performed similarly to the trainees in the direct coaching group, excluding EGD 6-10 where the virtual coaching group performed significantly better than the direct coaching group.



The average overall satisfaction rating for the course, including the online learning management system, virtual coaches, and simulation-based practice sessions was 9.3±1.2 (out of 10) with 90% of the trainees indicating interest in attending similarly structured courses for other endoscopic techniques (Table 4.3). Trainees reported high satisfaction for the realism of the virtual coaching set-up (9.2±0.95 out of 10), the helpfulness of their virtual coaches (9.5±0.79), and the scheduling availability of their virtual coaches (9.2±0.92). Twelve (57%) of the trainees indicated that the length of the course was appropriate while 29% (n=6) felt that it was too short and 14% (n=3) felt it was too long.

Table 4.3. Satisfaction survey among the virtual coaching group. Trainees in the virtual coaching group rated their satisfaction of the course highly with interest in attending similarly structured courses in the future.

	Virtual Coaching Group (n= 21)
Overall Satisfaction with the Course (out of 10)	9.3±1.2
Effectiveness of Course (out of 10)	9.2±1.2
Length of Course (too short, appropriate, or too long)	12 (57%) appropriate 6 (29%) too short 3 (14%) too long
Helpfulness of the Coaches (out of 10)	9.5±0.79
Interest in Attending Similarly Structured Courses for Other Techniques (yes or no)	90%
Realism of Virtual Coaching Set-Up (out of 10)	9.2±0.95
Ease of Use (out of 10)	8.3±1.4

Discussion

Our study shows the promise of SBML training program conducted through virtual coaching for upper endoscopy in gastroenterology trainees to improve the efficiency and

effectiveness of upper endoscopy training. Our study provides preliminary evidence in support of SBML training through virtual coaching, which has not yet been described in endoscopy.

Our results from this study suggest that virtual training is feasible for gastroenterology trainees learning how to perform basic endoscopy procedures for the first time. We conducted an international virtual EGD training course, enrolling 21 gastroenterology fellows simultaneously across 3 different time zones. Our study showed that trainees who underwent the SBML curriculum delivered through virtual coaching reached similar performance levels as trainees who underwent the SBML curriculum through direct in-person instruction.

Our findings in the successful application of virtual coaching for endoscopy are indeed novel. They expand on the literature of its application in other specialties. The use of telementoring or virtual coaching in surgery has shown to remotely train endovascular aortic aneurysm repair, a complex and high-risk procedure.[22] Patients who underwent the repair by surgeons trained using the virtual coaching sessions had similar outcomes to those treated by surgeons trained in-person. Nonetheless, the majority of the studies assessing virtual coaching in surgery provide low-quality evidence with limited data on changes in clinical outcomes.[18] Our study provides further evidence that virtual coaching may be an effective alternative to in person coaching when teaching upper endoscopy to novice trainees.

Virtual coaching provides several benefits for gastrointestinal endoscopy training. First, virtual coaching can facilitate the standardization of endoscopy education. We developed a robust EGD curriculum based on expert guidance, evidence-based clinical practices, and effective teaching strategies. Virtual coaching allows us to expand our reach and ensure that all trainees receive the same robust and effective training. Our program also provides standardized assessment across different countries by using established assessment tools that were previously validated and studied. Second, virtual coaching improves access to high-quality education and facilitates trans-continental shared learning. Trainees from around the world will have access to endoscopy experts who share their expertise and knowledge of evidence-based

practices that have been thoroughly studied. Third, virtual coaching is highly convenient for the training institution as on-site trainers provide minimal assistance. This may be attractive for sites with limited available trainers or large caseloads. Fourth, virtual coaching may also be attractive for more advanced trainees or practicing physicians who already have clinical experience and are seeking to train more complex techniques. SBML with virtual coaching can be applied to train colonoscopy, endoscopic retrograde cholangiopancreatography, and other advanced techniques where expertise is not as accessible and much more specialized. Lastly, virtual coaching can reduce costs and improve accessibility as trainers and trainees are no longer required to travel to specific training sites.

Simulation-based mastery learning with virtual coaching allows trainees to develop and master difficult procedural skills before performing endoscopy on patients. This method of learning can mitigate issues related to training in patient care such as improving patient outcomes, reducing complications and procedure time, and improving patient comfortability during endoscopy. Trainees learn proper posture, fine motor control of the endoscope, and common disease and cancer findings prior to their first patient endoscopy. This allows the trainees to reserve procedure time with patients to focus on performing a thorough examination and ensuring patient comfort. Moreover, the trainer can provide fruitful guidance during endoscopy without needing to teach the trainees how to perform basic endoscopic maneuvers.

While the results were promising, our experience revealed obstacles associated with virtual training. Virtual training requires significant time and effort dedicated to setting up the training course. The course staff prepared course materials (simulators, accessories, and set-up guides) to be shipped to each site at least two weeks before the course. Two research coordinators were available at all times to provide the trainers and trainees with technical assistance in navigating the virtual coaching system. In addition, research coordinators ensured that trainees were completing the required assignments on time and received consistent feedback from the trainers. We found that virtual coaching requires a stable internet connection

to be able to closely follow trainers' and trainees' intricate movements with the endoscope. Otherwise, the process of feedback and training may be delayed, potentially impacting the effectiveness of the training system. Most importantly, virtual training eliminates the trainer's ability to provide direct hands-on assistance during endoscopy. As such, the success of the virtual coaching system depends heavily on the mutual dedication and patience of both the trainer and trainee in properly communicating their actions. Future studies should consider these limitations to ensure seamless virtual training when connecting with international sites.

Limitations

Our study has some limitations. First, we had a small sample size as each site had 2-6 fellows eligible for the program. While our results are interesting, a future study with a larger cohort may further inform us on the effectiveness of our training program with virtual coaching. Second, we received limited clinical EGD evaluations from the virtual coaching group. Our findings did not represent 71% of our virtual coaching cohort. At the time, collecting consistent clinical evaluations was not feasible due to the reduced clinical procedures and increased workload from the COVID-19 pandemic response. Third, the clinical EGD evaluations for both groups were not stringently standardized. Attending physicians from the trainee's respective institution were given an overview of the assessment tool; however, we did not observe interrater variability to verify standardization across all raters. Fourth, the clinical significance of our findings is unclear. While we observed strong evidence of improvement in trainee skills on simulators, we need additional studies with increased participant enrollment to assess trainees' skills in clinical practice as well as the difference in patient outcomes after the training program. Lastly, we compared trainee performance after receiving the training program through virtual coaching versus direct coaching. To better understand the value and benefit of our training program, we will need to perform a non-inferiority randomized controlled trial to compare the virtual training performance to trainees who underwent traditional training under the

apprenticeship method. This research would allow us to determine if our virtual training program would be more efficient and effective than traditional training.

Future Directions

For the next step, we propose a larger noninferiority study with a robust evaluation strategy to assess the value and effectiveness of virtual endoscopy training. A future randomized controlled trial should compare the SBML program with virtual coaching, direct coaching, and traditional apprentice-based training. Similar to our study, the proposed study should assess baseline skills and clinical performance using previously validated assessment tools. Future studies should also collect more consistent performance evaluations for clinical EGDs at specific time points (immediately after training, one month after training, and six months after training) to ensure feasibility in retrieving the assessments and limiting selection bias. Furthermore, future studies should observe the specific time commitment from each trainer, costs of simulators and telementoring technology, and minimum internet bandwidth needed for adequate video connection to better understand the feasibility and value of virtual coaching in endoscopy training.

References

(1) Duloy, A.; Yadlapati, R. H.; Benson, M.; Gawron, A. J.; Kahi, C. J.; Kaltenbach, T. R.; McClure, J.; Gregory, D. L.; Keswani, R. N. Video-Based Assessments of Colonoscopy Inspection Quality Correlate With Quality Metrics and Highlight Areas for Improvement. *Clin Gastroenterol Hepatol* **2019**, *17* (4), 691–700. https://doi.org/10.1016/j.cgh.2018.05.060.

(2) Mahadev, S.; Jin, Z.; Lebwohl, B.; Rosenberg, R. M.; Garcia-Carrasquillo, R. J.; Ramirez, I.; Freedberg, D. E. Trainee Colonoscopy Quality Is Influenced by the Independent and Unobserved Performance Characteristics of Supervising Physicians. *Endosc Int Open* **2019**, *7* (1), E74–E82. https://doi.org/10.1055/a-0770-2646.

(3) Soetikno, R. M.; Chin, Y.; Nguyen-Vu, T.; Malvar, C.; Soetikno, A.; Asokkumar, R.; Shergill, A. K.; Sealock, R.; Patel, K.; Wani, S. B.; Kaltenbach, T. R. Sa1052 SIMULATOR-BASED TRAINING PROGRAMS ACCELERATE ACQUISITION OF COGNITIVE AND TECHNICAL SKILLS FOR UPPER ENDOSCOPY. *Gastroenterology* **2020**, *158* (6), S-S-259. https://doi.org/10.1016/S0016-5085(20)31327-5.

(4) Nguyen-Vu, T.; Malvar, C.; Chin, Y. K.; Kaltenbach, T.; Liu, A.; Myint, T.; Asokkumar, R.; Shergill, A.; Soetikno, R. Simulation-Based Mastery Learning (SBML) for Rapid Acquisition of Upper Endoscopy Knowledge and Skills–Initial Observation. *VideoGIE* **2020**, *5* (6), 222–225. https://doi.org/10.1016/j.vgie.2020.02.014.

(5) Soetikno, R.; Cabral-Prodigalidad, P. A.; Kaltenbach, T. Simulation-Based Mastery Learning (SBML) with Virtual Coaching - Experience in Training Standardized Upper Endoscopy to Novice Endoscopists. *Gastroenterology* **2020**.

(6) Soetikno, R.; Asokkumar, R.; McGill, S.; Kaltenbach, T. Simulation-Based Mastery Learning for Practicing Gastroenterologists - Renewed Importance in the Era of COVID-19. *American Journal of Gastroenterology* **2020**.

(7) Walsh, C. M.; Cohen, J.; Woods, K. L.; Wang, K. K.; Andersen, D. K.; Anderson, M. A.; Dunkin, B. J.; Edmundowicz, S. A.; Faigel, D. O.; Law, J. K.; Marks, J. M.; Sedlack, R. E.; Thompson, C. C.; Vargo, J. J. ASGE EndoVators Summit: Simulators and the Future of Endoscopic Training. *Gastrointestinal Endoscopy* **2019**, *90* (1), 13–26. https://doi.org/10.1016/j.gie.2018.10.031.

(8) Smith, S.; Lobo, V.; Anderson, K. L.; Gisondi, M. A.; Sebok-Syer, S. S.; Duanmu, Y. A Randomized Controlled Trial of Simulation-Based Mastery Learning to Teach the Extended Focused Assessment with Sonography in Trauma. *AEM Educ Train* **2021**, *5* (3), e10606. https://doi.org/10.1002/aet2.10606.

(9) Dyke, C.; Franklin, B. R.; Sweeney, W. B.; Ritter, E. M. Early Implementation of Fundamentals of Endoscopic Surgery Training Using a Simulation-Based Mastery Learning Curriculum. *Surgery* **2021**, *169* (5), 1228–1233. https://doi.org/10.1016/j.surg.2020.12.005.

(10) Wilcox, J. E.; Harap, R. S.; Stosor, V.; Cohen, E. R.; Grady, K. L.; Cameron, K. A.; Scholtens, D. M.; Wayne, D. B.; Shanklin, K. B.; Nonog, G. P.; Schulze, L. E.; Jirak, A. M.; Magliola, G. C.; Barsuk, J. H. Effect of Ventricular Assist Device Self-Care Simulation-Based Mastery Learning on Driveline Exit Site Infections: A Pilot Study. *J Cardiovasc Nurs* **2021**. https://doi.org/10.1097/JCN.0000000000000824.

(11) Kule, A.; Richards, R. A.; Vazquez, H. M.; Adams, W. H.; Reed, T. Medical Student Ultrasound-Guided Intravenous Catheter Education: A Randomized Controlled Trial of Overtraining in a Simulation-Based Mastery Learning Setting. *Simul Healthc* **2021**. https://doi.org/10.1097/SIH.0000000000000554.

(12) Nguyen-Vu, T.; Malvar, C.; Chin, Y. K.; Kaltenbach, T.; Liu, A.; Myint, T.; Asokkumar, R.; Shergill, A.; Soetikno, R. Simulation-Based Mastery Learning (SBML) for Rapid Acquisition of Upper Endoscopy Knowledge and Skills–Initial Observation. *VideoGIE* **2020**, *0* (0).

https://doi.org/10.1016/j.vgie.2020.02.014.
(13) Soetikno, R. M.; Asokkumar, R.; Sanduleanu-Dascalescu, S.; Shergill, A. K.; Maulahela, H.; Kolb, J. M.; Hammad, H. T.; Kaltenbach, T. R. 277 – Rapid Development of Fellows' Cognitive and Procedural Skills of Endoscopy Using a Systematic Stepwise Learning Framework. *Gastroenterology* **2019**, *156* (6), S-55-S-56. https://doi.org/10.1016/S0016-5085(19)36921-5.
(14) Ong, A. M.-L. Outrunning Burnout in a GI Fellowship Program During the COVID-19 Pandemic. *Dig Dis Sci* **2020**, *65* (8), 2161–2163. https://doi.org/10.1007/s10620-020-06401-4.
(15) Augestad, K. M.; Han, H.; Paige, J.; Ponsky, T.; Schlachta, C. M.; Dunkin, B.; Mellinger, J. Educational Implications for Surgical Telementoring: A Current Review with Recommendations for Future Practice, Policy, and Research. *Surg Endosc* **2017**, *31* (10), 3836–3846. https://doi.org/10.1007/s00464-017-5690-y.
(16) Han, S.; Obuch, J. C.; Duloy, A. M.; Keswani, R. N.; Hall, M.; Simon, V.; Ezekwe, E.; Menard-Katcher, P.; Patel, S. G.; Aagard, E.; Brimhall, B.; Ahmad, A.; Alghamdi, S.; Brown, M. D.; Broy, C.; Carlin, L.; Chugh, P.; Connolly, S. E.; Cooley, D. M.; Cowley, K.; Di Palma, J. A.; Early, D. S.; Ellert, S.; Gaumnitz, E. A.; Ghassemi, K. A.; Lebovics, E.; Lee, R. H.; Lunsford, T.; Massaad, J.; Mittal, M.; Morigeau, K.; Pietrak, S.; Piper, M.; Shah, A. S.; Shapiro, A.; Sonnier, W.; Sorrell, C.; Vignesh, S.; Woolard, S.; Wani, S. A Prospective Multicenter Study Evaluating Endoscopy Competence Among Gastroenterology Trainees in the Era of the Next Accreditation System. *Acad Med* **2020**, *95* (2), 283–292. https://doi.org/10.1097/ACM.0000000000002885.
(17) Soetikno, R.; Cabral-Prodigalidad, P. A.; Kaltenbach, T.; Academy of Endoscopy (AOE) Investigators. Simulation-Based Mastery Learning (SBML) With Virtual Coaching - Experience in Training Standardized Upper Endoscopy to Novice Endoscopists. *Gastroenterology* **2020**. https://doi.org/10.1053/j.gastro.2020.06.096.
(18) Erridge, S.; Yeung, D. K. T.; Patel, H. R. H.; Purkayastha, S. Telementoring of Surgeons: A Systematic Review. *Surg Innov* **2019**, *26* (1), 95–111. https://doi.org/10.1177/1553350618813250.
(19) Singh, P.; Aggarwal, R.; Tahir, M.; Pucher, P. H.; Darzi, A. A Randomized Controlled Study to Evaluate the Role of Video-Based Coaching in Training Laparoscopic Skills. *Ann Surg* **2015**, *261* (5), 862–869. https://doi.org/10.1097/SLA.0000000000000857.
(20) Riek, S.; Hill, A.; Plooy, A. M.; Horswill, M. S.; Cresp, A. S. G.; Marinovic, W.; Christofidis, M. J.; Burgess-Limerick, R.; Wallis, G. M.; Watson, M. O.; Hewett, D. G. A Novel Training Device for Tip Control in Colonoscopy: Preliminary Validation and Efficacy as a Training Tool. *Surg Endosc* **2017**, *31* (12), 5364–5371. https://doi.org/10.1007/s00464-017-5617-7.
(21) Neumann, M.; Hahn, C.; Horbach, T.; Schneider, I.; Meining, A.; Heldwein, W.; Rösch, T.; Hohenberger, W. Score Card Endoscopy: A Multicenter Study to Evaluate Learning Curves in 1-Week Courses Using the Erlangen Endo-Trainer. *Endoscopy* **2003**, *35* (06), 515–520. https://doi.org/10.1055/s-2003-39670.
(22) Di Valentino, M.; Alerci, M.; Bogen, M.; Tutta, P.; Sartori, F.; Marty, B.; von Segesser, L.; Gallino, A. Telementoring during Endovascular Treatment of Abdominal Aortic Aneurysms: A Prospective Study. *J. Endovasc. Ther.* **2005**, *12* (2), 200–205. https://doi.org/10.1583/04-1421.1.

Appendix

Appendix Table 1. Simulation-based EGD evaluation using a previously validated assessment tool adapted from Neumann et al.[21] Trainees were graded on a scale from 1 (very poor) to 6 (excellent).

P1 Introduction of the endoscope and passage through the throat
P2 Passage through the esophagus
P3 Complete assessment of the proximal cardiac folds
P4 Passage through the stomach down to the pylorus, along the lesser curvature
P5 Passage through the pylorus
P6 Complete (circular) assessment of the duodenal bulb
P7 Introduction of the scope into the descending duodenum
P8 Complete assessment of the duodenal folds
P9 Complete visualization of the antrum
P10 Localization/visualization of an antral ulcer
P11 Visualization of the angular fold
P12 Performance of the retroflexion maneuver
P13 Visualization of the gastric fundus and cardia in retroflexion
P14 Visualization of the gastric body in retroflexion, and of the lesser curvature
P15 Withdrawal through the esophagus
P16 Overall mark for the esophagus
P17 Overall mark for the stomach
P18 Overall mark for the duodenum
P19 General assessment (complete assessment of the upper gastrointestinal tract)

Appendix Figure 1. Clinical EGD Evaluation using the American Society of Gastrointestinal Endoscopy ACE Tool. Trainees were assessed on a scale of 1 (Novice) to 4 (Superior).

ASGE Assessment of Competency in Endoscopy (ACE). EGD Skills Assessment Tool

Staff: **Cumulative EGD#:**
Date of procedure:
Time of Intubation:
Time of Maximal Insertion Extent:
Time of Extubation:

1. Fellow's knowledge of the indication & pertinent medical issues (INR, vitals, allergies, PMH etc):
   - N/A Fellow observed
   - 1. Poor knowledge of patient's issue, or started sedating without knowing the indication (Novice)
   - 2. Missed an important element, i.e. allergies, GI surgical history or INR in pt on Coumadin (Intermediate)
   - 3. Missed minor elements (Advanced)
   - 4. Appropriate knowledge and integration of patient information (Superior)
2. Management of patient discomfort during this procedure (sedation titration, insufflation management, loop reduction):
   - N/A Fellow observed
   - 1. Does not quickly recognize patient discomfort or requires repeated staff prompting to act (Novice)
   - 2. Recognizes pain but does not address in a timely manner (Intermediate)
   - 3. Adequate recognition and correction measures (Advanced)
   - 4. Competent continuous assessment & management i.e. intermittently reassess sedation level and comfort (Superior)
3. What is the furthest landmark reached without any hands-on **assistance**?
   - Hypopharynx
   - Distal esophagus
   - Stomach
   - Duodenal bulb
   - Second portion of the duodenum
   - Other (Post-surgical anatomy encountered, fellow reached maximal intubation)
4. Scope tip control/advancement techniques (esophageal intubation, traversing pylorus & duodenal sweep)
   - 1. Unable to intubate esophagus or travers pylorus without significant coaching or assistance (Novice)
   - 2. Slow advancement, wide tip motions, repeated attempts needed to intubate esophagus or traverse pylorus (Intermediate)
   - 3. Reasonable fine tip control for intubation, traverse pylorus and inspection (Advanced)
   - 4. Safe & effective technique, efficient independent advancement without need for coaching (Superior)
5. Adequately visualized mucosa during withdrawal (including retroflexion)
   - 1. Difficulty with retroflexion, requires assistance to visualize significant portions of the mucosa (Novice)
   - 2. Able to visualize much of the mucosa but requires direction to re-inspect missed areas (Intermediate)
   - 3. Able to adequately visualize most of the mucosa without coaching (Advanced)
   - 4. Competent visualization around difficult turns and folds and good use of suction/cleaning techniques (Superior)
6. Pathology identification/interpretation
   - 1. Poor recognition of abnormalities. Misses or does recognize significant pathology (Novice)
   - 2. Recognize abnormal findings but **cannot** interpret i.e. "erythema" (Intermediate)
   - 3. Recognizes abnormalities and correctly interprets i.e. "erythema suggestive of gastritis" (Advanced)
   - 4. Competent identification & assessment e.g. "erythema with erosions in a pattern suggestive of NSAID gastropathy" (Superior)
7. Interventions performed by fellow (check all that apply):
   - N/A – fellow did not perform any interventions (go to question 8)
   - Biopsy
   - Band ligation
   - PEG tube placement
   - APC vascular lesion ablation (GAVE, AVMs)
   - Submucosal injection (saline, epinephrine, other)
   - Hemostasis (hemoclip, electrocautery, etc)
   - Dilation (balloon, savary, other)
   - Other _____

7a. What was the **fellow's participation** in the therapeutic maneuver(s) (tool & setting selection and ability to apply tool effectively)
   - 1. Performed with significant hands-on assistance (Novice)
   - 2. Performed with minor hands-on assistance or significant coaching (Intermediate)
   - 3. Performed independently with minor coaching (Advanced)
   - 4. Performed independently without coaching (Superior)

Overall Assessment:

8. The fellows overall **hands-on** skills:
   - N/A – Not assessed (i.e. fellow observed procedure only)
   - 1. Learning basic scope advancement; requires significant hands-on assistance and coaching (Novice)
   - 2. Acquired basic motor skills but still requires limited hands-on assistance and/or significant coaching (Intermediate)
   - 3. Able to perform independently with limited coaching and/or requires additional time to complete (Advanced)
   - 4. Competent to perform routine EGD independently (Superior)
9. Rate the fellow's overall **cognitive** skills (situational awareness (SA)/ abnormality interpretation/ decision making skills)
   - N/A – Not assessed (i.e. Fellow observed procedure only)
   - 1. Needs significant prompting, correction or basic instruction by staff (Novice)
   - 2. Needs intermittent coaching or correction by staff (Intermediate)
   - 3. Fellow has good SA, and interpretation/ decision making skills (Advanced)
   - 4. Competent to make interpretations and treatment decisions independently (Superior)