

Exploration of an effective training system for the diagnosis of pancreatobiliary diseases with EUS: A prospective study

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ABSTRACT

Background and Objective: There are limited data on multistage-based training programs focused on EUS. We aimed to explore an effective training system for diagnosing pancreaticobiliary diseases with EUS. **Materials and Methods:** Nine advanced endoscopy trainees (AETs) with less EUS experience from nine institutions were recruited. The training system consisted of multiple stages and multi-teaching methods, including biliopancreatic standard scanning, anatomy and imaging knowledge, simulator, hands-on operations, error correction, and case analysis over a 12-month training period. Grading for technical and cognitive skills was assessed using The EUS Skills Assessment Tool. **Results:** After training, the overall scores for radial (4.16 ± 0.21 vs. 1.46 ± 0.16 , $P < 0.01$) and linear (4.43 ± 0.20 vs. 1.63 ± 0.23 , $P < 0.01$) scanning were significantly improved. The aortopulmonary window/mediastinum station can be learned more easily by AETs compared with other stations ($P = 0.023$). The scanning of the descending part of the duodenum seemed to improve the slowest after training ($P = 0.0072$), indicating that the descending part of the duodenum can be more difficult and should be the focus of training. Every teaching method heightened EUS competence, especially case analysis and hands-on operations. AETs achieved equivalent EUS competence after training despite their initial experience. Through a poststudy questionnaire, it was found that all AETs strongly agreed they were satisfied with the training system, and their confidence was greatly enhanced when EUS was performed independently. **Conclusions:** The current multistage and multi-methods training system showed efficient performance in the cognitive and technical competence of EUS. Descending part of duodenum scanning was difficult for beginners and should be the focus of training.

Key words: biliopancreatic, education, EUS, training

INTRODUCTION

Due to the vague clinical symptoms and lack of effective detection methods for early biliopancreatic diseases, especially pancreatic cancer, the 5-year survival

rate remains low at 10%–25% with a median survival of 14–18 months.^[1] Therefore, accurate and early

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assessment of lesions is of great importance. Of tools for the detection of biliopancreatic diseases, the accuracy of EUS ranges from 70% to 93%, compared with 15%–75% for computed tomography, and 60%–88% for magnetic resonance imaging.^[2-4] EUS is indeed considered to be the best imaging modality compared to other methods.

However, the accuracy of EUS is closely related to the endoscopist's experience. Endoscopic ultrasonographic T-staging of less experienced endoscopic ultrasonographers was inferior in accuracy compared with that of experienced endoscopic ultrasonographers (91.9% *vs.* 72.2%, $P < 0.05$).^[5] Western EUS surveys also have reported that a lack of experienced endosonographers is the most common barrier to the widespread use of EUS.^[6,7] Therefore, it is of great importance to developing an optimal training system for the cognitive and technical competence of EUS.

To date, two main methods for learning EUS have been reported: formal training, consisting of fellowship in a designated training center for 6–24 months, and informal training, consisting of various in-class didactic sessions that usually include short hands-on experiences.^[8] In addition, network-based self-directed teaching is conducted mainly through case testing and expert performance. However, formal training programs are scarce in China due to the costs, time, and inaccessibility at dedicated didactic centers. While informal training self-education is feasible and effective for simple endoscopic procedures, there has been little validation for EUS.^[9-11] Moreover, basic anatomical and radiologic knowledge of the biliopancreatic system also affects the diagnostic performance of endoscopic ultrasonographers.

However, a useful systematic EUS training program for diagnosing biliopancreatic lesions has not yet been developed. The intensity and length of training, requisite curriculum, and extent of theoretical learning are not well defined.^[12] There are also limited data on independent practices among procedure-based training programs. Moreover, the demand for highly skilled endosonographers in Asia continues to rise, so the aim of this study was to develop and assess the efficacy of a newly designed multi-method systematic training program for beginners in EUS for diagnosing biliopancreatic lesions.

MATERIALS AND METHODS

Study participants

Advanced endoscopy trainees (AETs) from the endoscopy centers of Hubei hospital were recruited in this study from January 2019 to December 2019. Inclusion criteria for participants were as follows: (1) initiative, where participants should join in and complete the 4-stage training course actively with each stage held for 2 days; (2) necessity, where participants had minimal experience or training in EUS; and (3) feasibility, where participants had the opportunity to use EUS in their daily work. During the 4 months between the two stages, all AETs were required to practice in their daily work. Approval was obtained from the Ethics Committee of Tongji Medical College, Huazhong University of Science and Technology, and Chinese Clinical Trial Registry (ChiCTR2000029716). All AETs consented to be evaluated for the study and had access to the study data.

Questionnaire

AETs completed a questionnaire at study inception that assessed the baseline characteristics and prior experience with EUS [Supplement Table 1]. After training, AETs also completed a modified poststudy questionnaire that assessed the overall comfort level in independently performing EUS, as well as their comfort level performing individual components of the procedure [Supplement Table 2].^[13] The questionnaire responses were based on a 5-point scoring system ([1] strongly agree;^[2] tend to agree;^[3] neutral;^[4] tend to disagree; and^[5] strongly disagree). We also assessed which type of teaching model benefitted the most, and which station was challenging to perform as well as the satisfaction of the training system.

Competency Assessment Tool – The EUS Skills Assessment Tool

We used The EUS Skills Assessment Tool (TESAT), a validated tool with strong validity evidence endorsed by the American Society of Digestive Endoscopy to assess EUS skills in a continuous fashion throughout the duration of training by grading all relevant technical and cognitive skills [Supplement Figure 1].^[14] TESAT used a 5-point scoring system to grade these endpoints: (1) no assistance; (2) minimal assistance (one verbal instruction); (3) moderate assistance (multiple verbal instructions); (4) significant assistance (hands-on assistance from attending endosonographer needed); and (5) unable to achieve, requiring the trainer to take

over. Feedback was provided to the trainee at the end of each examination. Success was defined as a TESAT score of 1 (no assistance) or 2 (minimal verbal cues), whereas a score of ≥ 3 was considered a failure.^[12]

Study design

The study consisted of four stages; each stage included biliopancreatic standard scanning, anatomy and imaging knowledge, simulators, hands-on operations, error correction, and case analysis in the form of “Teaching – Expert performance – Hands-on operation – Teaching – Expert performance – Hands-on operation – Case analysis – Feedback” [Figure 1]. All AETs were introduced to both the cognitive and technical aspects of EUS procedures at the pretest of their training.

In Stage I, the standard imaging techniques was conducted using a radial scanning echoendoscope. In this stage, only biliopancreatic radial standard scanning was provided. This stage included 2 days and two rounds. Firstly, the purpose was to improve the cognitive competence of EUS. A teaching section was started. Radiologist gave a lecture about the anatomy of the biliopancreatic system and a EUS specialist then taught how to scan using standard imaging techniques. Second, to improve technical competence, a trainer performed a standard presentation on the TESAT stations [Figure 2a], followed by hands-on operations. Hands-on operations included simulator teaching [Olympus, Tokyo, Japan, EUS Phantom; Figure 2b] and operating on patients. During the hands-on operation session, trainees were provided with real-time technical assistance and targeted error correction. After completion of the hands-on EUS examinations, the expert showed the specific case analysis. Third, the second repeated the four sections mentioned above, and AETs were graded according to TESAT and through video cases studies to further improve their cognitive competence of EUS.

In Stage II, the standard imaging techniques was conducted using a linear scanning echoendoscope. First, AETs reported the number of operations and difficulties on EUS examination during independent radial scanning operations in the form of cases over 3 months. Second, AETs were graded to determine the effectiveness of Stage I educational course. During this session, trainees were also provided with real-time technical assistance and targeted error correction. Third, a teaching section that focused on linear scanning was started followed by

the trainer performing a standard presentation on the TESAT stations, hands-on operation teaching, testing, and finally, video case analysis just as the first stage. AETs were required to conduct standard scanning and video recording of the patients they had performed on and present it in the case analysis session with experts providing suggestions and error corrections.

In Stage III, a mixed operation was conducted using radial and linear scanning echoendoscopes. In this stage, the procedures were the same as Stage II. The training included not only radial but also linear standard imaging techniques.

In Stage IV, an EUS-FNA operation was conducted. The main purpose was to further improve the linear scanning experience. The procedures were the same as Stage III, but the theoretical lectures focused on EUS-FNA.

AETs who completed the first stage were invited to participate in the next stage. We also encouraged trainees to supplement their learning through lectures and self-learning from relevant textbooks, EUS atlases, journal articles, and going through selected vignettes of past procedures. A learning curve of each trainee for overall performance and each anatomic station was finally applied to assess competency.

Grading of advanced endoscopy trainees

AETs were graded on every EUS test by the trainer. This frequency was chosen to improve the feasibility and ensure that an adequate sample was available to analyze EUS training results. Grading was standardized and performed by only one EUS trainer who was required to grade the assessment immediately after the procedure to reduce recall bias and halo and recency effects. TESAT makes a clear distinction for the grading of procedures with biliary and pancreatic indications. Grading involved the ability to clearly identify important landmarks at various EUS stations. These included the anteroposterior window, celiac axis, body of the pancreas, tail of the pancreas, portosplenic confluence, head/neck of the pancreas, common bile duct (CBD)/hepatic bile duct (CHD), gallbladder, uncinat process, and ampulla [Figure 2a]. When applicable, the trainee also was graded on the ability to identify the lesion of interest, assign an appropriate TNM stage for suspected malignancy, and characterize the wall layer of subepithelial lesions as well as technical success with FNA. Procedures in which the AETs had no

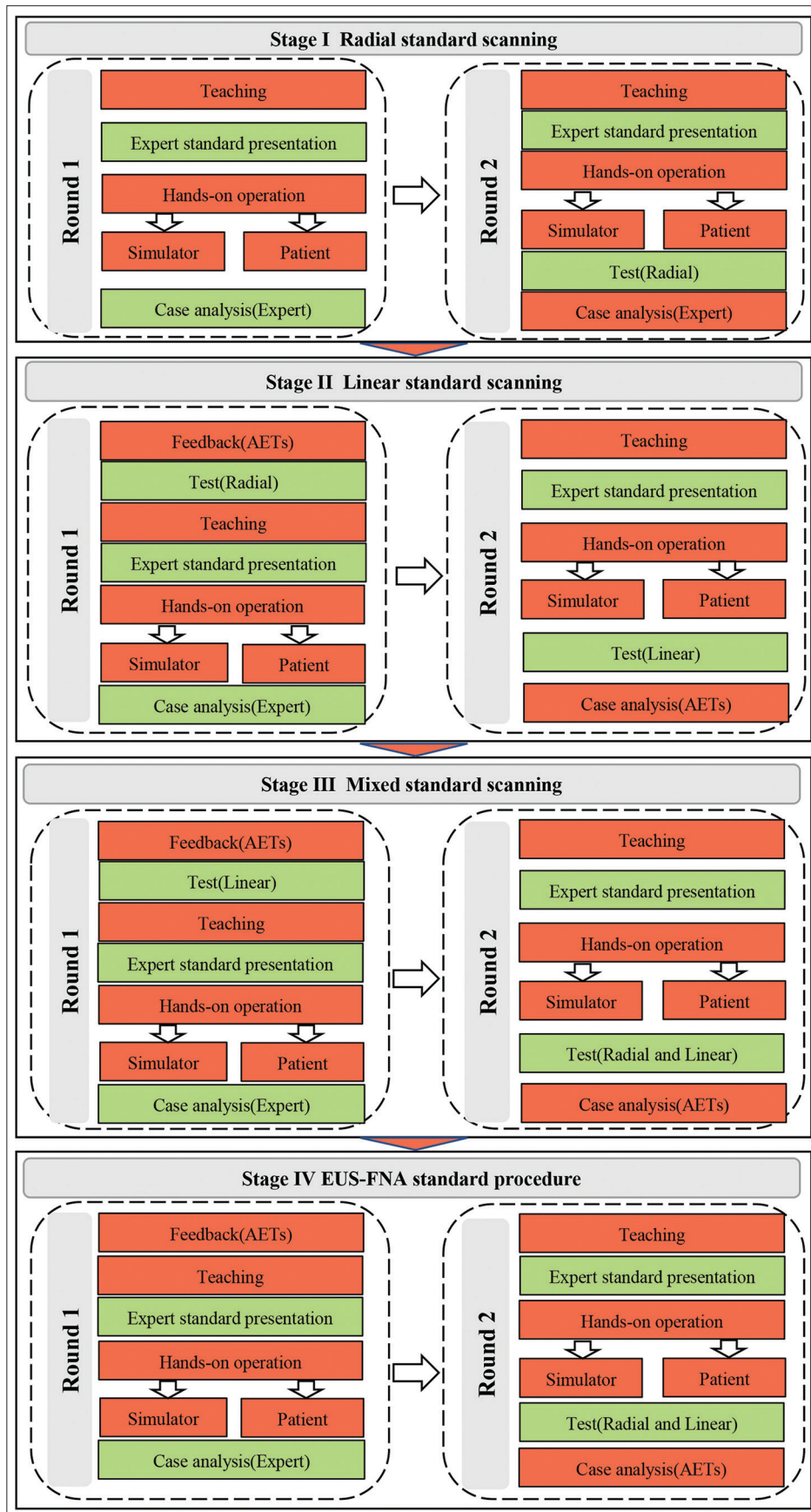


Figure 1. A systematic training program on EUS standard scanning was established

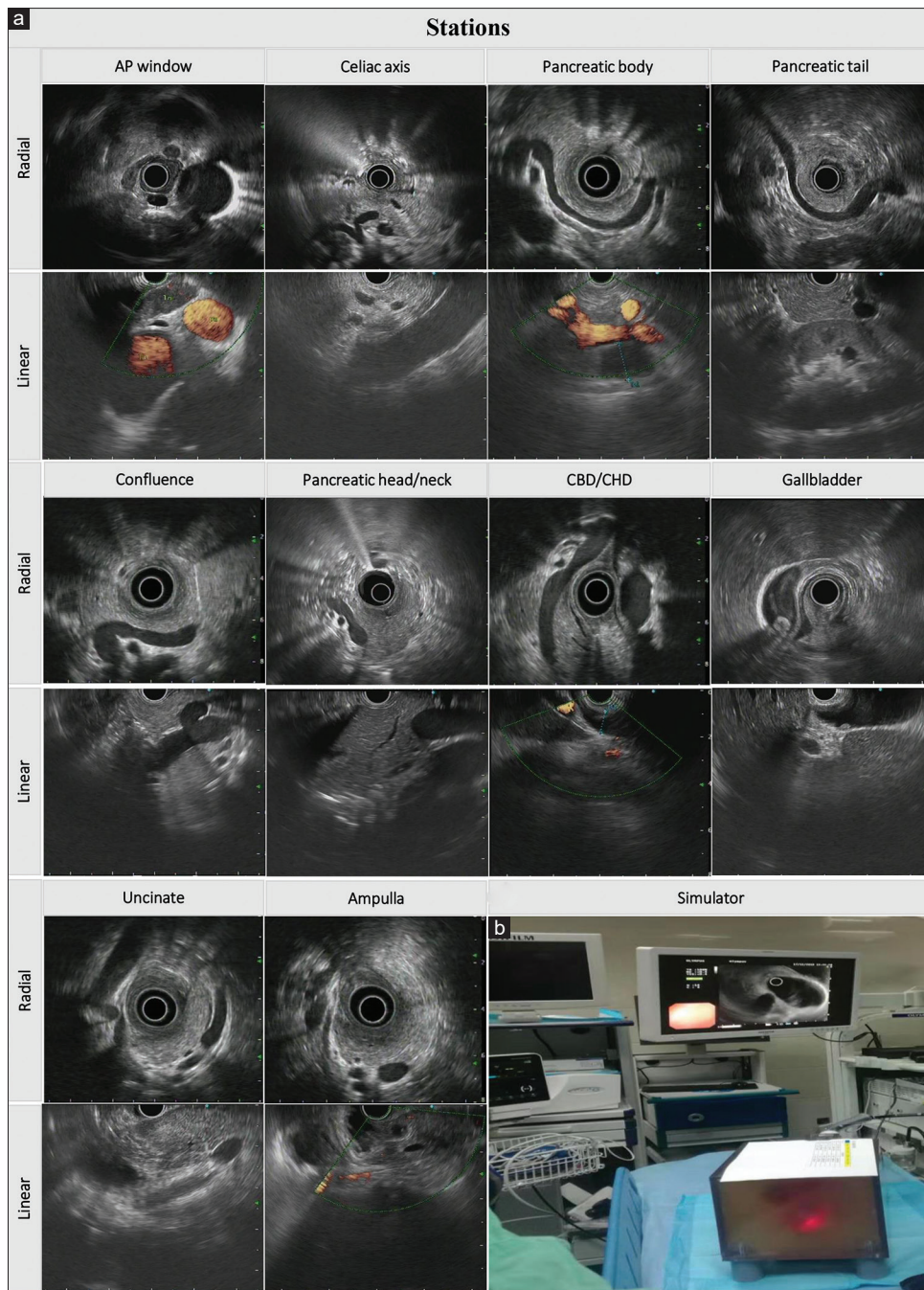


Figure 2. Training materials. (a) Typical pictures of stations for radial and linear scan; (b) Simulator for hands-on operation

hands-on participation were excluded from grading. The trainer and AETs were familiar with the tool's specific assessment parameters and score explanations.

EUS procedure

EUS examinations were performed using a curvilinear or radial array echoendoscope (Olympus processor EU-ME2, Olympus, Tokyo, Japan). To reduce bias, FNA was operated under EUS guidance with a 22G needle (ECHO-3-22G, Cook Endoscopy,

Winston-Salem, NC, USA). We used 6 MHz for scanning, as it was considered the optimal frequency to provide the best endosonographic imaging. Three basic scanning positions for pancreatobiliary EUS were used in all patients: (1) scanning from the stomach, (2) scanning from the duodenal bulb or gastric antrum, and (3) scanning from the descending part of the duodenum.^[7] The descending duodenal lumen was filled with de-aerated water to assist acoustic coupling and provide optimal EUS visualization.

Comprehensive data collection

Patient identifiers were deleted in compliance with the Health Information Portability and Accountability Act regulations. Grading forms from all AETs were deidentified, and all images of patients who underwent EUS examinations were stored in the endoscopy database in JPEG format. The number of EUS cases performed by each trainee at their own hospital was all registered. Data were divided into different subgroups according to the stages. Subgroups included radial and linear scanning from the stomach, duodenal bulb or gastric antrum, descending part of the duodenum, gallbladder, and mediastinum.

Statistical analysis

Categorical variables are presented as numbers and percentages, and continuous variables are presented as the mean ± standard error. Differences in categorical

variables were evaluated using McNemar’s test. Differences in continuous variables were evaluated using a Student’s *t*-test for independent samples. Statistical analysis was performed using IBM SPSS Statistics software (version 20.0, IBM Corp, Armonk, NY, USA). A significance level of $P \leq 0.05$ was used for all models (two-sided).

RESULTS

The basic characteristics of advanced endoscopy trainees

Nine AETs from nine centers participated in the training and completed all tests [Supplement Table 3 and Figure 3a]. They were gastrointestinal fellows with experience in diagnostic and therapeutic colonoscopies and gastroscopies but had less previous experience in EUS. At baseline, 66.7%

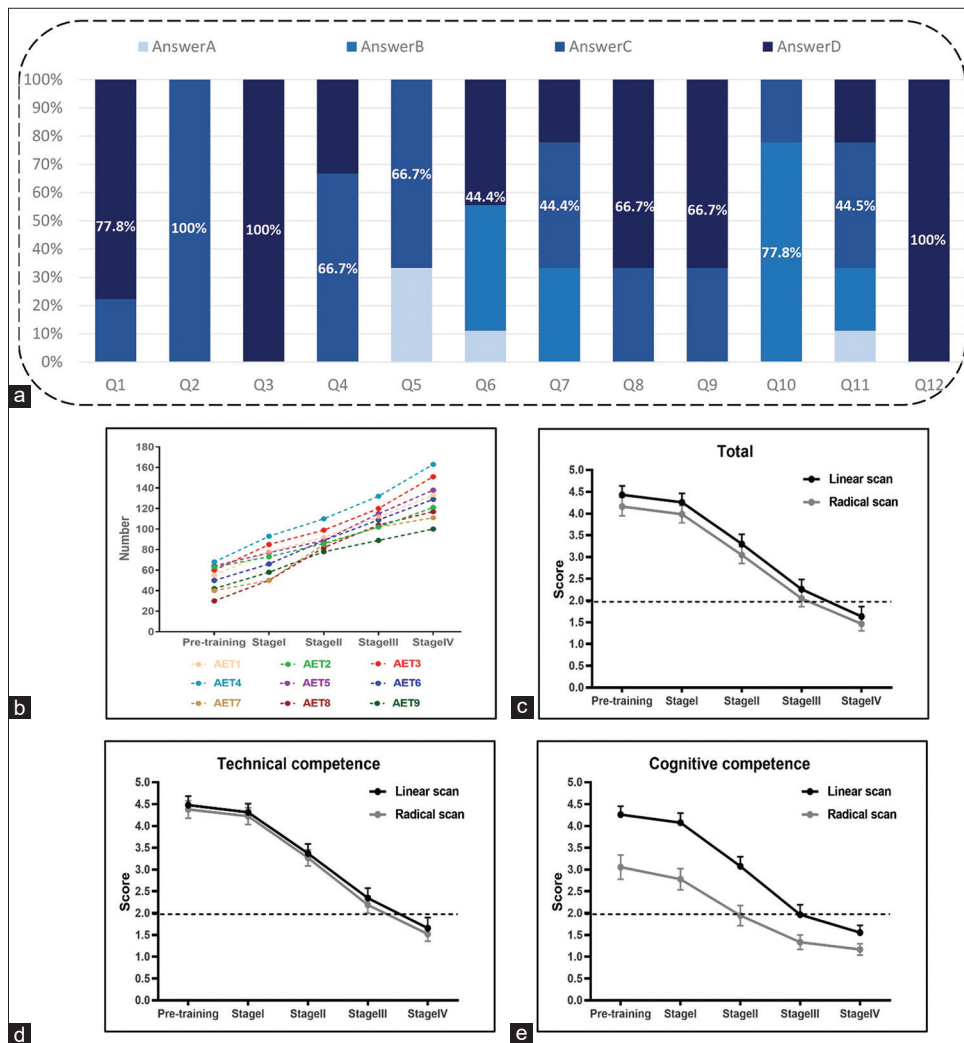


Figure 3. The answers for questionnaire at study inception and the results of total training achievements. (a) AETs completed the questionnaire of twelve questions that assessed baseline characteristics and prior experience with EUS; (b) The number of cases for each trainee during the training; (c-e) The scores of advanced endoscopy trainees achieving competence for overall, technical and cognitive competence during training

of AETs had received formal training on the cognitive aspects of EUS. Similarly, a majority of AETs reported at least some hands-on training in EUS (88.9%) before their training. The mean number of EUS examinations performed before AET was 52 (range, 30–68). Most could perform endoscopic submucosal dissection and ERCP, which also helped their endoscopic skills. There were no statistically significant differences between the more experienced (>50 cases) and less experienced (<50 cases) groups in terms of gender, age, or endoscopic skills of the trainees ($P = 0.183$). However, there were differences in the number of cases of EUS they had performed ($P = 0.001$). At the end of the training, AETs performed a mean of 129.2 EUS examinations (range, 100–163; total, 1163). These data also highlight the wide variation in the number of EUS procedures performed by each trainee at the two different levels of participating centers. The detailed AET is shown in Figure 3a and b.

The systemic training program for diagnosing biliopancreatic lesions is effective

Using the primary definition of success, the vast majority of AETs achieved competence in the cognitive and technical aspects of EUS. The overall scores for radial (4.16 ± 0.21 vs. 1.46 ± 0.16 , $P < 0.001$) and linear (4.43 ± 0.20 vs. 1.63 ± 0.23 , $P < 0.001$) scanning were significantly improved at the end of their training. The curve of radial learning was faster than that of linear learning. There was a significant improvement in the proportion of successful localization of structures posttraining compared to before training. The scores of AETs achieving competence for overall technical (Radial: 4.38 ± 0.19 vs. 1.52 ± 0.16 , $P < 0.001$; Linear: 4.48 ± 0.21 vs. 1.66 ± 0.24 , $P < 0.001$) and cognitive (Radial: 3.06 ± 0.28 vs. 1.17 ± 0.13 , $P < 0.001$; Linear: 4.26 ± 0.19 vs. 1.56 ± 0.17 , $P < 0.001$) endpoints after training are summarized in Figure 3c-e.

Individual analysis: learning curve and competence in EUS

When results from the individual domains were analyzed, variable results were noted for individual technical and cognitive endpoints. For linear scanning, the scores of AETs at each structure posttraining were as follows: aortopulmonary (AP) window (4.00 ± 0.28 vs. 1.44 ± 0.29 , $P < 0.001$), celiac axis (4.22 ± 0.27 vs. 1.22 ± 0.15 , $P < 0.001$), pancreatic body (4.22 ± 0.28 vs. 1.33 ± 0.17 , $P < 0.001$), pancreatic tail (4.33 ± 0.24 vs. 1.44 ± 0.24 , $P < 0.001$), portosplenic

confluence (4.33 ± 0.23 vs. 1.56 ± 0.29 , $P < 0.001$), pancreatic head/neck (4.44 ± 0.24 vs. 1.67 ± 0.29 , $P < 0.001$), CBD/CHD (4.89 ± 0.11 vs. 2.00 ± 0.23 , $P = 0.012$), gallbladder (4.56 ± 0.24 vs. 1.78 ± 0.28 , $P < 0.001$), uncinate process (4.78 ± 0.15 vs. 2.00 ± 0.24 , $P < 0.001$), and ampulla (5.00 ± 0.00 vs. 2.11 ± 0.26 , $P < 0.001$). AETs scored the highest mean score on the celiac axis section, and this was followed by the pancreatic body and AP window sections. The lowest competence rate was noted in the performance on the ampulla section. Similar results were noted in the assessment of learning curves for individual stations during the EUS radial examination. Graphical representation of the learning curves among trainees by using each score station across all stages is presented in Figure 4a-j.

Scanning from the descending part of the duodenum is difficult and should be the focus of training

We further divided stations into four parts: scanning from the mediastinum, stomach, duodenal bulb, and descending part of duodenum. The improvements were statistically significant in all four sections with the mediastinum (4.00 ± 0.28 vs. 1.44 ± 0.28 , $P < 0.001$), stomach (4.31 ± 0.25 vs. 1.44 ± 0.23 , $P < 0.001$), and duodenum (duodenal bulb: 4.72 ± 0.18 vs. 1.89 ± 0.56 , $P < 0.001$; descending part of duodenum: 4.89 ± 0.07 vs. 2.06 ± 0.25 , $P < 0.001$). However, not all AETs met the criteria for success at the duodenum (including duodenal bulb and descending part of duodenum). Three AETs needed minimal assistance, two AETs needed moderate assistance, and one AET needed significant assistance. In total, the mediastinum had a shorter learning curve for trainees compared with other stations ($P = 0.0023$). The descending part of duodenum seemed to improve the slowest after training ($P = 0.0072$), indicating that scanning from the descending part of the duodenum can be more difficult. Similar results were also found in radial scanning [Figure 4k and l].

The scores improved rapidly through case analysis error correction and hands-on operation sessions

Regarding the different teaching methods, AETs improved most through “case analysis” and “hands-on operation” [Figure 5a; poster study assessment question 4]. All participants were very impressed with these two methods and considered them to be the most useful. Combined with discussion forums following the procedure, it provided a platform for trainees to interact directly with experts and gain understanding from the meaningful case discussions.

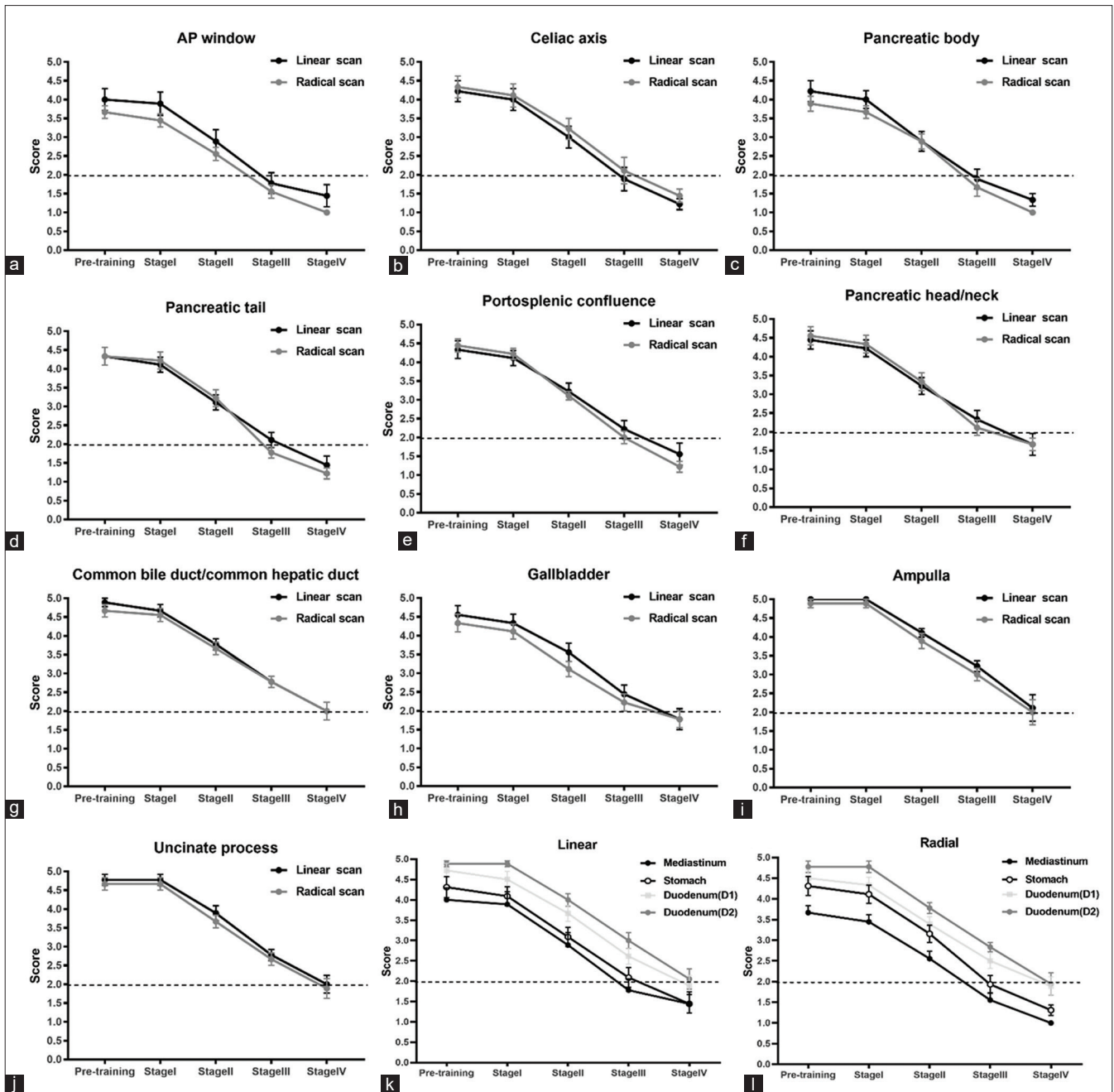


Figure 4. Graphical representation of learning curves among the trainees by using each score station across all stages. (a)for AP window; (b) for celliac axis; (c) for pancreatic body (d) for pancreatic tail (e) for portosplenic confluence (f) for pancreatic head/neck (g) for common bile duct/ common hepatic duct (h) for gallbladder (i) for ampulla (j) uncinata process (k) for linear (l) for radial

This effect was more pronounced in the less experienced group. Before starting training, three AETs had performed <50 EUS procedures, and their EUS operation scores were slightly lower than those of the more experienced group, although no significant difference was observed (4.87 ± 0.16 vs. 4.21 ± 0.18 , $P = 0.001$). However, in the final round, the score of all AETs significantly improved and the performance of AETs with different levels of initial experience reached equivalent levels (1.76 ± 0.23 vs. 1.56 ± 0.17 , $P = 0.112$), indicating that the diagnostic levels of

differentially experienced AETs reached the same level after training. Similar results were also found in radial scanning [Figure 5b].

Poststudy questionnaire: improving confidence in EUS

Finally, AETs were asked to finish a poststudy questionnaire regarding this new training program. These data demonstrate substantial similarities among trainees. All AETs (100%) strongly agreed/tend to agree that they were satisfied with this training system, and

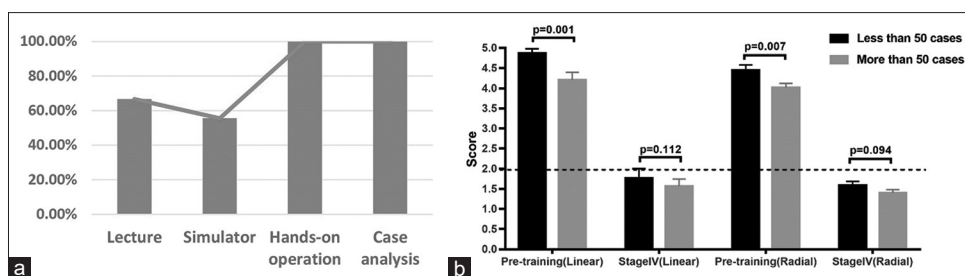


Figure 5. Postquestionnaire results and comparison of scores between the less and more experienced group. (a) Postquestionnaire results about trainer's assessment of the effectiveness for different teaching methods; (b) Comparison of scores between the less and more experienced group during the training at radial and linear scan

it enhanced their advanced endoscopy fellowship. The self-confidence of trainees was largely enhanced when independently performing EUS, and the performance of EUS-FNA as the end of AET received great interest. For evaluation of the question on which station was the most challenging to perform, 88.9% of AETs achieved competency in the AP window, celiac axis, and pancreatic body and tail. In the grading of the portosplenic confluence, head/neck of the pancreas, and gallbladder, 5 AETs demonstrated competency and 2 AETs demonstrated the need for ongoing observation, with another 2 AETs showing a trend toward attaining competency. For the evaluation of the uncinate process, 3 AETs demonstrated competency and 2 AETs showed a trend toward competency, whereas the other 4 AETs demonstrated the need for ongoing observation. Similarly, 4 AETs demonstrated the need for ongoing training for the common bile and hepatic ducts. Seven out of nine AETs demonstrated the need for ongoing observation in the clear identification of the ampulla, with only 2 ATEs achieving competency. Ampulla, uncinate process, and bile duct tracking were considered more challenging than other stations. With regard to the suggestions for training, 77.8% of trainers expected the majority of their practice focused on scanning from the duodenum (including duodenal bulb and descending part of duodenum). Furthermore, the AETs also put forward some other suggestions for this training, such as one-on-one tutoring, literature review, more case analysis and hands-on operations, and longer-term or continuous training.

DISCUSSION

EUS is operator dependent, and training requires the development of technical, cognitive, and integrative skills beyond that required for standard endoscopic procedures. The accuracy largely depends on the observer's experience. Competence in EUS has

historically been assessed by the trainers' subjective assessment of overall competence and/or meeting an arbitrary volume threshold for procedures completed;^[15,16] however, determining competency by training program cannot be assessed solely on this parameter. Prospective data are needed to help guide the development of evidence-based training guidelines. Therefore, a new systemic training program was conducted to explore the learning effort among AETs in this study. After training, there was a significant improvement in the proportion of successful structure localizations. Besides, the diagnostic levels of differentially experienced AETs reached the same level after training, with rapid improvements attributed to case analysis and hands-on operation.

Advanced endoscopy has conventionally been taught by apprenticeship, wherein a trainee is expected to develop skills with hands-on experience during a fixed duration of training. Previous training programs focused on showing EUS experience by means of lectures, web conferences sharing live cases and difficulties, and hands-on training sessions using phantoms and live pigs.^[17] To the best of our knowledge, this is the first EUS systemic training program with multiple methods and stages for diagnosing biliopancreatic lesions. The results of the study confirmed that structured EUS training does increase a trainee's EUS knowledge and skills.

Many factors may influence EUS accuracy, such as the mastery of pancreatobiliary EUS standardized scanning and understanding of specific real cases and endoscopic operation skills. In clinical practice, high skills in obtaining clear lesion images are necessary for endoscopists to maintain high diagnostic accuracy.^[18] In addition, anatomical and radiological knowledge is crucial for better comprehension of the images under EUS.^[19-21] Therefore, in this regard, we conducted a multi-method

training program, which was quite different from other studies. For example, Meenan's research was carried out only through limited learning of observing cases during live case demonstrations.^[22] Similarly, other studies based on clinical practice are permitted in most institutions.^[23,24] However, the resources are limited; and thus, they cannot completely meet the training demands of novices. There are also deficiencies with using simulator training. As the simulator model lacks fidelity and does not have simulated blood flow, no Doppler signals can be obtained.^[8,25] In our study, the diagnostic accuracy was significantly improved after each teaching method, especially case analysis and hands-on learning.

Regarding the different teaching methods, case analysis and hands-on learning were considered more useful. Skills were demonstrated by experts through video streaming of procedures. AETs also recorded their standard scans in their daily work and presented them in discussion forums. It provided a platform for trainees to interact directly with experts and gain understanding from meaningful case discussions. Our results demonstrated that after being trained through case analysis error correction sessions, more trainees were able to successfully localize structures at hands-on learning sessions. The trainees showed a significant improvement in their test scores and self-confidence levels. This indicated that case analysis error correction can help trainees to improve their ability to evaluate normal pancreatobiliary structures, which is an integral part of EUS training.

Multistage dynamic observation of the EUS skills of ATEs is different from other short-term structured EUS training programs. Short-term tutorials could not answer the question of whether such structured courses had a longer-term impact on EUS competency and the clinical practice of the trainees who completed the courses each time.^[26] Regular short-term intensive EUS training programs that provide training at various levels may help EUS practitioners improve and maintain EUS-related knowledge and skills. Our courses were offered in the form of progressive modules, starting from the fundamentals of EUS to carrying out the most complex of interventional procedures. The results are encouraging as they show that structured courses do enhance trainee competency.

There are several limitations in our study. First, the main limitation is that the criterion standard was the interpretive findings of the trainer, which is an inherent limitation of any study evaluating assessing competency

by using this methodology. The possibility of bias cannot be excluded because various stages and grades of disease cases were included in the grading process. Second, there were missed and incomplete evaluations in the TESAT survey; however, the purpose of this study was to assess overall competency in evaluating all stations during a EUS examination. Third, the training only recruited a small number of participants to explore an effective training program but did not include all regions in China, and not all AETs achieved competency in all structure stations, thus limiting the generalizability of the results. Nevertheless, defining a new learning system for EUS training in a prospective fashion by using multiple methods and stages are the strengths of this study. This project may lead to the creation of a large multicenter consortium that will provide objective data. The Chinese Society of Digestive Endoscopy or other training programs can use this study for reference.

CONCLUSIONS

The current multi-method and multistage training system showed efficient performance for cognitive and technical competence of EUS. The training program has significantly improved standard scanning for EUS, and most AETs expressed comfortability in performing independently EUS at the end of their training.

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Supplementary Materials

Supplementary information is linked to the online version of the paper on the *Endoscopic Ultrasound* website.

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Conflicts of interest

There are no conflicts of interest.

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| Affix AET sticker here | Affix patient sticker here | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|-----------------------------------|-------------------------------------|---|---|---|----------|---|----------|-----------------------------|---|---|---|---|---|----------|-----------------------|---|---|---|---|---|----------|---|---|---|---|---|---|----------|-------------------------|---|---|---|---|---|----------|-----------------------|---|---|---|---|---|----------|---------|---|---|---|---|---|----------|-------------|---|---|---|---|---|----------|----------|---|---|---|---|---|----------|---------|---|---|---|---|---|----------|
| 1=no assistance 2=minimal assistance (one instruction) 3=moderate assistance (multiple instructions) 4=significant assistance (attg manipulates scope to optimize visualization) 5=unable to achieve | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| <input type="checkbox"/> Radial <input type="checkbox"/> Linear Indication <input type="checkbox"/> Panc mass <input type="checkbox"/> Panc cyst <input type="checkbox"/> Bil dil <input type="checkbox"/> PD dil <input type="checkbox"/> Lymphadenopathy <input type="checkbox"/> Lumina GI cancer <input type="checkbox"/> Mediastinal mass <input type="checkbox"/> possible submucosal lesion <input type="checkbox"/> Chronic Pancreatitis <input type="checkbox"/> Other _____ | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Date ___/___/___ Case No. for fellow _____ Attending initials _____ Fellow initials _____ | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| EUS stations: Allow about 1 minute per station before assistance (please specify reason for NA) <table style="width: 100%; border-collapse: collapse;"> <tr><td>AP window</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>NA _____</td></tr> <tr><td>Celliac axis</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>NA _____</td></tr> <tr><td>Body of pancreas</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>NA _____</td></tr> <tr><td>Tail of pancreas</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>NA _____</td></tr> <tr><td>Portosplenic confluence</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>NA _____</td></tr> <tr><td>Head/neck of pancreas</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>NA _____</td></tr> <tr><td>CBD/CHD</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>NA _____</td></tr> <tr><td>Gallbladder</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>NA _____</td></tr> <tr><td>Uncinate</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>NA _____</td></tr> <tr><td>Ampulla</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>NA _____</td></tr> </table> | | AP window | 1 | 2 | 3 | 4 | 5 | NA _____ | Celliac axis | 1 | 2 | 3 | 4 | 5 | NA _____ | Body of pancreas | 1 | 2 | 3 | 4 | 5 | NA _____ | Tail of pancreas | 1 | 2 | 3 | 4 | 5 | NA _____ | Portosplenic confluence | 1 | 2 | 3 | 4 | 5 | NA _____ | Head/neck of pancreas | 1 | 2 | 3 | 4 | 5 | NA _____ | CBD/CHD | 1 | 2 | 3 | 4 | 5 | NA _____ | Gallbladder | 1 | 2 | 3 | 4 | 5 | NA _____ | Uncinate | 1 | 2 | 3 | 4 | 5 | NA _____ | Ampulla | 1 | 2 | 3 | 4 | 5 | NA _____ |
| AP window | 1 | 2 | 3 | 4 | 5 | NA _____ | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Celliac axis | 1 | 2 | 3 | 4 | 5 | NA _____ | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Body of pancreas | 1 | 2 | 3 | 4 | 5 | NA _____ | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Tail of pancreas | 1 | 2 | 3 | 4 | 5 | NA _____ | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Portosplenic confluence | 1 | 2 | 3 | 4 | 5 | NA _____ | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Head/neck of pancreas | 1 | 2 | 3 | 4 | 5 | NA _____ | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| CBD/CHD | 1 | 2 | 3 | 4 | 5 | NA _____ | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Gallbladder | 1 | 2 | 3 | 4 | 5 | NA _____ | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Uncinate | 1 | 2 | 3 | 4 | 5 | NA _____ | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Ampulla | 1 | 2 | 3 | 4 | 5 | NA _____ | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| <table style="width: 100%; border-collapse: collapse;"> <tr><th colspan="7" style="text-align: center;">Characterization/Sampling of Lesion</th></tr> <tr><td>Identify lesion of interest</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>NA _____</td></tr> <tr><td>Appropriate TNM stage</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>NA _____</td></tr> <tr><td>Characterize subepithelial lesion (wall layers)</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>NA _____</td></tr> <tr><td>Achieved FNA</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>NA _____</td></tr> </table> | | Characterization/Sampling of Lesion | | | | | | | Identify lesion of interest | 1 | 2 | 3 | 4 | 5 | NA _____ | Appropriate TNM stage | 1 | 2 | 3 | 4 | 5 | NA _____ | Characterize subepithelial lesion (wall layers) | 1 | 2 | 3 | 4 | 5 | NA _____ | Achieved FNA | 1 | 2 | 3 | 4 | 5 | NA _____ | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Characterization/Sampling of Lesion | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Identify lesion of interest | 1 | 2 | 3 | 4 | 5 | NA _____ | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Appropriate TNM stage | 1 | 2 | 3 | 4 | 5 | NA _____ | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Characterize subepithelial lesion (wall layers) | 1 | 2 | 3 | 4 | 5 | NA _____ | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Achieved FNA | 1 | 2 | 3 | 4 | 5 | NA _____ | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Procedural complication: _____ | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

Supplement Figure 1. The EUS Skills Assessment Tool was to assess EUS skills throughout the duration of training

Supplement Table 1. Advanced Endoscopy Trainee Baseline Questionnaire

1. The level of your hospital?
 - A. Grade B Class Two Hospital
 - B. Grade A Class Two Hospital
 - C. Grade B Class Three Hospital
 - D. Grade A Class Three Hospital
 2. What is your education background?
 - A. College Degree
 - B. Bachelor Degree
 - C. Master Degree
 - D. Doctor Degree
 3. How long have you been in clinical work?
 - A. Within 3 years
 - B. 3-5 years
 - C. 5-10 years
 - D. >10 years
 4. What is your professional title?
 - A. Resident physician
 - B. Attending physician
 - C. Assistant director/physician
 - D. Director physician
 5. Did you receive any training on the cognitive aspects for EUS?
 - A. Never
 - B. <10 times
 - C. 10 to 20 times
 - D. More than 20 timesIf received, by which means? (You can choose multiple answers)
 - A. Lecture
 - B. Network video
 - C. Case sharing
 - D. Conference
 6. Did you receive any hands-on training for EUS?
 - A. Never
 - B. <5 times
 - C. 5-10 times
-

Contd...

Supplement Table 1. Contd...

- D. >10 times
- If received, by which means? (You can choose multiple answers)
- A. Simulator
 - B. Live animals
 - C. Patients
7. Have you ever operated a side-viewing endoscope or an oblique-viewing endoscope?
 - A. Never
 - B. <50 cases
 - C. 50-100 cases
 - D. >100 cases
 8. Have you performed EUS for patients?
 - A. Never
 - B. Less than 10 cases
 - C. 10 to 50 cases
 - D. More than 50 cases
 9. How many cases of pancreaticobiliary diseases have you done?
 - A. Never
 - B. <10 cases
 - C. 10-50 cases
 - D. >50 cases
 10. What is your ability to recognize the EUS image of the pancreaticobiliary diseases?
 - A. Totally unclear
 - B. Understanding
 - C. Familiar
 - D. Mastering
 11. Have you operated ESD before?
 - A. Never
 - B. <10 cases
 - C. 10 to 50 cases
 - D. >50 cases
 12. Do you know about this training procedures before starting?
 - A. Totally unclear
 - B. Understanding
 - C. Familiar
 - D. Mastering
-

Supplement Table 2. Poststudy assessment

1. I feel confidence independently performing EUS as the end of my advanced endoscopy training?
 - A. Strongly agree
 - B. Tend to agree
 - C. Neutral
 - D. Tend to disagree
 - E. Strongly disagree
 2. I feel comfortable with independently performing EUS as the end of my advanced endoscopy training?
 - A. Strongly agree
 - B. Tend to agree
 - C. Neutral
 - D. Tend to disagree
 - E. Strongly disagree
 3. Did the training system provided by this study enhance your advanced endoscopy fellowship?
 - A. strongly agree
 - B. tend to agree
 - C. neutral
 - D. tend to disagree
 - E. strongly disagree
 4. Which format provided by this study benefits you the most? (More than one could choose)
 - A. Lectures
 - B. Simulator
 - C. Hands-on operation
 - D. Video case analysis
 5. I feel satisfied with this training system?
 - A. Strongly agree
 - B. Tend to agree
-

Supplement Table 2. Contd...

- C. Neutral
 - D. Tend to disagree
 - E. Strongly disagree
 6. I feel comfortable and great interest to performing EUS-FNA as the end of my advanced endoscopy training?
 - A. Strongly agree
 - B. Tend to agree
 - C. Neutral
 - D. Tend to disagree
 - E. Strongly disagree
 7. Which station is challenging to perform? (More than one could choose)
 - A. AP window
 - B. Celiac axis
 - C. Body of pancreas
 - D. Tail of pancreas
 - E. Portosplenic confluence
 - F. Head/neck of pancreas
 - G. Common bile duct/common hepatic duct
 - H. Gallbladder
 - I. Uncinate process
 - J. Ampulla
 - K. Other
 8. Would you plan to go to a better and more complete training system to study?
 - A. strongly agree
 - B. tend to agree
 - C. neutral
 - D. tend to disagree
 - E. strongly disagree
 9. How to be better?
-

Results of the PostStudy Questionnaire Assessing Comfort Level in EUS After Completion of Advanced Endoscopy Training. AP: Aortopulmonary

Contd...

Supplement Table 3. List of participating advanced endoscopy training programs

| AETs | Institution | Location | Hospital level |
|-------------|----------------------------|---------------------------|-----------------------|
| 1 | Wuhan First hospital | Wuhan, Hubei Province | Grade A Class Three |
| 2 | Xinhua hospital | Wuhan, Hubei Province | Grade A Class Three |
| 3 | Wisco General hospital | Wuhan, Hubei Province | Grade A Class Three |
| 4 | Huangpi People's Hospital | Wuhan, Hubei Province | Grade B Class Three |
| 5 | Huangshi Central hospital | Huangshi, Hubei Province | Grade A Class Three |
| 6 | Huangshi Fifth hospital | Huangshi, Hubei Province | Grade A Class Three |
| 7 | Xiangyang Central hospital | Xiangyang, Hubei Province | Grade A Class Three |
| 8 | Jianshi People's hospital | Enshi, Hubei Province | Grade B Class Three |
| 9 | Xiaogan Central hospital | Xiaogan, Hubei Province | Grade A Class Three |

AETs: Advanced endoscopy trainees