ORIGINAL ARTICLE

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Prior Radial-Scanning Endoscopic Ultrasonography Training Did Not Contribute to Subsequent Linear-Array Endoscopic Ultrasonography Study Performance in the Stomach of a Porcine Model

Wei Xu*, Yan Liu†, Peng Pan‡, Yan Guo‡, Ren-pei Wu‡, and Yin-zhen Yao‡

*Department of Hepatopancreatobiliary and Splenic Medicine, Affiliated Hospital of the Logistics University of the Chinese People's Armed Police Forces, Tianjin, †Department of Gastroenterology, 307 Hospital of the Chinese People's Liberation Army, Beijing, and ‡Department of Gastroenterology, Changhai Hospital, Second Military Medical University, Shanghai, China

See editorial on page 261.

Background/Aims: The optimal training mode for linear array endoscopic ultrasonography (EUS) has not been established. Prior radial-scanning EUS training seems to improve subsequent linear array EUS learning. The objective of this randomized controlled trial was to evaluate its value in linear array EUS training. **Methods:** In total, 18 freshman trainees conducted hands-on EUS operations on a live pig model. The training contents consisted of visualization and tracking of the pancreas and splanchnic vasculature and performing fine-needle aspiration of the body or tail of the pancreas and celiac plexus neurolysis through the stomach. The trainees were randomized into two groups: group A received linear array EUS training after receiving radial-scanning EUS training, whereas group B conducted linear array EUS training alone. Two teachers assessed the competence of each trainee using a scoring system and relevant parameters before and after the training process. **Results:** Groups A and B showed significant improvement between the pretests and posttests in terms of diagnostic and interventional procedures. There was no intergroup difference in terms of improvement. **Conclusions:** Prior radial-scanning EUS training did not contribute to subsequent linear array EUS study performance in the pig stomach model; thus, this training mode may need to be changed. **(Gut Liver 2015;9:353-357)**

Key Words: Linear array endoscopic ultrasonography; Live pig; Radial-scanning endoscopic ultrasonography; Training mode

INTRODUCTION

During the past two decades, linear array endoscopic ultrasonography (EUS) has been improved greatly for its interventional diagnostic and therapeutic role and is increasingly popular. Meanwhile, learning to conduct EUS is still formidable and time-consuming.[1,2] Thus the training for linear array EUS becomes more important than before. However, its optimal training mode is still undefined.

The biggest obstacle for beginners may be difficulty in identifying and interpreting anatomical structures in the ultrasound images from its longitudinal sections. In contrast, images from radial-scanning EUS for diagnosis alone are relatively easy to understand for beginners. Thus, it has become dogma that prior radial-scanning EUS training should be helpful to subsequent linear array EUS study and is believed to help beginners to learn splanchnic anatomical structures and to familiarise themselves with the properties and operation of echoendoscopy. In this context, to date, most endoscopic training centres have adopted a training session that arranges for trainees to learn radial-scanning EUS first and linear array EUS later.

Although this training mode is used widely, whether prior radial-scanning EUS training is, in fact, helpful in subsequent linear array EUS study, and, if so, how helpful it is, are still in doubt, in consideration of these two types of EUS have substantial differences in terms of imaging angle and operating pattern. Thus, in our study, we aimed to assess it in a randomized controlled trial using live pigs as a training tool.

MATERIALS AND METHODS

In total, 18 freshman trainees gathered in our specialist third-

Correspondence to: Yan Liu
Department of Gastroenterology, 307 Hospital of the Chinese People's Liberation Army, Beijing 100071, China
Tel: +86-13816772874, Fax: +86-22-24370605, E-mail: 407733451@qq.com
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tier endoscopic training centre (The Asian Pacific Society Training Centre for Digestive Endoscopy, Changhai Hospital, Shanghai, China) and received EUS training for an EUS diploma. The EUS training session consisted of 4 months of clinical observation and hands-on practice. Our study was conducted during the first week as a part of the session. All trainees spent 1 day on a hands-on EUS operation in a live pig model. This trial adopted a parallel design. The trainees were randomized into two groups with simple randomization. The allocation sequence was generated by a statistician using a computer software. Sealed opaque envelopes were used to conceal the allocation sequence until the beginning of training procedure. An independent doctor assigned the trainees to two groups. The group A received linear array EUS training after receiving radial-scanning EUS training while group B carried out linear array EUS training without preceding radial-scanning EUS training. Before randomization, a questionnaire survey was conducted to investigate trainees' demographic characteristics and their baseline endoscopic operation foundation.

Healthy, live pigs were provided by the experimental animal centre of the Second Military Medical University of the Chinese People's Liberation Army (SMMU, Shanghai, China) and were qualified for laboratory study, weighing 20 to 25 kg. All experimental procedures were approved by the ethics committee of SMMU for animal laboratory investigation and performed according to relevant Chinese regulations and the Guide for the Care and Use of Laboratory Animals of the U.S. National Research Council. The experimental setting was a surgical laboratory in the experimental animal centre of SMMU with endoscopy and emergency equipment. The pigs were fasted for 48 hours before the training and anaesthetised by intravenous injection of pentobarbital sodium, with monitoring of life signs and without tracheal intubation. Then, a specialised muzzle was placed within the mouths of the pigs, which were then ready for endoscopy training. The training was conducted using an Olympus EU-ME1 echoendoscope system (Olympus UCT240 for linear array EUS and UE260 for radial-scanning EUS; Olympus, Japan) and a 22-gauge fine-needle aspiration (FNA) needle (Cook Medical, USA).

Each trainee in group A received a 15-minute free period of hands-on practice with a radial-scanning echoendoscope at the beginning and then a 15-minute free period of hands-on practice with a linear array echoendoscope, together with trainees from group B. The competence of trainees was assessed both before and after the training process by one independent teacher who was blind to any other part of this trail. After a live demonstration by a EUS teacher, each trainee was requested to examine the biliary pancreatic system through the stomach and to perform interventional procedures with the echoendoscope. The procedures were as follows: visualization of the pancreas, splenic artery, splenic vein, abdominal aorta, celiac trunk, and superior mesenteric artery, and performing FNA of the body or tail of the pancreas and the celiac plexus neurolysis (CPN). The visualization of each anatomic site and each interventional procedure was scored according to the criteria in Table 1. The duration of each procedure, accuracy of the puncture, and numbers of operational errors were also recorded.

Table 1. Criteria for Trainee Competence Evaluation

Criterion for evaluation	Score
Operation and control is skillful; purpose of operation and vision is clear.	9–10
Operation, control, purpose of operation, and vision is good.	7–8
Operation, control, purpose of operation, and vision is passable.	4–6
Operation, control, purpose of operation, and vision is poor.	0–3

The accuracy of puncture was evaluated according to Barthet's method:[3] measurement of the distance between the initial marker placed on the target of the ultrasound screen by the teacher and the final location of the FNA needle obtained by the trainee.

The operational steps of interventional procedures were standardised in sequence: fixing the puncture plane, measuring the distance to the target, adjusting the needle sheath, locking the knob, uninterruptedly sucking mucosa, retreating of core needle, adjusting lift pliers, closing the suction, and puncturing. Numbers of operational errors were counted, including missing or making mistakes in steps.

Statistical analyses of the data were performed with the SPSS version 11.5 software (SPSS Inc., Chicago, IL, USA). Quantitative data are expressed as means±standard deviation. The significance of differences was tested using the paired Student t-test for comparisons of quantitative data between pretest and posttest, and the two-sample Student t-test for comparisons of quantitative data in groups A and B. Nonparametric tests (Wilcoxon signed-rank test and Wilcoxon rank-sum test) were performed when Student t-test was not appropriate. Qualitative variables in groups A and B were compared using the chi-square test with Fisher exact test. The level of significance was set at $p<0.05$.

RESULTS

All trainees were included in this trial and completed all procedures. None of the trainees quitted or was excluded from the trial.

1. Baseline parameters

The trainees from groups A and B showed no significant difference in any baseline parameter (gender, age, and endoscopic operational experience) (Table 2).

Table 2. Baseline Parameters of Groups A and B

Parameter	Group A (n=9)	Group B (n=9)	p-value
Male sex	3	3	1.000
Age, yr	32.4 (3.8)	33.2 (3.8)	0.672
Radial-scanning EUS experience			
None	6	8	0.576
1–25 cases	3	1	
Linear array EUS experience			
None	9	9	1.000
EUS-FNA experience			
None	9	9	1.000
ERCP experience			
None	9	7	0.471
1–25 cases	0	1	
25–50 cases	0	1	
Total endoscopy experience			
201–300 cases	0	1	1.000
>300 cases	9	8	

EUS, endoscopic ultrasonography; FNA, fine-needle aspiration; ERCP, endoscopic retrograde cholangiopancreatography.

Table 3. Pretest and Posttest Evaluations of Trainees in Group A

Group A	Pretest	Posttest	p-value*
Visualization of anatomical sites			
Pancreas	2.9±1.1	7.3±0.7	0.000
Splenic artery and splenic vein	3.1±1.2	7.3±0.5	0.000
Abdominal aorta	3.3±1.0	7.9±0.6	0.000
Celiac trunk and superior mesenteric artery	3.0±1.1	7.2±0.7	0.000
EUS-FNA of the body or tail of pancreas			
Duration, sec	150.0±29.1	90.0±17.3	0.000
Accuracy, mm	3.8±1.1	2.1±0.3	0.000
Operational errors, times	2.3±1.4	0.8±0.8	0.014
Score	3.3±0.9	7.6±0.5	0.000
EUS-CPN			
Duration, sec	173.3±34.3	101.1±19.0	0.000
Accuracy, mm	3.2±0.4	1.2±1.0	0.000
Operational errors, times	1.8±1.3	1.3±1.8	0.558
Score	3.3±0.9	7.4±0.7	0.000

Data are presented as mean±SD.
EUS, endoscopic ultrasonography; FNA, fine-needle aspiration; CPN, celiac plexus neurolysis.
*p-values were calculated using SPSS software and were corrected to three decimal places.

Table 4. Pretest and Posttest Evaluations of Trainees in Group B

Group B	Pretest	Posttest	p-value*
Visualization of anatomical sites			
Pancreas	2.9±1.5	7.1±0.9	0.000
Splenic artery and splenic vein	3.0±1.3	7.1±0.9	0.000
Abdominal aorta	3.4±1.2	7.7±0.9	0.000
Celiac trunk and superior mesenteric artery	3.0±1.6	7.0±1.5	0.000
EUS-FNA of the body or tail of pancreas			
Duration, sec	137.8±34.6	91.1±13.6	0.002
Accuracy, mm	4.0±1.3	2.1±0.9	0.003
Operational errors, times	2.3±2.0	1.1±0.8	0.117
Score	3.2±1.2	7.4±0.9	0.000
EUS-CPN			
Duration, sec	160.0±41.5	105.6±26.0	0.004
Accuracy, mm	3.0±0.9	1.6±1.2	0.011
Operational errors, times	1.8±1.3	0.9±0.6	0.089
Score	3.3±1.1	7.4±0.7	0.000

Data are presented as mean±SD.
EUS, endoscopic ultrasonography; FNA, fine-needle aspiration; CPN, celiac plexus neurolysis.
*p-values were calculated using SPSS software and were corrected to three decimal places.

2. Training outcomes

1) Group A (Table 3)

Diagnostic procedures: Differences between pretest and posttest were significant for visualization of all target sites.

Interventional procedures: For pancreatic FNA, a significant improvement was seen in terms of duration, accuracy, operational errors, and score. For CPN, a significant improvement was seen for duration, accuracy, and score, but not for operational errors.

2) Group B (Table 4)

Diagnostic procedures: Differences between pretest and posttest were significant for the visualization of all target sites.

Interventional procedures: For pancreatic FNA and CPN, a significant improvement was seen for duration, accuracy, and score, but not for operational errors.

3. Intergroup comparison

Groups A and B showed no significant difference in any parameter before training. The improvement (difference between pretest and posttest) also showed no significant difference in any parameter between groups A and B (Table 5).

Table 5. Improvements between the Pretests and Posttests for Trainees in Groups A and B

Improvement between pretest and posttest	Group A (n=9)	Group B (n=9)	p-value
Visualization of anatomical sites			
Pancreas	4.4±0.9	4.2±0.7	0.555
Splenic artery and splenic vein	4.2±1.0	4.1±0.6	0.774
Abdominal aorta	4.6±1.2	4.2±0.8	0.512
Celiac trunk and superior mesenteric artery	4.2±0.8	4.0±0.7	0.550
EUS-FNA of the body or tail of pancreas			
Duration, sec	60.0±22.4	46.7±30.0	0.301
Accuracy, mm	1.7±0.9	1.9±0.8	0.576
Operational errors, times	1.6±1.3	1.2±1.6	0.643
Score	4.2±0.8	4.2±0.7	1.000
EUS-CPN			
Duration, sec	72.2±24.4	54.4±34.0	0.220
Accuracy, mm	2.0±0.9	1.4±0.9	0.196
Operational errors, times	0.4±1.3	0.9±1.2	0.463
Score	4.1±0.6	4.1±0.8	1.000

Data are presented as mean±SD.
EUS, endoscopic ultrasonography; FNA, fine-needle aspiration; CPN, celiac plexus neurolysis.

DISCUSSION

It is widely accepted that the learning curve for EUS is formidable and time-consuming,[1] and that this learning is largely self-taught. In a survey of clinical practice of EUS in 191 attendees at the 13th International Symposium on EUS in 2002 in New York, only 36 (18.8%) had more than 6 months of dedicated hands-on EUS training, and more than a third of the respondents learned to perform EUS by observing others or were self-taught.[4]

Thus, there is an urgent need to develop effective EUS training tools and to improve training. To date, the training tools available include live pigs, hypostatic simulation models, software simulations, and *ex vivo* animal organ models. Eight EUS experts were questioned regarding the teaching utility of different tools (EUS-guided FNA box, EUS mentor, EUS RK model, and live pigs).[5] Scores for realism, compared with a human EUS, were the highest in the live pig model with regard to the anatomy of the pancreatic body and celiac axis, visualization, scope manipulation, and needle manipulation, but not for the anatomy of the mediastinum. Scores for teaching utility in EUS-FNA were also highest in the live pig model. Overall, the live pig model scored highest for overall simulation realism and for utility as an educational tool. Therefore, the swine model seems to be the best and is recommended by experts.

Barthet *et al*.[3] validated the use of live pigs in teaching EUS imaging and EUS interventions. In total, 17 trainees obtained hands-on EUS experience using a live pig model. Trainees were asked to visualize anatomical structures, to carry out FNA on lymph nodes in the liver hilum, and to perform celiac neurolysis. Assessments of the FNA procedure and CPN included measurement of time, evaluation of the precision of the puncture, and the existence of technical errors. Significant improvement pretest and posttest was found for diagnostic procedures. For lymph node FNA, significant improvements were observed in the duration of the procedure, and precision, but not in the technical error rate. For celiac neurolysis, a significant improvement was observed in procedure time, but not in the technical error rate or precision.

Our findings are generally consistent with those of Barthet. Regardless of whether they received radial-scanning EUS training, the vast majority of trainees enhanced their EUS skills greatly and were able to smoothly accomplish interventional procedures and the visualization and tracking of the major sites of the biliary pancreatic system. In contrast, most trainees had no experience in operating a side-viewing endoscope or echoendoscope before training. All animals survived the training process and drug anaesthesia, indicating no sign of acute intervention-related complications.

The scoring criteria in our study adopted a 10-point scale in four grades, a wider scoring span than Barthet's. Thus, our evaluation is more precise and better distinguishes differences in trainee skills. Meanwhile, the evaluation of operational errors was conducted by means of determining numbers of errors per person, providing more and more concise information.

After the hands-on training, all trainees had significantly higher scores than in the pretest for visualization of all target anatomical sites in EUS imaging diagnoses. For interventional procedures, trainees also had higher scores, shorter durations, and increased precision, but not fewer operational errors (except group A for FNA). The porcine pancreas and celiac ganglia are similar to the human organs in terms of anatomical position and identical in terms of tissue type and difficulty puncturing, perfectly simulating EUS in the human body.

Our results showed increased precision for CPN while Barthet reported no significant improvement for CPN. This slight difference may be due to differences in the baseline endoscopic operation experience and quality of training between the studies.

Despite rapid progress in EUS training tools, such as the live pig model, the arrangement of training material has not been widely studied or defined.[6,7] One important concern about training modalities is how to choose and arrange training in linear array EUS and radial-scanning EUS. Compared with radial-scanning EUS, linear array EUS produces longitudinal ultrasound images, which are more difficult to understand and read. Further, its interventional functions make linear array EUS more risky and challenging. In this context, it seems reasonable for

EUS novices to learn radial-scanning EUS first and linear array EUS subsequently.

However, our results showed that the two groups were not different posttest, indicating that prior radial-scanning EUS training was not, in fact, helpful in subsequent linear array EUS learning. This is likely because ultrasound images from the two types of EUS are mutually perpendicular and must be read differently, which may remove the benefit of prior radial-scanning EUS training. Therefore, the learning processes for the two kinds of EUS are largely independent, and EUS trainers ought to optimise the arrangement of training material to improve the training outcome.

Our study had two important limitations. First, typically biliary-pancreatic structures were scanned through stomach and duodenum in human EUS. The latter was the more difficult part of the whole EUS procedure. However, the echoendoscope used in this study was not long enough to reach the duodenum of the pig to visualize visceral and perform puncture, which may underestimate the efficacy of prior radial-scanning EUS training to improve line-array echoendoscope skills. Secondly, for the cost of using live pigs as a EUS tool was very high, each trainee from group A only received prior linear array EUS training for a short of 15 minutes. Given that the learning of EUS was time-consuming and experience-based, such a short time was likely to be inadequate to reflect the benefit of radial-scanning EUS training. Some other limitations also existed in our study design, such as the small number of trainees, open-label design, short time of hands-on training, and lack of trainee performance evaluations in clinical EUS. Further studies should address these limitations.

In conclusion, we validated the beneficial role of the live pig as an EUS training tool, and found that prior radial-scanning EUS training did not contribute to subsequent linear array EUS learning in the stomach of live pigs, suggesting that the training mode that is currently widely used may need a change.

CONFLICTS OF INTEREST

No potential conflict of interest relevant to this article was reported.

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REFERENCES

1. Eloubeidi MA, Tamhane A. EUS-guided FNA of solid pancreatic masses: a learning curve with 300 consecutive procedures. Gastrointest Endosc 2005;61:700-708.
2. Eisen GM, Dominitz JA, Faigel DO, et al. Guidelines for credentialing and granting privileges for endoscopic ultrasound. Gastrointest Endosc 2001;54:811-814.
3. Barthet M, Gasmi M, Boustiere C, et al. EUS training in a live pig model: does it improve echo endoscope hands-on and trainee competence? Endoscopy 2007;39:535-539.
4. Das A, Mourad W, Lightdale CJ, Sivak MV Jr, Chak A. An international survey of the clinical practice of EUS. Gastrointest Endosc 2004;60:765-770.
5. Matsuda K, Hawes RH, Sahai AV, Tajiri H. The role of simulators, models, phantoms. Where's the evidence? Endoscopy 2006;38 Suppl 1:S61-S64.
6. Faigel DO. Quality, competency and endosonography. Endoscopy 2006;38 Suppl 1:S65-S69.
7. Rösch T. State of the art lecture: endoscopic ultrasonography: training and competence. Endoscopy 2006;38 Suppl 1:S69-S72.