

Feasibility of Newly Developed Endoscopic Ultrasound with Zone Sonography Technology for Diagnosis of Pancreatic Diseases

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Background/Aims: To confirm the feasibility of using newly developed endoscopic ultrasound (EUS) with Zone sonography™ technology (ZST; Fujifilm Corp.). **Methods:** Seventy-five patients with pancreatic disorders were enrolled: 45 with intraductal papillary mucinous neoplasm; 15 with ductal carcinoma; five with neuroendocrine tumors; three with serous cystic neoplasms; and seven with simple cysts. The endoscopes used were EG-530UR2 and EG-530UT2 (Fujifilm Corp.). Two items were evaluated: visualization depth among four frequencies and image quality after automatic adjustment of sound speed (AASS), assessed using a 5-scale Likert scale by two endosonographers blinded to disease status. Because sound speed could be manually controlled, besides AASS, image quality at sound speeds of 1,440 and 1,600 m/sec were also assessed. **Results:** In all cases, sufficient images were obtained in the range of 3 cm from the EUS probe. Judgments of image quality before AASS were 3.49 ± 0.50 , 3.65 ± 0.48 , respectively. After AASS, A and B scored 4.36 ± 0.48 and 4.40 ± 0.49 ($p < 0.0001$). There were significant differences in the data before and after AASS and plus 60 m/sec, but no significant difference between the datasets were seen after AASS and at sound speeds manually set for minus 100 m/sec. **Conclusions:** EUS with ZST was shown to be feasible in this preliminary experiment. Further evaluation of this novel technology is necessary and awaited. (Gut Liver 2013;7:486-491)

Key Words: Endosonography; ZONE sonography technology; Enhanced attenuation; Automatic adjustment of sound speed

INTRODUCTION

Endoscopic ultrasound-guided fine needle aspiration (EUS-FNA) is now thought to be the useful and reliable diagnostic modality for the pancreatic diseases.¹⁻³ Regardless of these trends, there may be inevitable possibilities of dissemination or track seeding,⁴ though it is faint.

The development and sophistication of EUS images themselves should be the first step to the better understandings of pancreaticobiliary diseases.^{5,6} In the early 2000s, the main stream of EUS changed from a mechanical scanning method to electronic radial or linear scanning methods.⁷⁻⁹ Subsequently, useful applications in transabdominal ultrasonography came within reach of EUS, i.e., contrast-enhanced EUS and EUS-elastography.

And now, an entirely-new concept of ultrasonography named Zone Sonography™ technology (ZST; Fujifilm Corp., Tokyo, Japan) has come within reach of EUS. ZST is a novel ultrasound technology which transmits a broad ultrasound beam (contrary to the conventional method) to rapidly collect extensive echo data immediately by using large zones and it realizes the high-quality ultrasound images of deeper part of body irrespective of observation frequency used because it can put together the accumulated data in the memory. Moreover, this technology estimates the optimal sound speed which has been usually fixed as 1,540 m/sec and provides clear images for independent patients. We investigated the feasibility and usefulness of EUS with ZST in the diagnosis of pancreatic diseases.

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MATERIALS AND METHODS

1. Ethics

The study design was retrospective. The study protocol was approved by the Institutional Review Board according to the Declaration of Helsinki. Written informed consent was obtained from each patient.

2. Zone sonography™ technology (ZST)

ZST is an entirely new approach to ultrasound image acquisition and processing. Conventional systems acquire acoustic data line-by-line and focus it with a beamformer using only a small fraction of the actual information contained in the echo data set. ZST has the ability to utilize all of the information contained in the returning echo data set acquired in each large zone and as such can cover the field of view in much fewer transmit/receive cycles. The original raw echo information is retrospectively reprocessed multiple times in the Channel Domain Processor to form optimal images (Fig. 1).¹⁰ EUS system with ZST provides the two major advantages, i.e., enhanced attenuation and sound speed correction.

1) Enhanced attenuation

The principle of an enhanced attenuation is explained in Fig. 2. This system can produce the images retrospectively using various frequencies and depict the images of the distant field using lower frequency with higher frequency for the near field.

2) Sound speed correction

All conventional ultrasound systems have to make an assumption regarding the speed of sound in the tissue being imaged as 1,540 m/sec. However, different types of tissue have different sound properties¹¹⁻¹⁴ and even the same type of tissue may not have similar properties from patient to patient. Therefore, these built-in assumptions are often inaccurate. ZST could

analyze the actual echo data in a variety of ways to optimize the accuracy of tissue representation for that specific patients—rather than relying on rigid prior assumptions. ZST estimates the several images using several sound speeds, and next, frequency analysis is performed in all images. The sound speed that produced the highest lateral resolution is adopted as an optimal sound speed (Fig. 3).

3. Patients and methods

From December 1, 2010 to February 10, 2012, 75 patients with pancreatic disorders were enrolled in this study. Seventy-five patients consisted of 45 with intraductal papillary mucinous neoplasm (IPMN), 15 with invasive ductal carcinoma, five with pancreatic neuroendocrine tumor, three with serous cystic neoplasm, and seven with pancreatic simple cyst. Forty-five IPMNs were divided into 15 IPMAs and three IPMCs (minimally invasive) by surgical treatment and remaining 27 cases have been followed up using EUS or computed tomography without any changes for more than at least 6 months. The diagnostic criteria for the follow-up IPMNs were a communication with main pancreatic duct and the existence of mucus by ERP. Fifteen invasive ductal carcinomas were diagnosed by either EUS-FNA or surgical treatment. Five cases of neuroendocrine tumors and three cases of serous cystic neoplasm were all diagnosed by surgical resection. Seven pancreatic cysts having no communication with main pancreatic duct have been followed up as the diagnosis of simple cysts at least for more than 6 months.

Endoscopes used were EG-530UR2 (electronic radial method, viewing direction, 0 degree forward; distal end diameter, 11.4 mm; Fujifilm Corp.) and EG-530UT2 (electronic convex method, viewing direction, 40 degrees forward oblique; distal end diameter, 13.9 mm; Fujifilm Corp.) (Table 1), and SU-800 as ultrasound processor equipped with ZST. This system is now commercially available in Japan.

Evaluated items were as follows: first, comparison of the

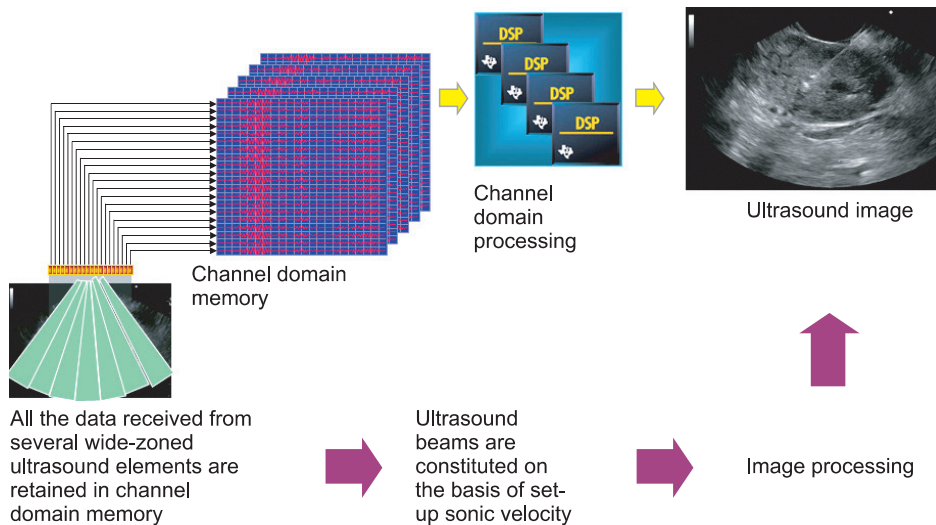


Fig. 1. Principle of Zone Sonography™ technology (ZST). ZST is an entirely new approach to ultrasound image acquisition and processing. ZST can utilize all of the information contained in the returning echo data set acquired in each large zone and, as such, can cover the field of view in fewer transmit/receive cycles. The original raw echo information is retrospectively reprocessed multiple times in the channel domain processor to form optimal images. DSP, digital signal processor.

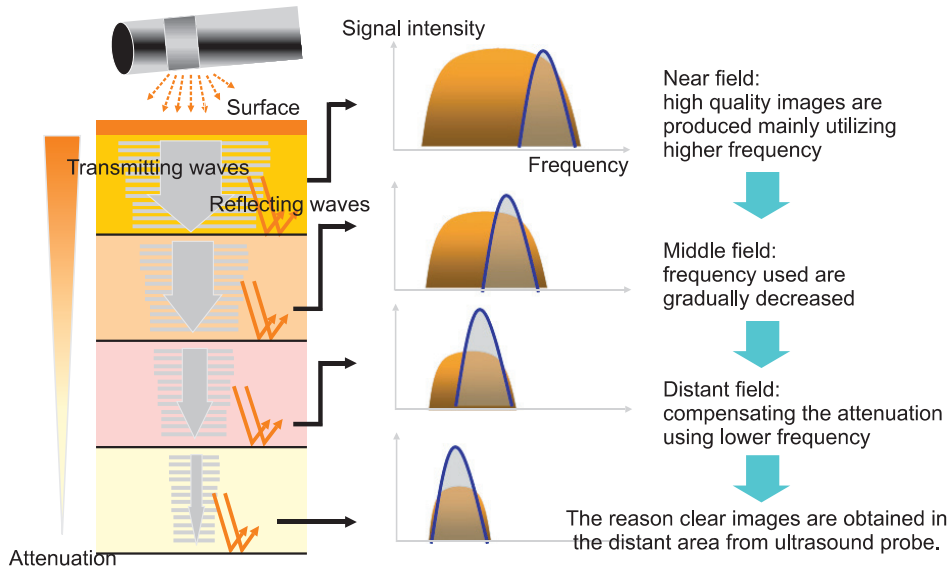


Fig. 2. Enhanced ultrasound attenuation using Zone Sonography™ technology. This system can produce the images retrospectively using various frequencies and depicts the images using a lower frequency for the distant field and a higher frequency for the near field.

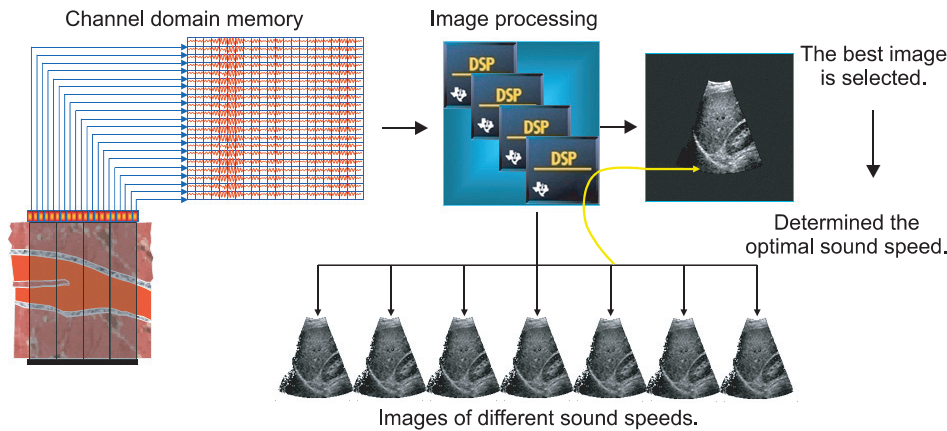


Fig. 3. The principle of automatic adjustment of sound speed. Zone Sonography™ technology estimates several images using several sound speeds, and frequency analysis is performed next in all images. The sound speed that produced the highest lateral resolution is adopted as an optimal sound speed. DSP, digital signal processor.

depth of visualization among four frequencies (5 MHz vs 7.5 MHz vs 10 MHz vs 12 MHz) employed for EUS observation. Depiction of 3 cm in depth from probe was regarded as sufficient; second, image quality after automatic adjustment of sound speed (AASS) was assessed using 5-scale Likert scale (from poor, 1 to excellent, 5) by two endosonographers (2,500 and 3,000 EUS experiences, respectively) who were blind to the information of diseases. Because sound speeds could be manually controlled, i.e., from minus 100 m/sec (1,440 m/sec) to plus 60 m/sec (1,600 m/sec) at 10 m/sec intervals, in addition to the automatic adjustment, we also evaluated the image quality at sound speed of 1,440 and 1,600 m/sec. Using video and still images, two reviewers (endosonographers A and B) judged the image quality mainly on the basis of the clearness and the contrast resolution of the contour and inner structures. An experienced (6,000 EUS experiences) physician performed the all examinations. All images evaluated their quality were obtained using 7.5 MHz.

Statistical analyses were performed using IBM SPSS version 19.0 (IBM Co., Armonk, NY, USA). Statistical analyses of group

differences (paired data) were performed using the Wilcoxon signed-rank test, the Steel-Dwass test for multiple comparison (not paired). The Spearman rank correlation coefficient was used for interobserver agreement. The data of descriptive statistics were expressed as mean±SD. A p<0.05 was considered to be statistically significant.

RESULTS

1. Enhanced attenuation of EUS

In all cases, sufficient images were obtained in the range of 3 cm from the EUS probe, that is, 6 cm between both ends of images in radial type EUS (Fig. 4).

2. Effects of AASS

The judgments of image quality by A and B before AASS were 3.49±0.50, 3.65±0.48, respectively and there was no correlation between each paired data (p=0.38). After AASS, A and B scored 4.36±0.48 and 4.40±0.49 and there was significant increase in scores by both A and B (p<0.0001), furthermore a

Table 1. Specifications of Endosonoscopes

		Model	EG-530UR2	EG-530UT2
Endoscopic functions	Optical system	Angle of visual field (maximum diagonal angle)	140°	140°
		Direction of visual field	0 Direct vision	40°
		Depth of observation	3-100 mm	3-100 mm
	Insertion unit	Outer diameter of the tip	Φ 11.4 mm	Φ 13.9 mm
		Outer diameter of the flexible part	Φ 11.5 mm	Φ 12.1 mm
		Effective length	1,250 mm	1,250 mm
	Forceps channel	Diameter of the forceps channel	Φ 2.2 mm	Φ 3.8 mm
	Curved part	Up	180°	160°
		Down	90°	160°
		Right	100°	120°
Left		100°	120°	
Total length		1,550 mm	1,550 mm	
Ultrasound functions	Display mode	Color Doppler/power Doppler/PW Doppler/M mode/B mode/THI	Color Doppler/power Doppler/PW Doppler/M mode/B mode/THI	
	Scan method	Electric radial	Electric convex	
	Scan direction	360°	124°	
	Frequency	5 MHz/7.5 MHz/10 MHz/12 MHz	5 MHz/7.5 MHz/10 MHz/12 MHz	
	Method of extracting	Balloon method/deaerated water filling method/contact method	Balloon method/deaerated water filling method/contact method	

PW Doppler, pulsed wave Doppler; THI, tissue harmonic imaging.

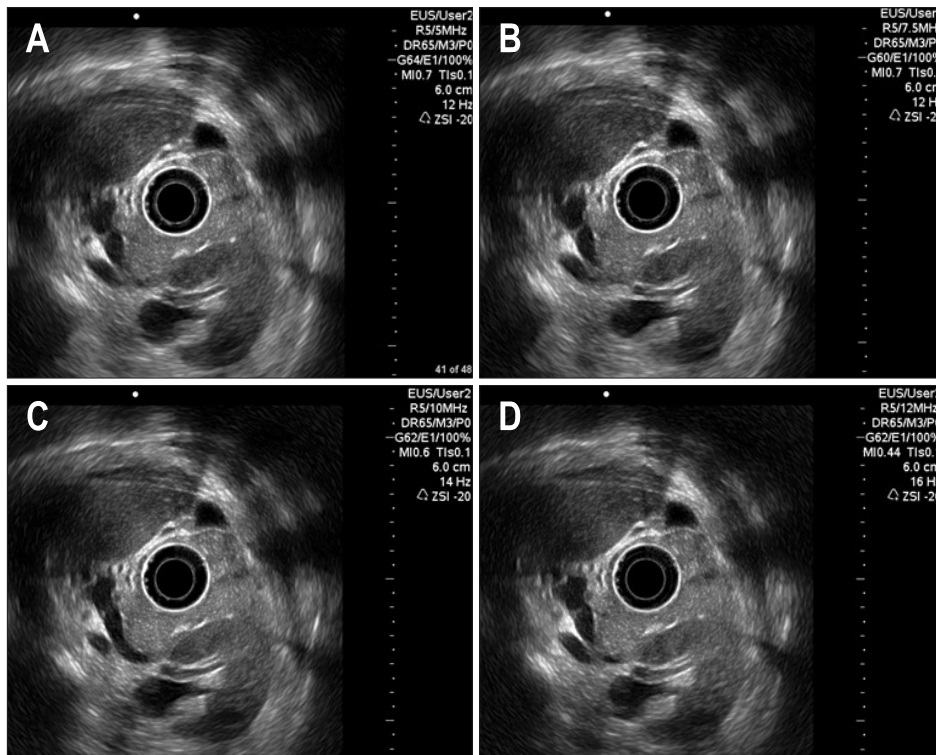


Fig. 4. Enhanced attenuation of various frequencies. The image of the same section at different frequencies (A, 5; B, 7.5; C, 10; D, 12 MHz) could clearly depict images 3 cm from the probe. There was no apparent deterioration in quality even in images of the distal side obtained using 10 or 12 MHz.

significant correlation was seen between paired scores of A and B after AASS. On average, AASS indicated the minus 17.3±8.3 m/sec compared with the assumed sound speed 1,540 m/sec. In

this study, there were no differences of the value of sound speed correction that AASS indicated between cystic lesions and solid lesions.

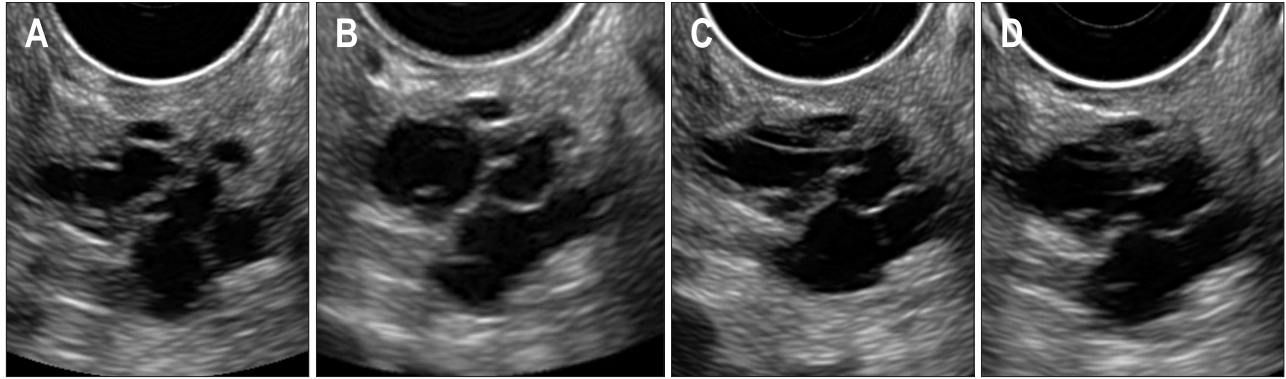


Fig. 5. Intraductal papillary mucinous neoplasm case observed by endoscopic ultrasound with Zone Sonography™ technology. (A) Original image (1,540 m/sec); 4 (endosonographer A) and 4 (endosonographer B) on the Likert scale. (B) After automatic correction of sound speed (1,530 m/sec); 5 (endosonographer A) and 5 (endosonographer B) on the Likert scale. (C) After manual adjustment (1,440 m/sec); 5 (endosonographer A) and 5 (endosonographer B) on the Likert scale. (D) After manual adjustment (1,600 m/sec); 3 (endosonographer A) and 3 (endosonographer B) on the Likert scale. The contour and inner structure are blurred compared to B and C.

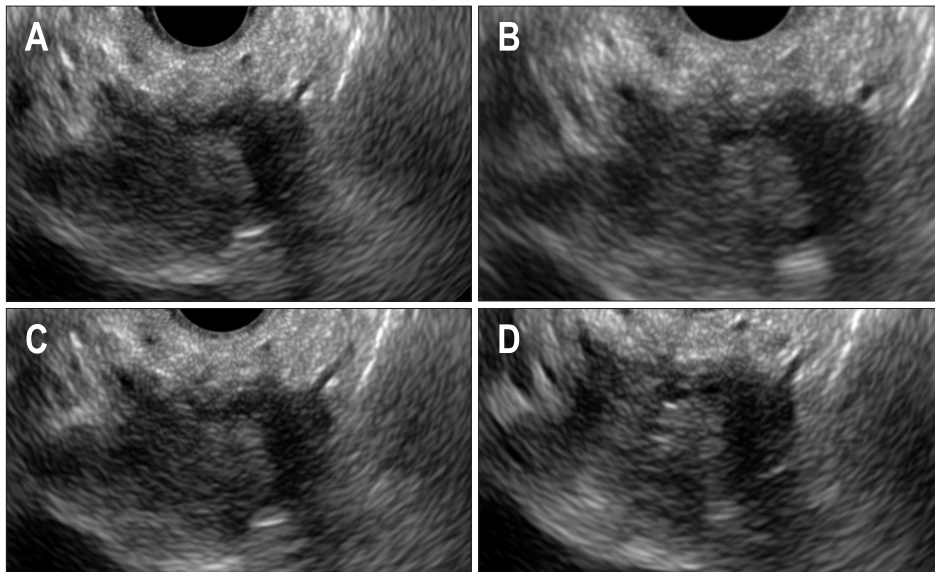


Fig. 6. Invasive pancreatic ductal cancer observed by endoscopic ultrasound with Zone Sonography™ technology. (A) Original image (1,540 m/sec); 4 (endosonographer A) and 4 (endosonographer B) on the Likert scale. (B) After automatic correction of sound speed (1,510 m/sec); 4 (endosonographer A) and 5 (endosonographer B) on the Likert scale. (C) After manual adjustment (1,440 m/sec); 5 (endosonographer A) and 5 (endosonographer B) on the Likert scale. (D) After manual adjustment (1,600 m/sec); 4 (endosonographer A) and 3 (endosonographer B) on the Likert scale. The contour and inner structure are blurred compared to B and C.

The Steel-Dwass test showed the significant differences among the data before and after AASS and plus 60 m/sec, but no significant difference between the data after AASS and those manually set for minus 100 m/sec.

Representative cases were shown in Figs. 5 and 6.

DISCUSSION

In this study, at first, we sought to elucidate the enhanced attenuation of EUS enabled by ZST. In the clinical setting of EUS in the diagnosis of pancreatic diseases, 3 cm in range may be a sufficient depth of observation. This study showed the sufficient attenuation of EUS irrespective of frequencies used, i.e., 5, 7.5, 10, and 12 MHz. According to the theory (Fig. 2), image quality deterioration was the matter of concern, but, any apparent worsening was not seen in this limited case series.

Weiwad *et al.*¹² reported the sound speeds of various tissues,

i.e., around 1,400 m/sec in fatty tissue and 1,600 m/sec in cardiac muscle. Contrary to our expectations, AASS provided no different sound speed between pancreatic cystic masses and solid masses. The algorithm of AASS contains the whole images obtained by EUS including solid area, cystic area, and so on, this may explain why there were no differences in the sound speed adjustment between solid masses and cystic masses. The fact that the average sound speed correction value after AASS was minus 17.3±8.3 m/sec may suggest the overestimation compared with assumed sound speed (1,540 m/sec).

Boozari *et al.*¹¹ reported the usefulness of evaluation of sound speed for detection of liver fibrosis. Transient elastography by Fibroscan (Echosens, Paris, France) has been accepted as a non-invasive method for assessment of liver fibrosis. Sound speed changes are also dependent on elastic properties of tissue. They compared the TE values and corrected sound speeds and concluded the sound speed of liver tissue depended on the fibrosis

stage. Their ultrasound machine could calculate an optimized sound speed of the target area (region of interest) and could determine hardness (or fibrosis) of the specific area.

Now our system is being upgraded to be able to calculate the specific point as Boozari *et al.*¹¹ did. For example, pancreatic cancer, neuroendocrine tumor, chronic pancreatitis have their own hardness, our system may give the differential diagnosis from the entirely different point of view if the upgrade mentioned above comes to realization.

In conclusion, EUS with ZST was feasible in this our preliminary experiences, regardless of the limitation such as small sample size and single-center study. Further evaluation of this novel technology is necessary and awaited.

CONFLICTS OF INTEREST

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

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