Endosonographic Instrumentation

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CONTENTS

Abstract

Endoscopic ultrasound is a relatively new technology that has a growing indication which extends beyond the field of gastroenterology. The high degree of resolution and the ability to perform real time imaging during both diagnostic and therapeutic interventions allow ultrasound to remain a highly valuable modality. The first and most important step in performing EUS is to have a thorough understanding on its mechanics as well as the available instrumentation. This chapter sets out to do both.

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INTRODUCTION: BASICS OF ULTRASOUND AND RATIONALE FOR EUS

Diagnostic ultrasonography is a relatively recently developed technology. Initial reports began to appear in the late 1950s and early 1960s (1), and ultrasonography rapidly gained acceptance in the 1970s. As with any technology, diagnostic ultrasound has advantages and disadvantages. When initially introduced, ultrasound provided a relatively unique ability to visualize soft tissue with high degrees of detail. The high degree of resolution and the ability to perform real time imaging during both diagnostic and therapeutic interventions allow ultrasound to remain a highly valuable modality. Advantages include reasonable portability, relatively low cost, and lack of a need for ionizing radiation (as opposed to CT).

Soon after its introduction, several limitations of standard ultrasound became apparent. Ultrasound is unable to image deep to air-filled structures or extremely dense structures such as bone or calculi. As such, ultrasound is of little value in imaging the mediastinum due to the overlying ribs, sternum, and adjacent lungs. Imaging of the pancreas and distal common bile duct is also greatly limited. Another limitation occurs due to a basic principle of sound transmission. Higher resolution imaging requires the use of relatively high frequency sound energy. Unfortunately, higher frequency sound travels poorly through tissue (or other media) – as evidenced by the booming bass sound coming from passing cars with loud stereos without audible treble tones. In order to image structures far from the body surface, standard ultrasound requires the use of relatively low frequency energy (3.5–5 MHz), which as a result produces lower resolution images. In an effort to overcome these limitations, endoscopic ultrasound and transesophageal echocardiography were developed in the early 1980s (2). By placing the ultrasound transducer within the body, it is possible to avoid air-filled or bony structures and reduce the distance between the transducer and the region of interest. As an example, a transducer placed in contact with the duodenal wall will be within 5 mm of the intrapancreatic portion of the distal common bile duct and avoids the interference caused by air in the duodenum, small bowel and colon.

Many issues arose during the initial development of EUS. Should the optical camera view in a forward angle like a standard endoscope or be side-viewing like a duodenoscope? Should the ultrasound transducer

produce images parallel to the long axis of the endoscopy (e.g., a linear or curved linear configuration) or perpendicular to the long-axis (e.g., a radial configuration)? What imaging frequency is ideal? Many of these questions are still debated; however, the currently available echoendoscopes are clearly vastly superior to the initial prototypes. In addition, the development of high-resolution videochip technology has provided higher resolution video imaging (as opposed to older fiberoptic devices) and allows smaller echoendoscopes with larger biopsy channels.

THE ULTRASOUND TRANSDUCER

Although a detailed explanation of the physics of ultrasound is beyond the scope of this article, a basic understanding of ultrasound physics is required. Ultrasound imaging relies upon the use of crystalline material with a unique property called the piezoelectric effect. These crystals vibrate in response to electrical stimulation and, as a result, produce sound. Different crystals produce sound of different frequencies. As important, however, is the reverse phenomenon in which sound energy contacting the crystal will result in the production of electrical current. As a result, the crystals can simultaneously produce a sound beam and "listen" for the portions of this sound energy, which are reflected back to the surface of the crystal. Measurement of the time taken for energy to return, in conjunction with the known speed of sound, allows a calculation of the distance to a given reflecting object. A computer can then display on a map the different locations which produced echoes. Regions which reflect a greater percentage of sound energy is displayed as brighter spots on the map. This is the basis for ultrasound imaging. Imaging with a single piezoelectric crystal will allow probing of a thin line (like a beam from a flashlight) extending from the crystal. By arranging hundreds to thousands of these crystals in an array, a wider region of tissue may be simultaneously imaged.

RADIAL ARRAY VERSUS LINEAR ARRAY

Ultrasound imaging is currently available in two primary imaging planes – radial array and curved linear array ("linear"). These imaging planes are determined by the orientation in which the individual piezoelectric crystals are arrayed on the echoendoscope. Historically, this difference reflected decisions made by separate manufacturers who made different choices with regard to the optimal imaging plane. Early devices produced by Olympus utilized only radial imaging, whereas

early Pentax devices were exclusively linear (although now both companies manufacture both types of devices). Early Olympus mechanical radial-array devices contained a small disc-shaped ultrasound transducer, which was attached to a motor drive and rotated in a plane perpendicular to the long-axis of the endoscope (Fig. 1a, b). This produced a circular image with the endoscope shaft located at the center (Fig. 1c). Pentax linear devices contained a fixed electronic (nonmoving) transducer oriented so as to produce a sector-shaped image parallel to the long-axis of the endoscope (Fig. 2a–c). The majority of early endosonographers learned EUS using the radial devices.

Linear array imaging has one major advantage compared to radial array. This is illustrated in Fig. 2c. A therapeutic device, such as a biopsy needle, which is advanced through the therapeutic channel of the echoendoscope will remain within the imaging beam. As a result, the

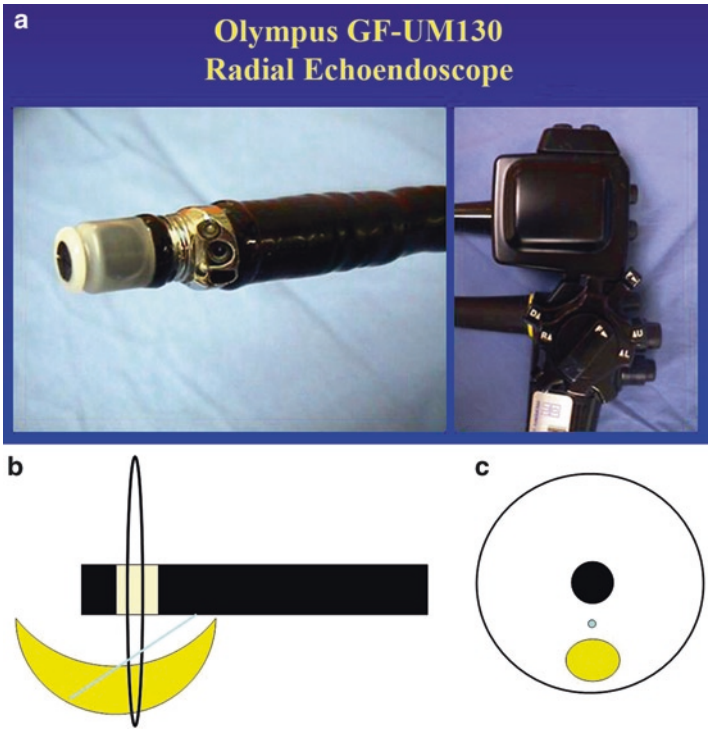

Fig. 1. (**a**–**c**) Early Olympus mechanical radial-array devices contain a small disc-shaped ultrasound transducer which is attached to a motor drive and rotated in a plane perpendicular to the long axis of the echoendoscope.

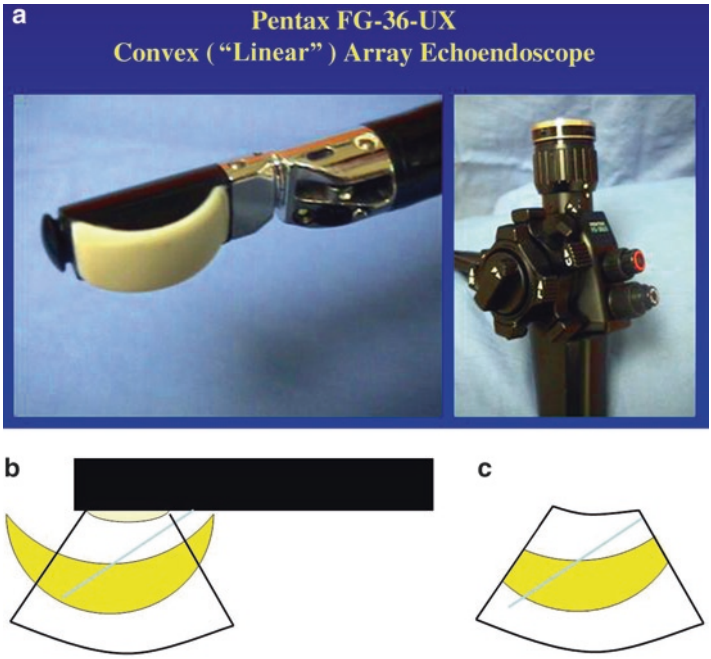

Fig. 2. (**a** – **c**) The early Pentax linear devices contain a fixed electronic transducer oriented so as to produce a sector-shaped image parallel to the long-axis of the endoscope. A biopsy needle will remain within the image beam.

entire length of a biopsy needle can be followed continuously as it is advanced through the bowel wall and into adjacent structures of interest. This allows precise placement of a biopsy needle within mass lesions (or other structures, as will be shown in subsequent chapters). This degree of visualization is simply not possible with radial devices. A biopsy needle advanced through a radial device will pass through the imaging beam at roughly a right angle – resulting in a small echogenic spot on the ultrasound image (Fig. 1c). There is no reliable means of determining how far beyond the imaging plane the needle was advanced. Although a few attempts were made to develop techniques for EUS-guided biopsy using radial devices, these approaches were impractical and rapidly abandoned (3).

Because most early endosonographers learned EUS using radial devices, there was significant resistance to adoption of linear EUS. It was often stated that radial EUS was easier to learn than linear, purportedly due to the fact that radial images more closely resembled standard CT imaging planes with which endoscopists were familiar. This is true,

however, only when the echoendoscope is oriented parallel to the spine – an orientation which is often not possible when imaging many abdominal structures such as the pancreas or liver. It was also argued that all EUS cases should be initially performed using a radial echoendoscope, reserving linear devices until a need for biopsy is identified on the radial exam. The argument for this approach was ostensibly due to the superiority of radial imaging, but more likely this indicated greater experience and comfort level with radial devices for the individual endosonographers. In the past 10 years, this practice has changed dramatically at many centers. It is becoming increasingly common to perform a majority of EUS exams entirely with linear devices. This trend likely reflects an increasing familiarity with and availability of linear devices, an increasing acceptance of the clinical utility of EUS-guided tissue sampling (with a concomitant increase in the percentage of cases during which biopsy is performed) and time constraints which discourage the routine use of two separate echoendoscopes for each examination. This discussion is not meant to imply that there is no longer a need for radial EUS. For example, radial array imaging may allow more expeditious screening of large portions of the GI tract wall. Linear imaging does not provide a 360° cross-section of the bowel wall surrounding the endoscope. The resulting blind-spot may be difficult to overcome in some locations without pressing on and distorting the wall – particularly in the antrum and duodenum. The blind spot also makes complete evaluation of the entire surface of circumferential GI tract tumors such as esophageal carcinoma somewhat tedious with a linear device (although in our experience often a critically important feature such as distant metastasis or obvious adventitial invasion can be rapidly identified with a linear device making detailed 360° evaluation unnecessary).

It is prudent to point out that linear and radial imaging are not, by necessity, mutually exclusive. Devices are available for use in transesophageal echocardiography which allows easy, quick rotation between linear and radial imaging. This requires a larger array of crystals, with a resultant larger amount of electrical wiring. At present, the amount of space needed for wiring would preclude the inclusion of other endoscope components which are necessary for EUS, such as biopsy channels and optics. Perhaps someday soon these space limitations will be overcome and a switchable radial/linear EUS scope will become available.

BASIC ECHOENDOSCOPE DESIGN

Although many differences exist between different echoendoscope models, there are many common features. All current echoendoscope models contain a videochip to provide endoscopic imaging, with an

associated light source and water irrigation system for washing the lens. In most instances, the videochip is located proximal to the ultrasound transducer and oriented at an oblique angle to the shaft. The ultrasound transducer is attached to the shaft distal to the optical sensor and oriented in either a linear or radial configuration. It should be noted that older versions of radial devices utilized a rotating disc which spun in a lubricated cap attached to the end of the scope; however, newer devices now use a fixed, annular array of crystals. This eliminates the need for a motor drive, provides clearer images without the potential for motion distortion and allows for color Doppler capability.

As stated earlier, ultrasound imaging is not possible through air. For transcutaneous ultrasound, this air interference is overcome via the application of acoustic coupling gel to the skin surface. It is not feasible, however, to fill the upper GI tract with acoustic coupling gel. Acoustic coupling for EUS is accomplished by either filling the GI tract with water or, alternatively, inflating a water-filled balloon around the transducer which can then be placed in contact with the bowel wall (Fig. 3). These balloons can be inflated using a two-stage water irrigation button – complete depression inflates the balloon while half-depression washes the endoscope lens. Deflation of the balloon involves either a two-stage button (complete depression deflates the balloon) or a switch valve which alternately determines if depression of the suction button empties the bowel lumen or deflates the balloon.

Fig. 3. A water filled balloon around the transducer of an echoendoscope helps to achieve acoustic coupling.

The opposite end of the echoendoscope has two heads. One of these is attached to the light source as with any other endoscope. The other is unique to the echoendoscope and attaches to a separate ultrasound imaging console to transmit the ultrasound data. Each specific manufacturer utilizes a unique ultrasound console; echoendoscopes from one manufacturer are not interchangeable with consoles from a different supplier.

LINEAR ARRAY ECHOENDOSCOPES

A variety of linear devices are now available from multiple manufacturers. These vary in minimal ways, as is detailed in Table 1. The shapes of the transducers vary slightly between suppliers, which influences the shape of the resultant image. The Olympus transducer (Fig. 4) has a more distinct curvature and wider field of view compared to the Pentax device (Fig. 5), providing imaging of more tissue anterior to the echoendoscope. These differences do not necessarily imply a distinct advantage of one type over another. Echoendoscopes are now available in both "diagnostic" and "therapeutic" sizes, determined by the diameter of the device channel. The larger, therapeutic echoendoscopes allow the use of larger therapeutic devices (up to 10 F in diameter) (Fig. 6). This is most relevant with regard to the ability to place large caliber stents directly through the echoendoscope under continuous sonographic guidance (most commonly used for endoscopic drainage of pancreatic pseudocysts). These larger echoendoscopes have, by necessity, a larger overall diameter, and therefore are somewhat more difficult to pass into the esophagus and maneuver through the duodenum.

RADIAL ECHOENDOSCOPES

Several radial array echoendoscopes are currently available, as detailed in Table 2. All except the Olympus GF-UM160 utilize a fixed, nonmoving array of crystals. The GF-UM160 utilizes a rotating disc-shaped transducer (similar to the GF-UM130 shown in Fig. 1a) requiring the use of a motor-drive. Other than this single mechanical-array device the available devices are fairly similar. Pentax radial echoendoscopes place the suction channel and optical sensor at the distal tip of the echoendoscope (Fig. 7) rather than displacing these proximal to the transducer as in the Olympus devices (Fig. 8). This initially led to problems with space limitations in allowing the suction channel and camera wiring to traverse the region of the transducer, requiring a blind spot in the sonographic image (Fig. 9); however, this problem has now been overcome.

Table 1
Linear echoendoscopes

Manufacturer	*Model (US processor)*	*Ultrasound field*	*Frequency (MHz)*	*Endoscopic image*	*Length (mm)*	*Diameter (maximum) (mm)*	*Display mode*	*Channel diameter (mm)*
Olympus	GF-UC140P-AL5 (Aloka SSD-Alpha5, Alpha10)	180° Electronic curved linear array	5/6/7.5/10	Video 55° Forward oblique 100° Field of view	1,250	14.2	B-mode M-mode D-mode Flow-mode Powerflow-mode	2.8
	GF-UCT140-AL5 (Aloka SSD-Alpha5, Alpha10)	180° Electronic curved linear array	5/6/7.5/10	Video 55° Forward oblique 100° Field of view	1,250	14.6	B-mode M-mode D-mode Flow-mode Powerflow-mode	3.7
	GF-UC160P-OL5 (Olympus EU-C60)	150° Electronic curved linear array	7.5	Video 55° Forward oblique 100° Field of view	1,250	14.2	Color power doppler	2.8
	GF-UCT160-OL5 (Olympus EU-C60)	150° Electronic curved linear array	7.5	Video 55° Forward oblique 100° Field of view	1,250	14.6	Color power doppler	3.7

(continued)

Table 1
(continued)

Manufacturer	*Model (US processor)*	*Ultrasound field*	*Frequency (MHz)*	*Endoscopic image*	*Length (mm)*	*Diameter (maximum) (mm)*	*Display mode*	*Channel diameter (mm)*
Pentax	EG-3630U (Hitachi 5500 or HIVISION 900)	Curved linear array	5/7.5/10	50° Forward oblique 120° Field of view	1,250	12.8	B-mode, color doppler	2.4
	EG-3870 UTK (Hitachi 5500 or HIVISION 900)	Curved linear array	5/7.5/10	50° Forward oblique 120° Field of view	1,250	12.8	B-mode, color doppler	3.8
Fujinon	EG-530UT (SU-7000)	110° electronic curved linear array	5/7.5/10/12	40° Forward oblique 140° field of view	1,254	13.9	B-mode, M-mode, Color Doppler, power doppler, PW Doppler, "THI"	3.8

Fig. 4. Olympus linear array echoendoscope.

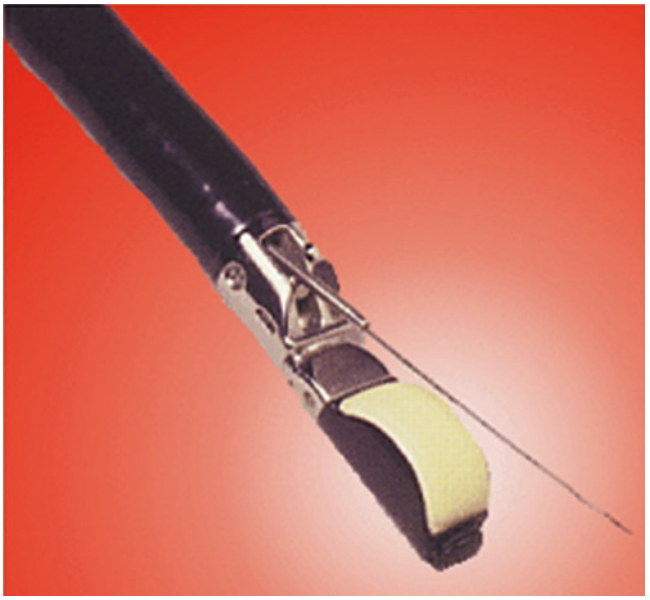

Fig. 5. Pentax linear array echoendoscope.

Fig. 6. Olympus therapeutic echoendoscope.

Table 2
Radial echoendoscopes

Manufacturer	*Model (US processor)*	*Ultrasound field*	*Frequency (MHz)*	*Endoscopic image (all are video)*	*Length (mm)*	*Diameter (maximum)*	*Display mode*	*Channel diameter (mm)*
Olympus	GF-UE160-AL5 (Aloka SSD-Alpha5 or Alpha10)	360° Electronic radial array	5/6/7.5/10	55° Forward oblique 100° Field of view	1,250	13.8	B-mode M-mode D-mode Flow-mode Powerflow-mode	2.2
	GF-UM160 (Olympus EU ME1 or EU-M60)	360° Mechanical radial	C5/C7.5/ C12/C20 (HyperBand)	50° forward oblique 100° Field of view	1,250	12.7	B-mode (no Doppler)	2.2
Pentax	EG-3670URK (Hitachi 5500 or HIVISION 900)	360° electronic radial	5/7.5/10	Forward-viewing 140° Field of View	1,250	12.1	B-mode, Color Doppler, Pulse wave CFA (color flow angio)	2.4
Fujinon	EG-530UR (SU-7000)	360° electronic radial	5/7.5/10/12	Forward-viewing 140° Field of View	1,254	11.5	B-mode M-mode Color Doppler Power Doppler Pulse wave	2.2

Fig. 7. In the Pentax radial echoendoscope, the suction channel and optical sensor is placed at the distal tip of the echoendoscope.

Fig. 8. In the Olympus radial echoendoscope, the suction channel and optical sensor is displaced proximal to the transducer.

ENDOBRONCHIAL ULTRASOUND DEVICES

Improvements in technology have recently allowed a significant reduction in the diameter of echoendoscopes. This has allowed a sufficiently small diameter to make insertion into the airway technically feasible (Fig. 10). Ultrasound imaging from within the trachea is clinically relevant because it allows visualization of lymph nodes, which are otherwise unable to be imaged with EUS performed from within the esophagus. Due to the inability to image through air, lymph nodes in the pretracheal region and pulmonary hila cannot be seen via the esophagus. These locations, however, are readily visualized if the transducer is placed in the trachea or main bronchi.

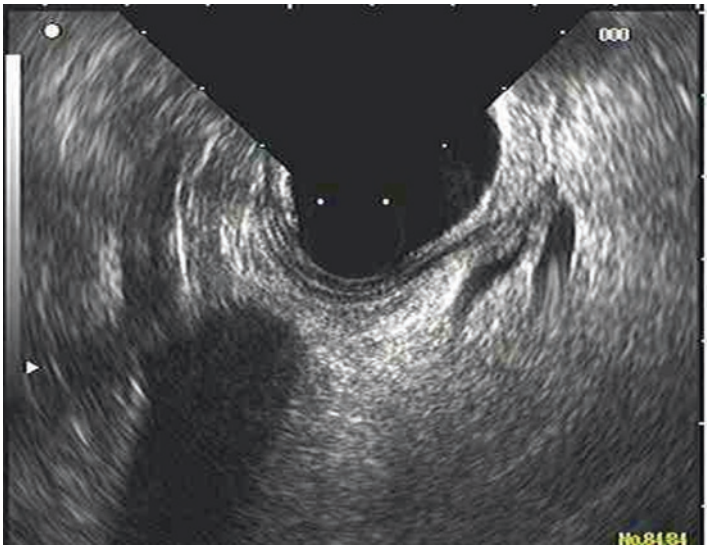

Fig. 9. In the Pentax radial echoendoscope system, placing the suction and optical sensor at the distal end of the echoendoscope led to space limitations in allowing the suction channel and camera wiring to traverse the region of the transducer, requiring a blind spot in the sonographic image.

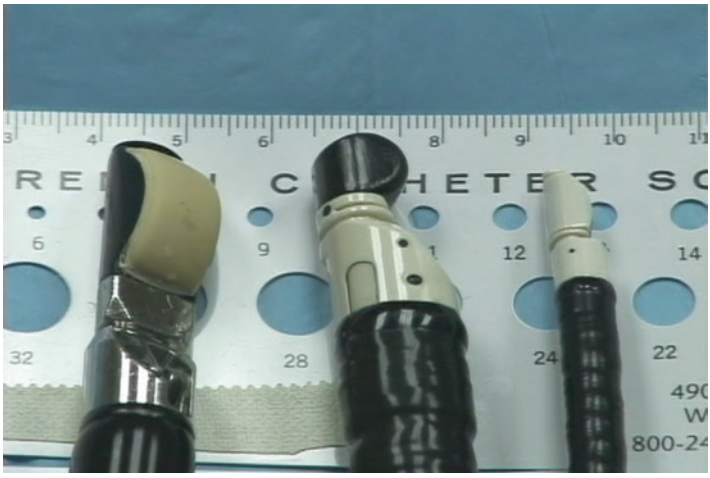

Fig. 10. Olympus endobronchial ultrasound scope.

There are several relevant differences between endobronchial devices and EUS scopes developed for GI applications. Obviously, endoscopes designed for use in the airway do not need to be as long as devices intended to be inserted into the distal duodenum. The current EBUS scope measures only 600 mm in length compared to 1,250–1,254 mm for currently available EUS devices. Other significant differences include the lack of ability to rinse the endoscope lens and the availability of only up/down deflection without right/left motion capabilities. The water balloon used for acoustic coupling is filled manually via a water-filled syringe attached to the scope, rather than via the use of a two-stage air-water button as with EUS.

Although intended for use in the airway, EBUS devices may have clinical utility in the GI tract as well (4). In particular, the small caliber may allow passage through extremely stenotic esophageal tumors, allowing the evaluation of the distal margin of the mass for complete T-classification. Although the shorter length of the device does not allow passage through the pylorus, the evaluation of the medial portions of the liver and left adrenal is possible to assess for metastatic disease. Assessment of nodal metastasis in the gastrohepatic ligament and celiac region may also be performed. If indicated, the linear orientation of the transducer allows directed needle aspiration for tissue sampling as well. Tissue sampling with this device in the stomach is somewhat challenging due to the extreme flexibility of the shaft, which often results in bowing of the echoendoscope in preference to needle penetration of the gastric wall. In selected cases (such as in patients with prior gastric bypass in whom laparoscopic gastrostomy may be performed to access the gastric remnant), the device may be useful in allowing EUS examination via percutaneous gastrostomies.

OTHER SPECIALIZED DEVICES

Table 3 summarizes the other miscellaneous echoendoscopes. A variety of unique devices have been developed for EUS examination. Not all of these remain clinically available. One of the most useful was the Olympus MH 908 esophagoprobe. This ultrathin, short device was designed to allow passage through tightly stenotic esophageal malignancies. The esophagoprobe has a much smaller caliber (8.5 mm) than other echoendoscopes. More importantly, the distal tip is tapered and contains a channel which allows the device to be passed over a guidewire through a stricture in a manner similar to a Savary dilator (Fig. 11). The device only allows radial imaging and as such does not allow for EUS-guided tissue sampling. The recent availability of small caliber linear array

Table 3
Miscellaneous echoendoscopes

Manufacturer	*Model (US processor)*	*Ultrasound field*	*Frequency (MHz)*	*Endoscopic image*	*Length (mm)*	*Diameter (maximum) (mm)*	*Display mode*	*Channel diameter (mm)*
Olympus	BF-UC160F-OL8 (Olympus EU-C60) for endobronchial US	50°	7.5	Video 35° forward Oblique 80° Field of view	600	6.9	B-mode Color power doppler	2.0
	BF-UC180F (Olympus EU-C60 OR Aloka SSD-Alpha5 or Alpha10) for endo-bronchial US	60° (Alpha5) or 50° (EU-C60)	5/7.5/10/12 MHz (only 7.5 MHz with EU-C60)	Video 35° Forward Oblique 80° Field of view	600	6.9	B-mode Color Power Doppler (with Alpha5: B-mode, M-mode, D-mode, Flow-mode, Powerflow-mode)	2.2

	MH-908 Esophagoprobe (Olympus EU ME1 or EU M60)	360° mechanical radial	7.5	NA	700	8.5	B-mode	NA
Pentax	EB-1970UK Hitachi 5500 or HIVISION 900 for endobronchial US	Curved linear array	5/7.5/10	Video Forward oblique 100° field of view	600	6.3	B-mode, color Doppler	2.0

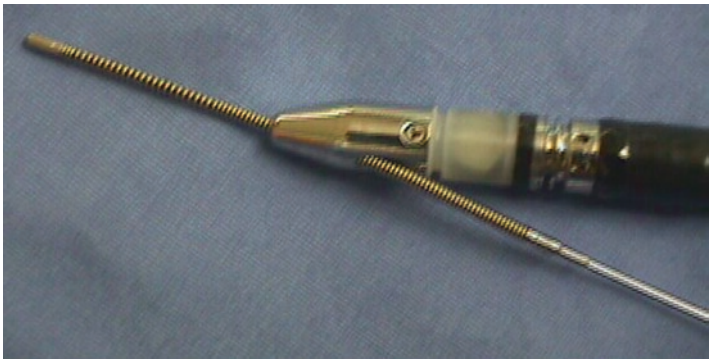

Fig. 11. Olympus MH 908 esophagoprobe.

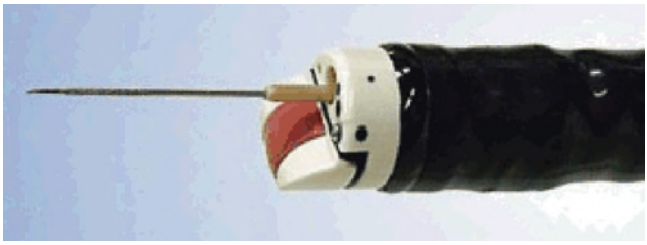

Fig. 12. Olympus end-viewing echoendoscope.

devices (e.g., EBUS scopes) which do allow needle aspiration may well make this device obsolete.

An end-viewing, long, radial-array device has been previously manufactured by Olympus for use in the colon. This has not gained widespread acceptance, probably because there are very few indications for colonic EUS. T-classification of colon cancer does not determine surgical management, and therefore preoperative ultrasound staging of colon cancer is not necessary. T-classification of rectal carcinoma, on the other hand, is critical to management decisions; however, adequate staging of rectal cancer can be performed with currently available echoendoscopes designed for use in the upper GI tract (or dedicated rigid rectal ultrasound probes). The primary indication for ultrasound imaging in the colon proximal to the extent of upper EUS devices is the evaluation of intramural, subepithelial tumors of the colon. These lesions are relatively uncommon, and adequate evaluation

can be performed in most cases using through-the-scope miniprobes (see below) via a two-channel colonoscope. EUS-guided needle aspiration is not possible with this approach (or, for that matter, with the dedicated radial device) but is rarely necessary and thus it is unclear whether the expense of a dedicated EUS colonoscope is warranted. Prototype EUS-duodenoscopes were also developed by Olympus but have never achieved widespread use.

Recently, a prototype end-viewing linear echoendoscope developed by Olympus has received considerable interest. The current prototype device, the Olympus GIF-UCT160J-AL5, measures 14.2 mm in maximal diameter and contains a large-caliber 3.7 mm channel. The combination of a linear imaging plane plus end-viewing optics (Fig. 12) has been touted as providing improved visualization for interventional EUS procedures such as cystgastrostomy. The degree to which the device attains widespread utilization remains to be determined.

EUS MINIPROBES

A variety of small-caliber miniature ultrasound probes are available (Table 4). These miniprobes can be advanced through the channel of a standard diagnostic or therapeutic endoscope or colonoscope. Acoustic coupling may be attained via either instillation of water in the GI tract or the use of specialized balloon sheaths (Fig. 13). Use of a two-channel endoscope is preferred as this allows for simultaneous sonographic imaging with the probe through one channel and water instillation/suctioning through the other. These devices are primarily utilized for the imaging of superficial esophageal, gastric malignancies, or small intramural/subepithelial mass lesions. In this case, the ability to directly place the transducer adjacent to the small structure of interest under endoscopic guidance can be quite useful. These probes cannot be used to perform EUS-guided tissue sampling. A wire-guided version, which can be advanced into the biliary or pancreatic ductal systems at the time of ERCP for intraductal applications, is available.

ULTRASOUND CONSOLES

Each brand of echoendoscope utilizes a specific ultrasound imaging console, and these consoles are not interchangeable. In the past few years, the technical performance and the quality of ultrasound imaging have continued to improve, and endosonographers have demanded imaging quality identical to that available for standard diagnostic ultrasonography.

Table 4
Miniprobes

Probe driver	*Model*	*Frequency (MHz)*	*Working length (mm)*	*Outer diameter (mm)*
Olympus				
MAJ-935 with EU-M60	UM-2R	12	2,050 (for all)	2.5
or MAJ-682 with EU-M30S	UM-3R	20		2.5
	UM-G20-29R (wire-guided)	20		2.9
or MAJ-682 with EU-M60	UM-S20-20R	20		2.0
	UM-S30-20R	30		2.0
	UM-S30-25R	30		2.4
	UM-BS20-26R (requires balloon MAJ-643R)	20		2.6
Fujinon				
SP-702 if Fujinon system or SP-711 (interface box to Hitachi system)	P2625	25	2,200 (for all)	2.6
	P2620	20		2.6
	P2615	15		2.6
	P2612	12		2.6
	P2025	25		2.0
	P2020	20		2.0
	P2015	15		2.0
	P2012	12		2.0
	PL2226-7.5 (requires additional adapter)	7.5		2.6

The current high-end consoles for Olympus (Aloka Alpha10) (Fig. 14) and Pentax (Hitachi HIVISION 900) (Fig. 15) are exceptional and, in the authors opinion, roughly equivalent. The newest Hitachi console offers a novel diagnostic modality termed "elastography," which interrogates the relative compressibility of adjacent tissue in response to manual pressure applied with the transducer. Relatively compressible

Fig. 13. With the EUS miniprobe, acoustic coupling may be attained by the use of specialized balloon sheaths.

Fig. 14. Olympus (Aloka Alpha 10) console.

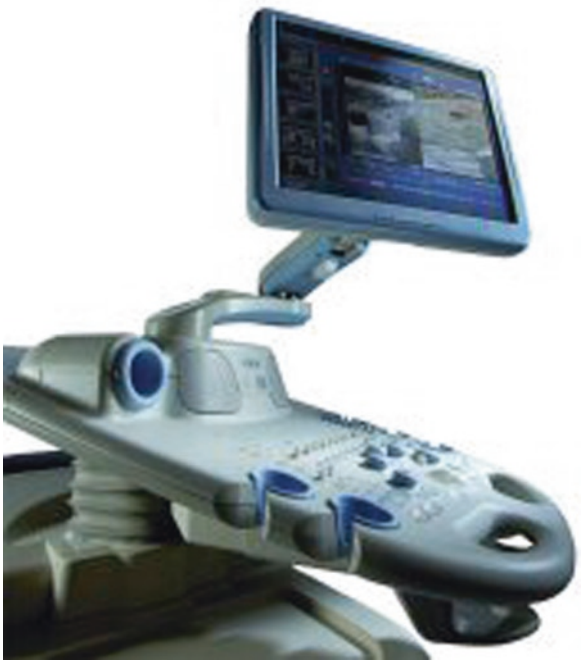

Fig. 15. Pentax (Hitachi HIVISION 900) console.

tissue is displayed as green on the ultrasound image, whereas less compressible (and presumably more likely to be malignant) tissue is displayed as purple (Fig. 16). The clinical applicability of elastography remains to be determined.

A variety of more compact ultrasound consoles are available from Olympus. This includes the Olympus EU-M60 console for use with the mechanical radial array echoendoscope. This console is relatively compact and similar in size to the Olympus light source, but cannot be utilized for the Olympus linear array devices. An even more compact and portable console, the EU-C60, offers an economic alternative to the larger, higher-end Aloka console but with fewer imaging options. For example, this console only allows imaging at 7.5 MHz, and the image resolution is less crisp compared to the higher-end models. Still, the console can be used for both linear and radial echoendoscopes, as well as the EBUS device, and does allow the use of color Doppler imaging. As such, it may provide a reasonable lower cost alternative for lower volume centers or facilities with less available capital.

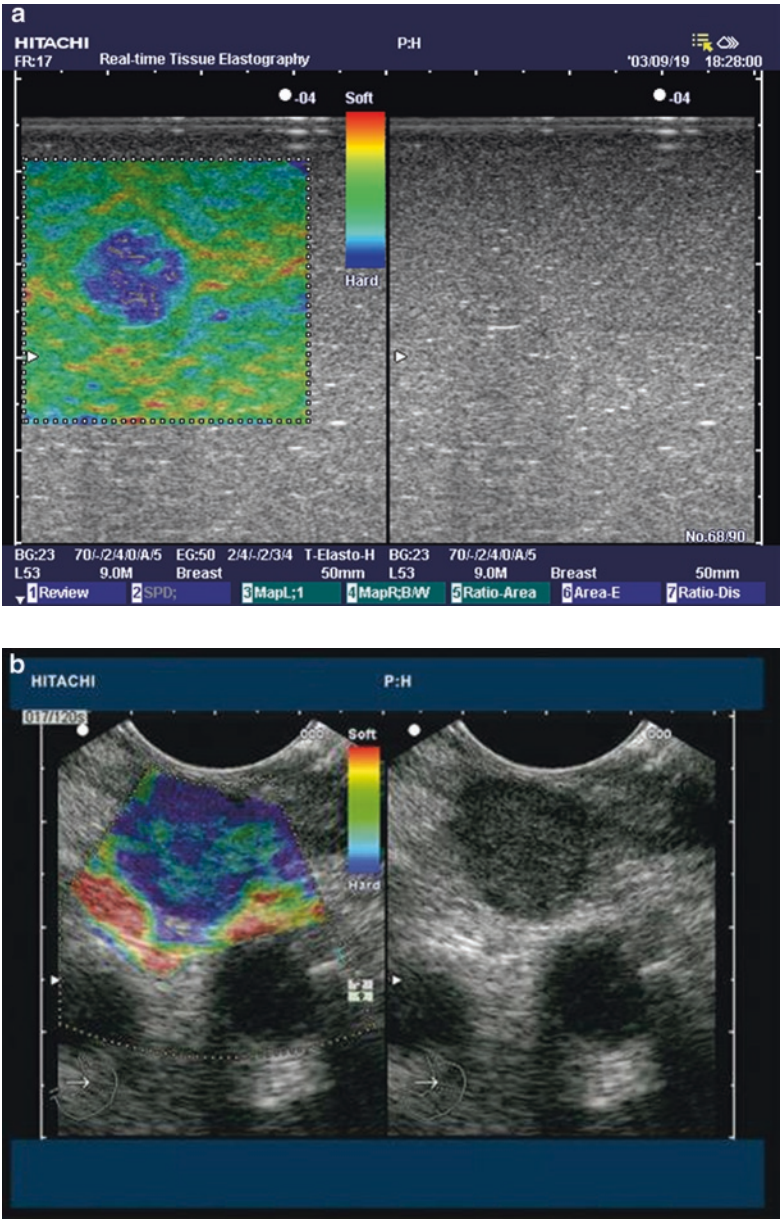

Fig. 16. (**a**, **b**) Elastography interrogates the relative compressibility of adjacent tissue in response to manual pressure applied with the transducer. Relatively compressible tissue is displayed as green on the ultrasound image, whereas less compressible (and presumably more likely to be malignant) tissue is displayed as purple.

EUS NEEDLES

EUS-guided intervention requires the use of specialized needles. The needles must be long enough to extend the length of the endoscope channel and must be protected within an outer protective sheath to prevent inadvertent puncture of the endoscope channel (Fig. 17). The needle tip must be long enough to penetrate through the bowel wall and extend into adjacent organs of interest (up to 8 cm to reach hepatic lesions). The needle handle must attach firmly to the echoendoscope handle in order to allow for controlled deployment. Finally, the needle tip is generally roughened or dimpled in order to increase the reflection of the ultrasound beam (Fig. 18).

The first dedicated EUS-FNA needles consisted of a reusable metal sheath and handle assembly into which a single-use needle was loaded (5). In the past few years, entirely disposable models, which have generally supplanted the reusable models, have been released by several vendors.

EUS needles are advanced into the biopsy channel and firmly attached to the echoendoscope via a Luer-lock (Fig. 19). In some models (those made by Cook Medical and Medi-Globe), the extent to which the protective sheath protrudes from the distal end of the echoendoscope may then be adjusted (Fig. 20) to account for subtle differences between echoendoscope manufacturers. It is important that the protective sheath extends beyond the biopsy channel in order to prevent needle damage to the

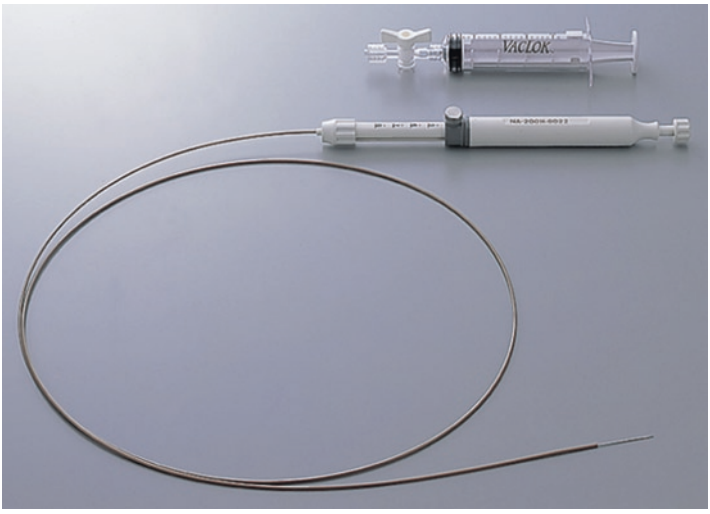

Fig. 17. An EUS needle.

Fig. 18. The needle tip of the EUS needle is often roughened or dimpled to increase reflection of the ultrasound beam.

Fig. 19. EUS needle is attached to the echoendoscope via a Luer-lock.

echoendoscope. The endosonographer should become familiar with the sheath length needed for their echoendoscopes and may initially wish to test this adjustment outside a patient prior to use. It is important to firmly lock the sheath adjustment device prior to needle puncture to prevent inadvertent sheath advancement during the FNA. The needle plunger is

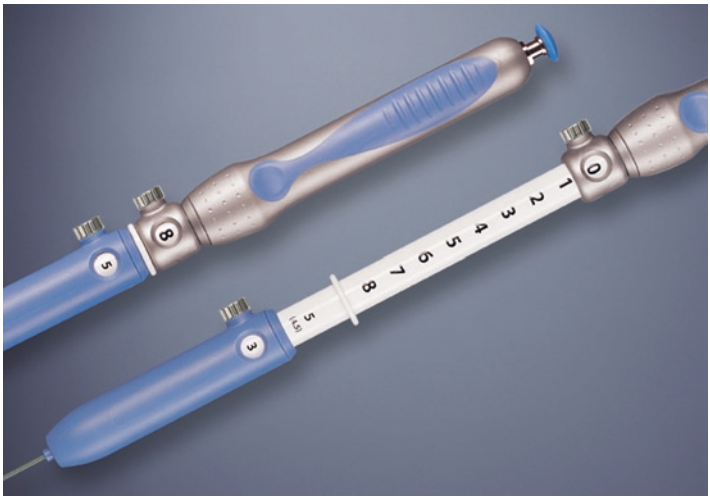

Fig. 20. EUS needle which allows adjustment of the extent to which the protective sheath protrudes from the distal end of the echoendoscope.

then unlocked from the handle assembly, allowing the needle itself to be advanced out of the protective sheath and into the lesion of interest under continuous sonographic guidance. Suction may then be applied either manually or via a preloaded suction syringe.

All currently available needles come packaged with stylets; however, the use of these stylets varies between endosonographers. Some endoscopists choose to keep the stylet in the needle during puncture. In this case, the stylet must be withdrawn a few millimeter into the needle tip so that it no longer protrudes beyond the beveled needle tip prior to puncture. Although some stylets are blunt-tipped and others beveled, it is the authors' experience that the beveled tip of the stylet does not always completely align with the needle bevel and thus needle puncture should not be performed with the stylet fully introduced. Other endoscopists, including the author, do not routinely utilize the stylet. In either case, the stylet should be kept clean as it may be needed later to unclog a needle in case the specimen clots prematurely. Once aspiration is complete, the needle is completely withdrawn into the protective sheath and relocked in place to prevent inadvertent needle advancement and scope trauma as the needle assembly is removed from the echoendoscope.

Several different models of disposable EUS needles are available. Although manufacturers may tout differences in needle visualization, these are minimal in the authors' experience. The needles are available in 25, 22, and 19 ga. Whether these differences in needle gauge result

in difference in cytologic yield is a focus of current study and has not been definitively resolved. In the end, needle choice is based primarily upon experience and endoscopist preference. Needles used for endobronchial ultrasound are, by necessity, shorter in length but of generally similar design.

A 19 gauge core biopsy needle (Quick-Core) has been marketed by Cook Medical (6). This needle is described in detail elsewhere; however, the design includes a permanent stylet with a depressed tissue tray (Fig. 21). The tissue tray/stylet is advanced into the target tissue under continuous sonographic guidance, and then the outer needle is fired forcefully along the outside of the stylet via an automated firing mechanism in order to cut a histologically intact core of tissue into the tray.

Another automated needle, the PowerShot, is manufactured by Olympus (Fig. 22). In this case, the automated, spring-loaded firing mechanism is not intended to obtain a core specimen, but is simply designed to aid in the rapid penetration of target structures with a 22 ga needle for subsequent cytologic aspiration. The needle may be manually advanced for a length up to 6 cm, with the mechanical firing mechanism allowing an additional 3 cm of rapid, automated, forceful penetration. The handle and sheath are reusable. This device may be helpful for the sampling of extremely dense/fibrotic structures or for endoscopists who have difficulty with the manual puncture of routine structures.

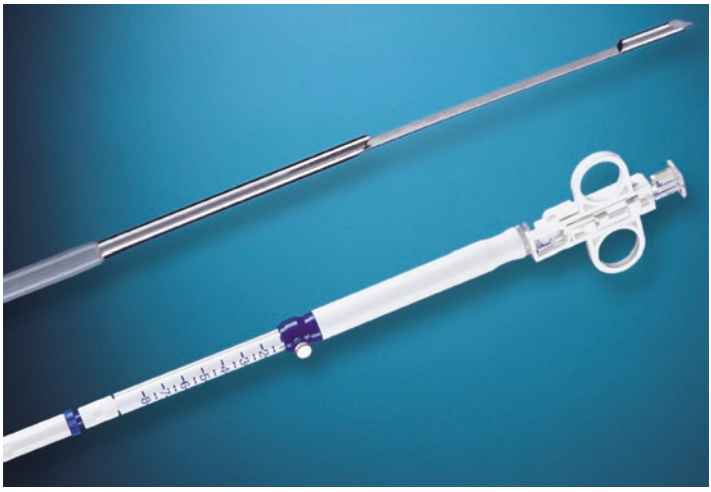

Fig. 21. Nineteen gauge core biopsy needle by Cook Medical.

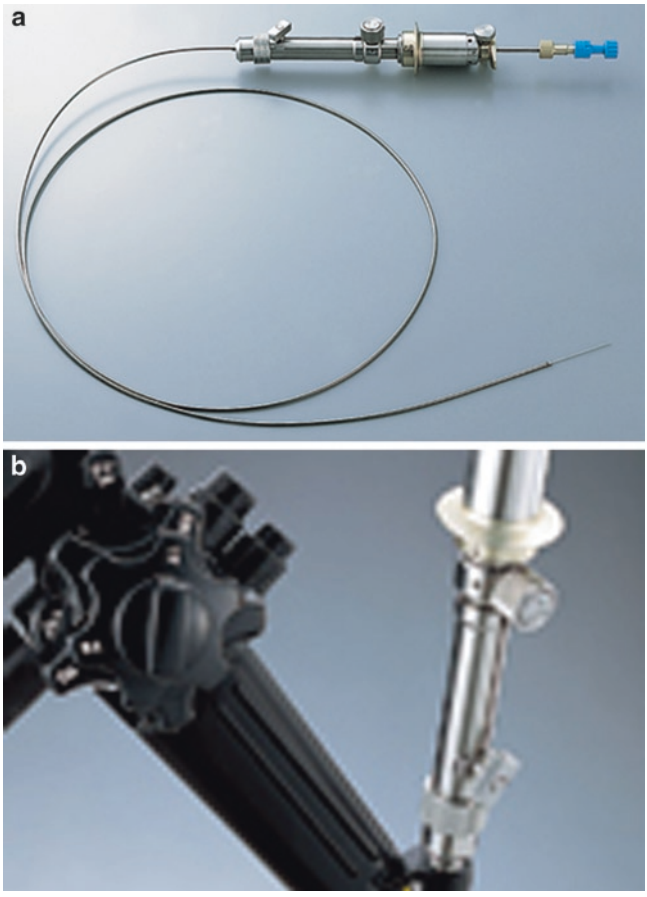

Fig. 22. (**a**, **b**) Olympus automated 22 gauge needle.

CONCLUSION

Despite the increasing utilization of endosonography, a relatively limited variety of echoendoscopes and accessories are currently available. As such, the endoscopist should be able to quickly become familiar with the current equipment and rapidly develop a reasonable comfort level with these devices. It is anticipated that an increasing number of specialized echoendoscopes and accessories will become available in the near future, and these developments will be welcomed.

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