Diagnostic ultrasound is fading as a primary imaging modality in U.S. radiology departments. It is gradually being supplanted by CT, MR, and PET, which have seen major advances in speed and quality in the past decade. Multislice CT acquisitions allow whole-body scanning in minutes. Higher field MR scanners with more advanced pulse sequences and better coils have not only speeded up MR imaging but have vastly improved its ability to image blood vessels and blood flow without contrast toxicity and radiation exposure. PET/CT's ability to image metabolically active tissues at high spatial resolution has made it the modality of choice for cancer evaluation.

The trend away from ultrasound is clear. For example, 15 years ago, ultrasound was the dominant procedure for detection of urinary calculi. Now that role is largely filled by CT. Even mainstay obstetrical ultrasound is being challenged by obstetrical MRI, which is costly but offers much higher image quality, especially in obese patients.

Several factors have contributed to declining interest in ultrasound in radiology:
- unmatched performance gains for CT, MRI, and PET;
- noisy ultrasound images further degraded by increasing obesity of U.S. population;
- failure to apply advances specifically to increase productivity, accuracy, and reproducibility;
- lack of approved ultrasound contrast materials to maximize tissue contrast and enhance blood flow studies;
- failure to leverage the strong interaction of ultrasound with tissue by adding new features that might make it a more robust diagnostic tool; and
- failure to use existing ultrasound technology to maximize image quality, organ coverage, and scan reproducibility.

Nowhere is the decline of ultrasound in radiology more apparent than in the vanishingly small numbers of radiology residents who choose it as a subspecialty. Many programs with imaging fellowships have not had a single person seriously working in ultrasound for over a decade. The most common answer I get to the question of what to do next with a specific ultrasound finding is "Get a CT." My impressions are based on experience at three institutions and the comments of dozens of other ultrasound directors who see the trend and are alarmed by it.

OTHER SPECIALTIES MAKE INROADS

Ultrasound is seeing increasing use as a diagnostic tool, however, by specialties outside radiology. Traditional users such as ob/gyn and cardiology have been joined by emergency medicine, urology, nephrology, gastroenterology, ENT, ophthalmology, and general surgery. All consider ultrasound a useful tool for diagnosis and procedure guidance. Increasing use of ultrasound by these nonradiologists, accompanied by their reports of its use at specialty meetings, puts pressure on otherwise reluctant clinicians to provide ultrasound imaging services to stay competitive. Adoption by nonradiologists is also driven by the low cost of ultrasound devices (as low as $1000 for a limited system), automation, miniaturization, and ease of use.

These trends could shift ultrasound expertise out of radiology departments to clinical specialties and result in operators with less experience producing lower quality examinations focused so narrowly that concurrent pathology is missed.

Manufacturers also face disadvantages in a heavily nonradiologist market:
- sales primarily of low-cost instruments;
- costly extensive training of inexperienced examiners; and
- low profit margins that leave few resources available for R&D on advanced ultrasound technologies and applications.

One could argue that giving up ultrasound will result in increased requests for CT and MRI, as clinicians work up abnormalities seen on their ultrasound studies. This argument assumes that ultrasound will never be competitive with CT and MRI, a viewpoint not widely held in other countries. If ultrasound should become competitive or be so perceived by clinicians, practitioners using ultrasound could refer fewer patients to CT and MRI.

If radiology maintains a strong presence in ultrasound, advances in the modality will benefit radiology as much as or more than other specialties. This would reduce the risk of losing high-margin ultrasound guidance procedures to other specialties. Radiology departments are generally best equipped to get the most out of any imaging modality by application of image enhancement procedures and proper archival. Image processing and enhancement are not yet widely applied in radiology, but these could bring about a higher diagnostic yield from imaging studies and lead to improved patient care.

Natural evolution might direct the more advanced ultrasound studies to radiology, while other specialties take on simpler examinations. This is already happening. Private offices perform ob/gyn studies but refer them to radiology when they prove to be technically difficult or if confirmation of unexpected findings is desired. To retain any sort of role in the future, the radiology examination must provide higher image quality, increased diagnostic expertise, or new ways of visualizing pathology using new technology such as 3D.

Another key ingredient for a future role in ultrasound is interest. Radiologists must remain invested in ultrasound as an imaging tool. Improved image quality, so important in maintaining radiology’s role in ultrasound, is also critical for maintaining the status of ultrasound within radiology. Other ways to make ultrasound more competitive with other modalities involve improvements in organ coverage, reproducibility of studies, and speed and efficiency.

New technology should be focused on areas that could lead to specific methods of improving image quality:

- thinner slices using 1.5 dimensional and higher order array transducers;
- higher frequency transducers that result in higher lateral and axial resolution;
- harmonic imaging that produces higher resolution and higher tissue contrast;
- phase aberration identification and correction that can help the operator identify where optimal acoustic windows exist and correct for degradation caused by a poor acoustic window; and
- speckle reduction that decreases noise and increases tissue contrast and specialized filtration that enhances subtle low-contrast lesions (e.g., improved detection of focal pyelonephritis compared with fundamental or harmonic imaging without speckle reduction) (Figure 1).

Improved organ coverage can be achieved by proper use of some of the same technologies that have enabled multislice CT to be used effectively. The ability to save a short video loop as a DICOM image series that can be viewed by scrolling through it on a PACS workstation allows the operator to sweep across an organ, slowly acquiring a large number of images, and then review that series by scrolling through it as with a CT data set. A scanner fitted with calibrated 3D capability could do this as well as measure and reconstruct 3D volumes accurately, allowing for far more complete coverage of organs and making diagnosis much more reliable and reproducible. Viewing the image series increases diagnostic confidence and decreases the need for after-scanning by the radiologist.

**WORKFLOW ISSUES**

Where ultrasound once dominated in examination efficiency and speed, it now lags behind CT and MR. CT, which had been slow and cumbersome relative to ultrasound, has become faster and more convenient even though contrast agents are usually required.

Interpretation efficiency in ultrasound is also low. Sonographers record images and measurements of various structures in multiple different orders, forcing the radiologist to scan back and forth through the images to find a needed image or measurement. The prevalence of traveling sonographers, who may record images and measurements differently from one another and house staff, often aggravates the problem.

Scanning by a sonologist, long a mainstay of academic ultrasound, can yield higher accuracy but at a huge cost in efficiency. The patient and sonographer must wait for the sonologist to become available, and then the patient must undergo an additional scan. Meanwhile, other sonographers are forced to wait for the sonologist to finish scanning before they can review their cases in progress or ask questions.

Using ultrasound sweeps rather than static images can reduce or eliminate the need for sonologist scanning without sacrificing diagnostic accuracy. Sweeps can also be acquired much more quickly,
increasing the speed of the examination. Protocols that specify the order of images can streamline the interpretive process, and use of structured reports giving measurements and summarizing the sonographer's findings can further improve interpretation efficiency. Improving reproducibility is another important way that ultrasound can remain competitive. Strictly regulated start and stop points for sweeps and measurements at reproducible locations are critical. Ultrasound sweeps will improve organ coverage, and 3D reconstructions can be used to reconstruct organs along standard planes, making comparison with prior studies fast and reliable. Structured reporting forms, especially those coupled with warnings appearing on the scanner screen when images or sweeps are forgotten, will help to enforce the use of similar scan planes from study to study. These forms will also facilitate comparison by making it easier for the sonographer to quickly review pertinent findings on the previous study (Figure 2) prior to beginning a new scan.

The strong interaction of ultrasound with tissue and the physical contact between scanner and patient during the examination make possible imaging based on several features other than acoustic backscatter. Doppler has led the way with a multitude of applications relying on frequency shift information rather than backscatter intensity. Tissue elasticity imaging-using ultrasound to create images of tissue hardness-is a good example of how ultrasound can be used to create new types of images that are diagnostically useful (Figure 3). Elasticity imaging may be used to detect and classify breast lesions and may be useful for the evaluation of lymphedema. Analysis of the frequency dependence of backscatter may be used to estimate the size of tissue structures such as glomeruli in the kidney. Advanced image filtration techniques can enhance images to bring out subtle details not visible without image processing.

Finally, programs designed to train interested radiology residents and fellows in high performance ultrasound are badly needed. The interested person would be given the scanning skills, leadership skills, and technology background needed to lead an ultrasound division into the future. Dr. Garra is vice chair of informatics and director of ultrasound in the radiology department at Fletcher Allen Health Care, University of Vermont, Burlington. Dr. Garra has received grants/research support and honoraria from GE Healthcare and is a member of GE Healthcare’s speakers bureau.

References
1. A good summary of the advantages of structured reporting is contained here: [http://www.structuredreporting.com/langlotz-article.htm](http://www.structuredreporting.com/langlotz-article.htm)

Disclosures:

Source URL:

Links:
[1] [http://www.diagnosticimaging.com/authors/brian-s-garra-md-0](http://www.diagnosticimaging.com/authors/brian-s-garra-md-0)