

A background image of a man wearing boxing gloves, looking forward with a determined expression. The image is in a warm, reddish-brown color palette.

# 3-D/4-D Ultrasound

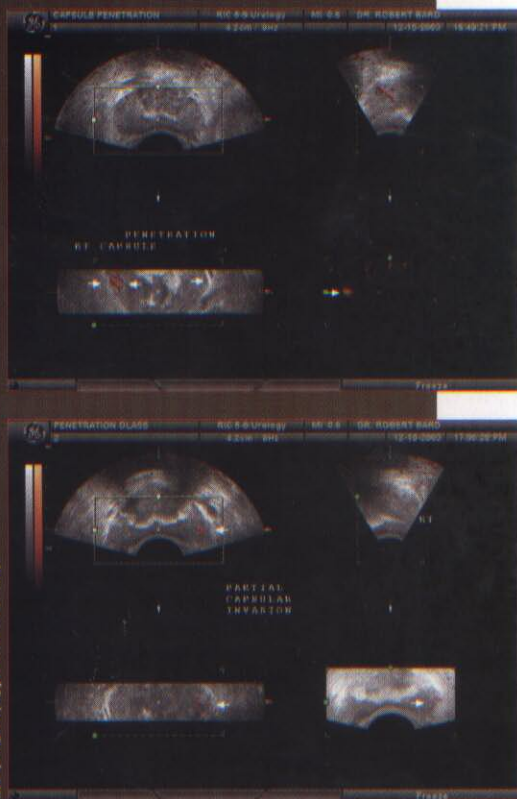
# FIGHTING PROSTATE CANCER IN REAL TIME

**Popular for its OB/GYN applications, this “real-time” technology is being regarded as a breakthrough for enhancing prostate cancer diagnosis and improving therapy.**

BY DAN HARVEY

**C**urrent statistics about prostate cancer offer heartening news but still indicate cause for concern. According to a recent European study, since 1990, death rates from prostate cancer in men aged 65 to 74 have decreased by one-third in North America. This drop follows a period (1986 to 1991) that saw a startling increase in prostate cancer incidence. However, according to the American Cancer Society (ACS), prostate cancer remains the second most deadly cancer in men after lung cancer. The ACS reports that more than 200,000 men throughout the world still die from the disease each year. In 2002, 30,000 men died from the disease in the United States. Annually, nearly 200,000 American males are diagnosed with prostate cancer.





(Top image) Full capsular penetration  
(Above) Partial penetration of the left capsule

### The Problem With PSA

The recent decline in North American death rates has been attributed to earlier and better diagnosis as well as better treatment technologies. More and more, medical professionals acknowledge the unreliability of the prostate-specific antigen (PSA) test. A study conducted last May at Memorial Sloan-Kettering Cancer Center in New York City indicated that a man's PSA levels fluctuate naturally over time, leading to elevated scores.

"Since that time, nothing has changed except that the PSA is worse than we expected, and power Doppler study is better than we expected," says Robert L. Bard, MD, a radiologist who treats prostate cancer patients in his New York City consulting practice.

As Bard's comment suggests, developments in diagnostic technology are supplanting the use of the PSA test. Bard himself has utilized Doppler-based ultrasound methods such as color Doppler and power Doppler sonography. Both add to the specificity and sensitivity of prostate sonograms through the imaging of blood vessels and quantification of blood flow in the prostate gland.

Even more developments that can further improve treatment for the prostate involve ultrasound with three-dimensional (3-D) and four-dimensional (4-D) imaging

that provide moving pictures of internal anatomy by adding the element of time.

### 3-D/4-D Ultrasound

4-D ultrasound takes 3-D diagnostic imaging to the next level. It involves a continuous acquisition of two-dimensional (2-D) images that are displayed as 3-D volume data to reveal and display images moving in real time.

The technology has garnered a great deal of attention because of its OB/GYN applications. For pregnant women, it offers startlingly detailed images of the fetus—revealing features of the face, body, fingers, and toes that couldn't be seen before. The imaging benefits have also been recognized in other areas of medicine. 3-D/4-D ultrasound is increasingly being used to enhance the diagnosis of and improve therapy for breast and prostate cancer. For example, the technology increases the accuracy of ultrasound-guided prostate cancer biopsies by revealing needle movements in three planes.

Bard describes 3-D/4-D imaging as a major breakthrough. "It is the next absolute step in what we need to do," he says. "A colleague told me that if you miss this, it would be like missing out on power Doppler."

### State-of-the-Art Technology

Bard works with the Voluson 730 (offered by GE Medical Systems), which is capable of displaying up to 25 volume scans per second in 3-D planes.

The system utilizes advanced signal processing and a probe that operates on 10 megahertz to produce high-quality ultrasound images. Bard, who tackles sports

surgeon sees is the tendon surface, but I could see the five tendon bands that mix and integrate to make up the rotator cuff."

In addition to the high resolution, the Voluson 730 provides spectral and color Doppler, as well as advanced 3-D imaging.

### Major Components

There are other 4-D systems on the market, but only the Voluson 730 offers the 25-scan-per-second rate. However, in general, all systems include four main components—automatic acquisition, multiplanar display, volume rendering, and real-time imaging—that provide the technology with its unique advantages.

Automatic acquisition is an advance over the traditional slice-acquisition method that requires manual movement of the probe across a patient's skin. This operator-dependent method often results in inconsistent spacing between slices and nonuniform data sets. *Automatic acquisition*, as the term implies, requires no manual movement. The probe remains still as data are acquired. With the Voluson 730, this capture is achieved with an electronic array that moves through the scanning transducer. As a result, the 3-D volume data collected are uniform and quantifiable. "It's a normal electronic transducer that has a mechanical motor that sweeps the probe from side to side," explains Robert Thompson, GE's global marketing manager for ultrasound. "The probe itself doesn't move—only the electronic array. It sweeps back and forth like a fan, capturing data and interpreting each one of the volumes back, which gives the user the multiplanar view."

Bard adds, "You simply put the probe in place over the body part—the uterus, breast, shoulder, or rectum—and the machine sweeps the whole area in approximately five seconds. The main feature for technologists is that it is totally automated. It's just a matter of pushing buttons."

## Medical professionals are using 3-D/4-D imaging for a variety of applications—imaging structures such as the uterus, liver, breast, pancreas, abdomen, and musculoskeletal system.

medicine injuries as well as prostate cancer, has been working with 3-D/4-D technology for several years now—first with body parts such as the shoulder and now with the prostate. He describes the image quality as extraordinary. As an example, he describes the detail that he obtained while imaging a shoulder injury: "I could see the entire rotator cuff tendon complex. All a

Because automatic acquisition provides such a high degree of accuracy, the 3-D multiplanar display reveals precise spatial relationships that enable more accurate volume measurements to be calculated. It also allows physicians to see lesions in three orthogonal scan planes—the sagittal (longitudinal), transverse, and horizontal (anterior and posterior). These planes can

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be rotated along three axes (x, y, and z) to obtain the best diagnostic view, allowing clinicians to see things that they normally couldn't with traditional ultrasound.

"With 2-D ultrasound, you can see the sagittal plane, but to see the transverse plane, you need to change to transducer orientation. With this [3-D/4-D], you don't need to," explains Thompson. "But, 4-D also gives you the coronal view or an anterior to posterior view that you can't get any other way. It gives you the landscape per-

spective," says Bard. "This machine puts everything together for you, and it shows things that we've never seen before."

### Tracking "Spread"

For the prostate, perhaps the most important new visual information that the technology has yielded is whether or not the cancer has spread beyond the capsule that covers the prostate gland in men treated for localized cancer. This spread—or extracapsular extension—can involve stage

treatment localization tool. The system provides a continuous stream of ultrasound images that can be utilized in real time to localize cancer targets before radiation therapy treatment. Specifically, it enables clinicians to easily move and align structure sets to ensure accuracy and precision required for intensity-modulated radiation therapy and conventional treatment. The greater accuracy reduces complications of treatment.

"We call it 'real time' because you can do about 32 frames per second with the ultrasound, and you have a continuous reconstructed structure set overlaying the image that can be dynamically positioned in a real-time fashion," says Joseph W. Habovick, NOMOS's product manager for image-guided therapy. "When you pan through the different angles with ultrasound in any degree or location on the body, the software reconstructs what the structure set is at that angle, giving the user the correct location of the target referenced, the treatment plan, and the isocenter of the treatment machine [linear accelerator]."

The system's real-time, interactive display provides a more complete picture of the internal structures than 2-D and 3-D imaging alone, and the user can position the treatment plan to match patient anatomy with a touch-sensitive computer screen.

"It takes care of the setup error with the skin marks and also the internal movement of the organs," says Habovick. "For instance, with the prostate, a fluctuating bladder and rectum volume can influence the prostate's location. The skin marks are not all that accurate either because the skin is mobile. The image guidance takes care of both problems. It reduces errors by correcting that motion and indicating exactly where the structure is at the time of treatment."

### Future Direction

Bard says that 3-D/4-D imaging is here to stay and will become part of radiologists' routines.

He indicates that even more benefits will become apparent and the technology will be applicable to any tumor in the body, even melanomas. He cites a study in France that involved power Doppler and 3-D. "It showed the 3-D volume of the skin cancer so the surgeon knew exactly how deep to cut instead of operating until there was no more tumor, which is the current surgical method."

Thus, he says, it has the potential to reduce a six-hour procedure to a 10-minute biopsy. "This is just extraordinary technology," he comments. "The future has landed in the lap of radiology."

— Dan Harvey is a contributing writer for **Radiology Today**.

## Developments in diagnostic technology are supplanting the use of the prostate-specific antigen test.

spective that helps with getting better spatial positioning of the pathology location or for looking at specific anatomy."

From his own experience, Bard finds the multiplanar display component especially helpful for treating prostate cancer. "Specifically, the horizontal plane allows you to see the actual invasion of the cancer," he says.

The third component—3-D volume rendering—is the process that obtains ultrasound image information and assembles it into a 3-D image. The final component, the real-time motion, brings the fourth dimension into play, adding movement to the 3-D images. "Instead of having a fixed hologram, you have a 3-D motion picture," explains Bard.

### Better Accuracy

Studies have shown that 4-D ultrasound can increase the degree of accuracy of ultrasound-guided biopsies to 100%, even with tumors that are less than 5 millimeters in diameter. Previously, with less-perfect resolution and without the benefit of real-time motion, visual information could be misleading, says Bard. "In other words, when looking to see the top from one angle, often you'd think you were in the area, but because the resolution wasn't perfect, you'd be on the side of the lesion. With this technology, not only do you see the movement of the needle, but you also see it in three dimensions so that you know you're exactly centered."

As Bard's comments suggest, 3-D/4-D imaging pretty much takes the mental guesswork out of the process. With 2-D ultrasound, physicians found it necessary to envision 3-D images in their heads to reach a diagnosis. For some, this proved somewhat difficult; however, the new technology performs all of the mental acrobatics. "The 3-D imaging allows you to see things in a plane that you can't appreciate with the usual mental integra-

T3 or T4 tumor, positive regional lymph nodes, or tumor at the margin of the excised tumor or metastases. This capability has profound importance for the patient. "It [the spread] changes the cancer from operable to inoperable," says Bard.

He adds that his hope is that the technology will reveal lymph nodes on the outside, too. "It hasn't been tried yet, but that is the next logical step," he says.

Bard also says that the impact will be as significant as Doppler technology. "This is going to be combined with power Doppler, making the combination the first test to be done."

Power Doppler combined with 3-D, Bard says, shows both the prostate and the vascularity of the prostate in one picture, which is important because of the neovascularity exhibited by aggressive cancers.

Bard refers to the work of Jean-Luc Sauvain, MD, a urologist with the Centre d'Imagerie Médicale in Vesoul, France, who recently conducted a study involving power Doppler imaging coupled with 3-D imaging and prostate cancer. In the study, Sauvain and colleagues found that power Doppler with 3-D effectively identified areas of neovascularization extending through the prostate capsule and thus improved the reliability of ultrasound for diagnosing and staging prostate cancer.

### Versatility

Medical professionals are using 3-D/4-D imaging for a variety of applications—imaging structures such as the uterus, liver, breast, pancreas, abdomen, and musculoskeletal system.

In addition, 3-D and 4-D ultrasound is being used in conjunction with other modalities. In 1998, the NOMOS Corporation of Cranberry Township, Pa., first introduced ultrasound guidance for radiation therapy. Last year, the company introduced ImageSync, an ultrasonic, real-time imaging/positioning technology used as a





Real-time 4D imaging is the next generation of performance in clinical ultrasound. GE Medical Systems is leading the way with the VOLUSON 730 EXPERT for women's health care addressing the needs for better diagnostic information delivered with greater speed and accuracy.

Learn more about this revolutionary 4D technology, please contact a GE representative at **888 202-5528** or visit [www.geultrasound.com](http://www.geultrasound.com).

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