Simultaneous biplane and 3D volume render mode images in prostate ultrasonography
This application note explains what simultaneous biplane prostate imaging is, and how to use it. It explains how to interpret simultaneous biplane images, provides prostate anatomy diagrams, and includes a biopsy model suggested in one of the latest studies on prostate biopsy techniques.

Background

The latest prostate cancer statistics

The American Cancer Society states that prostate cancer is the most frequently diagnosed cancer in men. It estimates that in the U.S. in 2006, there will be 234,460 new cases diagnosed and 27,350 deaths from prostate cancer.

Overall, the incidence of prostate cancer in the western world has increased steadily over the last two decades, and in the UK it has doubled over the same period (1).

The possibilities and limitations with staging

Accurate staging is critical to the management of prostate cancer. The more information the staging provides, the better informed the decision can be about the best kind of treatment.

Although screening tests such as DRE, TRUS and PSA used as a serum marker, help in prostate cancer detection, the lack of specificity and sensitivity confound the diagnosis (2). PSA alone offers only poor specificity. One in three cases of prostate cancer is associated with normal diagnostic values. Another issue related to the diagnostic value of PSA is the difficulty in distinguishing between prostate cancer and benign prostate disorders, particularly in the PSA range 4-10 ng/ml (3,4).

Transrectal ultrasound is most frequently used to guide and improve the accuracy of prostate biopsies, and methods are still being investigated to help reduce the number of understaging errors and the rate of false negatives. Saturation biopsy techniques (20-24 cores) have been proposed (5).

If extracapsular tumor extension goes undetected the risk of treatment failure may increase (6,7).

Concerning the sensitivity of cancer detection, it has been proposed that more lateral needle placement would improve sampling of the peripheral zone (8).

Anatomy of the prostate

For ultrasound purposes, the prostate can be said to consist of five zones: three glandular (the peripheral zone, transition zone and central zone) and two non-glandular (the periurethral zone and the fibromuscular stroma).

The semitransparent and sectional drawings (Figures 1, 2 and 3) represent the ultrasound anatomy of the prostate.

The peripheral zone

The peripheral zone makes up 70% of the glandular tissue. Studies indicate that 80 to 85% of prostate cancers can arise here (9).

A healthy peripheral zone displays a homogeneous isoechoic ultrasound pattern.

Depending on what section of the prostate you view in the transverse plane, the “surgical capsule” that separates the peripheral zone from the transition zone appears as a distinct boundary in the ultrasound image.

The transition zone

The transition zone consists of two separate lobes that lie superior to the verumontanum, lateral to the proximal urethra, and posterior to the fibromuscular stroma.

The transition zone is the site of benign prostatic hyperplasia (BPH). In a non-hypertrophied prostate gland, it makes up 5% of the glandular tissue. Enlargement of the transition zone due to BPH may alter the contour of the prostate in older men, compressing the peripheral zone or displacing it laterally.

Ten to 20% of prostate carcinomas arise in the transition zone.

The central zone

The central zone makes up 25% of the glandular tissue. Five to 10% of
cancers arise here.

The central zone lies posterior to the urethra and superior to the verumontanum and surrounds the ejaculatory ducts.

The anterior fibromuscular stroma

The anterior fibromuscular stroma forms the anterior surface of the gland. It may be up to 1 cm thick but thins out over the distal portion of the gland. The anterior fibromuscular stroma is more prominent sonographically in younger, non-BPH patients. It is thought that it may be a barrier to the spread of cancer.

The periurethral zone

The periurethral zone is a mid-line structure of cylindrical, internal smooth muscle sphincter that runs from the base of the verumontanum to the back of the bladder neck. Its function may be to prevent semen from flowing backwards into the bladder.

The periurethral zone includes the internal urethral sphincter, while the external sphincter is distal to the apex of the prostate.

The peripheral zone constitutes up to 70% of the glandular tissue in young patients not affected by BPH (see Figure 2 and 20). Later in life the transition zone tissue tends to develop BPH and by its growth occupy a significant percentage of the glandular tissue. This limits the volume of the peripheral zone to much less than 70% (see Figure 19). Eighty to 85% of prostate cancers have been shown to arise from the peripheral zone (9), which certainly makes this zone an area from which biopsies must be sampled.

Simultaneous biplane imaging

For the purposes of this application note, simultaneous biplane refers specifically to the type of scanning offered by the 8808 transrectal prostate transducer from B-K Medical.
One plane ultrasound vs simultaneous biplane ultrasound

Why is simultaneous biplane imaging important?

A one-plane view of the prostate can make it difficult to complete a biopsy regimen because you can’t be certain you are sampling from the targets you intend to. A simultaneous biplane view enables you to more correctly target the sections you want for biopsies. You can see exactly where and how deep the puncture is (Figures 6 and 7).

Simultaneous biplane is particularly valuable to target the proposed 6 lateral biopsies of the peripheral zone (see next section, “An 88% detection rate”) with greater precision, as the cranial aspect of the peripheral zone, certainly in...
A series of simultaneous ultrasound images from a 10 core biopsy scheme

Figures 8a and 8b. Targeting the extreme right lateral deep peripheral zone (A).

Figures 9a and 9b. Targeting the mid right lateral peripheral zone (B).

Figures 10a and 10b. Targeting the extreme right lateral low peripheral zone (C).

Figures 11a and 11b. Targeting the extreme left lateral deep peripheral zone (D).

Figures 12a and 12b. Targeting the mid left peripheral lateral area (E).

elderly patients with BHP, becomes very thin and difficult to target.

A real-time transverse image, for example, together with a sagittal image, provides a clear indication that the needle in the longitudinal plane is in the correct area, for quicker and more accurate biopsies.

An 88% detection rate

Several studies show that using simultaneous biplane imaging while taking biopsies can possibly increase detection rates.

A recent study (10) concluded that parasagittal sextant biopsies per se are inadequate in prostate biopsy protocols, and 28.2% of TRUS-detectable cancers would have been missed in the group of patients had only a sextant biopsy regimen been applied. A systematic 12-core biopsy protocol for detecting early prostate cancer was performed.

The different permutations and combinations of the 12-core biopsy samples were assessed. 98.6% of the TRUS-detectable cancers detected by the 12-core scheme were found by applying a 10-core strategy, whereby two parasagittal mid-zone biopsies are excluded but six cores taken from the left and right peripheral zone are included (see sidebar with Figures 8 - 17). The reason for achieving the high detection rate is likely due to the fact that most cancers occur in the peripheral zone(9).

With simultaneous biplane ultrasound, the doctor can use the

Additional caption to images 8 - 17, p. 5 - 6: On the left are simultaneous biplane ultrasound images taken during the execution of the 10-core regimen as suggested by the study. Effect of peripheral biopsies in maximising early prostate cancer detection in 8, 10 or 12-core biopsy regimens (10). Please note that left and right in the captions refers to the patient’s left and right. To the right of the ultrasound images are corresponding representations of the biopsy regimen. In those drawings, b=base and a=apex.
Figures 13a and 13b. Targeting the extreme left lateral low peripheral zone (F).

Figures 14a and 14b. Targeting the right deep parasagittal area (G).

Figures 15a and 15b. Targeting the low right apical area (I).

Figures 16a and 16b. Targeting the left deep parasagittal area (J).

Figures 17a and 17b. Targeting the low left apical area (L).

transverse image view to position the probe optimally to take extreme bilateral biopsies in the peripheral zone. One could not get nearly as good orientation for following a biopsy scheme with only a one-plane view.

Another study (11) also shows that adding of lateral peripheral zone biopsies can increase the sensitivity of cancer detection.

How to perform simultaneous biplane

The ultrasound procedure must always begin with a digital rectal examination of the prostate. The examining finger can detect obstructing or constricting lesions so that you can avoid injuring the patient when inserting the probe. Painful hemorrhoids and fissures can be anticipated and on occasion may be sparingly treated with Lidocaine jelly.

We recommend that you always start the scanning in the sagittal image plane. Move the transducer forward until you reach the base level of the prostate. Now start to rotate the transducer to the right or left lateral positions. This is ideal to evaluate the prostato-vescicular angle (fat plane). Any tumor extending out through this plane and into the seminal vesicles constitutes a T3b grade tumor. As well, you can use the same scanning sequence to examine the Denonvilliers fascia, seen interiorly to the prostate.

Figure 18: Sagittal image. The arrow points to the intact Denonvilliers fascia.
Volume render mode

We recommend that doctors utilize 3D ultrasound in addition to simultaneous biplane images. 3D ultrasound enables you to get even more information from images, especially if you use volume render mode technique (Figures 19 and 20).

A common technique, surface render mode, is used, for example, to capture images of an unborn baby’s facial contours.

Surface rendering techniques only give good results when a surface is available to render. This explains why the most common example is that of a fetus imaged while floating in amniotic fluid. These techniques fail when a strong surface (a shift in the ultrasound impedance of tissue) cannot be found, as in the case of the subtly layered structures within the anal canal, rectal wall, prostate etc.

High resolution 3D ultrasound acquires four to five transaxial images per 1mm of acquisition length (in the Z-plane). Due to this resolution in the Z-plane, which typically is close or equal to the axial and transverse resolution of the 2D image, 3D post processing facilities can offer significantly more features than are available in 4D data sets.

Under normal circumstances, an ultrasound image has no depth due to the requirements of keeping lateral resolution of the image as high as possible. The image may be compared a photographic image on a piece of paper. Ray tracing techniques may overcome this limitation.

Volume render techniques

Volume rendering mode techniques use a ray tracing model as their basis. A ray or beam is projected from each point on the display screen back into and through the volume data. As the ray passes through the volume data it reaches the different elements (voxels) in the data set. Depending on the various render mode settings, the data from each voxel may be discarded, used to modify the existing value of the ray, or stored for reference to the next voxel and used in a filtering calculation. All of these calculations result in the current color or intensity of the ray being modified in some way. At some point, the ray reaches a limit to its ability to penetrate the volume data. The current color or intensity value that the ray has acquired at this point is then shown on the display screen at the position where the ray trace started.

Some rendering modes also apply global operations to the ray calculations: Maximum Intensity Projection (MIP) tries to find the brightest or most significant color or intensity along a ray path.

Transparent modes allow the separation of color and intensity data and selective control of the transparency of the two components. Using this method, it is possible to reduce the intensity of the gray scale voxels so that they appear as a light fog over the color information. Color information hidden behind an obstruction can then be made visible.

Both of these methods require the ray trace to pass through the entire volume and, in the case of transparent display methods, to pass through the entire volume twice.

The Volume render effect may be particularly dramatic if a number of voxels inside an acquired 3D data set are produced from scanning hypoechoic structures. A hypoechoic focal lesion in the prostate is a good example. Voxel values behind, for example, a strongly reflective interface will also result in an illusion of looking into a semi-transparent dark cavity in the anatomy.
Conclusion

The 8808 transducer is the market leader for prostate examination and biopsies. It introduced simultaneous biplane imaging to urologists around the world. Together with B-K Medical scanners, such as the Pro Focus, users get a powerful solution that is easy to use and operate.

You can comfortably operate the 8808 transducer with one hand. Press the button on the handle to change planes, or to freeze, save or print the image.

The puncture guide is designed especially for prostate biopsies, and you can easily maneuver the transducer while taking biopsies.

The Pro Focus scanner makes 3D ultrasound easy. With just the press of a button on the scanner keyboard, you can get reconstructed 3D images on the screen, as the 3D feature is fully integrated into the Pro Focus software. You can browse through 3D data sets, share information with your colleagues and take the time you need to study images.

If you want more information on B-K Medical solutions for urology, you can start at www.bkmed.com. On the back of this application note is contact information for our regional offices.
References


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With more than 30 years of commitment to ultrasound innovation, B-K Medical specializes in the development, manufacture and distribution of dedicated ultrasound solutions.

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