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Urological Research

Transabdominal Real-time Sonographic Sector-scanning of Bladder, Seminal Vesicles and Prostate: Technique and Normal Anatomy

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Summary. There is a wide application of diagnostic ultrasound in urology. Hitherto the transrectal and transurethral approach for evaluation of the pelvic organs has been used much more often. However, since the development of high resolution real-time sector-scanners, the transabdominal suprapubic approach through the full bladder has become more promising. Using this technique which, as a screening procedure, is most acceptable for the patient, detailed normal anatomy can be seen such as the ureteric orifices, the base plate, the proximal part of the urethra, the seminal vesicles and the ampullae, the ejaculatory ducts and the zonal anatomy of the prostate. In this report, the sonographic appearance of these various structures is correlated with anatomical data and the advantages of the transabdominal approach are discussed.

Key words: Urology, Male pelvis, Anatomy, Ultrasonics, Real-time, Sector-scanner.

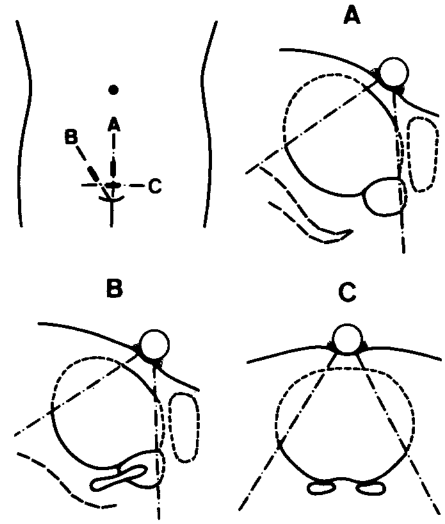

Fig. 1. Transducer head is moved along the lines *A*, *B* and *C*. *A*: sagittal cross-section; *B*: oblique-parasagittal cross-section; *C*: transverse cross-section

Introduction

Diagnostic ultrasound has become more and more important in urological practice [4, 7, 10, 16, 18, 20]. Hitherto the transrectal and transurethral approach for sonographic imaging of the pelvic organs has been used more often [6, 8, 15, 16, 19, 21]. However, the transabdominal suprapubic approach has become more promising since the development of the high resolution real-time sectorscanners [3–5, 20]. The small size of the transducer head and the sector-shaped field of view has made the suprapubic examination of the pelvic organs through the full bladder, functioning as an acoustic window, much more practical and much more comfortable for the patient than the transrectal or transurethral approach. Since ultrasound waves are not attenuated by urine, high frequency transducers can be used, which results in a good resolution. We describe our technique for sonographic visualisation of the bladder, seminal vesicles and prostate, using a real-time mechanical sector-scanner. Normal sonographic appearance seen in angled transverse and sagittal planes are presented.

Materials and Methods

So far a commercially available real-time mechanical sector-scanner (ADR-Kranzbühler) has been used in the examination of the bladder, the seminal vesicles and the prostate in more than 1000 patients.

All patients have a full bladder and are examined in the supine position. The choice of transducer is determined by the depth of the pelvis. Generally the 3.5 MHz transducer is used in adults. The 5.0 MHz transducer allows good visualisation in thin subjects; it also provides the best delineation of the prostate.

Cross-sections are made in different planes (Figs. 1 and 2). First transverse cross-sections are obtained holding the transducer on the midline, midway between the umbilicus and the pubic bone. The transducer is then moved along this line while being simultaneously angled cranially or caudally. Cranial angulation of the trans-

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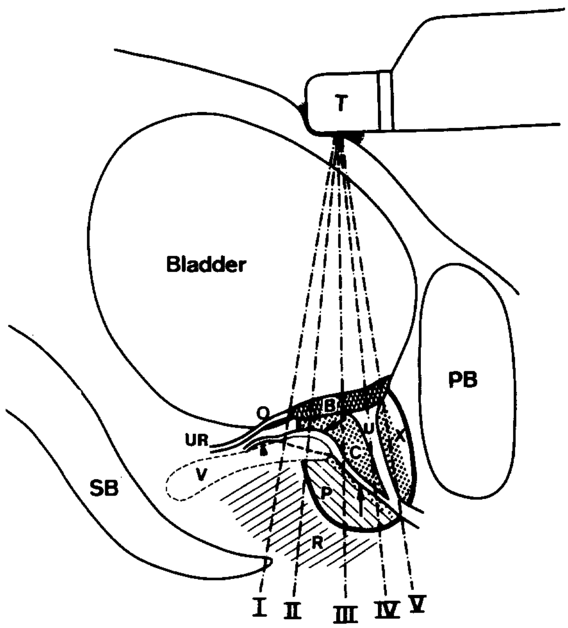


Fig. 2. Anatomy of bladder base and prostate in sagittal plane. Seminal vesicle and ampulla, deferential and ejaculatory duct, ureter and ureteric orifice are superimposed. Roman figures show different levels of transverse cross-sections obtained by angulation of the transducer. *T*: transducer head; *PB*: pubic bone; *SB*: sacral bone; *R*: rectum; *V*: seminal vesicle; *P*: peripheral zone of the prostate; *B*: base plate; *C*: central zone of the prostate; *U*: proximal part of prostatic urethra; *X*: blind area of the prostate; *UR*: ureter; *O*: ureteric orifice; *arrows*: ampulla and ejaculatory duct; *arrow-head*: deferential duct

ducer allows visualisation of the bladder dome, uterus and adnexae, and caudal angulation allows better visualisation of the bladder base, the uterine cervix, the seminal vesicles, the prostate, the urethra and the vagina.

Longitudinal cross-sections are then made in sagittal, parasagittal and oblique planes, with lateral angulation or again cranial or caudal angulation. In this way, the bladder wall, uterus, vagina, adnexae, seminal vesicles, ureters, prostate and urethra are well visualised. Freeze-frame images are recorded at different levels.

Observations and Results

1. Bladder

All parts of the bladder wall are clearly visualised except the anterior part, which is directly applied to the transducer. The wall is thin, regular and strongly reflective. In cases of cystitis or if the bladder is poorly filled with urine, the mucosa is represented as a hypo-echoic inner layer. The bladder lumen is always anechoic except in the area just below the transducer where reverberations are present, which must be differentiated from a tumour of the bladder wall. When adjusting the time-compensated gain correctly, a plate-like thickening of the wall is seen at the bladder base (Fig. 3). The echogenicity of the wall at this level is decreased. This structure represents the basal plate. It is visible either on transverse or sagittal scans and measures 2 cm in diameter and 4 mm in thickness. Posteriorly and laterally to this structure, the two ureteric orifices may be visualised as two small symmetrical elevations (Fig. 4). From these orifices, emanating bursts of echoes, caused by urine entering the bladder, may be observed (Fig. 5). The ureters themselves are frequently seen on transverse and longitudinal scans posteriorly to the ureteric orifices. They are displayed as two parallel lines outlining an anechoic area (Fig. 6). Finally the internal meatus of the urethra is visualised anteriorly as a small depression of the base plate (Fig. 7).

2. Seminal Vesicles

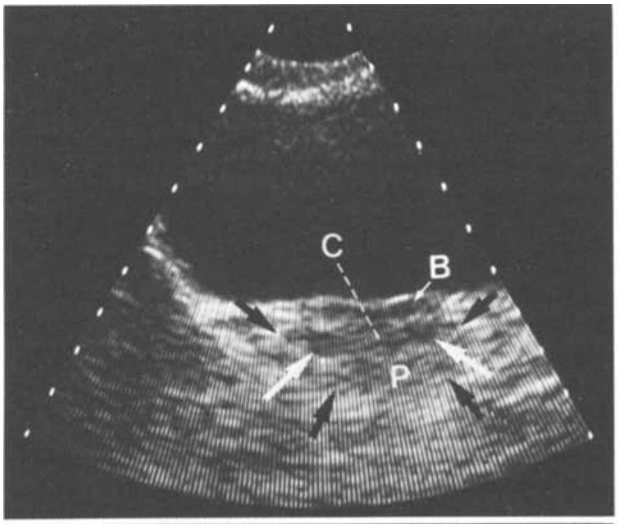
The seminal vesicles are always displayed either on transverse or on sagittal scans. On transverse scans they are displayed as two symmetrically located hypoechoic structures (Figs. 4 and 5). They are situated caudally to the bladder and superoposteriorly to the prostate. When scanning in an oblique parasagittal plane with slight lateral angulation, they are displayed as an elongated structure with round extremities (Fig. 8). The length of the seminal vesicles may be up to 6 cm and their width 1 cm. The ampullae are also frequently visualised caudal to the ureteric orifices and medial to the vesicles on transverse scans. They are anechoic and measure about 5 mm in diameter. When angulating the transducer more caudally the ampullae can be followed within the prostate, which they enter and in which they continue as ejaculatory ducts (Fig. 3). Sometimes in the region of the ampullae even the deferential ducts are visualised as very fine vessel-like structures, lying above the ampullae. They run nearly parallel to the ureters. The ampullae, the deferential and the ejaculatory ducts are seldom seen in their entire length on sagittal scans.

3. Prostate

The prostate is seen on a transverse scan as an oval-shaped, echogenic and symmetrical structure with sharp and smooth margins (Figs. 3, 7, 9–11). It is situated inferiorly to the base plate. The capsule is regular and more echogenic than the parenchyma. The anteroposterior and craniocaudal diameters usually measure 2 to 3 cm, the laterolateral diameter 3 to 4 cm.

Fig. 3. Transverse scan at level II. Margin of the prostate (*black arrows*). Central zone of the prostatic parenchyma (*C*) is situated inferiorly to the base plate (*B*), superiorly to the peripheral zone (*P*) and medially to the intraprostatic part of the ampullae (*white arrows*) ▶

Fig. 4. Transverse scan at level I showing ureteric orifices (*arrowheads*), seminal vesicles (*V*) and ampullae (*arrows*); rectum (*R*)



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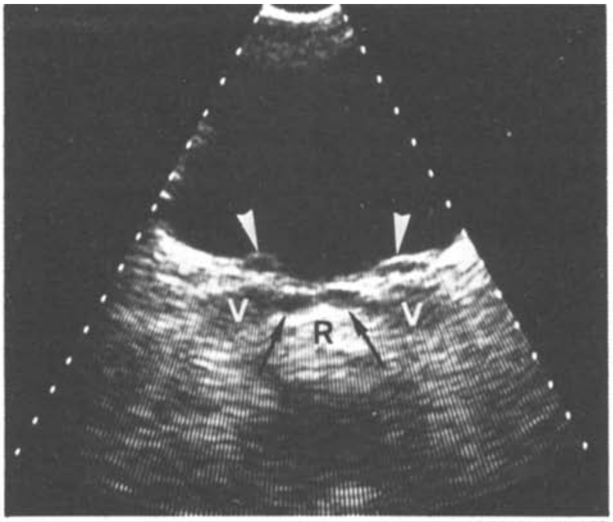

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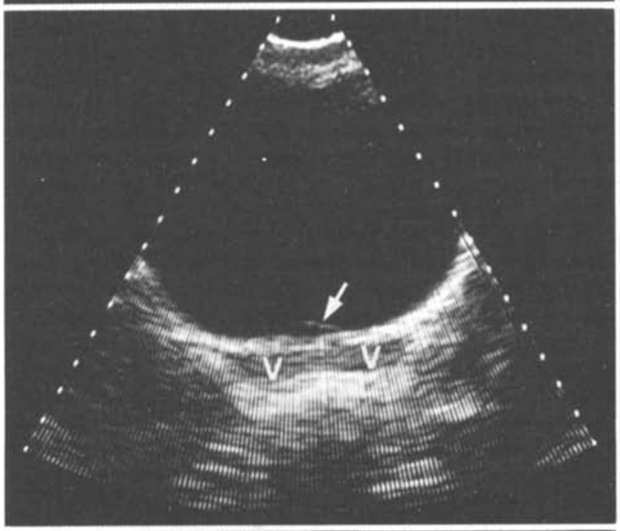

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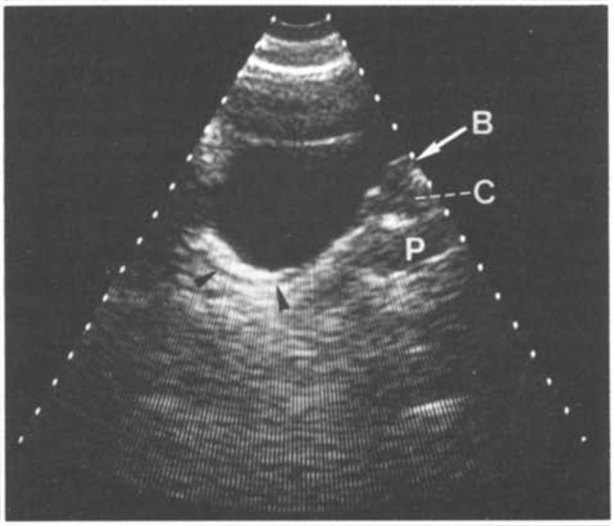

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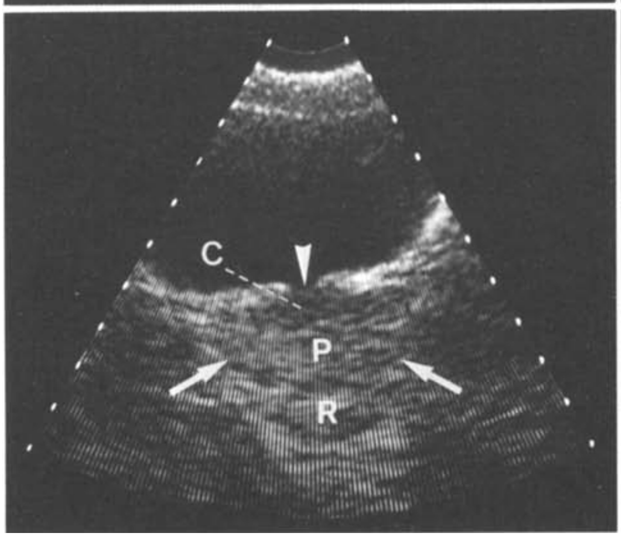

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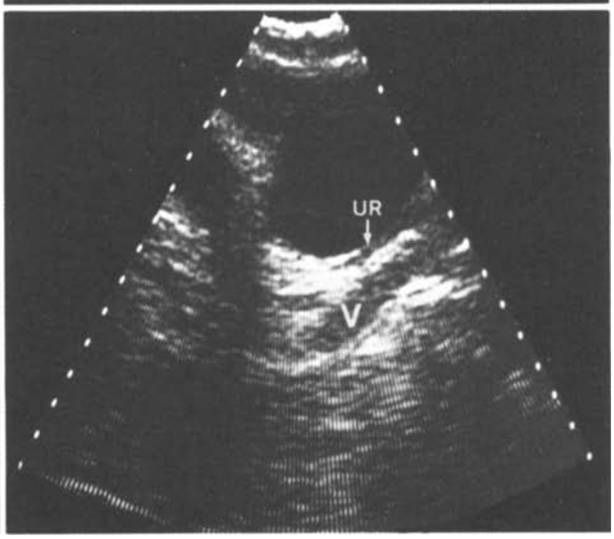

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Fig. 5. Transverse scan. *Arrow:* echoes caused by urine entering the bladder; seminal vesicles (*V*)

Fig. 6. Parasagittal scan showing a normal pelvic ureter (*arrowheads*). Central zone of the prostate (*C*) is shown as a hypoechoic wedge situated between the base plate (*B*) of the bladder base and the more echogenic peripheral zone (*P*) of the prostate

Fig. 7. Transverse scan at the level of the internal meatus. Posterior margin of the prostate (*arrows*). Inferiorly to the meatus (*arrowhead*) a small hypoechoic area (*C*) representing a part of the central zone of the prostate is observed. The peripheral zone (*P*) of the prostate is more echogenic; rectum (*R*)

Fig. 8. Oblique scan showing seminal vesicle in its length (*V*). Pelvic ureter (*UR*) near the bladder base

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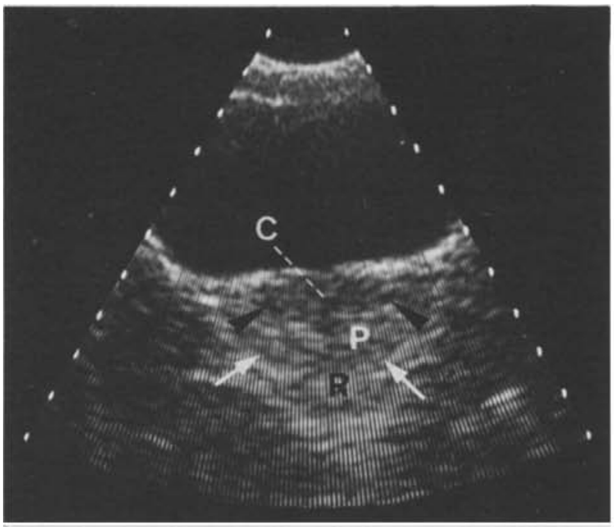

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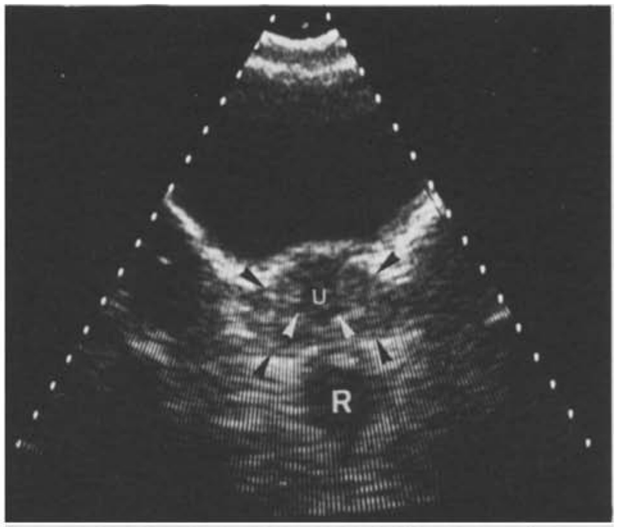

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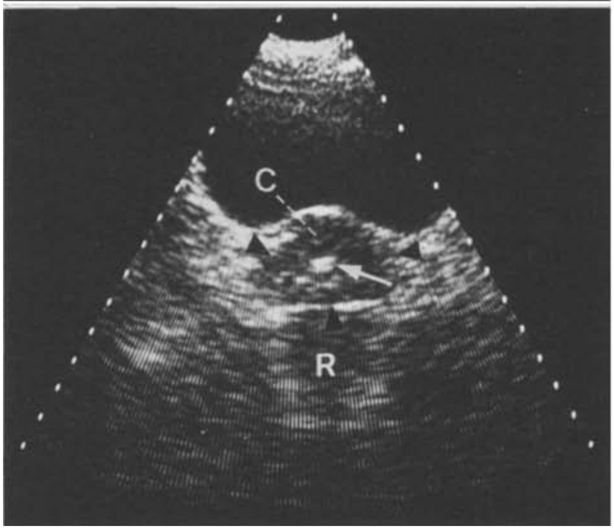

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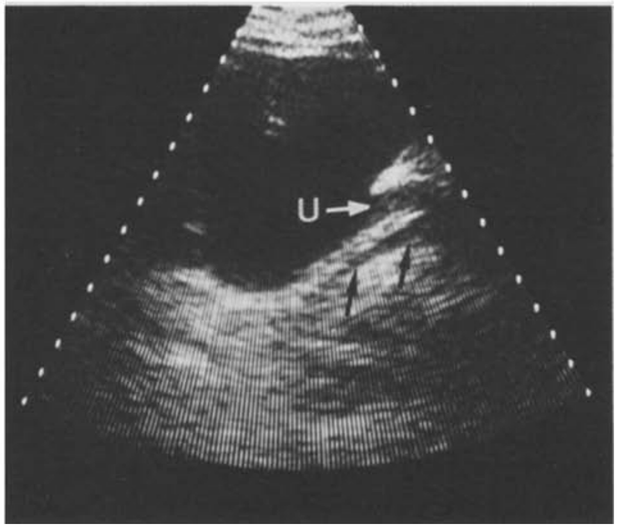

Fig. 9. Transverse scan at level III. Posterior margin of the prostate (*arrows*). The central zone (*C*) is displayed as a hypoechoic area; at the boundaries with the more echogenic peripheral zone (*P*) the ejaculatory ducts (*arrow-heads*) are visible as anechoic spots; rectum (*R*)

Fig. 10. Transverse scan at level IV. Margin of the prostate (*black arrow-heads*). The urethral zone is displayed as a hypoechoic band on the midline (*U*). At its lower end the ejaculatory ducts are visible as small anechoic spots (*white arrow-heads*); rectum (*R*)

Fig. 11. Transverse scan at level V. Margin of the prostate (*black arrow-heads*). The central zone of the prostate (*C*) is shown as a hypoechoic area. The echogenic spot at the center of the prostate represents an urinary catheter (*white arrow*); rectum (*R*)

Fig. 12. Sagittal scan showing the proximal part of the female urethra (*U*) as a hypoechoic band situated anteriorly to the vagina (*arrows*)

The normal prostate does not show a homogeneous echo pattern. When adjusting the time compensated gain properly, regions of different echogenicity within the prostate can clearly be distinguished. On the midline, anteriorly in the prostate, a hypoechoic area is visible. This area represents the prostatic urethra and the periurethral glands (Fig. 10). There is continuity between this region and the base plate at the level of the internal meatus. The diameter of the area is 5 mm. This area is wider and anechoic after transurethral prostatectomy. In patients with indwelling catheters a dense echo is seen within this region, caused by the catheter itself (Fig. 11). Early benign periurethral prostatic hyperplasia is characterised by a hypoechoic lobulated or nodular widening of this area. Two other regions can also be identified. First a wedge-like area of relatively decreased echogenicity is seen, situated in the middle of the prostate, inferiorly to and also close to the base plate (Figs. 3, 6, 7, 9, 11). Its base is directly applied to the base plate. This central region is surrounded dorsally and laterally by a more echogenic peripheral region, which represents the second region (Figs. 3, 6, 7, 9, 11). It surrounds the urethral region, but its largest part is situated beyond the latter. The central region is relatively more echogenic than the urethral region. The boundaries with the urethral region are not always sharply defined. However, the boundaries with the peripheral regions are most often clear and sharp (Figs. 6, 7, 9). The ejaculatory ducts and the intraprostatic part of the ampullae are visualised as small hypoechoic areas, situated symmetrically within this central region at the boundaries of the peripheral region (Figs. 3, 9, 10). The outer margin of the peripheral region is the prostatic capsule. The peripheral region constitutes the greatest part of the prostatic parenchyma (Fig. 9). Finally, a small anterior part of the prostate is usually impossible to visualise on suprapubic scanning because of its close proximity to the pubic bone.

4. Female Urethra

The proximal part of the female urethra is visualised on a transverse scan as a hypoechoic circular area of 5 mm diameter, situated between vagina and bladder. It is seen on a sagittal scan as a hypoechoic band situated anteriorly to the vagina (Fig. 12). Here, too, continuity of the urethra with the base plate is clearly visible.

Discussion

For many years transabdominal ultrasonography has been widely used for the examination of the uterus and adnexae, using the bladder as an acoustic window. For the examination of the prostate, transrectal and even transurethral techniques have been developed [6, 8, 15, 16, 19, 21]. However these techniques require sophisticated and expensive equipment: they are also invasive and cause patient discomfort. The development of the real-time sectorscanners provides new perspectives for the transabdominal examination of the pelvis [4, 20]. Since the contact area of the transducer with the skin is small, interfering bowel content and bone can be easily avoided. Moreover, scanning through the full bladder makes it possible to use high frequency transducers, which results in improved image resolution. Finally, the sectorscanner has wider applications and is not limited to echographic examination of the pelvis.

The anatomy of the bladder neck and urethra has been studied for the past decade [9, 11]. Morphological studies show the existence of a plate-like thickening of the bladder wall at the floor of the bladder, which is called the base plate. This structure is round and measures up to 2 cm in diameter. The internal urethral orifice is located anteriorly in this plate. The posterior part of the plate consists of the trigone. Posterior to this plate the urethral orifices are located. This plate also contains a part of the internal bladder sphincter. Continuity of this plate with the urethra has been shown.

A thickening of the bladder wall, characterised by a decreased echogenicity is clearly visible at the base of the prostate. The proximal part of the urethra is displayed as a hypoechoic band contiguous with the base plate at the level of the internal meatus. The ureteric orifices, urine entering the bladder and pelvic ureters in the region of the bladder neck have recently been described sonographically [3, 5]. They can also easily be visualised by a suprapubic approach using a real-time sectorscanner. Because of its size, location and structure, the prostate is one of the most suitable pelvic organs for ultrasonic examination. Hitherto it has been thought that the suprapubic approach to the prostate could only be useful in patients with a large prostate. However, in our experience the prostate can be clearly visualised in every patient, even in the child.

Several authors recently reported the existence of histological heterogeneity in the glandular tissue of the prostate [1, 2, 12, 13, 17]. They stated that different regions can clearly be distinguished within the prostate, according to their tissue composition and their susceptibility to pathological conditions such as inflammation, degeneration and neoplasia. They also pointed out that this regional morphology can only be clearly delineated on coronal sections through the prostate. In our experience these non-homogeneous areas of the prostatic parenchyma are well demonstrated by suprapubic ultrasonography, which in contrast to transrectal and transurethral sonography provides coronal cross-sections through the gland. The location of these different regions corresponds well with the anatomical regions. The sonically demonstrated central region consists of about 1/3 of the parenchyma. It is seen as a hypoechoic wedge-like area with its base at the base plate. It surrounds the ejaculatory ducts and the distal parts of the seminal vesicles and the ampullae. It can clearly be demonstrated on sonography that the ejaculatory ducts run through this central zone from its base to the apex. The central zone also surrounds the urethral region, the second region of the prostate. This area is situated anteriorly in the prostate and is a more hypoechoic band-like zone with a vertical course from the base plate to the apex of the central zone. In this area the proximal part of the prostatic urethra and the periurethral glands are situated. The continuity of the urethral region with the base plate is clearly visualised on sonography. Development of periurethral gland hyperplasia extending out of this area can also be displayed easily. Finally, two thirds of the prostatic parenchyma is formed by a more echogenic peripheral zone. In our opinion sonographic delineation of these regions is important since it has been shown that the peripheral zone is the preferential site of inflammation and neoplasia and that the periurethral glands are the preferential site of benign prostatic hyperplasia [14]. Recognition of these zones by sonography will help to distinguish normal anatomy from areas of focal pathology within the gland.

Conclusion

Detailed information about normal anatomy of the bladder, the seminal vesicles and the prostate can now be obtained by transabdominal ultrasonography, using a real-time sectorscanner. This method is acceptable to patients because of its non-invasiveness. Moreover it does not require special equipment. Therefore it appears likely to become the screening method of choice for evaluation of the male pelvic organs.

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