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Urological Research

Experimental Investigations on Intracavity Sonography

Part 2: Alteration of Imaging by Artificial Alterations in the Wall of Isolated Porcine Urinary Bladders

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Summary. Because the determination of the depth of urinary bladder tumors by means of intracavity sonography depends on several factors (tumor size, reflection behavior of the tumor etc.), we checked the imaging of this diagnostic technique in the isolated porcine urinary bladder under various experimental conditions. Different tissues of defined size were fixed on the inner or outer surface of the bladder wall; both the bladder mucosa and the foreign tissue were damaged thermally or by incision. The importance of a limited depth of sound penetration or of a sound shadow depending on the characteristics of the tissue under investigation was revealed; tissue types could not be distinguished unequivocally by the reflection pattern; above all, a sonographic diagnosis of the tumor was not possible in the presence of histo-pathologically detectable tissue changes due to thermal damage.

Key words: Experimental investigations II, Alteration of the wall characteristics, Isolated pig bladders, Depth of ultrasound penetration, Sonographic shadows.

Introduction

Sonographic phenomena in rigid hollow receptacles or in isolated porcine urinary bladders after filling with different fluids have already been reported in a previous paper. The ultrasonographic findings in isolated pig urinary bladders will be described below in order to check the suitability of this diagnostic method for determining the depth of invasion of a bladder tumor. The problem of intravesical sonography for exact definition of depth of invasion especially of advanced bladder tumors, has already been referred to elsewhere [2, 4]. Our experiments were designed to provide answers to the following questions: How is the ultrasound image altered by:

a) Attachment of tissues of different qualities to the inside or outside of the urinary bladder?

b) Damage to the inside of the urinary bladder by "cold cutting" (scalpel), diathermy resection or coagulation respectively?

Method

The ultrasonographic instrument has been described elsewhere.

Sonography of the Porcine Urinary Bladder with Added Tissue on the Inside and Outside Surfaces of the Bladder

As an experimental model of an urinary bladder tumor or for its sonographic representation, various tissues (pieces of striated musculature, subcutaneous fat, cartilage and bone 4 cm^2 in size and 1 cm thick) were sewn onto the inside and the outside of the bladder. After filling with physiological saline solution (100 ml), the ultrasonogram was recorded.

Sonography of the Porcine Urinary Bladder After Damage to the Inside Surface of the Bladder

The pig urinary bladder was entered through the bladder neck with a resectoscope sheath and was then filled with 100 ml nonionic, isotonic solution. The mucosa was resected (4–5 cm^2) with alternating current and was also coagulated. In a second experiment, an area of the mucosa of a corresponding size was removed with a scalpel through a longitudinal vesicotomy opening of the bladder. Afterwards, the ultrasonography was performed to establish the influence of the various mucosal lesions on the reflection pattern. For pathohistological examination, the thermally damaged tissue was embedded in paraffin at the Institute of Pathology, University of Bonn, and investigated by light microscopy after further processing.

Results

Reflection phenomena in fluid-filled rigid hollow receptacles or in isolated porcine urinary bladders without alteration of the wall characteristics have already been described in an earlier publication (part 1).

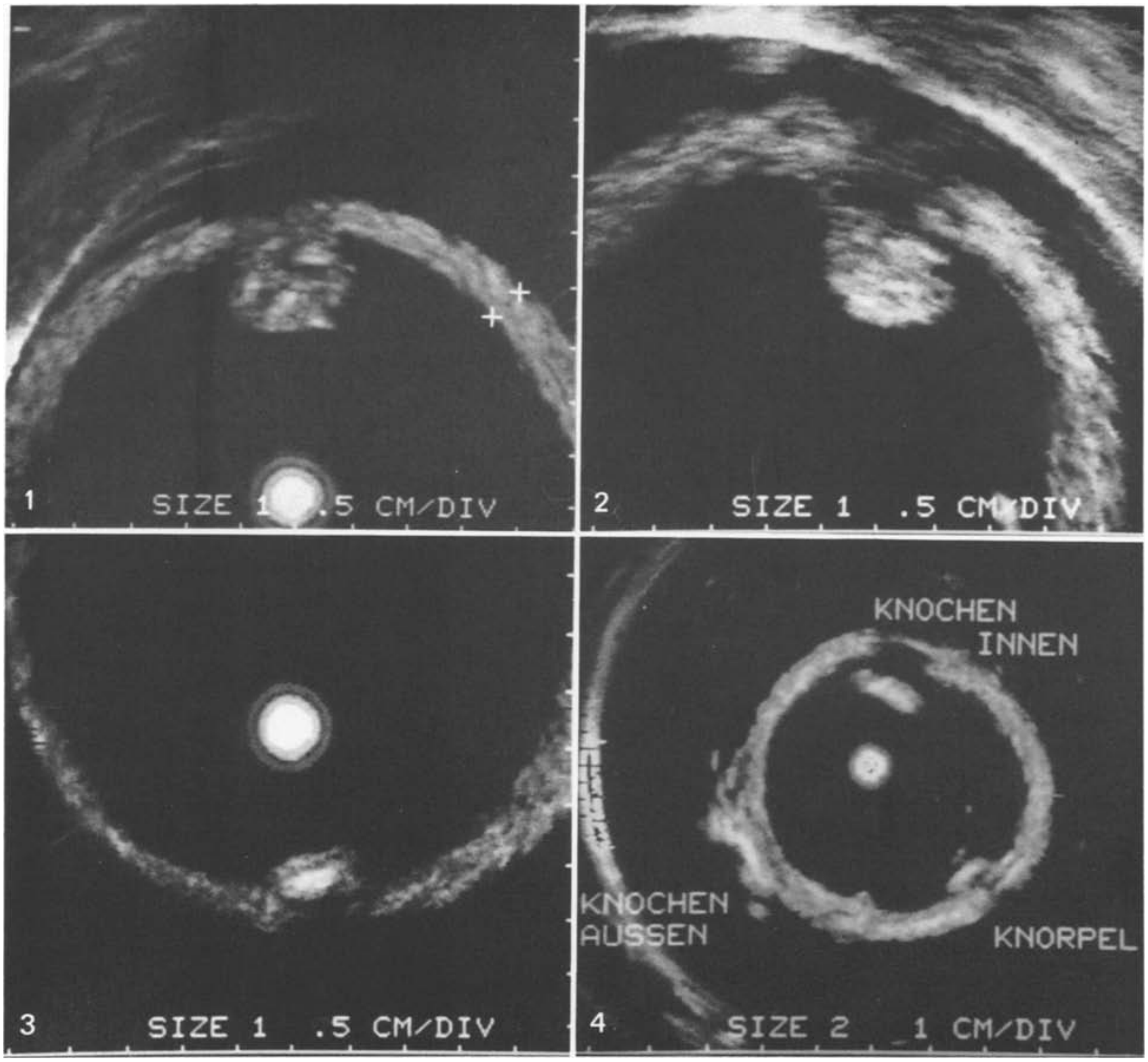


Fig. 1. Detail of the sonogram of a porcine urinary bladder after fixing skeletal muscle to the inside

Fig. 2. Detail of the sonogram of a porcine urinary bladder after fixing subcutaneous fat to the inside

Fig. 3. Detail of the sonogram of a procine urinary bladder after fixing costal cartilage to the inside

Fig. 4. Sonogram of a porcine urinary bladder after fixing cartilage or bone to the inside and after affixing bone to the outside

Results in Tissue Proliferation in the Region of the Inside Surface of the Bladder

After fixing skeletal muscle to the bladder mucosa (Fig. 1), a sonographic reflection pattern resulted which was slightly hypodense (weaker echos) compared to the bladder musculature. Due to the energy absorption of this foreign tissue, incomplete sonographic shadows arose in the more deeply situated bladder wall.

Subcutaneous fat tissue (Fig. 2) was slightly hyperdense (more echos) compared to the bladder wall. The sonographic shadow was accordingly more pronounced compared to the muscle area (Fig. 1).

When costal cartilage was attached to the bladder wall the impedance proved to be so large because of the raised rate of sound conduction that there was an almost complete reflection at the interface with water. In the more deeply situated region, the corresponding sonographic shadow was discerned. The tissue in that region could not be imaged (Fig. 3).

Bone showed an exceedingly bright sonographic reflection; the sonographic shadow was consequently most pronounced in this case (Fig. 4).

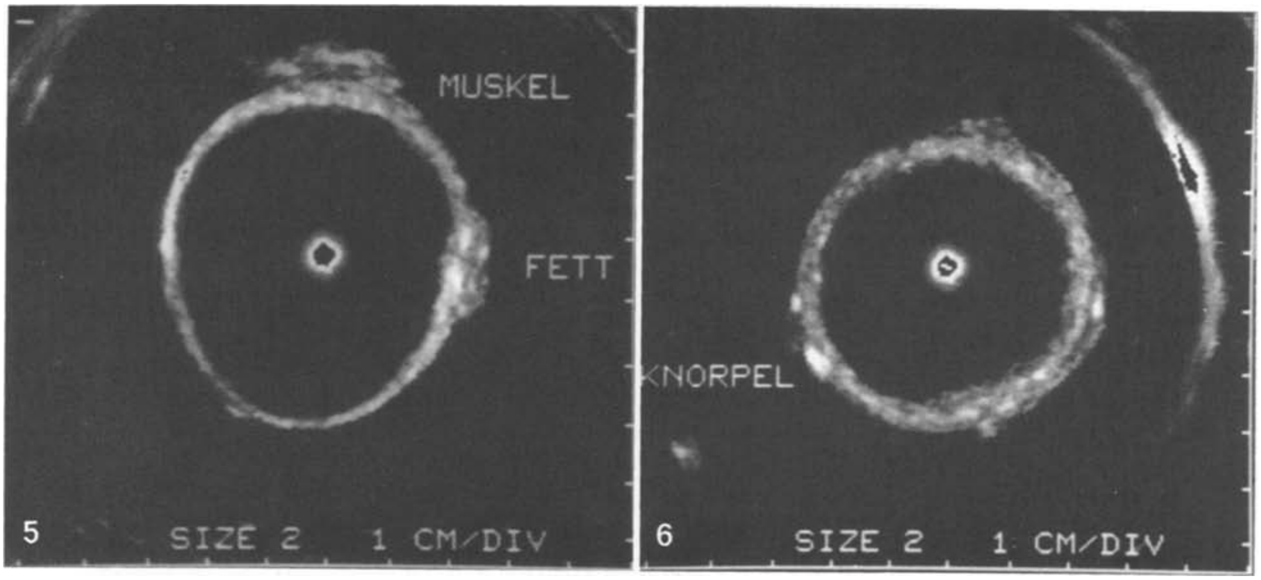


Fig. 5. Sonogram of a porcine urinary bladder after fixing skeletal muscle and subcutaneous fat to the outside

Fig. 6. Sonogram of a porcine urinary bladder after fixing costal cartilage to the outside

Results of Tissue Proliferation on the Outside Surface of the Bladder

The pattern of reflection of the muscle preparation fixed to the outside surface of the bladder (Fig. 5) appeared to be less echogenic and nonhomogeneous compared to the bladder muscle. In comparison to the inner attachment of muscle (Fig. 1), imaging was hardly altered in its "sound density". In this region, the bladder wall was not influenced in imaging quality.

Subcutanous fat attached to the outside surface (Fig. 5) had an echo pattern comparable to that of the bladder wall. Furthermore, it was hypodense compared to fat affixed on the inside. A partial sound energy absorpition by the bladder wall in front explains the difference in intensity compared to the fat preparation fixed on the inside (hyperdense reflection pattern).

Cartilage (Fig. 6) and bone (Fig. 4) on the outside surface produced a hyperdense image comparable to that seen in intraluminal attachment. The corresponding part of the bladder wall was slightly compressed due to the firm and hard consistency of the tissue sample.

Damage to the Inside Surface of the Urinary Bladder or the Foreign Tissue by Cutting or Electrocoagulation

After electroresection or coagulation of the porcine urinary bladder, the corresponding wall areas (Fig. 7) produced a striking echo density which pervaded the entire wall compared to the untreated part of the wall.

Pathohistologically (Fig. 8), a corresponding increase in density of the tissue structures was detected, which was easily distinguished from the undamaged parts of the wall.

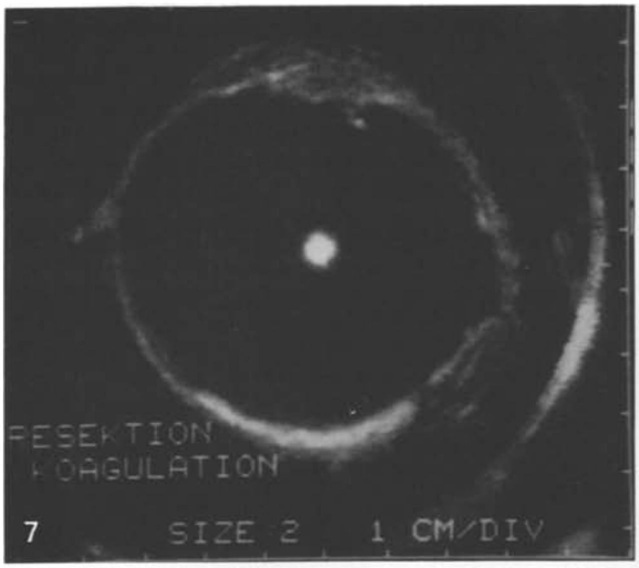
A muscle preparation fixed on the inner surface displayed a hyperdense echo pattern after electrocoagulation on the side of the bladder lumen, even though this was less pronounced than that of the bladder wall itself (Fig. 9). The more deeply situated bladder wall was shown up as hypodense (sonographic shadow) compared to the remaining parts. An intensified reflection from the damaged muscle must be assumed to be the cause. It only allows relatively little sound energy to pentrate up to the actual muscle layer of the urinary bladder.

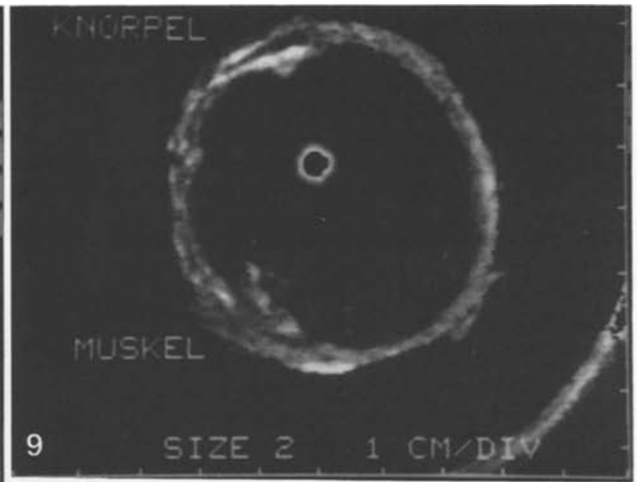
In sonographic terms, fat (Fig. 10) produced little alteration of the echo density due to coagulation apart from some surface changes. With thermal damage to cartilage, there was no alteration in density (Fig. 9).

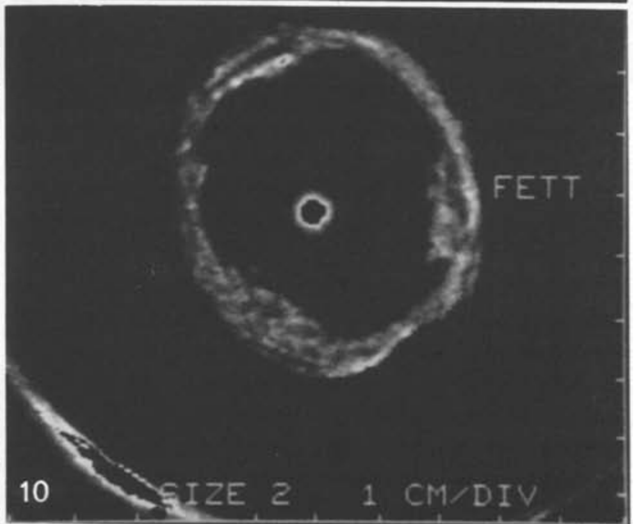
A surface resection of the mucosa with a scalpel produced a sonographic picture consistant with absence of the mucosa (Fig. 11). In this region, the bladder wall was discretely less echogenic. An accumulation of fluid in the wall musculature must be assumed to be the cause due to destruction of the urothelium.

Discussion of the Experimental Findings

As we have already communicated in an earlier publication, the same reflection does not take place from all areas of an object under investigation when the transducer is eccentrically located (nonperpendicular incident sound angle) (3). When the position of the transmitter crystal is nearer to the wall in a rigid hollow receptacle with a homogenous inner surface, only those areas are imaged on which the ultrasound falls perpendicularly; the remaining areas are shown up darkly. We failed to observe a comparable effect in our experimental investigations on the porcine urinary







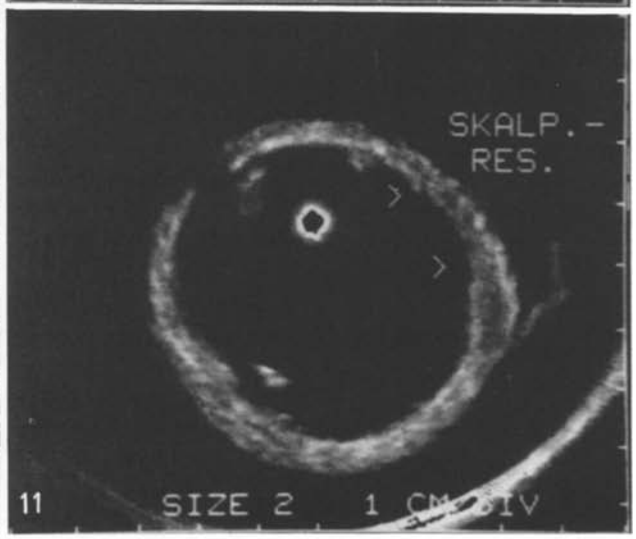


Fig. 7. Sonogram of a porcine urinary bladder after electrical resection and coagulation at the level of the mucosa over a large area

Fig. 8. Histological section after damage to the bladder wall following electroresection and electrocoagulation (cf. Fig. 7) (Sirius-Rot/112 : 1)

Fig. 9. Sonogram of a porcine urinary bladder after coagulation of muscle and cartilage fixed to the inside

Fig. 10. Sonogram of a porcine urinary bladder after coagulation of fat fixed to the inside

Fig. 11. Sonogram of a porcine urinary bladder after mucosal resection with a scalpel (resected area indicated by *arrows*)

bladder. This is due to the fact that the bladder wall consists of numerous tiny reflection surfaces with the most diverse arrangement. Nevertheless, the ultrasound source must be placed centrally, since the boundary between a pathological finding (tumor), normal bladder wall and perivesical tissue can only be visualized optimally in this way [3]. Furthermore, we were able to show that the characteristics of the sound conductor (composition of the bladder fluid) is of crucial significance for imaging.

In addition, the experimental results obtained after alteration of the bladder wall structure allow the following observations to be made:

1. Behind every sonographically detectable thickening of the bladder wall (sewn-on tissue such as muscle, subcutaneous fat, cartilage, bone as tumor models) we found a more or less pronounced sonographic shadow, which may not be interpreted as defect formation. This means that such a sonographic shadow may not be interpreted as tumor infiltration even in the human bladder with malignant neoplasia. Therefore there are limits to the applicability of the techniques of intravesical ultrasonographic investigation with regard to the clarification of more deeply located regions of the bladder wall, depending on the size or reflection behavior of a tumor.

2. Moreover, we found that the ultrasonogram of the various kinds of tissue sewn onto the inside of the bladder (muscle, subcutaneous fat, cartilage, bone) displayed different intensities. In the various kinds of tumor (papillary carcinoma, solid carcinoma) found in the urinary bladder, the difference in the sonogram is very much less pronounced than in the foreign tissues used in our experiment, so that an unequivocal comparison of the ultrasonogram to pathohistologically definable tissue findings is hardly possible.

3. After transurethral damage to the bladder mucosa by diathermy (i.e. resection and coagulation), an exceedingly hyperdense reflection pattern was found at the corresponding site in consequence of a pathohistologically demonstrable raised density which is accompanied by pronounced sound reflection from the remaining muscular layer. This phenomenon subsequent to use of diathermy has already been described by Bertermann et al. [1] and is likely to confuse the sonographic clarification of any tumor residues left behind after subtotal resection of bladder tumors.

References

1. Bertermann, H Seppelt U, Rathke J, Wand H (1983) Kontrolle transurethraler Blasentumor-Resektionen durch intravesikale Sonographie. In: Otto CH, Jann FX (eds) Ultraschalldiagnostik 82, Thieme, Stuttgart, pp 447–449
2. Jaeger N, Radeke H-W, Weißbach L (1984) Transurethral sonography – a non-invasive method to determine the infiltration of bladder tumors. In: Küss, R, Khoury S, Denis LJ, Murphy GP, Karr J (eds) Baldder cancer, part A. Alan R Liss, NY, pp 237–243
3. Kratochwill A (1977) Ultraschalldiagnostik in der Inneren Medizin, Chirurgie und Urologie. Thieme, Stuttgart
4. Lardennois B, Lomina D, Khansa A, Brandt B (1984) Operative ultrasonography in bladder cancer. In: Küss R, Khoury S, Denis LJ, Murphy GP, Karr J (eds) Baldder cancer, part A. Alan R Liss, NY, pp 245–253

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