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ORIGINAL PAPER

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# Ex vivo training model for percutaneous renal surgery

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**Abstract** Percutaneous endourological procedures require an advanced level of skills. To facilitate training in the proper technique, simulators are helpful. Non-biological models, useful for learning the basic steps, do not represent the clinical situation in an ideal way. Recently, we developed a porcine urinary tract model for ureteroscopy. Proceeding from this experience, we developed a further ex vivo model for training percutaneous endourological procedures. The kidney with the ureter is dissected off of the retroperitoneal organ package of freshly slaughtered pigs. It is embedded in silicon. The renal pelvis can be filled with saline to simulate hydronephrosis, stones can be implanted for percutaneous nephrolithotomy. This ex vivo model allows training of all percutaneous endourological procedures (e.g. percutaneous nephrostomy, percutaneous lithotomy, endopyelotomy). It is an ideal way to train these techniques, being superior to non-biological models in terms of "tissue feeling" for anatomic relations, and the great variety of procedures that can be trained. Nevertheless, it is readily available and inexpensive.

**Keywords** Percutaneous nephrolithotomy · Endourology · Minimally-invasive surgery · Training model · Urolithiasis · Teaching

## Introduction

There is a still ongoing trend toward non and minimally invasive procedures. Extracorporeal shock wave lithotripsy (ESWL) as a non-invasive procedure has gained wide acceptance for treating renal stones. With regard to larger calculi, lower pole stones, cystine and whewellite (calcium oxalate monohydrate) concretions, and caliceal diverticular stones, however, ESWL is less successful [1–5]. Therefore, there is an ongoing trend to treat these conditions with minimally invasive procedures such as percutaneous renal surgery. Since ESWL almost completely replaced percutaneous nephrolithotomy during the 1980s and 1990s in many urological departments, younger urologists usually do not have sufficient skills in these techniques. To perform percutaneous procedures efficiently and safely, a more advanced level of training is essential.

To learn the proper technique for percutaneous renal surgery, it is extremely helpful to start training with simulators. To our knowledge, until 2003 only one model existed (Limbs and Things, Bristol, UK). This model, very recently introduced onto the market, offers the possibility of puncturing the collecting system under radiological control. As it is made of plastic material, it does not give the real "tissue feeling", which is, however, important for a safe technique. Furthermore, it does not allow the use of ultrasound to puncture and access the collecting system, nor is it possible to dilate the tract and to train percutaneous nephrolithotomy. In 2004, another model was described using porcine kidneys in a chicken. Again this model does not allow the use of ultrasound guided puncture [6].

We therefore looked for a more natural ex vivo model which, nevertheless, had to be readily available. Proceeding from our porcine urinary tract model [7], we developed a further ex vivo model for training percutaneous endourological procedures.

## Preparation of the model

The retroperitoneal organs (kidneys with ureters and bladder, urethra, aorta, vena cava, intestine, rectum and anus) are cut out of freshly slaughtered adult pigs (male and female animals can be used) en bloc. Retroperitoneal vessels, intestine and rectum are carefully dissected off avoiding any injuries to the urinary tract. The

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kidneys together with the ureters are used as a training model for percutaneous renal procedures. The collecting system can be opened and filled with calculi of different sizes and compositions for training percutaneous nephrolithotomy. It is closed again using a running watertight suture. The ureter is intubated with a ureteral catheter (5 F). Using a rectangular mould, a base is founded with liquid silicone. After solidifying, the kidneys together with the ureters are positioned on this base (Fig. 1). Then, liquid silicone is pored onto the kidneys. As a result, the kidneys are completely embedded in silicone. Solidifying of the silicone gel takes about 3 h. The end of the ureteral catheter stays free to be filled with water to create hydronephrosis (Fig. 2). The model should be kept cool and can be used for about 1 week.

## Working with the model

The kidney can be imaged using an ultrasound probe (Fig. 3). The collecting system is punctured with an 18 gauge needle through one of the calyces. Fluid can be aspirated and contrast medium injected under fluoroscopic control to verify the accurate placement of the needle (Fig. 4). A guide wire is directed through the needle and placed in the renal pelvis or the ureter. After removal of the needle the tract can be dilated using coaxial dilators. After dilation of the tract, an Amplatz nephrostomy sheath is placed over the last dilator. The pyeloscope is now introduced through the Amplatz sheath allowing for retrieval of the stone and its extraction or disintegration using auxiliary instruments (e.g. forceps, basket, intracorporeal lithotripter) (Figs. 5,

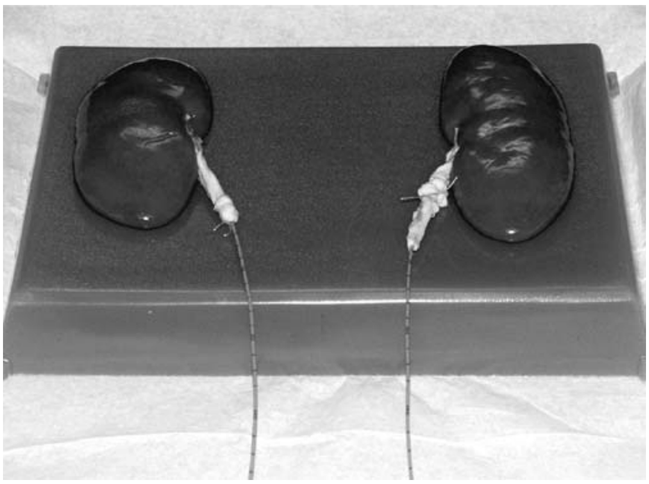

**Fig. 1** Kidneys positioned on the silicone base of the model

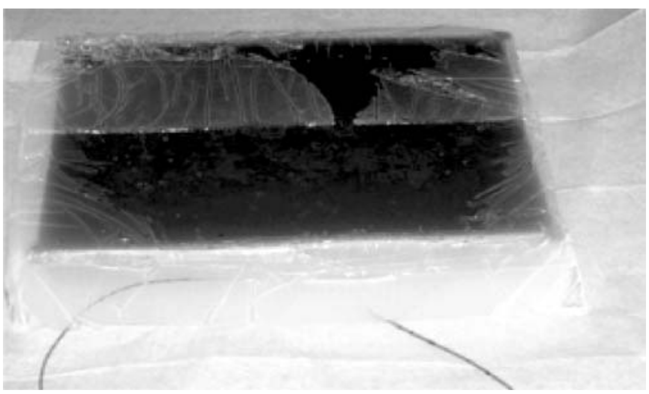

**Fig. 2** External view of the model with ureteral catheters for creating hydronephrosis

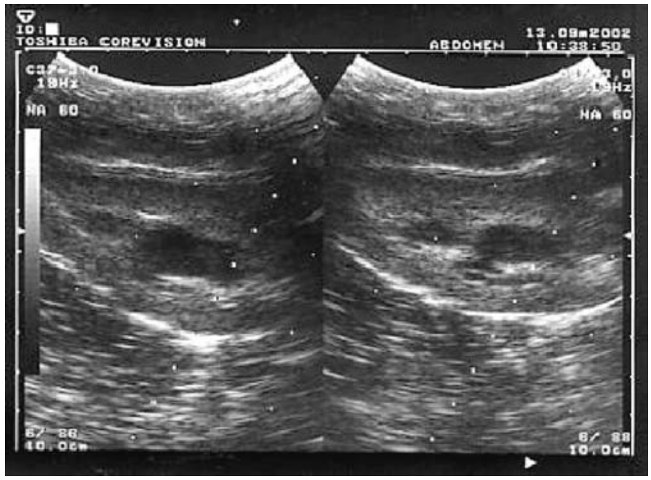


**Fig. 3** Ultrasound image of the porcine kidney embedded in silicon

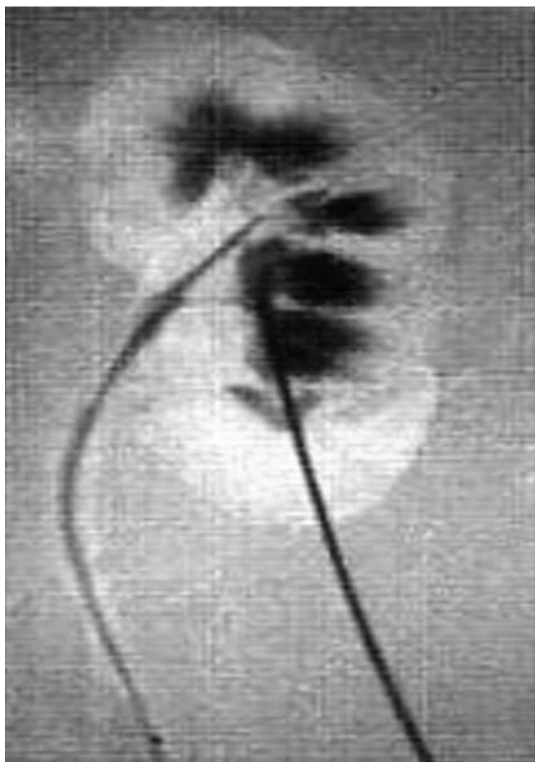

**Fig. 4** Antegrade pyelogram of the porcine kidney. Contrast medium injected through the puncture needle

**Fig. 5** View into the renal pelvis through the pyeloscope

**Fig. 6** Lithoclast probe touching the calculus

6). Procedures such as endopyelotomy, incision of caliceal neck stenosis, antegrade stenting and inserting percutaneous drainage catheters can also be trained.

The mucosa of the urinary tract is somewhat paler than in vivo due to the missing blood circulation. The "tissue feeling", however, and the anatomic relations represent the clinical situation in an almost ideal way.

## Discussion

Our ex vivo porcine urinary tract model allows for the training of all techniques used in diagnostic and therapeutic percutaneous endourology (rigid and flexible) in a way which is almost identical to the clinical situation in humans. The model is readily available and inexpensive. Since the organs are taken from slaughtered pigs, legal or ethic aspects have not to be considered. When compared to a simulator made of non-biological material, our model is closer to the human situation in clinical practice (anatomy, "tissue feeling", and placement of stents). So far, however, no scientific data are available comparing non-biological with biological models in terms of learning curves and effectiveness. In training courses on percutaneous renal surgery, we used the ex vivo model with great success. After learning the basic steps of the technique with the non-biological simulator, trainees proceed with our porcine model, thus smoothly bridging the gap between an artificial trainer and the clinical situation by a naturalistic ex vivo model.

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