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ORIGINAL PAPER

Improved ex vivo training model for percutaneous renal surgery

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Abstract Percutaneous endourological procedures require an advanced level of skills. To facilitate the training of the proper technique, some years ago we developed a porcine ex vivo model for training percutaneous endourological procedures. When dilating the percutaneous tract silicone and gelatine were frequently damaged thus inhibiting proper working with the endoscopes. To circumvent these problems we improved our ex vivo model in order to be as close to the clinical situation as possible. The kidney with the ureter was dissected off the retroperitoneal organ package of the freshly slaughtered pigs. The kidneys were put into bags cut into parts of the thoracic/abdominal wall of these pigs. The renal pelvis can be filled with saline to simulate hydronephrosis; stones can be implanted for PCNL. Our new model allows for even better training of all percutaneous endourological procedures (e.g. percutaneous nephrostomy, PCNL, endopyelotomy). Especially puncturing is extremely close to the situation in humans as the porcine thoracic/abdominal wall in principal has the same anatomy as the human one. The new model has been already used with great success in hands-on courses. Concerning "tissue feeling", the anatomic relations and the great variety of procedures that can be trained, it is superior to non-biological models. Nevertheless, it is easily available and inexpensive.

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

Introduction

During the last years, going along with technical improvements reducing the morbidity of endourological procedures for urolithiasis, the use of extracorporeal shock wave lithotripsy (ESWL) decreased considerably. With regard to larger calculi, lower pole stones, cystine and whewellite (calcium oxalate monohydrate) concretions, caliceal diverticular stones, however, ESWL is less successful than endoscopic procedures [1–5]. Since ESWL has almost completely replaced percutaneous nephrolithotomy during 1980s and 1990s in many urological departments, younger urologists usually do not have sufficient skills in these techniques. A more advanced level of training, however, is essential to perform percutaneous procedures efficiently and safely. This goes along with a steep learning curve [6, 7].

To learn the proper technique of percutaneous renal surgery, it is helpful to start the training with simulators. Non-biological and virtual simulators, however, do not give the real "tissue feeling", which is important for a safe technique.

Proceeding from our porcine urinary tract model [8], some years ago we developed an ex vivo model for training percutaneous endourological procedures [9]. In the meantime, several other models and simulators have been described [10–12] some of them not allowing for ultrasound guided access or not giving "tissue feeling".

Our model [9], although being quite close to the clinical situation and allowing for ultrasound guided access to the kidney had some drawbacks. When dilating the percutaneous

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tract, silicone and gelatine were frequently damaged thus inhibiting proper working with the endoscopes. To circumvent these problems we improved our model in order to work as close to the clinical situation as possible.

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 kidneys together with the ureters are used as a training model for percutaneous renal procedures (Fig. 1). The collecting system can be opened and filled with calculi of different size and composition for training percutaneous nephrolithotomy. It is closed again using a running watertight suture. The ureter is intubated with a ureteral catheter (5 F).

Bags were cut into parts of the thoracic/abdominal wall of these pigs. The kidneys were put into these bags keeping the intubated ureter outside (Fig. 2). Thus, the renal pelvis can be filled with saline to simulate hydronephrosis or contrast media to visualize the collecting system using X-rays.

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. Puncturing is extremely close to the clinical situation as the needle passes skin, fat and muscles before reaching the kidney, ribs are overlying the kidney all being like in human patients.

Fluid can be aspirated and contrast medium injected under fluoroscopic control to verify the accurate placement of the needle in the collecting system (Fig. 4). A guide wire

Fig. 1 Preparation of the kidneys

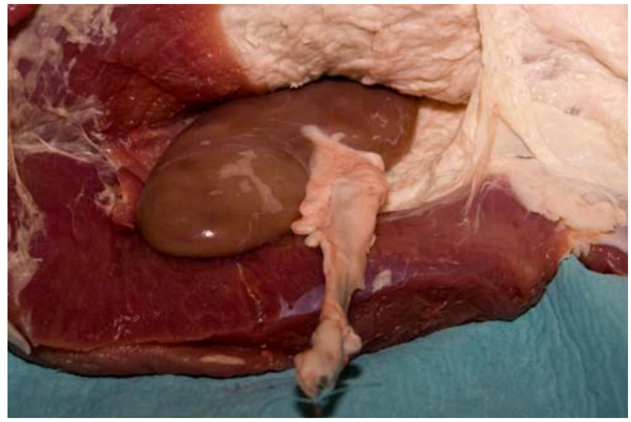

Fig. 2 Kidney placed in the segment of the thoracic/abdominal wall

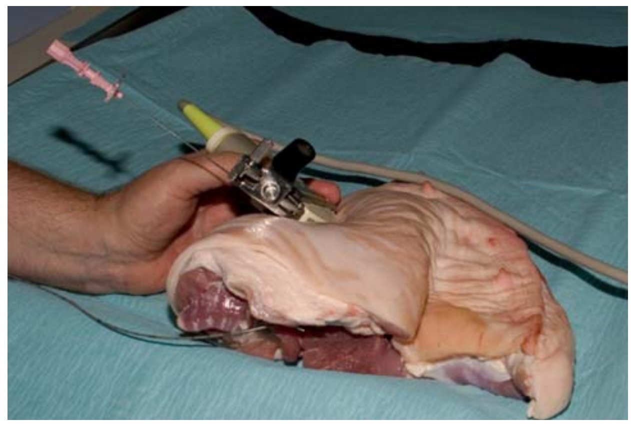

Fig. 3 Ultrasound guided puncture of the kidney

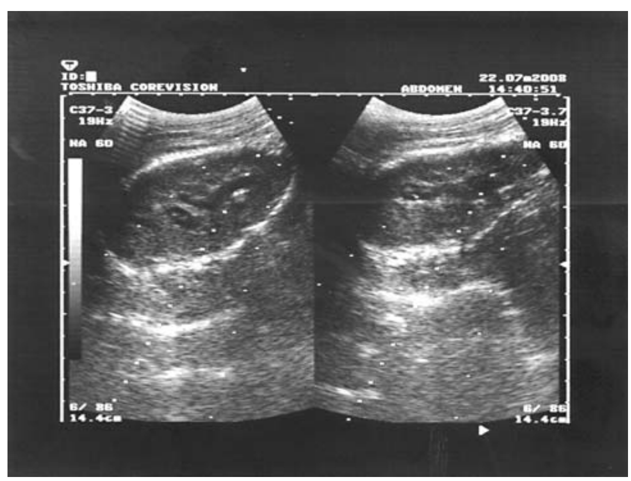

Fig. 4 Ultrasound image of the embedded porcine kidney

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. Now, the dilation process is also extremely close to the human patient.

Fig. 5 Antegrade pyelogram of the porcine kidney. Contrast medium injected through the puncture needle

Fig. 6 View into the renal pelvis through the pyeloscope showing an implanted stone and the guide wire

The pyeloscope is introduced through the Amplatz sheath allowing for retrieving the stone and to extract or disintegrate it using auxiliary instruments (e.g. forceps, basket, intracorporeal lithotripters) (Figs. 5, 6). Procedures as endopyelotomy, incision of caliceal neck stenosis, antegrade stenting and inserting percutaneous drainage catheters can be trained as well.

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

Discussion

Our improved ex vivo porcine urinary tract model allows for training of all the 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 quite easily 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, it is closer to the human relations 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 [6, 13]. 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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