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In vivo Porcine Model for Practicing Retrograde Intrarenal Surgery

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Key Words
Porcine model · Retrograde intrarenal surgery · Stone fragments

Abstract
Objectives: To examine the feasibility of retrograde intrarenal surgery (RIRS) in a porcine model. ***Materials and Methods:*** Female pigs (n = 3) were placed in a dorsal lithotomy position under general anesthesia, and stone material was inserted into the renal pelvis of the pigs. The bladder was entered with a cystoscope, and a 0.038-inch hydrophilic guidewire was passed into the renal pelvis. Following successful placement of the guidewire, a ureteral access sheath (9.5/11.5 Fr) was placed to allow for optimal visualization. A 7.5-Fr flexible ureteroscope (Karl Storz Flex-X2) and a 200-μm laser fiber were used for lithotripsy. When basketing was deemed necessary, zero-tipped nitinol stone baskets were used. Trainees then practiced all these manipulations on the model. ***Results:*** Urologists with moderate experience in advanced endourologic surgery were trained using this model. However, there were some surgical difficulties due to the urinary system anatomy of the pig. Intravaginal location of the urethra, bladder neck location of the ureters, tight ureteric orifices, tortuous ureters, longitudinally elongated renal pelvis, narrow infundibulopelvic angle and shallow calices made the passage of the instruments and maneuverability of the flexible ureteroscope more difficult than in a human model. ***Conclusions:*** Despite some difficulties, our porcine model was very effective, because all the trainees successfully practiced the RIRS manipulations on this model.

Introduction

Improvements in flexible ureteroscopy technology and availability of the holmium:YAG laser and other ancillary instruments have made retrograde intrarenal surgery (RIRS) a more attractive modality for the treatment of renal calculi [1]. Several groups reported the effectiveness of RIRS for small and medium-sized renal stones [1–3]. Furthermore, recent studies have demonstrated the efficacy and safety of this technique in the treatment of large renal calculi [4, 5]. Although this procedure has a high success rate, it also has a long learning curve to acquire the necessary experience. Practicing on patients may increase the morbidity and cost of this surgery. However, to date no report has been published in the medical literature describing a model to aid urologists in RIRS training.

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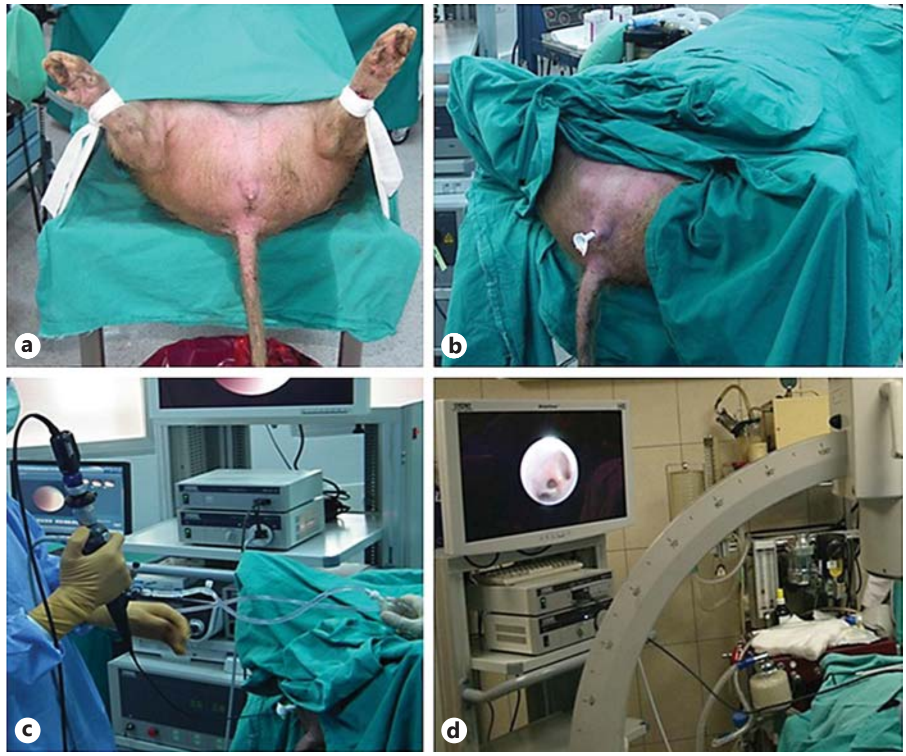

Fig. 1. Training model of retrograde intrarenal surgery. **a** Pig in dorsal lithotomy position. **b** Ureteral access sheath placement. **c** Flexible ureteroscopy manipulations. **d** Intrarenal exploration.

For the purpose of training in flexible ureteroscopy, we developed an in vivo porcine model that allows the placement of ureteral access sheath, intrarenal endoscopic exploration, holmium:YAG laser lithotripsy and basket extraction of stone fragments.

Materials and Methods

All procedures were performed after having obtained approval of the Institutional Animal Care and Use Committee. Three female pigs (large white breed, weight 35–40 kg) were used for this study. All procedures were performed under general anesthesia with endotracheal intubation using intramuscularly injected ketamine (30 mg/kg), xylazine (2 mg/kg), atropine (0.05 mg/kg) and intravenous propofol (2.5 mg/kg). The anesthetized pigs were placed in the dorsal lithotomy position (fig. 1a).

Cystoscopy was performed with a 22-Fr cystoscope, and a 0.038-inch hydrophilic guidewire was passed into the renal pelvis. Dilation of the ureter was necessary in all cases. Following successful dilation of the ureter, a ureteral access sheath (9.5/11.5 Fr, Cook Medical) was placed to allow for optimal visualization (fig. 1b). A 7.5-Fr flexible ureteroscope (Karl Storz Flex-X2) was used to inspect the renal collecting system (fig. 1c, d).

Stone material was inserted into the renal pelvis on either side by ureteroscopic or laparoscopic surgery. In 5 of the 6 kidneys, a stone (each approximately 6 mm in size) was introduced into the renal pelvis of the pig via retrograde access using a flexible ureteroscope and nitinol basket. In the other one, the stone was laparoscopically implanted into the renal pelvis, and ureteroscopic intervention was performed 7 days after the insertion of the stone.

Fig. 2. Practicing on the porcine model under the guidance of an experienced endourologist.

Stone fragmentation was performed using a 200-μm holmium:YAG laser fiber set at 8 W (1 J, 8 Hz). Basketing of the fragments was carried out with a 2.2-Fr zero-tipped nitinol stone basket (Cook Medical). The trainees practiced all these manipulations on the models (fig. 2). After the procedures were completed, the animals were sacrificed while still under general anesthesia.

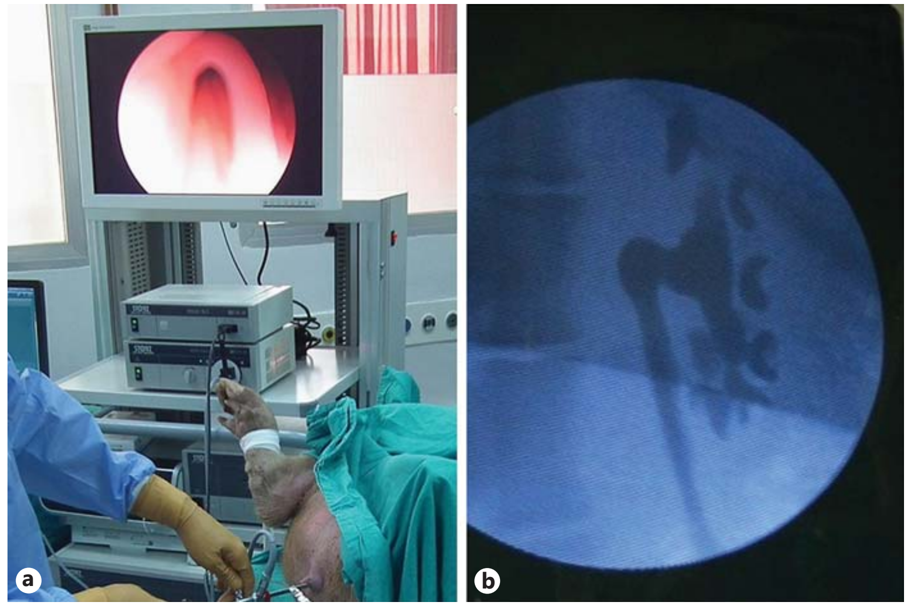

Fig. 3. **a** Location of right ureteric orifice in the porcine bladder. **b** Renal collecting system after retrograde administration of contrast material.

Results

Eight urologists with moderate experience in advanced endourologic surgery were trained using this model. They practiced in groups of four, each group being supervised by an experienced endourologist. All trainees successfully performed the placement of ureteral access sheath, intrarenal endoscopic exploration, holmium:YAG laser lithotripsy and basket extraction of stone fragments.

However, there were some surgical difficulties due to differences in the urinary system anatomy of the pig. For example, the introduction of the instruments was technically more difficult in pigs because of the intravaginal location of the urethra and the bladder neck location of the ureters (fig. 3a). In addition, tight ureteric orifices, tortuous ureters, longitudinally elongated renal pelvis, narrow infundibulopelvic angle and shallow calices made the passage of the ureteral access sheath and the maneuverability of the flexible ureteroscope more difficult than in a human model (fig. 3b).

Despite these difficulties, there was no significant intraoperative problem except in three cases. In two of them, traumatic bleeding occurred while using the ureteroscope, and the procedure was terminated because of impaired visibility. In the other one, the ureteroscope could not be introduced into the renal pelvis because of the ureteropelvic junction stenosis. In this case, the stone had been laparoscopically implanted into the renal pelvis, and this stenosis had occurred owing to suturing of the renal pelvis.

Discussion

The recent advances in the flexible ureteroscope technology and techniques have dramatically increased the potential indications of RIRS [6–8]. This increasing role of flexible ureteroscopy has highlighted the training issues, because this procedure has a long learning curve and this learning process may increase the morbidity and cost of the surgery. For this reason, several training models have so far been developed to reduce the learning process of endourologic procedures [9–14]. However, all these reports have been published for percutaneous renal surgery training and to date no report has been published in the literature describing a model to aid urologists in RIRS. Therefore, we cannot compare our findings with the results of other studies.

In the medical literature, several training models have been evaluated to date, consisting of different technical simulators and ex vivo or in vivo biological materials [9–14]. They concluded that an ideal training model needs to be realistic, commonly available and cost-effective. Animal models are known to be superior to nonbiological materials or virtual programs in terms of tissue feeling [9]. Also, the porcine kidney is believed to be the best animal model for endourologic research, because its collecting system anatomy is similar to the human kidney [15, 16].

In 1998, Sampaio et al. [15] investigated the structure of the pig kidney anatomy, and they concluded that porcine kidneys are the best animal model for urologic surgery. However, in the present study we detected some surgical difficulties due to the urinary system anatomy of the pig. Intravaginal location of urethra, bladder neck location of ureters, tight ureteric orifices, tortuous ureters, narrow infundibulopelvic angle and shallow calices make the passage of the instruments and the maneuverability of the flexible ureteroscope more difficult than in a human model. Despite these difficulties, our model allows the training of multiple steps of RIRS such as placement of ureteral access sheath, intrarenal endoscopic exploration, holmium:YAG laser lithotripsy and basket extraction of stone fragments. Also, training with this model was regarded as practical and helpful by most of our attendees.

Furthermore, we developed a new method for the implantation of stone material into the pig kidney. With this technique, stone material was placed within a 2.2-Fr nitinol basket and was advanced through the access sheath into the renal pelvis by using a 7.5-Fr flexible ureteroscope. This implantation technique was successfully performed in all cases, and it was less traumatic to the kidney than the laparoscopic approach. To laparoscopically implant stones into the renal pelvis was problematical; therefore, this technique can be used as an alternative procedure to the retrograde implantation method.

Conclusion

Despite some difficulties, our porcine model was very effective, because all the trainees successfully practiced the flexible ureteroscopy manipulations on this model under the guidance of an experienced endourologist.

Disclosure Statement

The authors declare no conflict of interest.

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