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DYNAMIC MANUSCRIPTS

Transvesical peritoneoscopy with rigid scope: feasibility study in human male cadaver

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Abstract
Background Transvesical port refers to the method of accessing the abdominal cavity through a natural orifice (i.e., urethra) under endoscopic visualization. Since its introduction in 2006, various reports have been published describing different surgical interventions using a rigid ureteroscope in a porcine model. The aim of this study was to test the access and feasibility of peritoneoscopy by using a rigid ureteroscope in a human male cadaver.
Methods Two adult male cadavers were used to perform the procedures. A rigid ureteroscope was used for the creation of transvesical access into the peritoneal cavity. Peritoneoscopy, liver biopsy, and identification and manipulation of the ileocecal appendix were performed.
Results Transvesical access into the peritoneal cavity was quickly established. The rigid ureteroscope easily allowed visualization of the abdominal cavity with good image quality. Liver biopsy and manipulation of ileocecal appendix were carried out without difficulties.
Conclusions Peritoneoscopy, liver biopsy, and ileocecal appendix manipulation using a rigid ureteroscope through a transvesical port is feasible in a cadaver model. The development of a specific rigid scope for the transvesical port might herald a promising future for this NOTES access.

Keywords Cadaver · Endoscopy · Surgery · Transvesical · NOTES

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The craving for the discovery of new, minimally invasive surgical procedures allowed a new surgery concept to emerge: natural orifice transluminal endoscopic surgery (NOTES). The main challenge of this new concept is the execution of numerous surgical procedures through natural orifices, with the consequent advantages that may result, such as cosmetic benefits due to the absence of a surgical incision. The absence of a surgical incision also means less risk of wound infection and potentially less pain. In 2004, Kalloo et al. [1] described access to the peritoneal cavity through the transgastric port in a porcine model. Since then, several studies have been performed using transgastric access [2–6]. However, many limitations were described, particularly when singly performed by transgastric port.

In 2006, Lima et al. [7] described the transvesical port going beyond the wall of bladder for access to the peritoneal cavity in a porcine model. Soon it became apparent that this access was not only a major shift in how the bladder was seen, but also a safe and fast means of access to the peritoneal cavity, with an excellent view of all the upper peritoneal structures [7]. This same group of researchers also described the execution of complex surgical procedures, including nephrectomy [8] and cholecystectomy [9, 10], which were carried out by an approach combining the transvesical port with the transgastric port. In both surgical procedures, the transvesical port represented not only a working port through which many instruments are used, but also a way of support and guidance in choosing the site of entry into the peritoneal cavity via the transgastric port [9, 10]. The transvesical port, although at the lower end of the abdomen, also allowed the execution of thoracic procedures in the porcine model [11].

Some critics question the feasibility and reproducibility of these procedures in the human being, particularly regarding the use of rigid instruments. The distance from the bladder to other organs in the abdominal cavity is larger than in the animal model, which could limit the imaging and manipulation of the organs of the upper abdominal cavity. Another questioned aspect is the possibility of obtaining images of the upper abdomen using rigid instruments without angulation, which might preclude the use of the scopes currently on the market in the transvesical approach in humans. Therefore, transvesical access to the peritoneal cavity might be a reality not only in the animal model, but also in the human model in the near future, especially if it is possible to use rigid instruments in this procedure.

The aim of this study was to describe and test the feasibility of NOTES procedures performed in a human male cadaver, with access to the abdominal cavity made through the transvesical port and by using rigid instruments.

Material and methods

The procedures were performed at the Institute of Forensic Medicine, North Delegation, Porto, Portugal. The experimental protocol was approved by the Institutional Review Committee. Two adult male cadavers were used.

Access

The cadaver was placed in the lithotomy position. An HD platform (Image 1 HD, Storz) was used. The procedure was started with the transurethral introduction of a 9.5 Fr rigid ureteroscope (Storz 27002L) connected to a saline system through one of its irrigation channels. A complete cystoscopy was performed by viewing at the ureteral orifices and all the bladder walls. Next, a precise point on the bladder dome was chosen for the creation of the transvesical access to the peritoneal cavity. A 5 Fr splitting forceps (Storz 27424U) was introduced through the 6 Fr working channel of the ureteroscope to make an incision in the bladder mucosa. Then a 5 Fr Péres Castro forceps (Storz 274525R) was introduced through the ureteroscope's working channel, allowing dissection of bladder muscle fibers and the direct creation of transvesical access to the peritoneal cavity without creating a submucosal tunnel.

Following entry into the peritoneal cavity, saline irrigation was replaced by gas (CO_2) insufflation and creation of the pneumoperitoneum was obtained with a maximum pressure of 12 mmHg.

Procedure

Peritoneoscopy was performed with visualization of the entire peritoneal cavity, including bowel loops, omentum, stomach, liver, and gallbladder. At the liver edge, a biopsy was performed by introducing a 5 Fr Péres Castro forceps (Storz 274525R). To identify the ileocecal appendix, bowel loops and omentum were lifted and the blind loops were explored, with the ileocecal appendix identified and isolated/manipulated at the end. After the peritoneoscopy, the ureteroscope was removed from the peritoneal cavity through the previously created bladder orifice, without it being dilated or lacerated. The same procedure was repeated on the other cadaver (see video).

Results

The mean duration of the entire procedure, including urethroscopy, cystoscopy, creation of bladder access, peritoneoscopy with liver biopsy, and ileocecal appendix identification with isolation, was 11 min. During the entire procedure the clarity of the images obtained was remarkable, with the use of either saline or gas. The pneumoperitoneum was obtained quickly resulting in an excellent view of intra-abdominal organs by keeping a maximum CO_2 pressure of 12 mm Hg. The progression of the ureteroscope within the peritoneal cavity was found to be safe, and no difficulty was encountered in identifying the structures of the upper abdomen (Fig. 1).

It was confirmed that the ureteroscope, with a maximum length of 43 cm, allowed us to reach easily the liver edge and to perform a biopsy (Fig. 2). The use of rigid biopsy forceps favored good tissue sampling as evidenced in the video. It should also be noted that bowel loops were easily

Fig. 1 Endoscopic view of upper abdominal organs provided by a ureteroscope

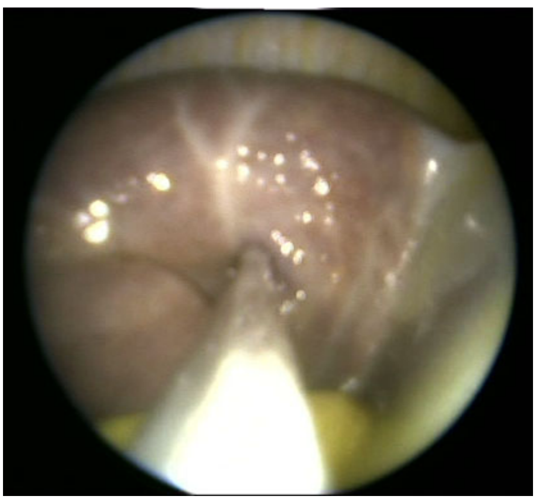

Fig. 2 Representative endoscopic views of liver biopsy

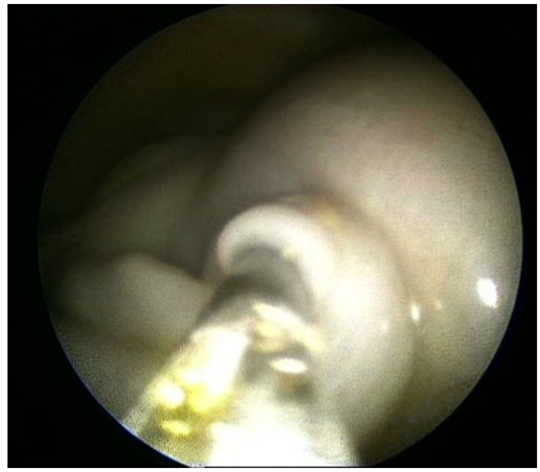

Fig. 3 Manipulation of the ileocecal appendix with the forceps introduced by the ureteroscope working channel

Fig. 4 Endoscopic view of the bladder orifice at the end of the procedure

mobilized by using forceps, without the need to change the position of the cadaver. It was also possible to identify the various segments of the intestine and the ileocecal appendix with its subsequent manipulation (Fig. 3).

At the end of the procedure the bladder orifice maintained the same diameter it had at the beginning of the procedure, i.e., a diameter of about 10 Fr (Fig. 4).

Discussion

The current study shows that peritoneoscopy with liver biopsy and ileocecal appendix manipulation is feasible in a human cadaver model by using rigid instruments exclusively through a transvesical approach.

Transvesical access to the abdominal cavity either alone or in combination with transgastric access has been used for a broad range of procedures such as peritoneoscopy, liver biopsy, lung biopsy, cholecystectomy, nephrectomy, and partial cystectomy [7–12]. More recently, Gettman et al. [13] reported the clinical feasibility of transvesical peritoneoscopy by using a flexible ureteroscope (DUR-8) during a case of robotic radical prostatectomy. They used the same technical mode of transvesical approach in a porcine model with a few modifications. However, in this study it was recognized that the flexibility of the scope was a disadvantage and a limitation mainly when applying force to tissue because it was very difficult to both push and pull at the same time. In fact, it was recognized that fixation and stiffening of the endoscope will be essential for transluminal procedures.

After performing a transvesical procedure, closure of the bladder hole is not thought to be necessary if bladder drainage is assured. Nevertheless, the development of an effective closure method might enable widespread adoption of the transvesical route in NOTES. This was the rationale for Lima et al. [14], who reported the usefulness, the feasibility, and the safety of endoscopic perforation closure with an endoscopic suturing kit (T-fasteners with a locking cinch system) in a survival porcine model. The authors concluded that this method for closing bladder perforations could be clinically applicable in NOTES procedures. More recently, Metzelder et al. [15] closed bladder perforations after five nephroureterectomies with an endoloop via a 15-mm umbilical trocar with the assistance of a 2-mm transurethrally placed endoscopic clamp.

Thus, the transvesical approach has been shown to be an excellent way to access the peritoneal cavity by providing several advantages: (1) it is naturally sterile, (2) its location is advantageous, i.e., it in the most anterior portion of the pelvic cavity allowing peritoneal access above the bowel loops, (3) it is possible to introduce rigid instruments via the working channels of the scopes, thus enhancing the possibility of retracting and grasping structures, (4) pneumoperitoneum is achieved quickly and easily, (5) the procedure can be performed on both genders. The unique disadvantage is that the diameter of the urethra limits the size of the devices used and the size of the specimen retrieved at the end of the procedure. Despite these potential advantages, several issues remain to be answered: (a) Would it be possible to use rigid instruments through the transvesical port in a human model? (b) Would it be possible to obtain images with the same clearness of the abdomen in the human model? (c) Would it be possible to easily handle and even perform procedures in the human model using rigid instruments through the transvesical port?

Our study revealed that it was easy to perform vesical access to the peritoneal cavity with the current rigid ureteroscope. Perforation of the bladder wall was rapid, easily manageable, and safe. It should be emphasized that the image provided by the ureteroscope allowed us to have a good view of the perivesical anatomy and to achieve the parietal peritoneum easily and then the peritoneal cavity. After entrance into the peritoneal cavity, saline irrigation was replaced by CO_2 insufflation and the ureteroscope working channel allowed the creation of a pressure-controlled pneumoperitoneum with a maximum pressure of 12 mmHg, as in swine experiments.

Regarding peritoneoscopy, we were able to identify easily the whole abdomen with good image quality. The length of ureteroscope used (43 cm) reached the edge of the liver so that we could perform biopsies without problems. However, this ureteroscope length was not suitable for reaching the upper portion of the liver and diaphragm. The forceps introduced through the ureteroscope's working channel allowed manipulation of the bowel loops and ileocecal appendix easily and without complications.

Current ureteroscopes were developed for diagnostic and therapeutic procedures in the urinary tract so they are far from ideal for use in a transvesical port. They have several restrictions limiting their capabilities: (1) their image quality is far from ideal, (2) they are short (biomedical engineering needs to develop longer scopes and instruments), (3) their working channels usually have small diameters which limits the size of instruments that can be used with them (the endoscope shaft should contain a larger channel so other instruments can be introduced with better efficiency, and (4) the current rigid ureteroscope is fine but the axis between the pelvis and abdomen suggests that there should be a slight curve in the endoscope to allow better visualization of other organs that are not in the axis where the scope is introduced.

In conclusion, peritoneoscopy, liver biopsy, and ileocecal appendix manipulation using a rigid ureteroscope through a transvesical port is feasible in a human male cadaver. The development of a specific rigid scope for a transvesical port might herald a promising future for this NOTES access.

Disclosures Frederico Branco, Giovannalberto Pini, Luís Osório, Victor Cavadas, Rui Versos, Mário Gomes, Riccardo Autorino, J. Correia-Pinto, and Estevao Lima have no conflicts of interest or financial ties to disclose.

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