



## Surgery in Motion

# Retroperitoneal and Transperitoneal Robot-Assisted Pyeloplasty in Adults: Techniques and Results

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### Abstract

**Background:** The surgical management of ureteropelvic junction obstruction (UPJO) has dramatically evolved over the past 20 yr due to the development of new technology.

**Objective:** Our aim was to report the feasibility and efficacy of robot-assisted pyeloplasty (RAP) performed by either the retroperitoneal or the transperitoneal approach. **Design, setting, and participants:** A stage 2 investigative study was conducted including development (stage 2a) and exploration (stage 2b) of transperitoneal and retroperitoneal RAP performed in 55 patients at an urban tertiary university department of urology.

**Surgical procedure:** Retroperitoneal RAP was performed with the patient in full flank position using a 12-mm Hasson-style optical port at the tip of the 12th rib, plus two operative 8-mm robotic trocars and an assistant 5-mm port. The stenotic ureteropelvic junction was excised, the ureter was spatulated, and a dismembered pyeloplasty was performed in all cases. Transperitoneal RAP was performed with the patients in the 60° flank position. The optical port is in the umbilical area, plus two 8-mm operative robotic ports and one 5-mm assistant port. The pyeloplasty technique is similar to the retroperitoneoscopic approach. In both groups, the stent can be positioned in an antegrade or retrograde fashion.

**Measurements:** Success consisted of no evidence of obstruction on computed tomography urography or mercaptoacetyltriglycine-3 diuretic renal scan, no postoperative symptoms, and no further treatment.

**Results and limitations:** Thirty-six patients underwent retroperitoneoscopic RAP and 19 transperitoneal RAP for UPJO. All the procedures were completed with robotic assistance. The overall objective success (measured by diuretic renal scan and/or imaging techniques) was 96% with two cases of recurrence (both in the retroperitoneal group). The main limitation was the short follow-up, although all patients reached at least a 6-mo follow-up.

**Conclusions:** RAP performed either retroperitoneally or transperitoneally was revealed as a feasible and reproducible surgical option for the treatment of UPJO, offering a subjective optimal plasty reconfiguration at short follow-up.

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## 1. Introduction

The surgical management of ureteropelvic junction obstruction (UPJO) has dramatically evolved over the past 20 yr due to the development of new technologies. Since its introduction into clinical practice in 1993, laparoscopic pyeloplasty (LP) [1] has progressively gained popularity and acceptance in the urologic community and has become a well-established surgical option for UPJO treatment [2–5]. The long-term results are comparable with those of open surgery with success rates ranging from 90% to >95% [6–8].

LP is performed using both the transperitoneal [9,10] and retroperitoneal approaches [5,11]. Nevertheless, it remains a technically demanding procedure requiring high proficiency in laparoscopic suturing and endoscopic skills. Thus with its dependence on extensive and precise intracorporeal suturing, LP is one of the laparoscopic procedures most likely to benefit from robotic assistance. In the last 5 yr, the worldwide spread of robotic surgical machines, such as the da Vinci system (Intuitive Surgical, Inc, Sunnyvale, CA, USA), has changed the way urologists approach complex laparoscopic reconstructive procedures.

Robot-assisted pyeloplasty (RAP) is usually performed by the transperitoneal approach [12–15], even though recent reports have stated the retroperitoneal robot-assisted LP approach is feasible and efficient [16,17]. In this study we have investigated the feasibility and efficacy of RAP performed via either the retroperitoneoscopic route or the transperitoneal approach, with a particular focus on the surgical details of the two procedures, the indications for each approach, the subsequent advantages and disadvantages, and follow-up.

## 2. Methods

We report a stage 2 investigative nonrandomized study including development (stage 2a) and exploration (stage 2b) [18] of transperitoneal and retroperitoneal robot-assisted LP performed between October 2007 and October 2009 at our urban tertiary university department of urology. The results from imaging techniques, mercaptoacetyltriglycine (MAG)-3 diuretic renal scans, and the presence of symptoms (eg, recurrent flank pain, fever, and recurrent urinary tract infection episodes) verified the need for surgical intervention for UPJO. Success rates were determined both by the subjective improvement of symptoms as well as the objective evidence showing the absence of the obstruction through a diuretic renal scan and/or imaging techniques. The follow-up program included an abdominal ultrasound, urinalysis and a urine culture after 1 mo, as well as a computed tomography urography and MAG-3 diuretic renal scan after 6 mo. Ultrasound was repeated annually, and an evaluation of symptom relief at each follow-up visit was done.

Elective criteria for a transperitoneal approach included previous renal surgery (excluding endopyelotomy), a wide pelvis (ie, >6 cm in diameter), concomitant multiple or large renal stones, pelvic kidney and horseshoe kidney, and cases where imaging showed a potential vascular crossing.

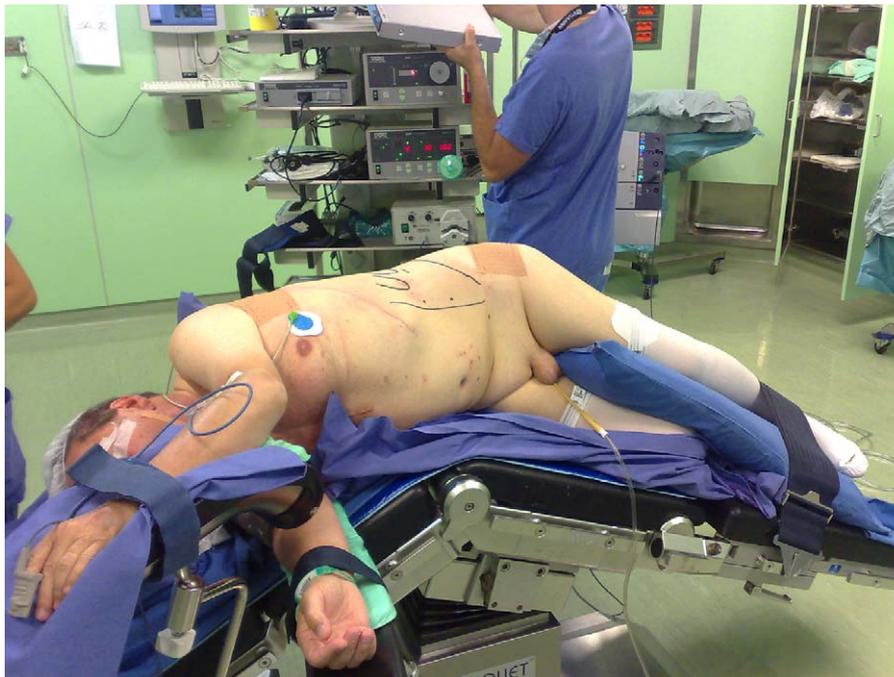
In the other cases of ureteropelvic junction (UPJ) repair, the decision whether to use a transperitoneal or retroperitoneoscopic approach was based on the surgeon's preference. Complications were reported according to the Clavien-Dindo classification system [19].

Patients signed an informed consent before surgery and were especially made aware of the possibility that the surgery might be converted into traditional LP or open surgery.

### 2.1. Surgical technique

#### 2.1.1. Retroperitoneoscopic robot-assisted pyeloplasty

Patients were positioned in the full flank position, with the bed flexed to bridge the surgical area and to increase the space between the iliac crest and the costal arch (Fig. 1). The retroperitoneum was bluntly entered at the tip of the 12th rib using two S retractors through a 1.5-cm skin



**Fig. 1** – Patient positioning for retroperitoneoscopic robot-assisted pyeloplasty. The patient is positioned in full flank position with the bed flexed (30°) to widen the space between the costal arch and the iliac crest.

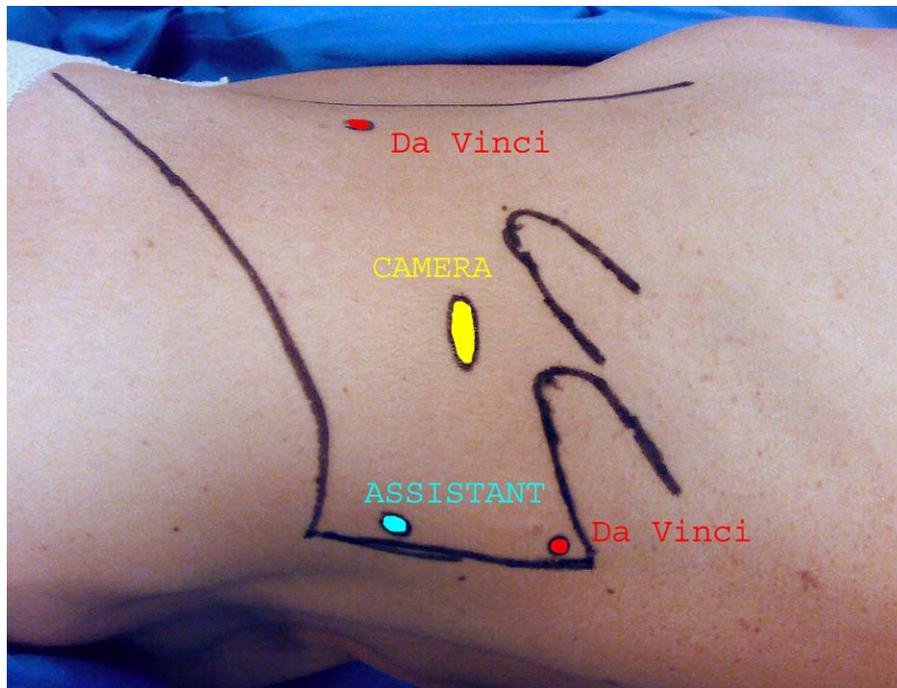


Fig. 2 – Port placement for retroperitoneoscopic robot-assisted pyeloplasty: The patient's head is at the right side of the picture.



Fig. 3 – Da Vinci standard position for retroperitoneoscopic robot-assisted pyeloplasty. The robotic arm system enters anteriorly approximately 25° from the head of the patient.

incision. The retroperitoneal space was created by using balloon dissection using our previously described technique [20]. Port placement is shown in Fig. 2. The 12-mm Hasson-style optical port was positioned at the tip of the 12th rib. The other two operative 8-mm robotic trocars were positioned at the conjunction of the 12th rib with the “erector spinae” muscle and at the level of the anterior axillary line 6–8 cm cranially to the iliac crest, respectively. The assistant 5-mm port was positioned along the erector spinae muscle, some centimeters cranially to the iliac crest, and was used for suction, retraction, and needle insertion/removal. The da Vinci robotic system was then positioned as shown in Fig. 3 with the arms entering 25–30° anteriorly to the head of the patient. A 30° optic was always used. Gerota’s fascia was longitudinally incised to widen the surgical area and to directly expose the target structures, such as the ureter, the dilated renal pelvis, and the stenotic UPJ.

Robotic bipolar forceps and monopolar scissors were used to dissect the proximal ureter and the dilated renal pelvis. The stenotic UPJ was excised; the ureter was then spatulated longitudinally and the pyeloplasty performed according to the Anderson-Hynes technique [21]. The plasty was performed with an interrupted 5-0 Vicryl suture with an RB2 curved needle in the first 12 patients. In the last series, the plasty reconfiguration was performed using running sutures to fasten the procedure. The posterior aspect of the anastomosis was performed, and then the double pigtail ureteral stent was inserted. Once the stent was correctly positioned, the anterior aspect of the anastomosis was completed. At the end of the procedure, once complete hemostasis was achieved, a suction drain was left in place. In the case of a crossing vessel, a dismembered pyeloplasty with transposition of the reanastomosed ureter ventral to the vessels was performed.

#### 2.1.2. Transperitoneal robot-assisted pyeloplasty

Patients were positioned in a 60° flank position with the bed flexed (Fig. 4). Pneumoperitoneum was induced with the Hasson technique, typically in the umbilical area for aesthetic reasons. In obese patients the optical port was positioned on the pararectal line 2.3 cm cranially to the umbilicus. Fig. 5 shows the port placement in the case of transperitoneal



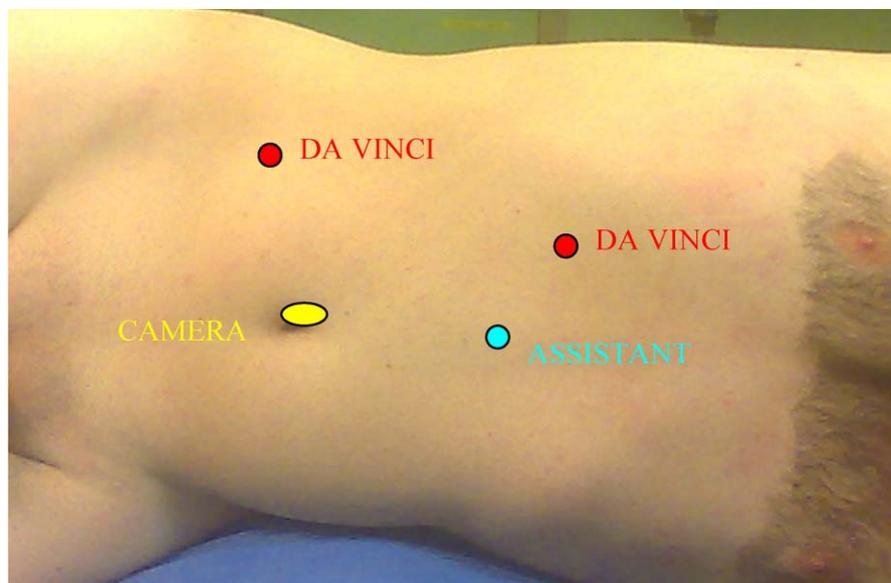
**Fig. 4 – Patient positioning for transperitoneal robot-assisted pyeloplasty. The patient is positioned in a 60° flank position, and the bed is slightly flexed to better expose the surgical field.**

RAP. The two operative robotic ports are positioned respectively at the midpoint between the anterior superior iliac spine and the umbilicus and on the pararectal line 1 cm beyond the costal arch. The 5-mm assistant port is positioned on the midline at the midpoint between the umbilicus and the xiphoid process. A 30° laparoscope (down) is routinely used. In Fig. 6 the robot arms positioning for transperitoneal pyeloplasty is shown. The right side of the parietal peritoneum, overlying Gerota's fascia, is incised, and the target structures (the ureter, the dilated renal pelvis, and eventually the aberrant crossing vessels) are exposed. On the left side, typically the white line of Toldt is incised and the left colon is mobilized medially to expose Gerota's fascia, which is incised isolating the target structures. In slender patients with a dilated pelvis, a

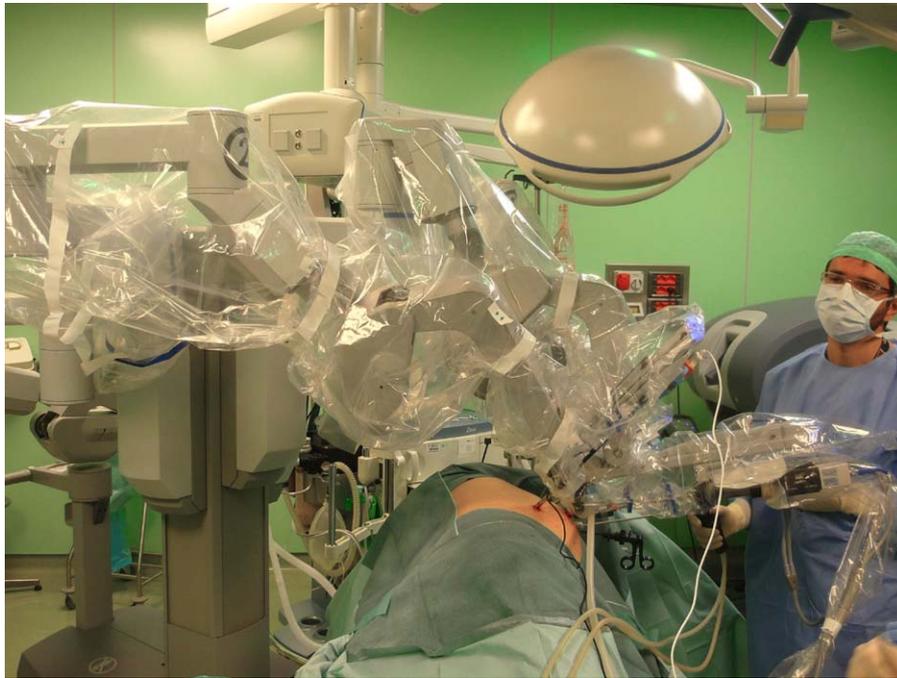
transmesocolic approach can be used to directly reach the target structures. The pyeloplasty technique is similar to what has already been described when performing the retroperitoneoscopic approach.

### 2.1.3. Stent positioning

The double pigtail ureteral stent can be inserted in an antegrade or retrograde fashion. In cases of antegrade insertion, the bladder is filled with 150 ml of saline with drops of indigo blue before stent insertion to have adequate bladder distension for optimal stent placement. Filling the bladder with saline also allows us to check the correct distal positioning of the stent thanks to the reflux of blue drops from the upper tip of the stent in the surgical area. In cases of retrograde insertion, the



**Fig. 5 – Port placement for transperitoneal robotic pyeloplasty.**



**Fig. 6 – Da Vinci S HD position for transperitoneal robot-assisted pyeloplasty. The robotic arm system enters from the back of the patient approximately 45° from the head.**

procedure is performed using a flexible cystoscope that does not require modifying the position of either the patient or the robot. Total operative time is defined as the first skin incision to the last stitch (Fig. 6).

### 2.2. Postoperative care

The indwelling catheter is removed on postoperative day 2. The drain is removed the following day after catheter removal on the condition that the output is <50–60 ml. Patients are then discharged from the hospital.

The patient is seen 4 wk following the procedure and assessed via an abdominal ultrasound, urine culture, and urinalysis. The stent is usually removed at this time.

## 3. Results

Since October 2007, 55 patients have undergone retroperitoneal (group A;  $n = 36$ ) or transperitoneal (group B;  $n = 19$ ) RAP for UPJO. Table 1 summarizes the demographic characteristics. All procedures were completed using

robotic assistance. In both groups, port placement results proved to be adequate with no “chasing swords” phenomenon (the conflict of robotic arms into the operative space), and the surgical field was wide enough for optimal robotic dissection of the target structures for suturing during the plasty reconfiguration. Table 2 lists the intraoperative and perioperative results of the two groups of patients.

In all patients with renal stones, it was possible to resolve the lithiases intraoperatively, in both the retroperitoneal and transperitoneal groups, as a result of the intraoperative pyeloscopy.

Due to the presence of crossing vessels, the transposition of the ureter was performed in three patients in the retroperitoneal group (where the crossing vessel was not evident at the preoperative imaging) and four patients in the transperitoneal group.

The mean time of indwelling catheter was similar in both groups. The drain was removed the day after catheter removal in all patients in the absence of urinary fistulas.

**Table 1 – Demographics of patients submitted to retroperitoneoscopic (group A) and transperitoneal (group B) robot-assisted pyeloplasty**

	Group A	Group B
Patients, $n$ (male/female)	36 (20/16)	19 (9/10)
Mean age, yr (median)	40 ± 16.1 (38)	42 ± 18.36 (43)
Side	23 R/13 L	8 R/11 L
Concomitant renal stones, $n$ *	3	7
Previous UPJ surgery <sup>†</sup>	2	2
Body mass index (median)	22.25 ± 3.93 (21)	23.75 ± 4.08 (22.7)
Symptoms	Flank pain: 18 patients; UTI: 2 patients	Flank pain: 12 patients; UTI: 3 patients

L = left; R = right; UPJ = ureteropelvic junction; UTI = urinary tract infection.

\* In the retroperitoneal group, the stones were single, located in the pelvis, and <1 cm in diameter.

† Two cases of failed endopyelotomy in the retroperitoneal group and one case of failed endopyelotomy and one case of failed laparoscopic pyeloplasty in the transperitoneal group.

**Table 2 – Operative and early postoperative findings of patients who underwent retroperitoneoscopic (group A) and transperitoneal (group B) robot-assisted pyeloplasty**

	Group A	Group B
Operative time, min (median) <sup>*</sup>	139.57 ± 46.17 (125)	137.5 ± 41.13 (125)
Decrossing of aberrant crossing vessels	3 <sup>†</sup>	4
Catheterization time, d (median)	2.26 ± 1.14 (3)	2.13 ± 0.74 (3)
Drain removal, d (median)	3.2 ± 1.16 (4)	3.1 ± 0.70 (3)
Hospital stay, d (median)	3.6 ± 1.38 (4)	3.7 ± 0.56 (5)
Recurrence, <i>n</i>	2	0
Mean follow-up, mo (median)	16.86 ± 5.89 (18)	16.95 ± 5.64 (6)

<sup>\*</sup> Operative time included da Vinci docking time during the procedure.  
<sup>†</sup> Not evident at standard preoperative imaging.

No significant surgical perioperative complications were reported; one patient had transitory hyperpyrexia treated with antipyretics (Clavien–Dindo grade I). Moreover, after 4 wk, the ultrasound evaluation and urine culture were negative in all patients, and stent removal was possible in all cases.

All patients reached at least a 6-mo follow-up; the mean follow-up was 16.86 ± 5.89 mo in group A and 16.95 ± 5.64 mo in group B. The overall objective success (measured by diuretic renal scan or intravenous urography) was 96%, with two patients in group A showing a recurrence of UPJO, whereas no objective failure was observed in the patients in group B. The two cases with recurrence of UPJO were successfully treated with open pyeloplasty (one patient) or endopyelotomy (one patient) 6 mo after the robotic procedure.

#### 4. Discussion

Although dismembered open Anderson–Hynes pyeloplasty shows high success rates, its morbidity is not negligible. Over the last few years, technological advances have allowed the introduction of minimally invasive (endoscopic and laparoscopic) techniques with the aim of maintaining the same functional results of classic open surgery and reducing morbidity. Endoscopic approaches were initially promising, but unfortunately the long-term success rates were lower than those reported for open pyeloplasty [22]. The success rate of endopyelotomy was 33.9% in patients with crossing vessels. A greater risk of developing fibrosis and subsequent restenosis was also prevalent [23] even though the success rates had increased in peculiar clinical conditions such as a high ureteral insertion. LP proved to duplicate the open technique, and long-term results were equivalent to those of open surgery [6–8]. Although experience and training have resulted in shorter operative times and lower complications, the major disadvantage of the LP is the fact that it is technically more challenging due to the high proficiency level needed for intracorporeal suturing [24,25]. The introduction of the da Vinci robotic system in the urologic field has expanded the breadth of UPJO repair yet at the same time has preserved the benefits of minimally invasive techniques, allowing the novice laparoscopist to perform UPJO surgery reproducibly and with short learning curves [26].

RAP is predominantly performed using the transperitoneal approach because of the bulky aspect of the da Vinci system and the friendlier vision of anatomy for the laparoscopists of the intraperitoneal anatomy [12–15]. Ten cases of retroperitoneal dismembered RAP in the adult population have only recently been reported by Kaouk et al [17], although it had already been described in the pediatric population by Olsen and Jorgensen [16].

The advantages of the retroperitoneal approach may be (1) direct access to the target structures, (2) minimized risk of injury to intraperitoneal organs, and (3) allowance for a conservative treatment in urinary fistula cases or anastomotic leakage because urine does not come into contact with the peritoneal cavity and organs. Furthermore, it may be used successfully in morbidly obese patients with body mass index >30 because the full flank position and the flexion of the surgical table allow for an anterior passage through both the subcutaneous and abdominal fat. This facilitates the surgical procedure compared with the transperitoneal approach. Nevertheless, retroperitoneoscopy has some disadvantages; the proper recognition of anatomic landmarks can be more difficult, especially at the beginning of the retroperitoneoscopic experience. The surgical field may become reduced compared with the transperitoneal approach and subsequently with the potential closeness of the operative ports. Finally, with the retroperitoneal approach it can be more difficult to properly judge the role of a crossing vessel in the obstruction and whether the vessel must be decrossed or not, especially at the beginning of the experience.

The RAP technique continues to develop, and some variations of this technique deserve to be mentioned. For example, using the retroperitoneal approach, the robot positioning in our series differs from the pediatric technique [18] because it enters anteriorly and from the head of the patient rather than from the back. This allows adequate space at the level of the surgical field so the assistant can work comfortably during the entire procedure. Kaouk et al reported a similar position, although port placement is slightly different because the assistant port is positioned anteriorly [17]. In our experience, we found the assistant trocar positioned more posteriorly may reduce the risk of conflicts with the robotic arm system during the procedure. Currently, the transperitoneal approach of the robot and port placement technique is well described, and the various

authors report a similar technique in their series. We suggest a cranial positioning of the assistant port to ease the antegrade stent positioning.

Among the elective indications for a transperitoneal approach, there is redo pyeloplasty in cases of UPJO recurrence after open pyeloplasty or LP.

The transperitoneal approach allows for a wider operative field and a friendlier approach compared with the retroperitoneal one in cases of surgical repair of previously failed pyeloplasty [27]. Hemal et al supported the use of robot-assisted redo LP because it allows meticulous dissection, better delineation of the previous scarred tissue, preservation of the periureteral sheath containing blood supply to the ureter, clean and fine fashioning of ureteral and pelvic flaps, and finally, a watertight anastomosis with fine sutures [27]. In our experience, patients with failed endopyelotomy can be successfully treated with both the retroperitoneal and transperitoneal approaches without experiencing particular difficulties or disadvantages of one approach compared with the other.

It has been reported that 38–71% of patients with UPJO have crossing vessels, although these vessels were noted in only 20% of patients with a normal UPJ [28]. Nevertheless, significant controversy persists regarding UPJO management in the presence of crossing vessels and the importance of crossing vessels in the outcome of surgical treatment. Traditionally, dismembered pyeloplasty with transposition of the UPJ anastomosis to the anterior side of the crossing vessel has been the conventional treatment. However, it is improbable that the crossing vessel alone can cause a real UPJO because the real etiology is typically a primary lesion of the UPJ that causes dilation and ballooning of the renal pelvis over the aberrant vessel, thus worsening the clinical status. We have found that it is possible to transpose the ureter even with the retroperitoneal approach. The EndoWrist and robotic technology allow for an adequate plasty reconfiguration even in challenging conditions. When the retroperitoneoscopic approach is performed, the kidney is pushed medially and anteriorly during the ancillary maneuvers for retroperitoneal cavity creation. However, the transperitoneal approach for UPJ cases makes it much easier to judge whether the crossing vessel should be decrossed or not during the procedure because the kidney is left untouched in its anatomic position.

Even though some surgeons use retrograde stenting to prevent stent malpositioning, we prefer using an antegrade stenting. Mufarrij et al [26] reported that only 6 of 99 patients who were stented anterogradely required ureteroscopy to reposition the stents, which led to increased anesthesia time and a risk of manipulation or disruption of the reconstructed UPJ. In three of our patients treated with the retroperitoneal approach, the antegrade positioning of the stent was not possible due to some difficulties. In those cases a flexible cystoscope was used using retrograde positioning, avoiding patient repositioning during the procedure as well as avoiding a significant increase of operative time.

Due to the limited working field offered by the retroperitoneal route, our experience shows that the antegrade stent

positioning appears easier with the transperitoneal approach compared with the antegrade stent positioning in the retroperitoneal approach. Moreover, the typical cranial position of the assistant port in the transperitoneal approach (although this port positioning may create some conflicts during the dissection phase of the procedure on the right side for a right-handed surgeon) eases the antegrade stent positioning compared with the more posterior and caudal position of the assistant port in the retroperitoneal approach.

We experienced two cases of UPJO recurrence. Both cases were in the retroperitoneal group and were diagnosed at a 6-mo follow-up. Failures occurred in the first 10 patients. One case was related to an unrecognized crossing vessel (the one treated with open surgery due to the patient refusing a new laparoscopic procedure); in the other, an endopyelotomy was sufficient to widely open the stenotic ring. After a review of imaging and audio recording of the procedure, we do not think that the failures were correlated to technical suturing problems or the reduced working field offered by the retroperitoneal approach. The main limitation of our study was the short follow-up due to the evolution from one technique to another. Despite the fact that failures after 6 mo are rare, according to our observations and the observations of Inagaki et al, longer follow-up is mandatory [29].

## 5. Conclusions

RAP performed either retroperitoneally or transperitoneally was shown to be a feasible and reproducible surgical option for the treatment of UPJO, offering a subjective optimal plasty reconfiguration at short follow-up.

**Author contributions:** Andrea Cestari had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

**Study concept and design:** Cestari, Guazzoni, Lazzeri.

**Acquisition of data:** Cestari, Lista.

**Analysis and interpretation of data:** Cestari, Guazzoni, Buffi, Lazzeri.

**Drafting of the manuscript:** Cestari, Buffi, Guazzoni, Lazzeri.

**Critical revision of the manuscript for important intellectual content:** Guazzoni.

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**Other (video editing):** Buffi, Fabbri, Scapaticci, Sangalli.

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## Appendix A. Supplementary data

The Surgery in Motion video accompanying this article can be found in the online version at [doi:10.1016/j.eururo.2010.07.020](https://doi.org/10.1016/j.eururo.2010.07.020) and via [www.europeanurology.com](http://www.europeanurology.com). Subscribers to the printed journal will find the Surgery in Motion DVD enclosed.

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