Original Article

Techniques in minimally invasive transperitoneal pyeloplasty: A compilation

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Abstract

Context: Minimally invasive management (laparoscopic/robot assisted) is currently the standard of care for managing pelvi ureteric junction obstruction (PUJO). Open techniques of management of PUJO are well described in literature. However, there appears to be relative lack of description of minimally invasive techniques in the literature.

Objective: This article is aimed at describing in detail, with images, the various techniques and modifications in laparoscopic or robot-assisted management of PUJO.

Evidence Acquisition: A review of literature on PubMed was performed and all articles which detailed any technique of minimally invasive pyeloplasty were included.

Evidence Synthesis: The various techniques of minimally invasive pyeloplasty as well as the authors' techniques are compiled and described in detail with intraoperative images.

Conclusions: Operative techniques of minimally invasive pyeloplasty are not well described in literature. We have attempted to present a comprehensive resource of different techniques of minimally invasive pyeloplasty and the clinical scenarios in which they may be appropriate. This should prove to be a useful reference to the practicing urologist.

Patient Summary: In this paper, we have compiled the various surgical techniques of treating obstruction at the PUJ of the kidney along with intraoperative photograph.

Keywords: Compilation, pyeloplasty, techniques

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INTRODUCTION

Pelvi ureteric junction obstruction (PUJO) is a common cause of hydronephrosis.[1] An adynamic segment of PUJ leading to impeded flow of urine from the renal pelvis to ureter is thought to be the cause of PUJO.[2] Initially, Fenger pyeloplasty and flap pyeloplasties were described for the surgical management of PUJO.[3,4] Later, dismembered pyeloplasty was described by Anderson and Hynes (AH) and was rapidly adopted by the urological community all over the world, having excellent short- and long-term results.[5] The rapid adoption of laparoscopy and robot-assisted surgery have revolutionized the management of PUJO. These minimally invasive techniques have strived to replicate the technique of pyeloplasty as done by the open

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method. However, due to the unique nature of minimally invasive surgery, viz., two-dimensional vision (laparoscopy), fixed ports, and rigid instruments (laparoscopy), it may not be possible to exactly replicate the steps of the operation as applied in open surgery. Many complex situations demand modifications in technique to achieve a successful outcome. Here, we attempt to compile and describe the various techniques which may be useful in minimally invasive pyeloplasty, together with the different scenarios in which these techniques may be utilized.

TECHNIQUES

Dismembered (Anderson Hynes) pyeloplasty

This is the most popular technique of pyeloplasty, first described by AH, two plastic surgeons in 1949.[5] The technique offers many advantages over other methods, viz., excision of the adynamic segment of PUJO, circumventing lower pole crossing vessels by transposing the PUJ anterior to the vessels, and reduction of the pelvis in cases of dilated redundant pelvis. The long-term success rate of minimally invasive AH pyeloplasty is over 90%.[6] In cases of redo AH pyeloplasty for previous failed pyeloplasty, the result is 77.8%–100%.[7]

The technique has been well described in various articles. Briefly, the pelvis and the ureter are dissected circumferentially and mobilized. A pyelotomy is done from the superomedial aspect to the inferolateral aspect of the pelvis. The anterior wall of the pelvis is excised slightly more than the posterior wall. The adynamic segment of the PUJ is excised. The ureter is spatulated on its lateral aspect. The inferolateral angle of the pyelotomy is advanced and anastomosed to the apex of the ureteric spatulation. Sometimes, it is difficult to anastomose the inferolateral angle of the pelvis to the ureter without tension. In such cases, keeping a slightly larger posterior wall (as described above) is beneficial. This allows the dependent part of posterior wall to be brought down comfortably without tension and complete the anastomosis in a tension free manner. Another advantage of keeping the posterior wall slightly larger is that in cases of a crossing vessel, the pelvi-ureteric anastomosis can be performed below the vessels and not exactly at the level of the vessels. Both walls of the anastomosis are completed with a continuous absorbable suture, preferably 4-0 or 5-0. An abdominal drain is placed at the discretion of the surgeon. At follow-up, the stent is removed at 4 weeks of surgery. A renal isotope scan is done after 3 months of operation to document satisfactory drainage.

Although the technique has been well described, a few points need attention [Figure 1a-h]. We prefer to place the laparoscopic working ports at approximately 150-degree angle to the camera port.[8] This keeps the ports near the horizontal axis of the anastomosis which is very helpful for suturing. A stay suture of 1-0 monofilament nonabsorbable on a large cutting needle (straight needle) through the anterior wall of the pelvis and fixed transabdominally may help with the retraction of the anterior wall of the pelvis. It also helps in visualization in cases where a small pelvis tends to recede behind the hilar vessels after pyelotomy. Finally, it keeps the posterior wall taut, enabling easier intracorporeal suturing.

The spatulation on the ureter should be performed with a straight scissor. Spatulation should be done with the jaws of the scissor open, much like how a tailor cuts the cloth. This ensures a clean cut without ragged edges. Spatulation is adequate when longitudinal folds of ureteric mucosa are visualized and the edges of the ureteric wall fall apart like an open book. Usually, spatulation length equal to the scissor jaw length (approx. 1.5 cm) is considered adequate.

The initial few stitches of the pelvis to the ureter near the apex of the ureteric spatulation should be interrupted. Stitch on the apex of the spatulation should be avoided

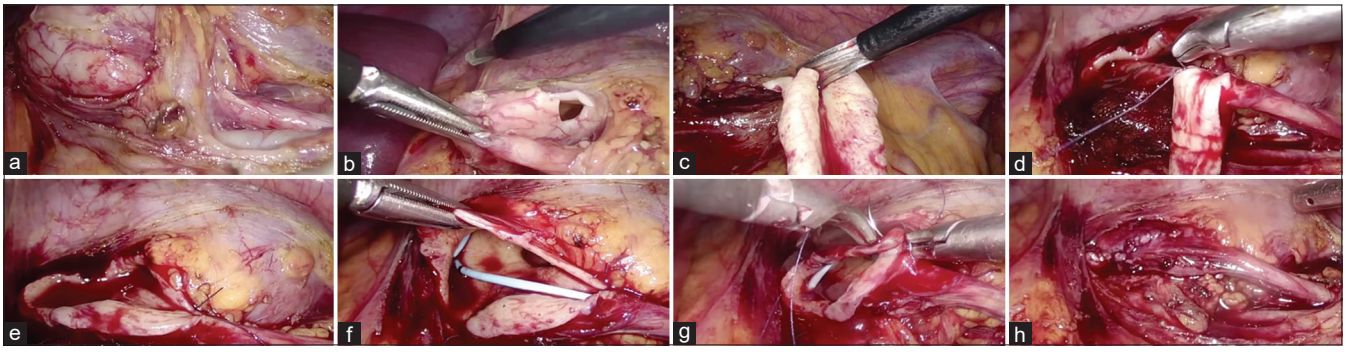

Figure 1: Anderson Hynes pyeloplasty. (a) Initial appearance of pelvi ureteric junction obstruction due to crossing vessels. (Pelvis to left, ureter to right), (b) Pyelotomy, (c) Spatulation of ureter, (d) First stitch from angle of ureteric spatulation to lowermost part of pelvis, (e) View after completion of posterior wall, (f) DJ stent placed after completion of posterior wall, (g) Anastomosis of anterior wall started, (h) Final appearance after pyeloplasty

and stitches should be taken on either side of the apex. This is because the apex of the spatulation is the most critical area of the new pelvi-ureteric anastomosis and avoiding any stitch on the apex prevents any obstruction or stricture in this area.

In cases of tension when approximating the pelvis with ureter, it is advisable to start the suturing not at the apex but from the posterior wall and come up to the apex. This avoids initial tension and possibility of suture cut-through near the apex, which is the most critical part of the anastomosis.

Postanastomotic dismemberment technique

This is a variation of the dismembered pyeloplasty where complete excision of the PUJ is avoided, the pelvis is transected except at the superior part which is left attached [Figure 2]. The ureter is spatulated and the dependent part of pelvis is anastomosed to it. Once the posterior layer is finished, the attachment of pelvis with ureter is transected and then the anterior layer is anastomosed. The advantage is that undue tension in the first sutures of the anastomosis is avoided.[9] Furthermore, with this technique, orientation of the ureter is maintained without torsion, as one end of the spatulated ureter is still attached. This technique is especially valuable in cases of a small pelvis.

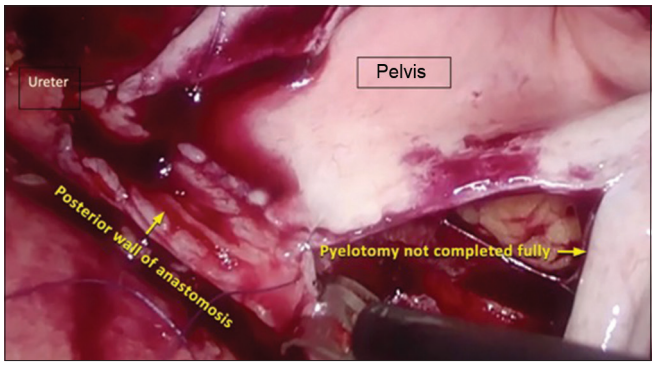

Figure 2: Post anastomotic dismemberment

RENAL DESCENSUS

This involves mobilization of the kidney from its superior and lateral attachments, so that the kidney and along with it, the pelvis, moves caudally. This is valuable in cases of PUJO with long-segment ureteric narrowing, where a long length of ureter may need to be excised. Renal descensus allows the pelvis to be anastomosed to the ureter without undue tension in such scenarios.

Y-V PLASTY [FIGURE 3A-G]

Y-V plasty may be used in scenarios where the dismembered pyeloplasty is expected to result in undue tension when anastomosing the pelvis with ureter. Such scenarios may be encountered in: redo pyeloplasty, high insertion of ureter with small intrarenal pelvis, malrotated kidney or ectopic kidney. For ease of discussion, we have named the parts of the y-shaped flap as shown (both short limbs and long stem, apex) [Figure 2]. In open pyeloplasty, a lateral y shaped flap of the renal pelvis is raised. However, this configuration of the pelvic flap in minimally invasive techniques is difficult to achieve; hence, anterior wall-based pelvic flaps are used. Both the short limbs of the Y are marked on the anteromedial surface of the pelvis as shown. The apex of the short limbs is at the PUJ. From the apex, the long stem of the Y is made as a longitudinal incision on the ureter. Finally, the apex of the y is advanced into the ureteral incision and the flap closure is completed, giving the final "V" shaped appearance. In a small pelvis with high ureteral insertion, a classical Foley Y-V plasty with a lateral pelvic flap is possible.

VERTICAL FLAP

Vertical flap pyeloplasty is particularly suitable for performing pyeloplasty in a low lying ectopic kidney [Figure 4a-h]. Usually, such kidneys are situated at the

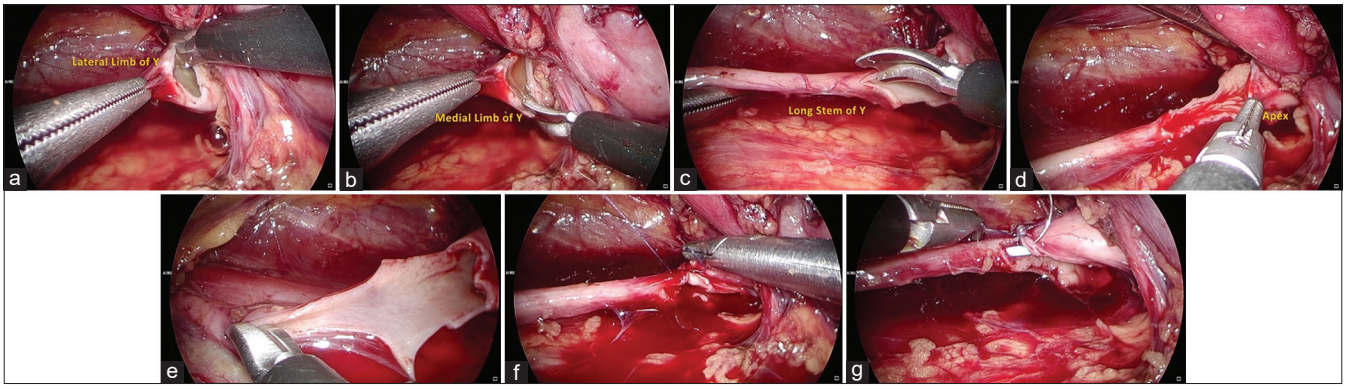

Figure 3: Y-V plasty. (a) Lateral limb of Y flap being made on pelvis (Pelvis to right, ureter to left), (b) Medial limb of Y flap, (c) Long stem of Y made on ureter, (d) Apex of pelvic flap formed by medial and lateral limbs of Y flap, (e) Spatulation on ureter being further extended, (f) Apex of Pelvic flap being advanced and sutured, (g) DJ stent placed before completing the anastomosis

level of the pelvic brim, with the ureter following the curve of the sacrum and coursing posteriorly relative to the kidney. When "looking" at the kidney from the superior aspect, as is the case in minimally invasive approaches, it may be difficult to perform the traditional Anderson Hynes dismembered pyeloplasty. In such cases, a vertical flap of the pelvis is raised as shown. The ureter is incised longitudinally beginning from the lower margin of the vertical flap. The flap is laid beside the ureter and the posterior wall is anastomosed. The anterior wall is anastomosed after placing a double j stent.

URETERAL INCORPORATION FOR PELVI URETERIC JUNCTION OBSTRUCTION IN DUPLEX MOIETY

This technique is applicable for duplex moieties with one of the moieties having PUJO and both the ureters join a short distance below the PUJ. The spatulation is carried across both the PUJs. A new PUJ is created by incorporating the wall of the normal moiety into the anastomosis [Figure 5a-f].

MEDIAL FLIP

This technique is used when the pelvis is facing posteriorly in a malrotated kidney. By mobilizing the kidney from the lateral aspect, the kidney may be flipped medially. Once this is done, the pelvis and PUJ face anteriorly and are now amenable to reconstruction using the standard techniques. In cases which require medial flip, an additional port is required in the flank, with the right hand port now becoming the telescopic port and the telescopic port becoming the left hand port.

TRANSMESOCOLIC PYELOPLASTY

The ideal candidate for a transmesocolic pyeloplasty is a child or a thin adult with a favorable arrangement of colonic vasculature such that the dilated pelvis and PUJ are visible through the mesocolon. The pelvis and PUJ are dissected directly through the mesocolon avoiding colonic mobilization. The rest of the steps are similar to any of the pyeloplasties described.

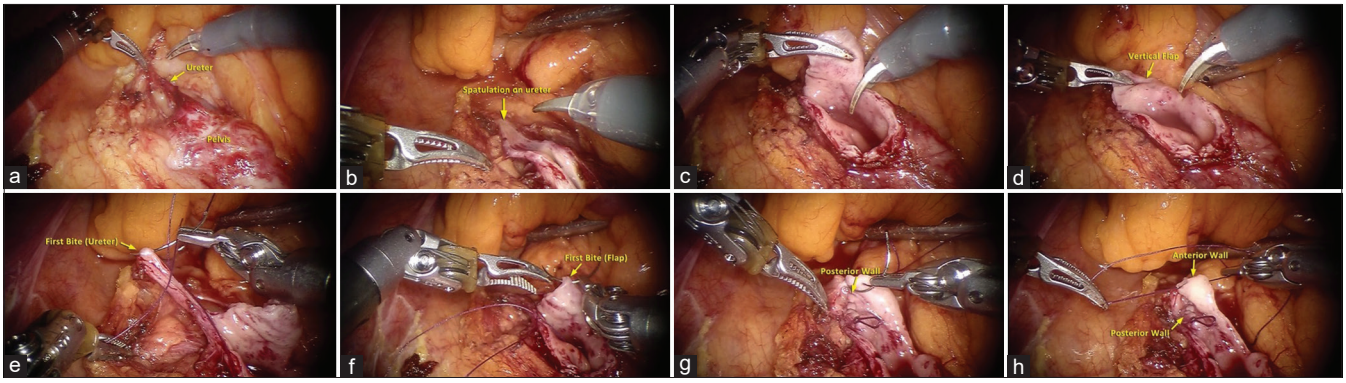

Figure 4: Vertical flap. (a) Initial appearance of pelvi ureteric junction obstruction in a pelvic ectopic kidney, taken up for robot assisted laparoscopic pyeloplasty, (b) Spatulation on ureter, (c) Developing vertical flap from pelvis, (d) Developing vertical flap from pelvis, (e) Vertical flap being brought down and sutured to ureteric spatulation, (f) Vertical flap being brought down and sutured to ureteric spatulation, (g) View after completion of posterior wall, (h) Anastomosis of anterior wall started

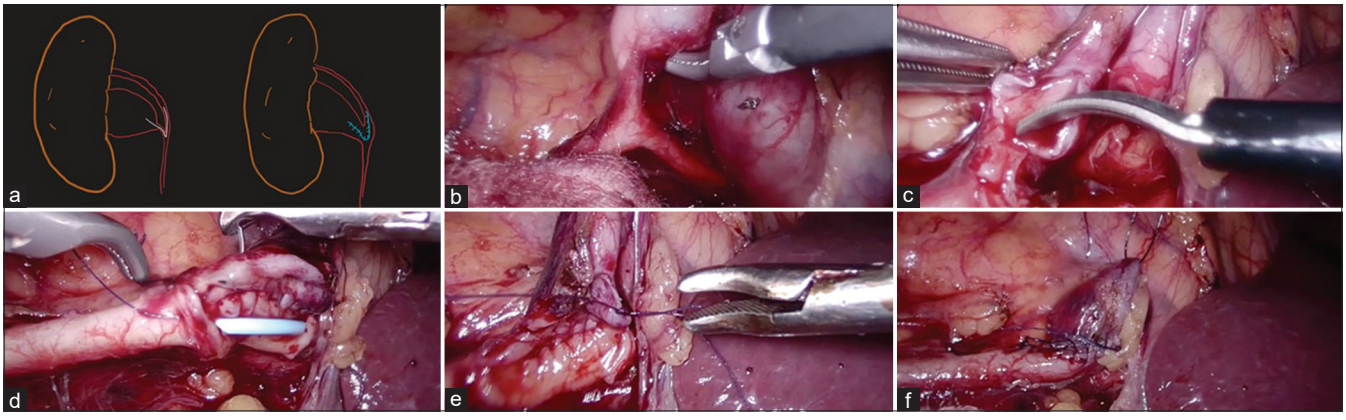

Figure 5: Ureteral incorporation. (a) Diagrammatic representation of the technique, (b) Initial appearance of a duplex system with lower moiety pelvi ureteric junction obstruction (PUJO), (c) Incision onto the lower moiety PUJ, (d) Appearance after suturing the posterior walls of upper and lower moiety. A stent has been inserted, (e) The suturing of the anterior wall has been started, (f) Final appearance, showing how the junction of both moieties is moved up cranially with this procedure

PYELOPLASTY WITH PYELOLITHIOTOMY

Kidneys with PUJO are prone to stone formation because of the relative stasis of the urine in the dilated pelvis and calyces. Removal of the secondary stones so formed may be accomplished by the following maneuvers:

- Rigid ureteroscopy: A rigid URS (ureterereno scope) may be passed through one of the laparoscopic ports and stones extracted. This method needs an extra EndoVision trolley with screen so visualize the images from the ureteroscope
- Laparoscopic forceps: A small pyelotomy is made and stones are extracted using laparoscopic forceps. It is essential to make the initial pyelotomy only so big so as to allow the laparoscopic forceps to go through. This minimized the chances of stone migration into the peritoneal cavity
- Inserting the laparoscopic camera into the pelvis after enlarging the pyelotomy affords excellent vision of the interior of the pelvicalyceal system (PCS) and clearance of stones
- Flexible ureteroscopy: Flexible ureteroscopy is advantageous as compared to rigid ureteroscopy in reaching all calyces in difficult angles
- Carbon dioxide insufflation into the PCS: A drawback of using saline irrigation to visualize stones inside the PCS during laparoscopy is that the stones may migrate out of the PCS through the pyelotomy along with the saline flow. A second drawback is that the irrigating fluid leaking out through the pyelotomy accumulates in the peritoneal cavity. This causes the bowel to float in the fluid, hampering vision. To circumvent both these problems, carbon dioxide may insufflated into the PCS through the irrigation channel of the ureteroscope [Figure 6]. This enables clear vision and stone extraction without the above-mentioned problems. Insufflation pressures in the PCS are around 14–16 mmHg, with corresponding intra-abdominal pressure being around 7–8 mmHg lower
- Mobilizing kidney and making lower pole dependent. This enables easier extraction of lower calyceal stones
- Placing a gauze near the pyelotomy. The extracted stones can be placed on the gauze and their migration can be prevented.

HORSESHOE KIDNEYS AND PELVIC KIDNEYS

Care has to be taken not to excise too much pelvis, because in such malpostioned kidneys, usually the calyces are extra-renal, fusing more medially than usual to form the pelvis. After the initial pyelotomy, it is advisable to identify the calyceal openings and then plan the amount of pelvis to be resected.

Figure 6: Nephroscopy with carbon dioxide

URETEROCALICOSTOMY

This is a salvage procedure where dissection near the PUJ is difficult because of previous surgery, very small pelvis, etc., The ureter and the lower pole are dissected. The ureter and the lower pole are divided, exposing the dilated infundibulum. The ureter is spatulated laterally and anastomosed in side-to-side fashion to the infundibulum. This creates a dependent drainage from the pelvi-calyceal system into the ureter. Anastomosis of the ureter end-on to the calyx is not recommended as this leads to a round configuration of the anastomosis which is prone to stricture formation and failure.

DECISION-MAKING IN MINIMALLY INVASIVE PYELOPLASTY

Minimally invasive pyeloplasty requires a mental reconstruction of the three-dimensional orientation of the pelvis, ureter, and neo-PUJ, from the two-dimensional images seen on the screen. As such, minimally invasive pyeloplasty is as much an art as science. The factors which influence the technique of pyeloplasty are the redundancy of pelvis, level of insertion of the ureter on the pelvis (high or low insertion), the presence of crossing vessels, the length of ureteric narrowing after spatulation, and the extent of surrounding inflammation especially in redo cases. In left-sided PUJ obstruction, the disposition of the mesocolon and its vessels is important in deciding for or against a transmesocolic pyeloplasty. Apart from these patient factors, the angle of instruments and camera also plays an important role in the performance of pyeloplasty.

A redundant pelvis is amenable to dismembered pyeloplasty with reduction and tailoring of the pelvis. Flap pyeloplasty

is best suited for a high inserting ureter with a roomy pelvis. Dismembered approach is the best to deal with crossing vessels, so that the vessels are transposed posteriorly relative to the neo-PUJ and obstruction is fully relieved. Extensive surrounding inflammation as in redo cases may mean limited mobilization with a flap pyeloplasty based on the anterior-medial wall of the pelvis. Small pelvis is best served by a Y-V plasty. Renal descensus is also a valuable technique in cases of small pelvis. In cases of tension, while approximating the pelvis with ureter, it is advisable to start the suturing not at the apex but from the posterior wall and come up to the apex. This avoids initial tension and possibility of suture cut-through near the apex, which is the most critical part of the anastomosis.

An algorithm for decision-making in pyeloplasty is suggested [Table 1].

DISCUSSION

The minimally invasive approach is the de facto gold standard currently for performing pyeloplasty. As is evident, the steps of the open approach may not be exactly replicated in the minimally invasive approaches due to the different angle of visualization and the fixed nature of the working ports as compared to open surgery. Hence, surgeons use modifications to perform pyeloplasty in the minimally invasive manner. As in the open approach, the goals of pyeloplasty by the minimally invasive approach remain the same, i.e. reduction of the redundant part of the pelvis, achieving a dependent, unobstructed, and funneled configuration of the PUJ.

Surprisingly, despite the widespread adoption of the laparoscopic or robot-assisted laparoscopic approach in pyeloplasty, there is a relative dearth of literature on the specific operative techniques. The first report of lap pyeloplasty was by Schuessler *et al*. Initially, they used stay sutures to help in proper orientation of pelvis and ureter. However, the tails of these sutures materials was confusing and later they placed only one single posterior stay suture.[10]

Table 1: Decision-making in minimally invasive pyeloplasty

Kidney
Orthotopic
Small pelvis: PAD, Y-V
Large pelvis: A-H
High ureteral insertion: A-H, vertical flap
Long length stricture: A-H, vertical flap, renal descensus
Malrotation: Medial flip
Ectopic (pelvic)
Adequate pelvis: Vertical flap
Small pelvis: y-v flap

PAD: Postanastomotic dismemberment, A-H: Anderson Hynes dismembered pyeloplasty

Tasian and Casale in 2015 described the dismembered pyeloplasty using the robotic platform. They noted that small intrarenal pelvis and long ureteral stricture are difficult scenarios and are relative contraindications to the minimally invasive dismembered pyeloplasty. They favored the modified Fenger plasty for intrarenal pelvis. For long stricture, they favored culp deweerd, vertical flap, or ureterocalicostomy.[11]

Wolf published his experience of lap pyeloplasty. For short obstructive segments, he preferred the Y-V plasty over Fenger plasty owing to better results of Y-V plasty. Microscissors are used for accurate incisions. For long obstructed segments, he preferred a flap pyeloplasty; however, the exact configuration of the flap was not described.[12]

Gorgen *et al*. described using the articulated needle holder (driver) for pyeloplasty and noted that it eases the performance of the procedure.[13]

Aminsharifi described laparoscopic *in situ* pyeloplasty, which is similar to post anastomotic dismemberment technique (PAD). The mean operative time for PUJ anastomosis was lesser in laparoscopic *in situ* pyeloplasty group.[14] This technique is similar to PAD technique described by Ahlawat *et al*.[9]

Nishi *et al*. described taking a stay suture on the pelvis, taking it out through the abdominal wall and fixing it under tension using endoclose.[15] They reported a 100% success rate in their series of redo pyeloplasty. A similar technique, named the "anchoring technique," was used by Leung *et al*.[16]

Yilmaz *et al*. described the used of barbed suture to eliminate intracorporeal knot tying problems in pyeloplasty.[17]

Eichel *et al*. described three changes which increased the efficiency of laparoscopic pyeloplasty: an upper midline port placement, double-armed suture used in a continuous fashion for the anastomosis, and antegrade stent placement.[8]

Pattaras described the "endo stitch" device for faster suturing in laparoscopic pyeloplasty.[18] A similar instrument was described by Lam *et al*.[19]

Cascio *et al*. described their techniques which help in performance of pyeloplasty in an accurate and efficient manner: instruments directly inserted through abdominal wall, transabdominal pelvic hitch stitch, and PAD technique

followed on posterior walls. Of note, the first technique is more suitable to infants and may not be applicable to older children or adults.[20]

Romero *et al*. described their technique and experience of transmesenteric pyeloplasty performed in 18 patients. Three midline laparoscopic ports were used. The transmesocolic approach was used if the renal pelvis and ureter could be seen easily through the mesentery.[21] After a longitudinal incision through the mesenteric window, the pelvis and ureter were dissected, and then a standard dismembered pyeloplasty was done. After that, the mesenteric defect was oversewn. They noted that the mean operative time was lowered by 22.5% and decreased hospital stay by 19.2%.

Nerli *et al*. described umbilical access only laparoscopic pyeloplasty. Five-mm camera port was placed in the inferior umbilical crease. Three-mm instruments were directly inserted on either side of the telescope. Laparoscopic trocars were not used. This avoids the multiple incisions of conventional laparoscopic surgery. They noted that operative time may be prolonged due to crossing of instruments.[22]

Brunhara *et al*. described their modification to deal with pyeloplasty in horseshoe kidneys and pelvic kidneys. The laparoscopic access was established by open method and the working ports were placed more medially and caudally.[23]

Chandrasekharam described placing the ports close to the midline, as the PUJ is usually close to the midline. This facilitates dissection and placement of sutures.[24]

Sarhan *et al*. noted that in some cases, it may be necessary to dismember the isthmus of HSK to allow the performance to a funnel shaped dependent pyeloplasty, even though others argue that this is unnecessary if the ureteric peristalsis is normal.[25]

The treatment of lower pole ureteropelvic junction (UPJ) obstruction in cases of incomplete duplication of renal pelvis and ureter was reviewed by Vanderbrink *et al*.[26] In incomplete duplication, both the ureters join each other a short distance from the UPJ, and hence the reconstruction if the lower pole UPJ can be challenging. They described the use of the normal upper pole ureter in the reconstruction of lower moiety UPJ, similar to the technique we have described above.

Kouriefs *et al*. described carbon dioxide gas to insufflate the PCS for pyelonephroscopy and stone extraction during laparoscopic pyelolithotomy.[27] They claimed the following advantages of gas over saline as the irrigant medium: improved clarity as the vision is not blurred due to blood or increasingly murky solution. There is no whirlpool effect and stone migration while using gas for pyeloscopy, leading to steady access to stones and faster completion of the procedure. Finally, gas-urine level provides a horizon useful to orient picture and the camera.

As is evident from the above discussion, operative techniques of minimally invasive pyeloplasty are not well described in literature. We have attempted to present a comprehensive resource of different techniques of minimally invasive pyeloplasty and the clinical scenarios in which they may be appropriate. This should prove to be a useful reference to the young urologist and the seasoned practitioner, alike. It must be emphasized, however, that minimally invasive pyeloplasty is an advanced reconstructive procedure, and mastery of basic laparoscopic skills and intracorporeal suturing is highly desirable before embarking on the procedure. Observing the recognized experts doing the procedure, watching surgical videos, practicing in a wet lab or on a simulator are some of the ways in which one's surgical skills may be enhanced. A well-described model which can be easily implemented involves use of crop and esophagus of a chicken, which simulates the right side renal pelvis and ureter, respectively.[28]

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Conflicts of interest

There are no conflicts of interest.

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