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UROLOGY - ORIGINAL PAPER

Laparoscopic modified bypass pyeloplasty: a simple procedure for straightforward ureteral spatulation and intracorporeal suturing

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Abstract
Purpose Bypass pyeloplasty (BP) is a simple, non-dismembered procedure that is a side-to-side anastomosis without dividing the ureteropelvic junction (UPJ). BP has been considered more suitable especially for novice surgeons than dismembered pyeloplasty via the laparoscopic approach, but not reported. However, the disadvantage of laparoscopic BP is that it is difficult to suture the side of the anastomosis that is far from the camera. To overcome this disadvantage, a modified technique was developed. This procedure and its initial results are reported.
Methods Twenty-six consecutive patients underwent laparoscopic modified BP. The patients' median age at surgery was 10.5 years. Ten patients were adults and 16 were children. The key step of modified BP involves dividing the UPJ after ureteral spatulation and suture of the dependent portion. This provides both better visualization of the anastomosis portion and easy anastomosis.
Results All procedures were completed by laparoscopic modified BP. The median operative time was 246 (range 170–357) min. The median time for ureteropelvic anastomosis was 205 (range 145–311) min. There were no significant differences in mean operative time and ureteropelvic anastomotic time between adults and children (adults/children = 243 ± 49 min:252 ± 58 min, $p = 0.66$, 192 ± 33 min:214 ± 48 min, $p = 0.21$, respectively). Successful resolution of UPJO was observed in 96 % of cases.
Conclusions Laparoscopic modified BP combines the advantages of non-dismembered and dismembered pyeloplasty. Because there were no differences in mean operative and anastomotic times between adults and children, laparoscopic modified BP might be an efficient procedure for all ages, especially children.

Keywords Children · Laparoscopy · Pyeloplasty · Ureteropelvic junction obstruction · Urology

Introduction

Recently, laparoscopic pyeloplasty has gained acceptance as a minimally invasive alternative to open pyeloplasty for ureteropelvic junction obstruction (UPJO) both in adults and in children, with success rates similar to traditional open pyeloplasty [1, 2]. Anderson–Hynes dismembered pyeloplasty is a gold standard procedure for UPJO in both the laparoscopic and open approaches [3, 4]. However, when we performed laparoscopic Anderson–Hynes dismembered pyeloplasty, we sometimes experienced difficulty with spatulation and anastomosis of the dependent portion after dividing the ureter and renal pelvis.

Bypass pyeloplasty (BP) is a simple procedure that is a side-to-side anastomosis between the ureter and renal pelvis without dividing the ureteropelvic junction (UPJ) [5]. Hence, BP has been considered more suitable especially for novice surgeons than dismembered pyeloplasty for laparoscopic pyeloplasty, but it has not been reported via the laparoscopic approach. However, when we performed BP via the laparoscopic approach, mobilization of the ureter was restricted because the ureteropelvic junction (UPJ) is not

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removed. Thus, when the side-to-side anastomosis between the ureter and renal pelvis is performed in this procedure, it is difficult to suture the side of the anastomosis that is far from the camera. This represents a key disadvantage of BP performed via the laparoscopic approach. To overcome this disadvantage, an improved technique of modified BP was developed. This procedure and its initial results are presented.

Methods

A total of 26 patients underwent laparoscopic modified BP for treatment of UPJO at our institutions between September 2010 and September 2013. The patients' median age at surgery was 10.5 years (range 15 months–68 years). Of these cases, 21 were on the left side, and 5 were on the right side. The patients were divided into adults (≥16 years, 10 patients) and children (≤15 years, 16 patients; Table 1). All patients underwent preoperative radiological imaging, including computed tomography and/or MR urography, ultrasonography, and diuretic renography (DR), for the diagnosis of UPJO. Indications for surgery included an increasing degree of hydronephrosis, a low split renal function (less than 40 %), and/or an obstructive pattern on DR and/or symptoms such as pain and constipation, as well as urinary tract infection [6, 7]. Patients with extrinsic UPJO responsible for crossing vessels were excluded from the present study. These patients were laparoscopically performed Anderson–Hynes dismembered pyeloplasty. Informed consent was obtained from all patients or their parents before the study, after explaining the purpose and methods. Postoperative ultrasonography was performed monthly, and diuretic renograms were performed at 6 and 12 months, and annually thereafter. The criteria for short-term success were a marked reduction in hydronephrosis on ultrasonography, preservation of split renal function, improvement in the drainage curve on diuretic renography, and symptom resolution at 6 months [6, 7]. Overall, the surgical outcomes of 24 patients could be evaluated. The reason why two patients were excluded from the analyses of the surgical outcome was that diuretic renography was performed at more than 6 months after operation in these two patients. In one patient, diuretic renography was performed at 7 months after operation, and in the other patient, it was performed at 12 months after operation.

Informed consent was obtained from all patients before the study after explaining its purpose and methods. The study protocols were approved by the ethics committee at our institution.

Table 1 Patients' characteristics and operative outcome

Variable	Number, median, or mean (±SD)
Patient count	26
Age (years)	10.5 (15 months−68 years)
Diseased side (left/right)	21:5
Adults (≥16 years)/children (<16 years)	10:16
Operating time (right/left) (min)	253 ± 53:228 ± 62 ($p = 0.36$)
Operating time (≥16 years/<16 years) (min)	243 ± 49:252 ± 58 ($p = 0.66$)
Anastomotic time (≥16 years/<16 years) (min)	192 ± 33:214 ± 48 ($p = 0.21$)

Anastomotic time: the time required for ureteropelvic anastomosis, including the time needed for the hitch stitch for the renal pelvis and placement of the Double J catheter

Laparoscopic procedures

Mesrobian et al. [5] initially reported the operative procedure and initial results of BP in 2009. In BP, a 1- to 2-cm side-to-side anastomosis is created between the dilated and elastic portion of the ureter just distal to the UPJO and the lower and dependent portion of the hydronephrotic renal pelvis without disturbing the UPJ or reducing the renal pelvis (Fig. 1a–c). On the other hand, modified BP involves dividing the UPJ after the suture of the dependent portion, facilitating easy suture of the far side of the side-to-side anastomosis (Fig. 1d–f).

Exact method of laparoscopic modified BP was described as below. Each patient was placed in the supine position with the ipsilateral side raised to a 45° angle. A small incision was made at a level just cephalad to the umbilicus, and the peritoneum was dissected under direct vision. A 5- or 12-mm trocar was inserted intraperitoneally, and pneumoperitoneum was performed to observe the inside of the abdominal cavity clearly using a 30° scope. Two additional 5-mm trocars were inserted for working ports. Then, 3- or 5-mm curved dissectors were used for grasping and blunt dissection. 3- or 5-mm curved scissors were used for incising, and a 3-mm needle driver was used for suturing. Selection of instruments including the trocar for the camera depended on the patient's organ size.

The peritoneum overlying the kidney was incised to expose the UPJO with medial mobilization of the colon. However, in patients with left UPJO, the transmesenteric approach was used [8]. The renal pelvis and ureter were dissected, resulting in complete mobilization. A percutaneous hitch stitch was placed in the renal pelvis to facilitate exposure of the renal pelvis and UPJ and to fix the surgical field (Fig. 2a).

In laparoscopic modified BP, before ureteral spatulation and apical ureteral stitch placement, UPJO was not removed to prevent the rotation and kinking the ureter. Namely, the dilated and elastic portion of the ureter just

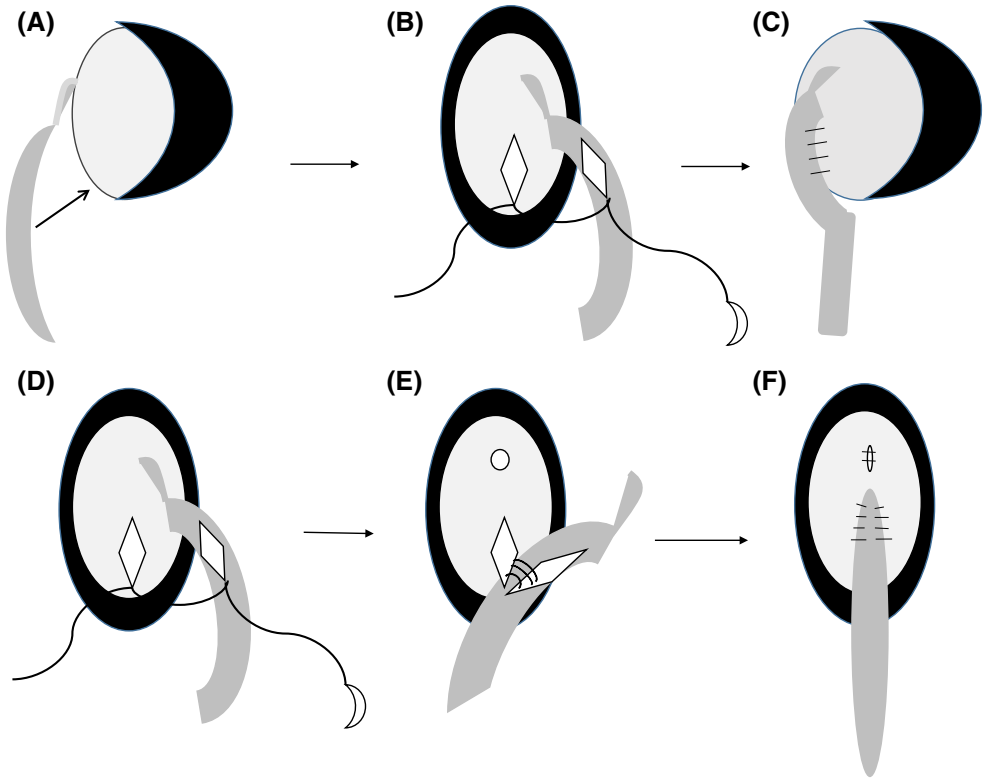

Fig. 1 Original method of bypass pyeloplasty. Diagram showing **a** the suture site between the ureter located just distal to the ureteropelvic junction and the lower pole of the hydronephrotic renal pelvis; **b** side-to-side anastomosis without dividing the ureteropelvic junction; **c** completed bypass pyeloplasty. Modified laparoscopic bypass pyeloplasty; **d** suture of the dependent portion without dividing the ureteropelvic junction; **e** creation of the side-to-side anastomosis after dividing the ureteropelvic junction; **f** completed modified laparoscopic bypass pyeloplasty

distal to the UPJO, which was considered as a healthy portion, was only spatulated for 1–2 cm (Fig. 2b), and a 1- to 2-cm incision in the direction of the long axis was made in the renal pelvis. The lower corner of the ureter was sutured to the lower edge of the pelvis with an everting 5-zero poliglecaprone 25 suture (PDS™ RB-3 11 mm 1/2 circle) or 6-zero poliglecaprone 25 suture (PDS™ BV-1 9.3 mm 3/8 circle) as an apical ureteral stitch placement. The UPJO was then divided and removed after suture of the dependent portion, obtaining better visualization and facilitating easy suture of the far side from the camera in a running fashion (Fig. 2c). This is the overarching point of the modified BP. In laparoscopic modified BP, the anterior side of the renal pelvis was on the far side from the camera due to the hitch stitch of the renal pelvis. Then, a Double J® catheter was inserted in an antegrade manner over a guide wire. After insertion of a Double J catheter, the near side of the side-to-side anastomosis was performed. At last, suture ligature was performed to the ureter located proximal to the UPJO, to prevent the postoperative urinary leakage (Fig. 2d). The Double J catheter was removed after 6–8 weeks.

Statistical analysis

All values are presented as mean ± standard deviation or medians. Correlations between parameters of operative duration and age were investigated by simple regression analysis using the Spearman's rank correlation coefficient. Two-sided Mann–Whitney *U* testing was used to determine significant differences in parameters of operative duration or renal pelvic anterior–posterior diameter using binary variables. Values of $p < 0.05$ were considered significant. Analyses were performed with StatView version 5.0 software (Abacus Concepts, Berkeley, CA).

Results

All procedures were completed by laparoscopic modified BP. The median operative time was 246 (range 170–357) min. There was no significant correlation between age and operative time ($r = -0.1$, $p = 0.6$). The median time required for ureteropelvic anastomosis was 205 (range 145–311) min, including the time needed for the hitch stitch for the renal pelvis and placement of the Double J catheter.

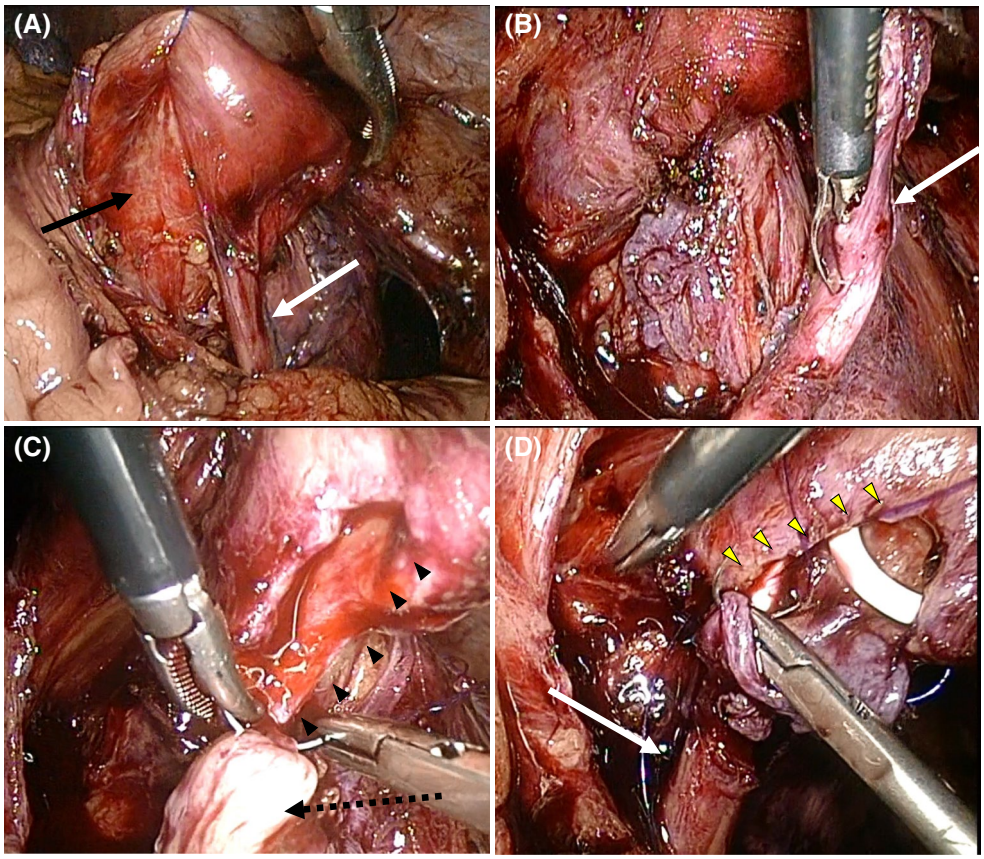

Fig. 2 Intraoperative findings during modified laparoscopic bypass pyeloplasty (*left side*). **a** A percutaneous hitch stitch is placed in the renal pelvis. The renal pelvis and ureter are raised up and fixed in the surgical field; **b** the elastic portion of the ureter just distal to the ureteropelvic junction obstruction is spatulated 1–2 cm without dividing the ureteropelvic junction (UPJ); **c** side-to-side anastomosis that is far from the camera is performed after dividing the UPJ. The anterior side of the renal pelvis is on the far side from the camera due to the hitch stitch to the renal pelvis; **d** the near side of the side-to-side anastomosis is performed after insertion of a Double J catheter. The posterior side of the renal pelvis is the near side of the camera due to the hitch stitch to the renal pelvis. The *white arrow* indicates the ureter. The *black arrow* indicates the renal pelvis. The *black arrow head* indicates the far side from the camera. The *yellow arrow heads* indicate the near side from the camera. The *black dotted arrow* indicates the ureter lifting the restriction

There was no significant correlation between age and ureteropelvic anastomotic time ($r = -0.35$, $p = 0.07$). There was no difference in the mean operating time between right- and left-sided procedures (right/left = 253 ± 53 min: 228 ± 62 min, $p = 0.36$; Table 1). There was no significant difference in the mean operative time between adults and children (adults/children = 243 ± 49 min:252 ± 58 min, $p = 0.66$), as well as no significant difference in the mean ureteropelvic anastomotic time between adults and children (adults/children = 192 ± 33 min:214 ± 48 min, $p = 0.21$; Table 1). Postoperative pain management was optimal using only non-steroidal anti-inflammatory drugs for a few days, except in one patient. No patients required postoperative percutaneous nephrostomy. No patients required treatment for urinary tract infection with antibiotics, while the Double J catheter was indwelling.

No major perioperative complications occurred. However, several complications have occurred. In one patient, the Double J stent could not be removed due to the attachment of calcium-based calculi to the tip of the catheter. The catheter could be removed after transurethral ureterolithotomy of the calculi attached to the Double J stent under general anesthesia. One patient had stent occlusion due to blood clot, and postoperative pain was prolonged until the Double J stent was removed.

The mean follow-up time was 31 ± 18 months. The mean renal pelvic anterior–posterior diameter on ultrasonography was significantly decreased from 4.4 ± 1.2 cm preoperatively to 1.7 ± 0.6 cm postoperatively ($p = 0.0005$). The mean preoperative and postoperative split renal functions on diuretic renography were 37 ± 10 % and 40 ± 11 % ($p = 0.08$), respectively. Hydronephrosis did not improve only in one patient owing to anastomotic stenosis. We considered that this patient was 1/24 failure. We did not count as a success, although hydronephrosis in this patient was improved by repeat surgery. Namely, the operations

performed to the 23 patients excluding this one patient were judged as successive procedures (23/24; 96 %).

The results excluding the analyses of the surgical outcome were as follows: In one patient, diuretic renography was performed at 7 months after operation, and in the other patient, it was performed at 12 months after operation. Both patients preserved split renal function [preoperative split renal function (%)/postoperative split renal function (%) = 44:48 % (the patient in which the diuretic renography was performed at 7 months after operation), 50:53 % (at 12 months after operation), respectively], and the drainage curve was improved on diuretic renography in both patients. It goes without saying that marked reduction in hydronephrosis on ultrasonography and symptom resolution was acquired at 6 months after operation in both patients. Therefore, although we could not make a correct judgement about these two patients, probably these two operations would not be judged to be failure.

Discussion

Laparoscopic pyeloplasty has remained a technically demanding operation requiring advanced intracorporeal suturing skills [9, 10]. In addition, two of the most difficult, awkward, and at the same time important steps of the procedures are ureteral spatulation and apical ureteral stitch placement [11]. In particular, when laparoscopic dismembered pyeloplasty was performed, freeing the ureter completely made ureteral spatulation and apical ureteral stitch placement significantly more difficult and awkward than the fixed ureter attached to the UPJ. In this regard, laparoscopic modified BP has the advantage over standard dismembered pyeloplasty, because rotation and kinking of the ureter are restricted due to attachment of the UPJ, facilitating both easy ureteral spatulation and easy suturing of the dependent portion. If optimal angles between the jaws of scissors or needle and ureteral axis could not be achieved, ureteral spatulation or suturing of the dependent portion could be quite difficult or even impossible [11]. Although such a situation did not occur in the present study, various techniques, including ex vivo spatulation [11] and using articulating scissors [12], might be useful in laparoscopic modified BP.

The difference of laparoscopic modified BP from the original BP method is lifting the restrictions of the ureter by dividing the UPJ after suture of the dependent portion. This has made intracorporeal suturing relatively more straightforward compared with the original method of BP, in particular, in suturing the side of the anastomosis that is far from the camera.

In general, it is difficult to perform the laparoscopic pyeloplasty for the mid- or high insertion of the ureter into the renal pelvis due to necessity of both reducing renal pelvis and translocation of suturing position between renal pelvis and ureter [13, 14]. In that regard, both original BP and laparoscopic modified BP were suitable for the mid- or high insertion of the ureter into the renal pelvis because both procedures were side-to-side anastomosis without reducing renal pelvis or translocation of suture site. In addition, laparoscopic modified BP was successfully performed in all patients, not only the mid- and high ureter insertion types but also the non-mid- and non-high ureter insertion types. The reason why laparoscopic modified BP was successfully performed in all patients might be due to the percutaneous hitch stitch to the renal pelvis causing the ureter to raise to the surgical field. Raising the ureter into the surgical field made all the patients become a mid- or high insertion type of UPJO. As a result, all types of UPJO could be performed with laparoscopic modified BP. This is one of the overarching points of this procedure. Hence, modified BP appears to be an efficient procedure for laparoscopic pyeloplasty.

It is generally accepted that intracorporeal suturing is more difficult in children than in adults. Hence, the time for ureteropelvic suturing tended to be longer in children than in adults [6]. In the present study, there were no significant differences in mean operative time and ureteropelvic anastomotic time between adults and children. Moreover, the short-term success rate of modified bypass BP was 96 %, similar to that of laparoscopic pyeloplasty reported previously [14–16]. Hence, laparoscopic modified BP might be efficient for all ages, especially children.

Two methodological limitations must be considered in the present study. First, we did not demonstrate the superiority of modified BP compared with other dismembered pyeloplasty or original BP. Therefore, we need comparative studies, such as randomized control study. Second, patients with extrinsic UPJO responsible for crossing vessels could not undergo modified BP, because dividing the UPJ was needed before anastomosis of the dependent portion.

In conclusion, laparoscopic modified BP combines the advantages of both non-dismembered and dismembered pyeloplasty. One advantage is that prevention of rotation and kinking of the ureter due to attachment of the UPJ facilitates easy suturing of the dependent portion. The other is that lifting the restrictions of the ureter by dividing the UPJ after the suture of the dependent portion makes it easy to suture the side of the anastomosis that is far from the camera. Modified BP appears to be an efficient procedure for laparoscopic pyeloplasty.

Moreover, because there were no significant differences in mean operative time and ureteropelvic anastomotic time between adults and children, laparoscopic modified BP might be efficient for all ages, especially children.

Compliance with ethical standards

Conflict of interest We have no conflict of interest.

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