Original Article

Retroperitoneal laparoscopic non-dismembered pyeloplasty for uretero-pelvic junction obstruction due to crossing vessels: A matched-paired analysis and review of literature

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Abstract   *Objective:* To compare laparoscopic Anderson-Hynes pyeloplasty (LAHP) and retroperitoneal laparoscopic YV-pyeloplasty (LRYVP) in ureteropelvic junction obstruction (UPJ) in presence of a crossing vessels (CV).

Methods: Our database showed 380 UPJO-cases,who underwent laparoscopic retroperitoneal surgery during the last 2 decades including 206 non-dismembered LRYVP, 157 dismembered pyeloplasties LAHP, and 17 cases of laparoscopic ureterolysis. Among them 198 cases were suitable for a matched-pair (2:1) analysis comparing laparoscopic retroperitoneal non-dismembered LRYVP (Group 1, $n = 131$) and dismembered LAHP (Group 2, $n = 67$) in presence of a crossing vessel. Patients were matched according to age, gender, kidney functions, and obstruction grade. Complications were graded according to modified Clavien-classification.

Results: Comparative data were similar between both groups (LRYVP *vs.* LAHP) including mean operating time (112 min *vs.* 114 min), complication rates (4.2% *vs.* 7.3%) mainly Grade 1—2 according to Clavien classification, and success rates (90% *vs.* 89%). These results reflected in the reviewed literature indicate that LRYVP provides the advantage of minimal dissection in case of CV with similar outcome. However, redundant pelvis and anteriorly crossing vessels still require a dismembered pyeloplasty LAHP.

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Conclusion: LRYVP has achieved similar results compared with the previous golden standard of open surgery, especially in case of crossing vessels apart from presence of a redundant pelvis or anteriorly crossing vessel. This can be further improved when using the small access retroperitoneoscopic technique respectively mini-laparoscopy.

1. Introduction

Uretero-pelvic junction (UPJ) stricture represents a common congenital cause of upper urinary tract obstruction leading to progressive dilatation of the renal collecting system [1]. Clinical manifestations of uretero-pelvic junction obstruction (UPJO) include flank pain, renal colic and infection, which may result in progressive deterioration of renal function [2]. Gold standard surgical treatment for UPJO has been open dismembered pyeloplasty using the Anderson-Hynes pyeloplasty (AHP) yielding >90% success rates (Table 1) [3—12]. In contrast to this, percutaneous antegradeor ureteroscopic retrograde endopyelotomy did not sustain the test of time due to higher recurrence rates [13—18]. On the other hand, laparoscopic and retroperitoneoscopic repair with and without robotic assistance became the method of choice at several centres within the last decade providing same success rates like open surgery with significantly less morbidity (Table 2) [19—28].

Among these techniques laparoscopic retroperitoneal pyeloplasty using a non-dismembered YV-plasty (LRYVP) has evolved as a viable alternative [29—31]. Additionally, mini-laparoscopic approaches like the small access retro-peritoneoscopic technique (SMART) could further decrease the morbidity of the operation with improvement of the cosmetic result [30—32]. Based on our experiences with 380 patients treated by laparoscopic pyeloplasty during the last 20 years we described our actual technique and discussed the future role of LRYVP in presence of the existing literature.

2. Materials and methods

2.1. Classification of UPJO

UPJO can be classified into intrinsic (primary) stenosis and extrinsic (secondary) stenosis.

Table 1 Open pyeloplasty—results of the literature.

Author (year)	n	Age (year) (range)	Access	Primary UPJ-stenosis (%)	Crossing vessels (%)	Mean OR-time (min)	Success / excellent rate (%)	Complication rate (%)
Nguyen (1989) [3]	68	2 (<1—28)	Flank	100	n.a.	n.a.	93.4/n.a.	17.1
MacNeily et al. (1993) [4]	75	1 (<1—19)	Flank	100	n.a.	n.a.	90.7/85.0	17.0
Woo and Farnsworth (1996) [5]	63	<1	Flank	100	n.a.	n.a.	94.0/n.a.	11.0
Wiener and Roth (1998) [8]	17	3	Flank	100	n.a.	110	94.0/n.a.	23
Wiener and Roth (1998) [6]*	16	4	Lumbar	100	n.a.	107	94.0/n.a.	12.5
McAleer and Kaplan (1999) [7]	79	1 (<1—18)	Flank	100	n.a.	n.a.	90.0/71.0	n.a.
Bauer et al. (1999) [8]	35	n.a. (adults)	Flank	100	38	163	94.0/82.9	11.0
Sanchez Zalabardo (2000) [9]	62	29 (<1—68)	Flank	n.a.	n.a.	n.a.	90.3/n.a.	29.0
Austin et al. (2000) [10]	137	2 (<1—10)	Flank	100	n.a.	n.a.	99.0/91.0	2.9
O'Reilly (2001) [11]	28	39 (12—72)	Flank	100	n.a.	n.a.	82.2/67.9	17.9
Klingler (2003) [12]	15	41 (13—69)	Flank	100	47	n.a.	93.3/n.a.	40.0
Total	595	<1—41 (<1—72)			38—47	107—163	90—99/68—91	2.9—40.0

*Comparative studies; UPJ, ureteropelvic junction; OR, operating room; n.a., not available.

Table 2 Laparoscopic pyeloplasty—results of the literature and personal series.

Author (year)	n	Age (range)	Access	Primary UPJ-stenosis (%)	Crossing vessels (%)	Mean OR-time (min)	Success rate (%)/excellent	Complication rate (%)
Tan (1999) [19]	18	2 (1—15)	Trans	89	n.a	90 (70—160)	87/n.a	11
Janetschek et al. (2000) [21]	67	36 (11—77)	Trans/retro	100	79	119 (90—210)	98/n.a.	3
Soulie et al. (2001) [23]	55	35 (17—72)	Retro	98	41.9	185 (100—260)	90.1/87.2	12.7
Eden et al. (2001) [24]	50	36	Retro	92	42	164 (100—210)	98/84.0.	4
Jarrett et al. (2002) [25]	100	37 (12—85)	Trans	83	57	252[a] (120—480)	98/n.a.	13
Türk et al. (2002) [26]	49	34 (6—65)	Trans	100	57.1	165 (90—240)	97.7/81.6	2
Klingler et al. (2003) [12]	40	36 (15—57)	Trans	88	82.5	n.a.	92.5/87.5	17.5
Sundaram et al. (2003) [27]	36	34 (16—60)	Trans	n.a.	87	372+ (162—600)	94/83	25+
Rassweiler et al. (2007) [28]	52	37 (6—75)	Retro	78	76	137 (60—260)	94/88	6
Present series 2018	380	34 (0.5—92)	Retro	92	58	113 (29—240)	92/88	5.5
Total	847	34—37 (0.5—92)		83—100	42—87	119—185	90—98/82—87	2—17.5

[a] Inclusive cystoscopy and stent placement; + only secondary ureteropelvic junction (UPJ)-obstruction; n.a., not available.

2.1.1. Intrinsic stenosis

Intrinsic causes of UPJO may represent mucosal valves or an adynamic segment with infiltration of collagen and considerable decrease in intracellular myofilaments. This typically results in a hydronephrotic kidney with clockwise rotation of the pelvis and high ureteral origin. Intrinsic UPJ-stenosis is usually found in neonates or infants, and nowadays easily detected due to widespread of maternal ante- and postnatal ultrasound [33,34].

2.1.2. Extrinsic stenosis

Crossing vessels (CV) have been identified as the main cause of extrinsic UPJ-stenosis [15]. Precise dissection of upper ureter and pelvis during retroperitoneoscopic pyeloplasty showed a variety of pathological findings such as (i) a posteriorly crossing lower pole artery, (ii) an anteriorly crossing lower pole artery, (iii) two crossing vessels (vein and artery), (iv) additional small arterial branches circumflexing the ureter at the level of UPJ or (v) small lumbar or gonadal veins crossing the ureter [28]. Extrinsic UPJ-stenosis is predominantly found in adults. New-onset adult UPJO is seen as a completely different entity from congenital stenosis [35]. Whether a crossing vessel represents the underlying cause of obstruction or only an incidental finding is still a matter of debate. Janetschek et al. [36] detected CV by means of colour duplex ultrasonography close to UPJ in 116 of 331 (35%) non-obstructed renal units of healthy volunteers, whereas the incidence of CV in obstructed patients is more than twice as high.

2.2. Diagnostic algorhythm for evaluation of UPJO

Modern diagnosis of UPJO (Fig. 1) is based on findings of coloured duplex ultrasound, and magnetic resonance urography (MRU), respectively isotope nephrogram with split function and a furosemide washout evaluating functional relevance of stenosis. The advantage of MRU represents the lack of exposure to radiation. Both techniques create time-curve patterns for categorization of obstruction (no, indeterminant, compensated, definitive). There are distinct advantages of colour-duplex sonography especially the non-invasive determination of the resistancy index (RI) with a cut-off value of 0.75 (indicating presence of obstruction). This may replace one renogram per year [36,37]. The role of intravenous pyelography (IVP) diminished significantly. In specific cases, computed tomography or MR-angiography may be helpful.

2.3. Indication for operative management

The Society for Fetal Urology applies following guidelines: Observation includes ultrasound and renography/MRU at 6-month intervals for the first year and yearly thereafter [33]. Indications for surgery represent significant deterioration of function and persistant hydronephrosis (i.e., a loss of 10% of differential function actually represented at least a 20% decline in differential renal function). Further criteria for surgical intervention are symptoms such as recurrent urinary tract infection (i.e., acute
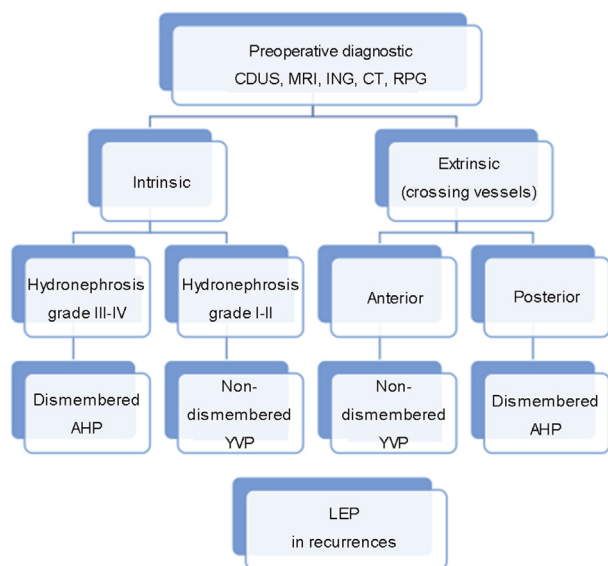
Figure 1 Algorhythm of modern diagnosis of uretero-pelvic junction (UPJ)-obstruction primarily based on findings of colour-duplex ultrasound (CDUS), and magnetic resonance urography respectively isotope nephrogram (ING) with split function and a furosemide wash-out) to evaluate functional relevance of the stenosis. Retrograde pyelography (RPG) is used prior to the procedure. AHP, Anderson-Hynes pyeloplasty; LEP, laserendopyelotomy; YVP, YV-pyeloplasty; CT, computed tomography.

pyelonephritis), acute flank pain (*i.e.*, more than three episodes per year) or stone formation.

2.4. Matched-paired comparison

From January 1995 to December 2016, a total of 515 patients underwent treatment for UPJ-stenosis at the Department of Urology and Pediatric Urology, SLK Kliniken Heilbronn, University of Heidelberg, Heilbronn, Germany. Among them 115 patients were treated by laser-endopyelotomy and 20 by open pyeloplasty. The remaining 380 patients underwent a laparoscopic approach including 206 cases of non-dismembered (YV) pyeloplasty (RLYVP), 157 cases of dismembered pyeloplasties (LAHP), and 17 cases of laparoscopic ureterolysis. We preferred the retroperitoneal access and the majority of YV-pyeloplasties were performed in presence of a crossing vessel. Of these 198 patients were suitable for a matched-paired (2:1) analysis compared to laparoscopic retroperitoneal YV-plasty (LRYVP; Group 1, $n = 131$) versus the traditional laparoscopic retroperitoneal dismembered pyeloplasty (LAHP; Group 2, $n = 67$) in case of UPJO due to a crossing vessel. The matched-paired analysis parameters included age, gender, kidney function and obstruction grade.

2.5. Review of the literature

Additionally we performed a non-systematic Medline/PubMed research focussing on the keywords "laparoscopic pyeloplasty" ($n = 963$), "laparoscopic retroperitoneal pyeloplasty" ($n = 114$), "retroperitoneoscopic pyeloplasty" ($n = 60$), "laparoscopic transperitoneal pyeloplasty" ($n = 189$), "robot-assisted laparoscopic pyeloplasty" ($n = 130$), and "SMART-pyeloplasty" ($n = 2$).

2.6. Definition of success

The success of the procedure was based on the improvement of drainage either on postoperative IVP or diuretic renogram respectively improvement of hydronephrosis on ultrasonography. Thus, we distinguished between overall and excellent success: (i) Excellent success was defined as complete absence of symptoms and significant improvement of hydronephrosis and renal drainage on IVP or diuretic renal scan; (ii) Overall success included also those cases with improvement of symptoms and no deterioration of hydronephrosis or renal function.

3. Technique of laparoscopic retroperitoneal pyeloplasty

3.1. Preoperative investigations

Prior to laparoscopic pyeloplasty, a retrograde examination is performed to demonstrate the course of the ureter and to verify UPJO. If the ureter shows a kinking indicating a significant extrinsic cause of obstruction (40%—50% of patients with adult UPJO), a double J-stent (7 Fr) is inserted. Some authors do not place a JJ-catheter to be able to estimate original anatomic conditions intraoperatively [26]. In infants and smaller children, a retrograde pyelography may not be necessary [19,29]. However, intraoperative antegrade placement of a JJ-catheter might be challenging.

3.2. Retroperitoneal standard access

Theoretical advantages of the retroperitoneal access include less dissection trauma to reach ureter (*i.e.*, no need to mobilize the colon), less problems with urine extravasation (*i.e.*, no contact of urine with bowel). A relative disadvantage represents the reduced working space, which becomes more important when robotic-assistance is applied respectively in case of infants or smaller children.

The patient is placed in typical kidney position with 20° Trendelenburg decline. A 15 mm incision is made in the lumbar (Petit's) triangle (lumbar trigonum) between the 12th rib and the iliac crest, bounded by the lateral edges of the latissimus dorsi and external oblique muscles (Fig. 2). A tunnel down to the retroperitoneal space is created by blunt dissection using a Kocher forceps. This tunnel is dilated until an index finger can be introduced to push the peritoneum forwards, thus creating a retroperitoneal cavity. Alternatively — to minimize access trauma — the retroperitoneal space can be expanded by use of a 10 mm balloon-trocar (Herloon; Aesculap, Tuttlingen, Germany). The space between lumbaraponeurosis and renal fascia (Gerota's fascia) is then dissected with the index finger or using the balloon-tocar. Two secondary

trocars (Port II and III, 5 and 10 mm) are inserted under control by the index finger. The initial wound (Port I, 12 mm) is closed using a mattress suture to prevent gas leakage. After establishment of pneumoretroperitoneum (max. CO_2-pressure 12 mmHg) the renal fascia is opened longitudinally for exposure of the psoas muscle. If necessary, a further 5 mm port can be inserted medially at the rim of peritoneum.

3.3. SMART

A tunnel is created via a 6 mm skin incision bluntly to the retroperitoneal space using an Overhold forceps. The retroperitoneal space is developed with a specially designed home-made 6 mm balloon trocar (Fig. 3A) blowing up the finger glove tied at the end of a 5 mm-trocar using an air-filled bladder syringe (Fig. 3B). The balloon trocar-system enables endoscopic monitoring of balloon dissection. Then the HD wide-view camera system attached to a 5 mm 30°-telescope (Karl Storz, Tuttlingen, Germany) is inserted through a 6 mm trocar, and two 3.5 mm working ports are placed under endoscopic control using same trocar arrangement as for standard retroperitoneoscopy (Fig. 3C). We use specially developed 3 mm instruments (Metzenbaum scissors, dissecting and grasping forceps bipolar coagulating forceps, ultra-micro needle holder, suction and irrigation tube; Karl Storz). Suture material is blindly inserted via the 6 mm optic port and retrieved via the 3.5 mm trocar after straightening the needle. In the last 91 cases (Group I, $n = 61$; Group II, $n = 30$) we were able to use an ergonomic platform (ETHOS; Ethos, Seattle, WA, USA), which proved to be very helpful particularly during suturing (Fig. 3D). Obviously, this was not relevant for the matched-paired analysis.

3.4. Dissection of UPJ and ureterolysis

Following incision of Gerota's fascia, the stented lumbar ureter can be easily identified and followed towards the renal pelvis. If a crossing lower pole artery is found, it is important, whether this vessel is crossing anteriorly or posteriorly to the ureter (Fig. 4): In this situation ureterolysis as well as arteriolysis of crossing/aberrant vessels are of most importance. The excision of the stenotic ureteral segment is of minor importance, because many authors demonstrated similar success rates after non-dismembered pyeloplasties with integration of the stenotic part into the renal pelvis and caudal displacement of the neo-UPJ.

3.5. Indication and technique of non-dismembered pyeloplasty RLYVP

In case of an anteriorly crossing vessel (*i.e.*, lower pole artery) a non-dismembered YV-plasty RLYVP is recommended. Since the correct anatomical course of the ureter is posterior (*i.e.*, dorsal) to the vessels, only a posteriorly crossing lower pole artery may need a dismembered pyeloplasty LAHP with anterior transposition of the ureter.
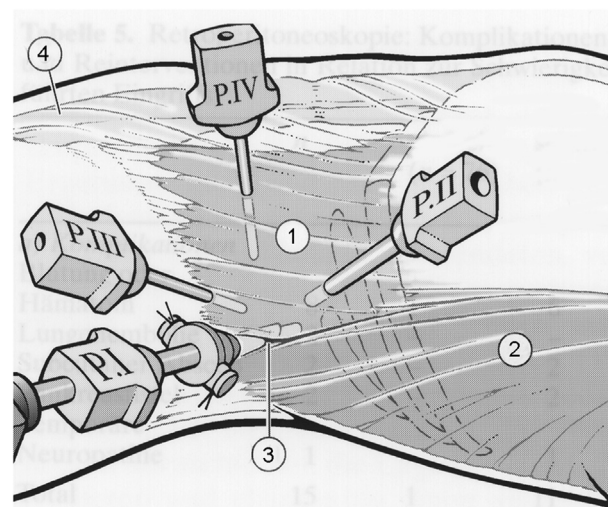

Figure 2   Trocar arrangement for right laparoscopic retroperitoneal pyeloplasty: Optic port (PI) between M. abdominisexternus ① and M. lattisimusdorsi ② at the lumbar trigone ③. Five or ten micrometer port for right hand (PII), 3/5 mm ④ rectus muscle port for left hand (PIII). Optional 3/5 mm port (PIV) medially.

Similar to the principle of an open non-dismembered pyeloplasty, the pyelon is incised above the stenosis and a wide-based V-shaped flap is constructed from the anterior pelvis. Subsequently, the ureter is incised longitudinally over the stenotic part of the UPJ and spatulated for further 2 cm (Fig. 5A). Now the V-shaped flap is anastomosed to the ureter starting at the distal edge using interrupted or continuous sutures (Fig. 5B—5D). Thereby, the stenotic part of UPJ is integrated into the pelvis and the neo-UPJ is transposed distally.

3.6. Technique of dismembered pyeloplasty LAHP

The renal pelvis is circumferentially incised above the stenotic area taking care not to damage the JJ—catheter (Fig. 6). The pelvic part still attached to the ureter can be used as a handle to manipulate and incise the stenotic part of the ureter followed by spatulation of the ureter up to 2 cm. In case of a redundant pelvis the size of the pyelon is reduced accordingly, however, one has to take care not to be too close to the caliceal orifices. Consensus exists with respect to the size of the suture (4-0, Vicryl or PDS). The suturing technique of anastomosis has not yet been completely standardized.

3.7. Postoperative care

A Robinson—drain is inserted routinely via the 5 mm port. Foley catheter is removed on second or third day. The drain is withdrawn on day 3—4 and the patient discharged. The JJ-catheter is removed 3—6 weeks postoperatively following a retrograde pyelogram confirming ureteral patency and excluding any extravasation. The follow-up includes colour-duplex-ultrasonography with RI on day 1 and 6 weeks after
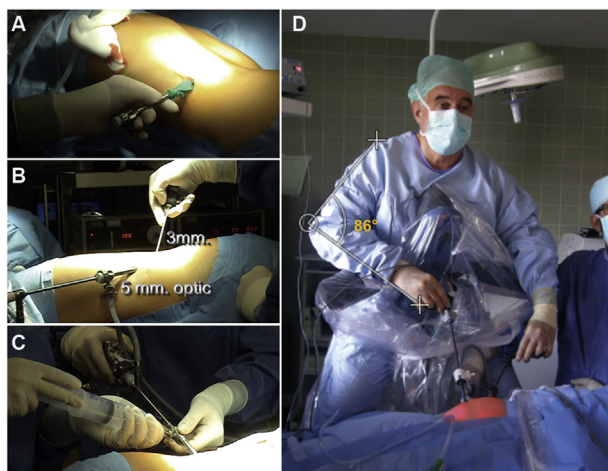
Figure 3 Access for small-access retroperitoneoscopic technique (SMART)-pyeloplasty (A) Self-made balloon-trocar using finger of latex-free glove fixed to 5 mm-trocar; (B) Balloon dilatation using air-insufflation via 5 mm-trocar und endoscopic control; (C) Placement of two 3 mm-trocars under endoscopic control; (D) Use of ETHOS-platform during small access retroperitoneoscopic technique SMART-pyeloplasty providing armrests and a support for the chest of the surgeon.

stent removal. Six months later, an isotope-renogram/MRU is carried out. Thereafter, ultrasonography is performed every 6 months and a renal scan is obtained at yearly intervals.

4. Results

4.1. Matched-paired analysis

A total of 198 patients were enrolled into the analyses. There were 74 females, 57 males and 33 females, 34
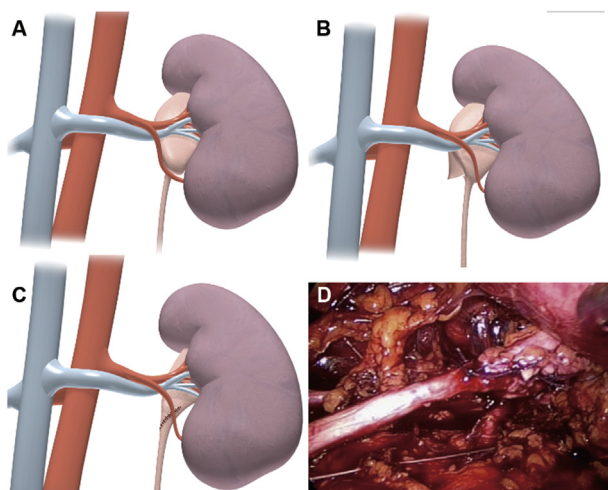

Figure 4 Laparoscopic retroperitoneal pyeloplasty using YV-plasty (LRYVP) in case of anteriorly crossing vessel (A) Schematic drawing of left anteriorly crossing vessel; (B) Schematic drawing of principle of YV-plasty; (C) Schematic drawing of anatomical situation after YV-plasty; (D) Final endoscopic view after anastomosis.

males in Group 1 and Group 2, respectively. The mean follow-up was 24.8 ± 4.9 months. Mean age was 33.9 ± 19.1 years (Table 3). Most of the patients admitted were referred to our clinic with flank pain and/or hydronephrosis. The CV was located ventral to UPJO and the side of CV was similar in both groups. We could identify 52% of the CV with color-duplex ultrasound (CDU) in this series. Mean operative time, preoperative and post-operative kidney functions, and success rates were similar in both groups. As well, the success rate was both 90% in Group 1 and Group 2 (Table 4).

There was no significant difference in terms of complications between the groups (Table 4). The most common complications were urinary tract infection (Clavien Grade 1; one patient in Group 1 and three patients in Group 2) and haematuria (Clavien Grade 2; two patients in each group). These were managed conservatively. Two patients needed stent change under local anaesthesia (Clavien Grade 3a) in Group 1. Patient with retroperitoneal urinoma was needed drainage placement under regional anaesthesia (Clavien Grade 3b). There was no Clavien Grade 4 and 5 complications in the study.

4.2. Impact of SMART

In a recent study evaluating the impact of SMART, all procedures were completed without any conversion to open or classic retroperitoneoscopic technique [30]. No intraoperative complications were collected in both groups. No statistical differences were recorded in terms of operative time, pre- and post-operative Hb-difference, time to JJ—catheter removal, RI-improvement, and success rates. The SMART group showed faster drain removal and shorter hospital stay [30]. Concerning postoperative pain there was no statistically significant difference, but the cosmetic cumulative data were statistically significant in favour of SMART. Patient scar assessment and observer scar assessment differed significantly. Al-Nasser et al. observed significant differences with respect to "vascularisation" and "thickness" comparing 3.5 mm versus 10/12 mm trocar wounds after 19 months, when comparing the long-term cosmetic outcome of SMART with standard retroperitoneoscopy [31]. However there was no statistically difference between 3.5 mm and 5 mm port sites (Fig. 7). Based on this study, we mainly use 5 mm ports as working trocars and 3 mm ports only for retraction. Of course, mini-laparoscopy may have the same functional and cosmetic outcome [32].

4.3. Success rates of laparoscopic pyeloplasty in the literature

In accordance with patient selection, the percentage of CV is relatively high ranging between 41% and 87% in the different series (Table 2). In the majority, anteriorly crossing vessels have been described. In most series only cases with primary UPJ-stenosis have been included, but it has been shown that secondary UPJ-stenosis, *i.e.*, after failure of acucise-incision, laser endopyelotomy or open surgery can also be treated safely and effectively by laparoscopy [28].
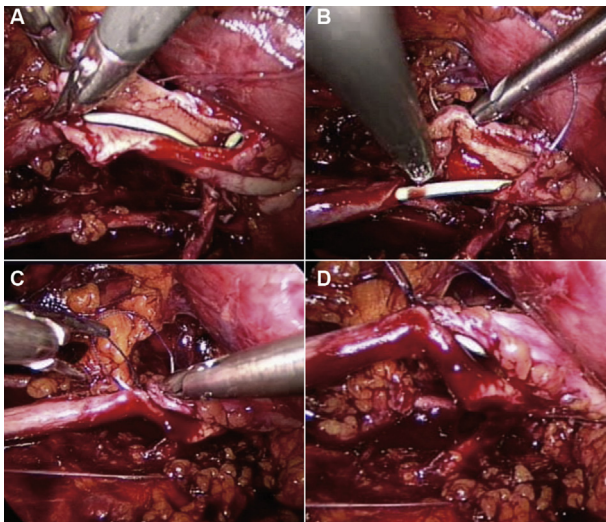
Figure 5 Laparoscopic retroperitoneal pyeloplasty—technical details of non-dismembered pyeloplasty (SMART-technique). (A) Incision of renal pelvis and spatulation of ureter in a Y-form. The incised stenotic UPJ is included in the pelvis; (B) Initiation of pyeloplasty in a continuous fashion (Vicryl, 4-0, RB1-needle) at the medial side of the pelvis and ureter; (C) Creation of neo-UPJ anastomosing the pelvic flap to the spatulated ureter; (D) Exposition of the medial part of the anastomosis in V-form. SMART, small access retroperitoneoscopic technique; UPJ, uretero-pelvic junction.

The results of all groups are above 90%, ranging from 90% to 98% for the overall success and from 82% to 87% for the excellent success rates (Table 2). Some groups found higher success rates for primary versus secondary obstruction (*i.e.*, 97.6% *vs.* 88.2%) [27], and higher success rates for the dismembered versus non-dismembered pyeloplasty (*i.e.*, 96.0% *vs.* 73.3%) [12]. Others could not detect such differences [28,29]. If the indications are properly selected, there are no differences in results between dismembered and non-dismembered pyleoplasty at high-volume centres (Table 1). Moreover, the success of laparoscopic pyeloplasty does not depend on the type of access (transperitoneal *vs.* retroperitoneal *vs.* SMART), which should be kept to surgeon's preference.

4.4. Complications of laparoscopic pyeloplasty in the literature

To enable optimal comparison, intraoperative complications should be classified using the Satava-classification distinguishing between three grades. Intraoperative complications ranged from 2.0% to 2.3% in large series excluding recurrent UPJ-stenosis (Table 2). Postoperative complications should be classified according to the modified Clavien-Dindo-classification distinguishing between five grades. Postoperative complications were observed between 12.9% and 15.8% in large series respectively up to 22.5% in smaller cohorts (Table 2). There are very few late complications due to recurrence of the UPJ-stenosis (*i.e.*, anastomotic stricture) requiring open pyeloplasty in nine cases (2.1%) respectively laparoscopic nephrectomy in three (0.7%)
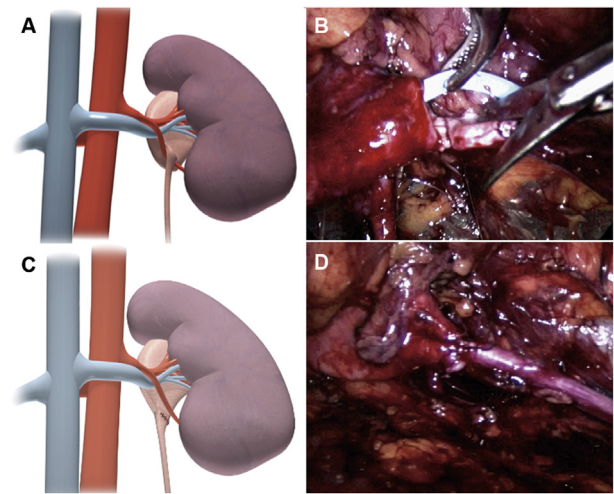

Figure 6 Laparoscopic retroperitoneal pyeloplasty—Dismembered pyeloplasty (LAHP) in case of posteriorly crossing vessel. (A) Schematic drawing of posteriorly crossing vessel; (B) Resection of stenotic part, reduction of pyleon and spatulation of ureter; (C) Schematic drawing of anatomical situation after dismembered pyeloplasty. (D) Laparoscopic picture of the reconstructed ureteropelvic junction after dismembered pyeloplasty.

cases. In the literature recurrent UPJ-stenosis requiring any reoperation was seen in 3.5%—42.8%.

5. Discussion

Laparoscopic pyeloplasty is able to meet the success criteria of open surgery for the management of UPJO in adults. However, there are now several approaches and modifications of access and technique available.

5.1. Selection criteria for management of UPJ-stenosis

Previously the open dismembered pyeloplasty represented the treatment of choice for UPJ-stenosis. The main reason for the preference of the Anderson-Hynes technique represented the fact that with this operation, the presence or absence of a CV became negligible. However, in multimodal minimally invasive management of UPJ-stenosis, these patho-anatomical factors may play an important role for adequate patient selection, such as (i) children *vs* adults, (ii) intrinsic *vs.* extrinsic stenosis, (iii) anteriorly *vs.* posteriorly CV, and (iv) redundant *vs.* moderately distended pelvis.

5.2. Children *vs.* adults

In children mostly an inborn intrinsic UPJ-stenosis is found associated with a high insertion. This can be still performed by open dismembered pyeloplasty mainly because the access trauma of a lumbotomy in the infant is relatively low compared with laparoscopy or retroperitoneoscopy. However, in the meantime the armamentarium of laparoscopic surgery has been significantly improved including wide-angle 5 mm HD-videosystems and telescopes, 3 mm

Table 3 Patient data of laparoscopic retroperitoneal pyeloplasty: Comparison of dismembered and non-dismembered pyeloplastyin presence of a crossing vessel (Department of Urology and Pediatric Urology, SLK Kliniken Heilbronn, University of Heidelberg, Heilbronn, Germany).

Parameters	Non-dismembered (LRYVP)	Dismembered pyeloplasty (LAHP)	p-Value
n	131	67	
Mean age (year)	34.6 ± 2	32.6 ± 1.6	0.5
Gender			0.3
Female (%)	74 (58)	33 (49)	
Male (%)	57 (42)	34 (51)	
Preoperative pain	116 (89)	57 (85)	0.3
Preoperative obstruction grade n, (%)			0.3
Grade 1	3 (3)	2 (3)	
Grade 2	75 (57)	29 (43)	
Grade 3	53 (40)	36 (54)	

LAHP, laparoscopic Anderson-Hynes pyeloplasty; LRYVP, retroperitoneal laparoscopic YV-pyeloplasty.

instruments and needle-like retractors enabling transperitoneal mini-laparoscopy respectively SMART [30—32]. Also for the Da Vinci-device, 8 mm-3D-telescope and 5 mm instruments providing Endowrist™-technology are available [32,38]. All this has led to increasing the use of laparocopic pyeloplasty also in children [29,39].

5.3. Importance of crossing vessels

Johnston and associates [40] found CV only in 27% of 219 pediatric cases. In contrast to this, in the adults, the incidence of CV/periureteral adhesions is relatively high (40%—70%) indicating an acquired extrinsic cause of the UPJ-stenosis. This may even cause only intermittent episodes of pain or hydronephrosis. The question, whether the CV are relevant for the UPJ-stenosis or only an associated finding, has gained significant interest among endourologists because of its negative impact on the results of endopyelotomy [41]. Also in our early series, the majority of failures of laser endopyelotomy were in the presence of an aberrant vessel [17,28]. This is the main reason why we have practically abandoned the use of endopyleotomy for primary UPJ-stenosis supported

by the fact that we were able to improve and standardize our technique of laparoscopic retroperitoneal pyeloplasty. Another factor represented the use of ETHOS during the procedure (Fig. 3D), which helped us equally in both techniques (LAHP and LRYVP).

However, it remains debatable to what extent crossing vessels are really responsible for the UPJ-stenosis. In accordance to early observations of Johnston et al. [40], the CV itself was not the cause of obstruction, but either periureteral adhesions, circumflexing small-caliber arteries or even an associated intrinsic stenosis was. All this could be optimally demonstrated by means of laparoscopic dissection with up to 10-fold magnification. Conclusively, the ureterolysis is one of the most important steps of the procedure. Complete ureterolysis usually results in remarkable transposition of the CV away from the ureteropelvic junction, independently, whether the vessel was anterior or posterior. Therefore, a dismembered pyeloplasty may not be required to achieve a similar effect. In accordance with the study of Pesce et al. [42], we feel that the main reason for the success of a plastic reconstruction does not represent the transposition of the ureter, but the

Table 4 Results of laparoscopic retroperitoneal pyeloplasty: Comparison of dismembered and non-dismembered pyeloplasty in presence of a crossing vessel (Department of Urology, SLK Kliniken Heilbronn, University of Heidelberg, Germany).

Parameters	Non-dismembered (LRYVP)	Dismembered pyeloplasty (LAHP)	p-Value
n	131	67	
Mean preoperative kidney functions	35.1 ± 1.1	35.9 ± 1.0	0.5
Mean postoperative kidney functions	36.3 ± 1.0	37.7 ± 1.0	0.2
Mean operation time (min)	112 ± 33.4	114 ± 45.1	0.3
Complications according to Clavien Classification n (%)			0.2
Grade 1	1 (0.8)	3 (4.4)	
Grade 2	2 (1.4)	2 (2.9)	
Grade 3a	2 (1.4)	0	
Grade 3b	1 (0.8)	0	
Grade 4	—	—	
Grade 5	—	—	
Success rate, n (%)	118 (90)	60 (89)	0.6

LRYVP, retroperitoneal laparoscopic YV-pyeloplasty; LAHP, laparoscopic Anderson-Hynes pyeloplasty.
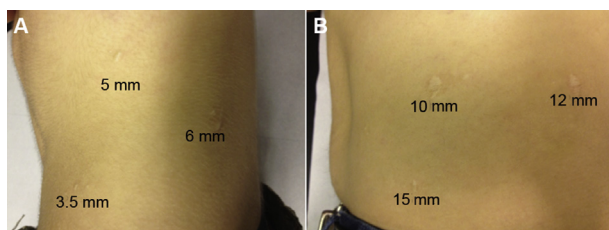
Figure 7 Cosmetic aspect of small access retroperitoneoscopic technique (SMART)-pyeloplasty *vs.* retroperitoneoscopy. (A) Minimal scars 3 months after SMART; (B) Significantly larger scars after conventional retroperitoneoscopy.

transposition of the vessel away from the ureteropelvic junction does.

5.4. Dismembered *vs.*non-dismembered pyeloplasty

Only in the comparative study of Klingler et al. [12] the results of LRYVP were inferior compared to dismembered open or laparoscopic pyeloplasty (73.3% *vs.* 93.4% *vs.* 96.0%), but they used preferably a Fenger-plasty rather than a YV-plasty [21]. All other series showed similar success rates, particularly for the YV-plasty which allows realization of all important technical points, such as incorporation of the stenotic part into the renal pelvis, creation of a wide neo-uretero-pelvic junction more distally to the previous one. A LAHP is only indicated if transposition of the ureter (*i.e.*, in presence of a posteriorly crossing vessels) is required. Advocates of LAHP emphasize that this technique allows excision of the diseased (*i.e.*, aganglionic or inflammated) segment [43,44]. However, the good results of open and laparoscopic non-dismembered techniques have clearly demonstrated that this theoretical reason is no justification for a LAHP (Table 4).

6. Conclusion

Endourology, laparoscopy and retroperitoneoscopy have completely revolutionized the management of upper tract stenosis. Especially, laparoscopic retroperitoneal pyeloplasty has achieved similar results compared with the previous golden standard of open surgery. However, it provides the advantages of minimally invasive surgery. Particularly in case of a posteriorly crossing vessels, a non-dismembered (*i.e.*, RLYVP) represents a safe and effective option. This can be further improved when using the SMART respectively mini-laparoscopy.

Conflicts of interest

The authors declare no conflict of interest.

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