



Pyeloplasty the Dilemma: Open – Endoscopic – or Laparoscopic?

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Abstract

Ureteropelvic Junction Obstruction [UPJO] is defined as anatomic or functional impedance to urine flow at the ureteropelvic junction [UPJ] leading to progressive dilation of the renal collecting system. UPJO is one of the most congenital disorders of the urinary tract (1:2000 - 5000 live births). The disorder is more common in males, more on the left side, and can be found bilaterally in 10% to 40% of cases.

Etiology

The etiology of UPJO can be classified either according to onset into primary (congenital) or secondary (acquired) or, more commonly, according to the cause of obstruction into intrinsic or extrinsic. Functional or intrinsic UPJO may result from disorganization of the muscle bundles leading to failure of propagation of the peristaltic wave and transmission of urine across the UPJ. Extrinsic obstruction by a crossing vessel is a subject of a major debate and controversy [3-5].

Natural History

Initially the urinary tract responds to obstruction in a compliant way by dilatation in order to maintain a low intraluminal pressure. However, persistent obstruction evokes increased smooth muscle activity leading to muscular hypertrophy with subsequent decreased compliance and increased intraluminal pressure with its subsequent effect on GFR and parenchymal function but the outcome after correcting obstruction might be unpredictable in terms of full recovery of renal function [6,7]. Although UPJO in most of cases is a congenital disorder, its clinical presentation may be delayed till much later in life since up to 80% of cases might remain asymptomatic after birth to present later as palpable abdominal mass, recurrent urinary tract infection, flank pain particularly with diuretic states e.g. beer drinking and rarely with hematuria or azotemia in bilateral cases or UPJO in a solitary kidney.

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Diagnosis

The aim is to confirm the diagnosis of obstruction, exclude mimic conditions, identify those who can be managed conservatively from those who require intervention, and finally aid in guiding the nature of intervention (endourologic, laparoscopic or open surgery).

Ultrasound [US]

Thanks to the wide application of routine antenatal ultrasound monitoring, the diagnosis of UPJO is no longer a palpable flank mass in newborn, but can be achieved before birth. Antenatal hydronephrosis [AHN], particularly UPJO, is the most common abnormality being reported in 50% to 90% of all cases with genitourinary abnormalities [8,9]. However, it is of paramount importance to recognize that a mere urinary tract dilatation is not equal to obstruction as there is a significant overlap with physiological and transient hydronephrosis which are actually the most common causes of antenatal hydronephrosis [AHN]. There is a chance for spontaneous resolution to this dilatation but a dilated non obstructed system can be obstructed at any time even asymptotically. There is no golden test to diagnose obstruction in utero and, serial evaluations are usually required but the definitive diagnosis can be only reached after birth. The Society for Fetal Urology has adopted a classification system that relies on the degree of caliceal dilatation [10], most reports depend on measurement of the anteroposterior diameter of the renal pelvis, a 15 mm renal pelvis dilatation was a significant threshold to suspect obstruction in 80% of fetuses [11].

Differential diagnosis of ANH includes; transient or physiological hydronephrosis, vesicoureteral reflux, posterior urethral valve, multicystic dysplasia, prune belly syndrome, ectopic

ureter, obstructive ureterocele [8,12,13].

Postnatal US and auxiliary US procedures such as measuring the intrarenal resistive index before and after relief of obstruction could serve as an important predictive parameter in assessment of a functionally significant obstruction in the UPJO patient [14,15].

Fetal Sampling and markers

Fetal serum β 2-microglobulin has been used as an index of fetal GFR, with modest discriminatory potential in the prediction of postnatal GFR [16]. Other useful urinary biomarkers indicative of the status of the obstructed kidney include; urinary matrix metalloproteinase-9 [17,18] and urinary angiotensinogen which is highly correlated with intrarenal angiotensin concentration [19]. In addition, karyotyping studies had shown that a DD-genotype of angiotensin converting enzyme is indicative of a significantly greater parenchymal damage and more rapid loss of the GFR in comparison to those with the II or DI genotype.

Intravenous Urography [IVU]

Although intravenous urography is still considered to be the cornerstone to outline urinary tract morphology and function in many urologic centers, however, its role might be questionable in the era of 3-dimensional cross-sectional imaging (CT & MRU). Classic diagnostic findings on IVU are; variable degrees of pelvicaliceal dilatation, delayed excretory function, with a normal or a non-visualized ureter. Adequate hydration with administration of a diuretic is helpful in uncovering equivocal cases [20-23].

Renal scan

The role of renal scan is not only limited to patient evaluation and defining patients in whom active intervention is required, but also it is extended to include follow up whether an active or a conservative treatment approach was taken. A properly performed renal scan, diuretic MAG3, provides extremely valuable functional data on baseline differential renal function and whether a functionally significant obstruction is present or not i.e. hydrodynamic data.

Renal scan may also play an important role in predicting the success of active intervention; as a 3-month better functioning unobstructed diuretic renogram predicts surgical success and that no further evaluation is necessary [24].

Factors Affecting Successful Outcome

Since the goals of active intervention are to promote renal drainage, preserve kidney function and resolve symptoms, failure would be defined as inability to achieve or maintain any of these goals. A successful treatment must be defined and based on clinical, anatomical/morphological and functional standards. In absence of such clear standards defining success at a certain period of follow up it might be difficult to decide whether a further intervention is required or not. Recently success was defined as symptomatic resolution and relief of more than 80% of preoperative pain, either stable or improved renal function and dilatation in the excretory urography and improved washout from the renal pelvis on renal scan as well as a resistance index of less than 0.7 [25].

Crossing vessel dilemma

Several controversial issues are linked to the subject of the "crossing vessel". Starting from its anatomical nature (normal Vs, aberrant, Vs accessory), its clinical contribution to obstruction, value of preoperative workup aiming to its detection with its

relation to intraoperative hemorrhagic complications when incise endourologic techniques are used, and finally its impact on treatment outcome. Given the unpredictability of crossing vessel associated with UPJO, the current recommendation of most centers is to image preoperatively or intraoperatively before endoscopic incision using additional imaging studies than the usual routine work up [24]. Depending on the method of imaging used, the detection rate of a crossing vessel in patients with UPJO was 39% in patients evaluated with conventional angiography [26,27], 40% [27] to 80% [28] in patients evaluated with spiral CT, 53% [29] to 71% [30] in patients evaluated with endoluminal US, and 80% in patients evaluated with color Doppler [31].

In a prospective comparative study Keeley et al. [32] found that endoluminal US was more sensitive than CT angiography for identifying crossing vessels and septa between the ureter and renal pelvis. The addition of digital subtraction and three-dimensional image reconstruction (CT angiography, CTA) has made CTA an attractive preoperative imaging option providing more precise details of renal vascular anatomy. The study has achieved excellent performance and close association to operative findings in detecting the presence of a crossing vessel with a reported test sensitivity and specificity of 91 % to 100%; and 97% to 100%, respectively [33,34].

MRA [Magnetic Resonance Angiography] displays of renal vascular anatomy present challenges identical to the clinical applications of CTA. The greater spatial resolution of CTA and ability to visualize the crossing vessel regardless of its nature (artery or vein) over MRA favors the CT application over MRA.

During open and laparoscopic pyeloplasty a crossing vessel has been found in ~40% of cases [36]. Crossing vessels as a cause for UPJO; has been doubted based on several observations e.g. the high prevalence of non-obstructive crossing vessel in many individuals with a normal UPJ, a crossing vessel is not a constant findings in all cases of UPJO, histologic evaluation has almost always revealed intrinsic factors (muscular discontinuity) even when a crossing vessel was present, and the anatomic studies based on three-dimensional imaging concluded that crossing vasculature bears no direct relation to the point of transition in many cases [37,38]. Last of all, crossing vessels are more commonly observed in adults, than in pediatrics and even less commonly observed in infants with UPJO. Since UPJO is a congenital disorder, the infrequent finding of crossing vessels in infants casts doubt on a vascular etiology for UPJO [36]. Crossing vessel may influence the treatment approach and the clinical results in several aspects. A negative impact of endopyelotomy have been reported by Van Cangh et al. [39] as they concluded that the presence of crossing vessels was the single most important factor for failure of endopyelotomy as it decreased the success rate of antegrade endopyelotomy from 86% to 42%. A number of subsequent trials had confirmed the negative impact of the presence of a crossing vessel as it may lower the overall success rate of endopyelotomy by 24% to 50% [30,39], while the success rate of endopyelotomy may approach 100% if no crossing vessel was detected on endoluminal US [40].

On the contrary, Nakada et al. [27] found that 38% of patients who had a successful outcome 2 years after endopyelotomy had a crossing vessel. The authors added in their conclusion that the adverse influence of the crossing vessel is not sufficient to justify the added expense of preoperative angiography, spiral CT or endoluminal ultrasound. Others would consider crossing vessels to be a contraindication to endopyelotomy which cannot correct the underlying abnormal

spatial relationship between the UPJ and the offending vessel and would recommend dismembered pyeloplasty rather than to continue with antegrade endopyelotomy [41]. Even if endopyelotomy was anticipated, it is crucial to avoid inadvertent injury to a crossing vessel in order to prevent hemorrhagic complications and need for transfusion which have been reported in up to 9% to 23% of cases with a potential loss of functioning renal tissue since the crossing is a segmental artery in the majority of cases [42-45].

Nature and pathology of the stricture itself

Strictures longer than 2cm are usually avascular, associated with dense fibrosis and generally have a worse prognosis, therefore such strictures or those associated with complete luminal obliteration are considered a contraindication to endopyelotomy, therefore open surgical dismembered reconstruction is preferred [46,47].

Both primary and secondary strictures are amenable to endoscopic correction which is generally preferred in secondary cases, and has a slightly higher success rate (84% vs. 79%) [48]. Endoscopic procedures as a repeat intervention for management of failed prior open or laparoscopic pyeloplasty are favored due to its minimally invasive nature. Varkarakis et al. [49] reported a 70% success rate with a repeat intervention following a failed primary laparoscopic pyeloplasty. Reports on the results of endopyelotomy for 1ry or 2ry UPJO are contradicting and not conclusive, as Gupta et al. [50] reported a higher success rate with secondary UPJO (89% Vs. 82%), while on the contrary Matin et al. [51] reported higher success with primary UPJO (68% Vs. 50%). It is also to be noted that endopyelotomy following a failed pyeloplasty achieves a higher success than a repeat endopyelotomy (71% vs. 55%) [52]. However, laparoscopic pyeloplasty has been described as a feasible salvage procedure for failed endopyelotomy or open pyeloplasty with success rates ranging from 90 to 100% without associated increased open conversion or complication rates [53,54].

Degree of hydronephrosis

An inverse relationship between the degree of hydronephrosis and outcome of endopyelotomy has been observed in several clinical reports [45,55]. A marked degree of hydronephrosis or pyelocaliceal dilatation may significantly compromise the results of corrective procedures for UPJO. Gupta et al. [50] achieved a 96% success rate in patients with moderate hydronephrosis vs. only 50% success in those with a high-grade hydronephrosis. Van Cangh & Nesa (1998) confirmed such an inverse relationship; in addition, the presence of a crossing vessel is a further risk predictor. Endopyelotomy failure may be as high as 95% for high-grade hydronephrosis in the presence of crossing vessels vs. 39% failure rate for low-grade hydronephrosis with a crossing vessel [56,57].

In cases associated with high-grade hydronephrosis, reconstructive open or laparoscopic approach are generally recommended in order to excise redundant parts of the renal pelvis and allow tailoring of a dependent UPJ. However, experience from endopyelotomy series claim that pelvic drainage following endopyelotomy may be helpful in cases associated with redundant renal pelvis [58].

Degree of kidney function

Poor overall or split kidney function prior to endopyelotomy or pyeloplasty is a well recognized negative predictor. Decreased urinary flow through the corrected UPJ has been proposed as a possible mechanism [57,59]. Generally, endopyelotomy is not advised in kidneys with a percentage renal function <20% [60], and nephrectomy

is recommended for poorly functioning kidneys (<15%) [61].

Impact of early diagnosis and prenatal detection

Logically it is expected that waiting renal function to decrease in order to do pyeloplasty, is not warranted since it does not improve even if obstruction is corrected. However, an earlier antenatal diagnosis would improve outcome as it allows earlier interference, however, several clinical trials failed to reach to such conclusion. Thomas (2008) reviewed the long-term outcome of prenatally diagnosed urinary tract abnormalities. Congenital UPJO, unlike posterior urethral valve, follows a benign course and the risk of chronic or end stage renal failure is exceedingly low unless the condition is bilateral or a solitary kidney is involved [62]. However, the beginning of the era of prenatal diagnosis was associated with doubling of the number of patients (age 0 to 19 years) performing pyeloplasty although asymptomatic [63]. With a more conservative approach many cases show a stable kidney function and it seems that early antenatal detection has led to over treatment and performing a quite large number of unnecessary pyeloplasty.

Management

Indications for surgical intervention in cases of ureteropelvic junction obstruction (UPJO) include symptoms related to the obstruction, progressive deterioration of ipsilateral renal function, infection or the development of stones [65]. Therefore, intervention is aimed at preservation of renal function and relief of symptom [66]. In cases with bilateral obstruction staged procedure can be planned with an 8 to 12 weeks interval although a double-J stent or a nephrostomy tube to improve the less functioning kidney during correction of the better kidney is a suitable rational.

Various surgical approaches have been developed for correction of this condition but until now the ideal and universal treatment is still elusive and controversial [67]. Over the past 2 decades, minimally invasive surgery has been utilized with increasing frequency aiming to offer less morbidity and shorter convalescent periods than open surgery. Minimal invasive surgery included balloon disruption of UPJ, endopyelotomy and more recently minimal access pyeloplasty i.e. laparoscopic pyeloplasty with or without robotic assistance [68].

Open pyeloplasty

Several open reconstructive techniques have been described but historically open dismembered pyeloplasty described in 1949 by Anderson and Hynes is the gold standard as it allows complete excision of abnormal UPJ and reduction of the redundant renal pelvis thus providing a widely patent, dependently positioned, well-funneled ureteropelvic junction [66]. Stenting with or without nephrostomy diversion has been challenging but generally it minimizes the morbidity and improves the success. Open pyeloplasty has been used as a template, and has gained the most universal acceptance because it can be applied to all types of UPJO, can treat all anatomical and pathological causes of obstruction, can be performed in most centers by most urologist and provides a short term success between 90% to 100%, a reliable long-term success rate in excess of 90% [69]. However pain, long lumbar incision and prolonged convalescence have been its major drawbacks [70]. The Y-V non-dismembered modification which is recently reported, can be performed by either routes (open and laparoscopic), and is only suitable for the UPJO in patients with short stenotic segment, redundant pelvis and no crossing vessels [71]. Furthermore it requires validation and longer follow up as delayed pyeloplasty failure have been reported after laparoscopic procedure

[72].

Minimally invasive techniques

Balloon dilatation of UPJ: Dilatation of UPJO is performed under fluoroscopic control and can be performed via both antegrade and retrograde routes. The balloon is inflated until the waist seen on fluoroscopy disappears. The advantage of the technique is its short learning curve and the low risk of bleeding. However, it does not appear to have gained popularity, as there is only a success rate of 67% to 81% [66].

Incisional techniques

Endopyelotomy: Endopyelotomy involves full thickness incision through the obstructing ureteropelvic junction allowing the urothelium and ureteric muscle to regenerate in a wider lumen around a ureteric stent. The incision is usually performed laterally or posterolaterally to avoid any crossing vessels.

In 1983, Wickham and Kellett and one year later in 1984, Arthur Smith performed antegrade endopyelotomy via a percutaneous approach using a cold knife. Ureteroscopic endopyelotomy soon followed using the rigid ureteroscope. Although it was difficult to reach the ureteropelvic junction in cases with complete obliteration of the lumen and to use the rigid ureteroscope in all situations, the availability of flexible instruments prompted the wider acceptance of flexible ureteroscopic endopyelotomy [73].

This approach can be performed using either laser or diathermy for incision either under endoscopic vision or under fluoroscopic guidance by Acucise device.

In the last two decades, endopyelotomy has been widely performed because of its technical simplicity and decreased morbidity. Therefore, it has supplanted open pyeloplasty as an initial non-invasive treatment option for most adults and older children with primary UPJ obstruction [39,42,58].

Success rates for endopyelotomy using retrograde ureteroscopic procedure range from 73% to 90% in different series [40,45,74].

The most important factor predicting the outcome of these procedures is patient selection. Degree of hydronephrosis, degree of ipsilateral renal function, stricture length and the presence of crossing vessels are all factors that should be addressed prior to intervention, as these components have significant predictive impact on the success after intervention [75-77].

Furthermore, several studies have shown that the presence of a crossing vessel impacts negatively on the outcome of the endopyelotomy [39,40,57]. However, some authors don't agree that this condition represent a contraindication for performing endopyelotomy [78] or that they adversely affect the result [36].

Collectively, Butani and Eshgi reported that in selected patients with stenosis <2 cm, no massive hydronephrosis, and renal function >25%, success rate of 96% with primary endopyelotomy and 85% with secondary endopyelotomy have been achieved using cold knife incision [79].

When comparing endopyelotomy with other treatment options, it was found to be less invasive, requires less operating room time, enables performing the procedure on an outpatient basis or with a very short hospital stay, and was associated with a shorter convalescence period [80,81], furthermore it may provide a reasonable and successful treatment for patients who have failed open

pyeloplasty [82]. Although success rates average 82% with retrograde endopyelotomy with no significant difference between primary and secondary cases, the success rate falls significantly to less than 50% for those submitted to repeated endopyelotomy. Thus, endourological intervention after initial endourological failure has significantly reduced success rate [82]. In contrast, a failed endopyelotomy does not appear to adversely affect the success rate of subsequent open pyeloplasty [83].

Significant intraoperative and postoperative bleeding is one of the major concerns of endopyelotomy either antegrade or retrograde, with an incidence of 1.2% to 9% [84]. However, Acucise, which is a blind procedure, is theoretically claimed to have a higher risk of bleeding from crossing vessels [85]. Kim et al. [86] reported that bleeding was encountered in three (4%) out of 76 cases and all patients required blood transfusion while 2 required angiography and emolization. In a study of 40 patients with primary or secondary UPJ obstruction randomised to be treated by laser endopyelotomy or the Acucise device, El-Nahas and his colleagues have found after a mean follow up of 29.9 months success rates of 85% and 65%, respectively [87,88].

Endopyeloplasty: In a trial to provide a potential functional superiority over conventional endopyelotomy, a horizontal suturing of a standard longitudinal endopyelotomy incision is performed using a nephroscope. The procedure was associated with a longer operative time, higher functional success compared with endopyelotomy and a successful outcome similar to those of laparoscopic dismembered pyeloplasty. It entails an optimal full thickness healing by primary intention without contrast extravasation outside the lumen. Furthermore the procedure is associated with shorter duration of stenting. The initial reports of this technique which needs certain equipment and experience have shown a sustainable success for one year to all cases submitted to this procedure [89].

Minimal incision pyeloplasty

Laparoscopic Pyeloplasty [LP]: Initial experience in laparoscopic management of the obstructed UPJ has been reported by Schuessler, Kavoussi L and Peters C. in 1993 [90]. Since that time, better optics, instruments and greater experience in suturing have reduced operating times to be similar to open surgery.

A high success rates following laparoscopic pyeloplasty that equal to those of the open procedure with the advantage of the minimally invasive techniques such as decreased pain, short hospital stay, early return to full activity as well as avoidance of a substantial wound have been always and frequently reported [91,92].

The procedure can be performed via both a transperitoneal and a retroperitoneal route depending on the preference and experience of the surgeon involved, however the operating times and success rates are reported similar using both approaches [93]. However with the transperitoneal procedure, the working space is larger with clear anatomic guide marks while the retroperitoneal route provides a direct exposure to the urinary tract and allows easy detection of crossing vessels.

The principle difference between LP, which fulfill all principles of open dismembered Anderson Hynes technique and its endourologic counterparts lies in its ability to treat all patients as it addresses all situations related to UPJO including patients with high insertion ureter, complete luminal obliteration, significant hydronephrosis and those with crossing vessel with no need for preoperative or

intraoperative imaging to exclude these vessels, which saves time and money [70,91]. The main drawback has been the relatively steep learning curve, difficulty in intracorporeal suturing and knotting and in the conversion rate to open surgery which varies from 0 to 6.4% [66,73,94].

In a comparative study between LP and endopyelotomy [EP], Dimarco found the success rate for laparoscopic pyeloplasty to be significantly greater than for endopyelotomy and estimated 3, 5 and 10-year recurrence-free survival rates for EP to be 63%, 55% and 41% compared to 85%, 80% and 75% for LP respectively [73,88,95].

Brooks and Kavoussi 1995 have reported the results of a comparative study of open pyeloplasty versus three minimal access treatment modalities: antegrade endopyelotomy, Acucise endopyelotomy, and transperitoneal LP. In this retrospective and non-randomized study the success rates with a mean follow-up period of 21 mo were 100% for both open (n=11) and laparoscopic pyeloplasty (n=12), 78% for Acucise endopyelotomy (n=9), and 77% for antegrade endopyelotomy (n=13). Predictably, Acucise endopyelotomy resulted in a shorter convalescence of one week than LP with a conclusion that LP was as effective as open pyeloplasty in relieving UPJ obstruction, but led to a more rapid return to normal activities.

Therefore, Laparoscopic dismembered pyeloplasty has been settled as an excellent and reproducible management to all types of UPJO competing open pyeloplasty the long-held gold standard. Due to improvement in the technical skills, proven safety, effectiveness with minimal morbidity and increased success rate to be similar to open techniques with more than 90% in many big series, the argument that open approach is still the gold standard is strongly debatable particularly in equipped centers and by experienced urolaparoscopist [25,93,96,97].

Robot-assisted laparoscopic pyeloplasty: The da Vinci robot pyeloplasty first performed by Sung and Gill in 1995 on a porcine model has commonly been performed transperitoneally [98] but recently Kaouk has described retroperitoneal robotic pyeloplasty with excellent clinical and radiological success rate. The additional benefits of robotic surgery are free movement of joysticks that allow free movements into seven degrees of freedom and articulations at the tips of the instrument with motion scaling, tremor filtering, and a magnified ($\times 10$) three-dimensional vision [70]. These advantages can significantly facilitate precise intracorporeal both incision and suturing and subsequently can overcome the steep learning curve of the standard lap pyeloplasty [99]. It has been also proven as an effective and safe reconstructive procedure for PUJO in children with operative time approximating that of open surgery [100-102]. In a meta-analysis reviewing robotic LP versus conventional LP, Braga et al. [103] showed that robotic-assisted pyeloplasty is associated with a reduction in the operative time, a slightly shorter hospital stay, and similar complication and success rates.

Schwentner and Pelzer [104] recently reported a large experience of the robot-assisted pyeloplasty on ninety-two patients with a mean follow-up time of 39.1 months and a success rate of 97% based on clinical and radiological outcomes of an IVP and MAG3 scintigraphy.

Conclusion

The overall success rate after dismembered pyeloplasty to correct UPJO whether performed by laparoscopy, robotic assisted technique

or open surgical procedures are in the range of 90% to 100% among most published data. While the first procedure has been linked to those experts in laparoscopy, the second procedure is a costly technology that fulfills the skills and the dreams of the urologists with broader applications than pyeloplasty. The open procedure is stable with time and has high successful outcome more than 50 years, and can be performed in any urology center all over the world by a trained urologist. The other non dismembered minimally invasive procedure has not only a 10% to 25% lower successful outcome but also has certain indications at the UPJ. Therefore, a prospective multicenter randomized clinical study are still needed to compare the efficacy and long term results guided by a standard clinical and radiological parameters to provide a relevant evidence of the efficacy of robotic pyeloplasty relative to its high cost with all other treatment modalities including the minimally invasive laparoscopic and open procedures.

Taking safety, morbidity and experience with availability of the suitable equipments and cost effectiveness in consideration on the long term success, a clear international guidelines will be helpful for the new urologists to know, is it the time to give up open pyeloplasty ; which of these procedures and when it can be the gold standard.

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