Upper Urinary Tract Obstructions

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91.1 Pelviureteric Junction Obstruction

91.1.1 Historical Overview

The detection of renal abnormalities during prenatal ultrasonography was first reported in the beginning of the seventeenth century (Garrett et al. 1970). Since then, the routine use of ultrasonography for the detection of congenital anomalies has become a part of routine care during the antenatal period. Currently, it is estimated that genitourinary anomalies comprise nearly 20% of all prenatally detected fetal anomalies. Amongst these, hydronephrosis is one of the most commonly detected anomalies, seen in approximately 1–5% of all pregnancies and occurs due to various causes. Thus, we have an increasing number of patients who are presenting to the clinician with a presumptive diagnosis, rather than a symptom, and sometimes before they are even born. Although the initial reports of surgical outcome of the correction of the neonatal PUJ obstruction were excellent (King et al. 1984), following observations regarding renal function preservation during conservative treatment have started a new era in the treatment of antenatal hydronephrosis (Ransley et al. 1990). In our earlier reports, we clearly demonstrated that prenatal diagnosis of hydronephrosis with close follow-up after delivery is much superior, in terms of renal function preservation, compared to those children who were diagnosed to have PUJ obstruction due to clinical symptoms (Chertin et al. 1999). Multiple reports demonstrated that approximately 30% of children will require surgery during surveillance, therefore expectant management will spare the majority of children from surgery (Koff and Campbell 1992; Koff 2000; Ulman et al. 2000; Onen et al. 2002; Chertin et al. 2002).

91.1.2 Incidence

The overall incidence of neonatal hydronephrosis, which leads to the diagnosis of PUJ obstruction, approximates 1 in 500 births. The ratio of males to females is 2:1 in the neonatal period, with left-sided lesions occurring in 60% of cases. In the newborn period, a unilateral process is most common, but bilateral PUJ obstruction was found in 10–49% of neonates in some reported series (Gokce et al. 2012).

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91.1.3 Etiopathogenesis

PUJ obstruction is classified as intrinsic, extrinsic, or secondary. Intrinsic obstruction results from the failure of transmission of the peristaltic waves across the PUJ, with the failure of urine to be propulsed from the renal pelvis into the ureter, which results in multiple ineffective peristaltic waves that eventually causes hydronephrosis by incompletely emptying the pelvic contents. Extrinsic mechanical factors include aberrant renal vessels, bands, adventitial tissues, and adhesions that cause angulation, kinking, or compression of the PUJ. Extrinsic obstruction may occur alone but usually coexists with intrinsic ureteropelvic junction pathology. Secondary PUJ obstruction may develop as a consequence of concomitant severe vesicoureteric reflux (VUR), which occurs in 15–30% of children who have ipsilateral PUJ obstruction, in which a tortuous ureter may kink proximally.

91.1.4 Pathophysiology

Renal morphogenesis is a complex, temporally and spatially regulated process by which precursor cells develop into a structurally and functionally normal kidney. Abnormal or dysregulated renal development results in a wide range of renal abnormalities, collectively known as congenital anomalies of the kidney and urinary tract (CAKUT), which compose the most common cause of end-stage renal disease (ESRD) in children. In humans, kidney and urinary tract development begins at approximately 3 weeks gestation, with the formation of the initial urinary excretory precursor, the pronephros, which undergoes complete involution (Little and McMahon 2012; Combes et al. 2015; Short and Smyth 2016). By 34–36 weeks gestation, nephrogenesis is complete, and the structural and functional relationship of each nephron segment is fully developed. On average, 1 million (range 0.2–2.7 million) individual nephrons in each kidney arise from the embryonic precursor cells. Concurrent with the morphogenesis of the kidney, functional development of the fetal kidney also progresses with increasing gestational age. Prenatally, the placenta controls fluid and electrolyte homeostasis, and the primary function of the fetal kidney is the production of urine to maintain amniotic fluid volume. In the later stages of gestation, urine output, tubular function, and glomerular filtration increase with gestational age.

After birth, the neonatal kidney undergoes physiologic changes to adapt to the extrauterine environment; rapid changes occur over the first several weeks and continue until reaching adult levels at 1–2 years of life. Changes in hydrostatic pressure in the renal pelvis and individual nephrons are critical in determining the effects of obstruction on Glomerular Filtration Rate (GFR). Normal proximal intratubular pressure of 12 mmHg increases in direct correlation with rising intrapelvic pressure with a maximum of approximately 40 mmHg. Higher intrapelvic pressure of 50–70 mmHg is not transmitted to the proximal tubules, perhaps because of compression of the renal papilla. Continuation of obstruction increases in preglomerular vascular resistance (afferent arteriolar vasoconstriction), which in turn could lead to the increased accumulation of fibrotic tissue and appearance of renal dysplasia. Furthermore, chronic partial obstruction leads to the gradual decrease in GFR and is accompanied by an increase in the fractional excretion of filtered sodium, indicating decreased tubular reabsorption. Leaving the obstruction untreated might lead to the irreversible tubular and glomerular injury with eventual renal loss.

91.1.5 Diagnosis

91.1.5.1 Prenatal Diagnosis

The bladder is visualized by 14 weeks gestation. The ureters are usually not seen in the absence of distal obstruction or reflux. The fetal kidney may be visualized at the same time as the bladder. If not, they are always visualized by 16th weeks gestation. However, it is not until 20–24 weeks gestation, when the fetal kidney is surrounded by fat, that the internal renal structures appear distinct. Renal growth can then be assessed easily. Beyond 20 weeks, fetal urine production is the

main source of amniotic fluid. Therefore, major abnormalities of the urinary tract may result in oligohydramnios. Because of the distinct urine tissue interface, hydronephrosis can be detected as early as 16 weeks gestation. An obstructive anomaly is recognized by demonstrating dilated renal calyces and pelvis. A multitude of measurements and different gestational age cut-off points have been recommended in the assessment of fetal obstructive uropathy.

Routine estimation of anteroposterior (AP) diameter of renal pelvis in the fetus with hydronephrosis is considered a useful marker for classification of renal dilatation and possible obstruction. AP renal pelvis threshold values ranged between 2.3 and 10 mm. Positive predictive values for pathological dilatation confirmed in the neonate ranged between 2.3 and >40% for AP renal measurements of 2–3 mm and 10 mm, respectively. One study, which included more than 46,000 screening patients, published the standards regarding renal pelvic measurement. This study clearly demonstrated that only fetuses exhibiting third-trimester AP renal pelvis dilatations >10 mm would merit postnatal assessment. In order to standardize postnatal evaluation of prenatal hydronephrosis a grading system of postnatal hydronephrosis was implemented in 1993 by the Society for Fetal Urology (SFU). In SFU system, the status of calices is paramount while the size of the pelvis is less important. In SFU grading of hydronephrosis, there is no hydronephrosis in Grade 0. At Grade 1, the renal pelvis is only visualized. Grade 2 of hydronephrosis is diagnosed when a few (but not all) renal calices are identified in addition to the renal pelvis. Grade 3 hydronephrosis requires that virtually all calices are depicted. Grade 4 hydronephrotic kidneys will exhibit similar caliceal status with the involved kidney exhibiting parenchymal thinning. Often this classification is applied also on prenatal hydronephrosis. We have published our data regarding prenatal findings with the special emphasis on the natural history of hydronephrosis during the postnatal period. Our data shows that SFU grade of prenatal hydronephrosis is not a significant predictive factor for surgery in unilateral hydronephrosis. However, SFU Grades 3–4 prenatal bilateral hydronephrosis indicates that the majority of the children will require surgical correction during the postnatal period.

In 2014, the "urinary tract dilation (UTD)" classification system was introduced to replace the SFU system and other grading systems. It consists of 6 parameters, namely APD of the renal pelvis, urinary tract dilation, parenchymal thickness, parenchymal appearance, ureteral status, and bladder status, furthermore distinguishing whether these parameters are antenatal ("A") or postnatal ("P"). There are two antenatal and three postnatal categories of risk: A1 (low risk) or A2–3 (intermediate/high risk) for antenatal UTD; and P1 (low), P2 (intermediate), P3 (high risk) for postnatal UTD. Persistent UTD A1 or UTD A2 to A3 warrants postnatal evaluation (Nguyen et al. 2014).

In the case of severe prenatal bilateral hydronephrosis, severe hydroureteronephrosis, or severe impairment of the solitary kidney, fetal bladder aspiration for urinary proteins and electrolytes is recommended from 17 weeks of gestation in some reports in order to predict the renal injury secondary to obstructive uropathy. Fetal urinary sodium level less than 100 mmol/L, chloride level of less than 90 mmol/L and an osmolality of less than 210 mOsm/kg are considered as prognostic features for good renal function.

91.1.5.2 Clinical Presentation

The most common presentation is abdominal flank mass. Fifty percent of abdominal masses in newborns are of renal origin with 40% being secondary to PUJ obstruction. Other clinical presentations include urinary tract infection irritability, vomiting, and failure to thrive. Ten to 35% of PUJ obstructions are bilateral and associated abnormalities of the urinary tract are seen in about 30%. PUJ problems are often associated with other congenital anomalies, including imperforated anus, contralateral dysplastic kidney, congenital heart disease, VATER syndrome, and esophageal atresia.

91.1.5.3 Differential Diagnosis

With the increasing number of antenatally diagnosed hydronephrosis it is difficult to interpret

the underlying pathology and its significance. Severe obstructive uropathies are detrimental to renal function. However, on the other hand, hydronephrosis without ureteral or lower tract anomaly is common. The important aspect of postnatal investigations is to identify the group of patients who will benefit from early intervention and those who need to be carefully followed.

Ultrasound: Follow-up ultrasound examination is necessary in the postnatal period in antenatally detected hydronephrosis. If bilateral hydronephrosis is diagnosed in utero in a male infant, postnatal evaluation should be carried out within 24 h primarily because of the possibility of posterior urethral valves. If the ultrasound scan is negative in the first 24–48 h in any patient with unilateral or bilateral hydronephrosis, a repeat scan should be performed after 5–10 days, recognizing that neonatal oliguria may mask a moderately obstructive lesion.

If hydronephrosis is confirmed on the postnatal scan, further careful scan of the kidney, ureter, bladder, and in boys, the posterior urethra is essential (Fig. 91.1a).

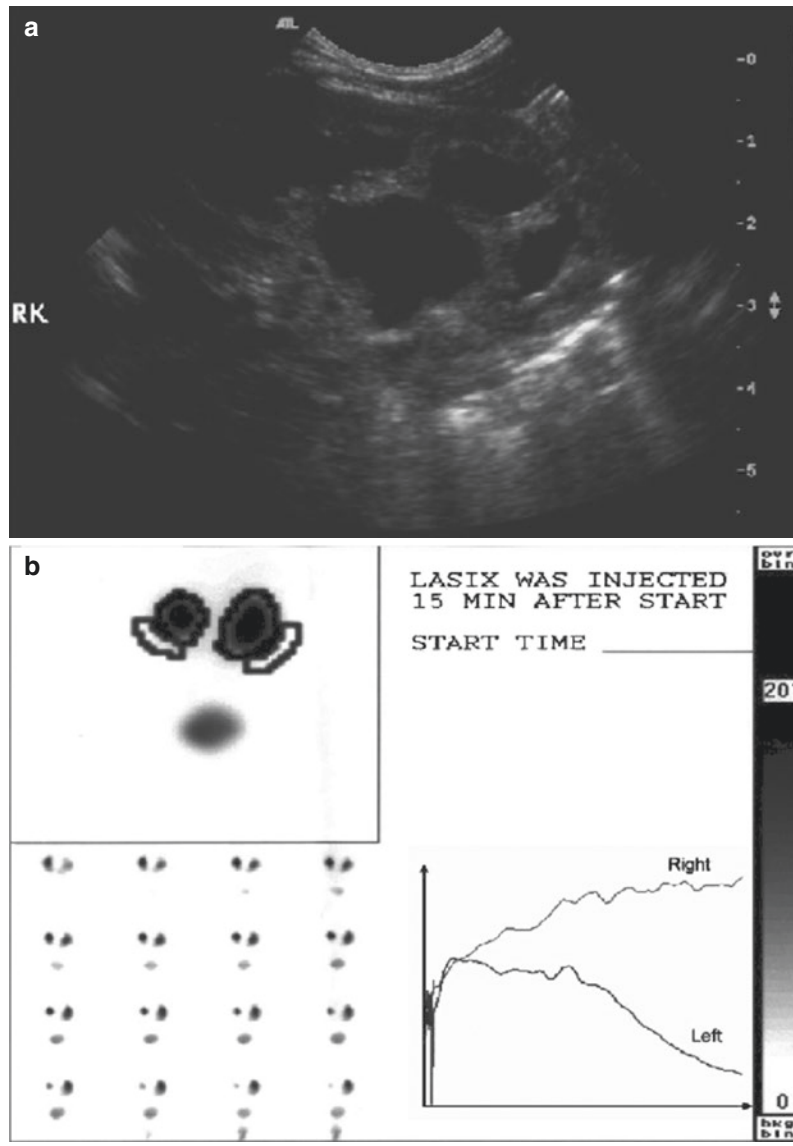

Fig. 91.1 (**a**) A sagittal plane scan through the obstructed right kidney confirms obstruction at the level of the pelviureteric junction. (**b**) 99Tc MAG3 scan in the above patient. Clearance curve for right kidney confirming the high-grade obstruction on this side

Radionuclide Scans: DTPA is completely filtered by the kidneys at maximum concentration of 5% being reached in 5 min, falling to 2% at 15 min. Recently, it has been reported that use of tracers that rely on tubular extraction such as 123 I-Hippuran and 99Tc MAG3 (Fig. 91.1b) may improve diagnostic accuracy. The kidney of the young infant is immature; renal clearance, even when corrected for body surface, progressively increases until approximately 2 years of age. Therefore, the renal uptake of tracer is particularly low in infants, and there is a high background activity. Thus, the traces with a high extraction rate, such as 123 I-Hippuran and 99Tc MAG3, provide reasonable images enabling the estimation of the differential kidney function during the first few weeks of life. It is also helpful in assessing the size, shape, location, and function of the kidney. Diuretic augmented renogram is a provocative test and is intended to demonstrate or exclude obstructive hydronephrosis by stressing an upper urinary tract with a high urine flow. Obstruction usually is defined as a failure of tracer washout after diuretic stimulation. If unequivocal, it eliminates the need for further investigations. In equivocal cases, F15 in which furosemide is given 15 min before the test provides a better assessment of the drainage of upper urinary tract. Forced hydration prior to a scan increases THE predictive value of non-obstructed patterns by up to 94%. Since glomerular filtration and glomerular blood flow are still low in the newborn, the handling of isotype is unpredictable and can be misleading.

Functional magnetic resonance urography (MRU) has been recently proposed by many study groups as an alternative technique to evaluate the drainage curve and split renal function (SRF) in obstructive uropathy. This method allows the precise understanding of the kidney anatomy while providing information regarding renal functioning without radiation exposure obviating the need to use contrast media. When surgical correction is planned, MRU aids in clearly identifying anatomically crossing vessels and obstructive pathology.

Pressure-Flow Study: In the equivocal cases and in the presence of impaired function, the pressure-flow study (Whitaker Test) and antegrade pyelography may be necessary to confirm or exclude obstruction. Whitaker Test is based on the hypothesis that if the dilated upper urinary tract can transport 10 ml/min without an inordinate increase in pressure, the hydrostatic pressure under physiological conditions should not cause impairment of renal function and the degree of obstruction if present is insignificant. However, it is an invasive test and is seldom required. Antegrade pyelography may be performed with ultrasound guidance in patients where diagnosis is difficult. Retrograde pyelography is seldom required to determine the status of ureters. The disadvantages include difficulty in ureteral catheterization in neonates, trauma, and edema that may change partial obstruction to the complete one. In patients where diagnosis is equivocal, serial examinations may be necessary. Routine use of micturating cystourethrogram (MCUG) in patients with antenatal unilateral hydronephrosis is controversial. Some authors advocate regular use of MCUG as a part of postnatal evaluation citing 15–30% of incidence of concomitant VUR either uni- or contralateral. Others recommend only performing MCUG in patients with SFU Gr III and IV hydronephrosis. We have abounded to perform MCUG routinely in children with unilateral antenatal hydronephrosis based on the fact that even if the reflux exists usually it is of low grade and does not require any treatment. We reserve MCUG only for patients with bilateral hydronephrosis or for those whose ureter was seen at any stage of antenatal or postnatal follow-up.

91.1.6 Management

A considerable controversy exists regarding the management of newborn urinary tract obstructions. Some authors advocate early surgical intervention to prevent damage to maturing nephrons, while others feel that early surgery carries no specific benefit. During late prenatal and early postnatal life, there is progressive increase in glomerular filtration rate. Additionally, this transition is associated with an

abrupt decline in urine output from what appears to be a quite high in utero output to a rather low early neonatal level of urine production. These physiological observations may explain the common observation of hydronephrosis detected antenatally, which on postnatal follow-up reverts to an unobstructed pattern. Surgery is usually undertaken in infants whose renal function deteriorates during the observation period. We have analyzed our database of 343 children (260 males and 83 females) with an antenatal diagnosis of hydronephrosis, which led to the postnatal diagnosis of PUJ obstruction, who were deliberately followed up conservatively at our department over a 16-year period, in order to define which factors lead to surgery (Chertin et al. 2006). One hundred and seventy-nine children (52.2%) required surgical correction in the course of conservative management. Average age at surgery was 10.6 months (range 1 month–7 years). Of these, 50% underwent surgery during the first 2 years of life and majority of the remaining patients underwent surgery between the age of 2 and 4. Only two patients required surgery later on. Univariate analysis revealed that child sex, side of hydronephrosis are not significant predictive factors for surgery. However, SFU Grades 3–4 of postnatal hydronephrosis ($p < 0.0001$, Odds ratio 0.06281), RRF <40% ($p < 0.0001$, Odds ratio 0.1022) were significant independent risk factors for surgery. A number of different operations have been described for surgical correction of PUJ obstruction. The classical traditional approach is an extraperitoneal approach via lateral flank incision. In cases where suspicion of an obstruction distal to the PUJ arise, antegrade or retrograde study of the ureter upon or during surgery are recommended. In some cases, posterior lumbotomy may be applied. The use of muscle splitting rather than muscle cutting makes it almost a minimally invasive procedure. The location of the incision just under and parallel to the 12th rib has a cosmetic advantage. The bilateral procedure is possible if indicated under the same anesthesia without position changes. This approach should not be used in older children or significantly obese.

The various techniques of pyeloplasty are divided into dismembered and non-dismembered pyeloplasty. The basic principle of these operations is an excision of the PUJ, with a subsequent oval-shaped anastomosis between the ureter and lower part of the pelvis. Different types of stents are placed for drainage usually for 6 weeks. The most popular are Double J Paediatric Stents or Pipi-Salle Stent nephrostomy (Cook, USA).

In the last decade, minimal invasive approaches have replaced the classic gold standard open dismembered Anderson-Hynes pyeloplasty. Since it was first described (Schuessler et al. 1993), laparoscopic pyeloplasty has developed into a successful approach. Introduction of robotic technology has helped overcome some of the limitations of complex laparoscopic procedures such as offering magnified three-dimensional vision, tremor reduction, motion scaling, extended range of motion for the surgical arms, and better ergonomics (Andolfi et al. 2020). These features render robotic surgery ideal for many reconstructive and ablative procedures. Robot-assisted laparoscopic pyeloplasty (RALP) can be performed by a trans or retroperitoneal approach. Suturing is done with a 6-0 monofilament absorbable suture, but one can utilize any 5-0 or 6-0 suture depending on the size of the patient. Currently, it appears that nothing larger than 6-0 for small children and infants is recommended. RALP is associated with excellent success rates, noninferior to those with the open approach, without increased complications (Kafka et al. 2019). Recent studies have found that RALP decreased length of hospitalization, decreased postoperative narcotic requirement, improved cosmetic results, and decreased human capital losses to the parents.

Although antegrade and retrograde endopyelotomy has been shown to be effective in children, this approach has not been recommended in neonates, infants, or young children. However, it should be considered in older children or in those with failed primary dismembered pyeloplasty.

Bilateral Pelviureteric Obstruction: Surgical correction of the symptomatic side or side with better function should take precedence. If a

nephrectomy is considered on one side, the pyeloplasty should precede this.

Postoperative Complications: infection, adhesive obstruction (transperitoneal approach), temporary obstruction at the anastomosis resulting in excessive urine leakage and failures due to postoperative stricture at anastomotic sites. An overall reoperation rate of 8.2% was reported in the early series. However, in the latest series, when temporally double-J stents were utilized, the reoperation rate was negligible.

Follow-up and Results: Follow-up ultrasound may be performed 3–6 months after operation when maximum improvement can be seen. A follow-up radionuclide scan should be done 6–8 months following pyeloplasty, in order to evaluate an improvement in the renal function and drainage. Pyeloplasty in the neonatal period when indicated gives excellent results. Moreover, successful pyeloplasty after the prenatal diagnosis of PUJ obstruction is associated with improved renal function throughout puberty even in children with initial poor renal function.

Conclusions: The majority of children with antenatal diagnosed hydronephrosis which led to the diagnosis of PUJ obstruction may and should be followed conservatively. When surgery is indicated, SFU 3&4 Grade of hydronephrosis and initial renal function less than 40% seems to serve as a positive predictive factor for surgical intervention. Utilization of RALP is increasing rapidly, suggesting that the robotic approach may be the new gold standard for minimally invasive pyeloplasty. RALP is associated with excellent success rates compared with the open approach without increased complications.

91.2 Megaureter, Ureterovesical Junction Obstruction

91.2.1 Historical Overview

Megaureter involves a ureter that is dilated out of proportion to the rest of the urinary tract and above the norms. Originally coined by Caulk in 1923 as *megaloureter,* other synonyms in use include wide ureter and hydroureter. Cussen (1971) and later Hellstrom et al. in 1985 have established the normal measurement of the ureteral diameter in infants and children from 30 weeks of gestation to 12 years of age. Normal ureteral diameter in children is rarely greater than 5 mm, and ureters larger than 7 mm can be considered megaureters.

Classification: The Paediatric Urology Society in 1976 adopted a standard nomenclature for categorizing megaureters, which is a useful guide for management (Smith et al. 1977). There are three types described:

1. Refluxing ureter which may be primary or secondary to distal obstruction or pathology
2. Obstructive: which may be primary and include intrinsic obstruction, or secondary due to distal obstruction or extrinsic causes.
3. Non-refluxing, non-obstructed which may be primary-idiopathic type or secondary to diabetes insipidus or infection.

In 1980, King subsequently modified this classification by adding a fourth group consisting of the refluxing, obstructed megaureters (King 1980).

91.2.2 Incidence

The true incidence of primary obstructive megaureter (POM) is not known but it is considered to be a cause of 10–23% of antenatally detected upper urinary tract dilations (Gokce et al. 2012). Primary obstructive megaureter is more common in males than females, and the left ureter is more likely to be involved than the right. Seventeen to 34% patients have bilateral megaureters, which is associated with contralateral dysplasia or obstruction in 10–15% of cases. Most POMs are detected by antenatal ultrasound screening with the vast majority being asymptomatic.

91.2.3 Etiopathogenesis

The most common etiologic causes of obstructive megeureters are: (1) alteration in muscular

orientation, (2) muscular hypoplasia with fibrosis or excessive collagen deposition resulting in a discontinuity of muscular coordination, and finally (3) disturbance in the electric syncytium along with the nexus injury causing pathological innervation. Prenatal Diagnosis: Currently the vast majority of obstructive megaureters are discovered on prenatal ultrasound. Usually ureter is not seen in fetal scans. Visualization of dilated ureter to the level of vesicoureteric junction without abnormal bladder may suggest obstruction or reflux. However, this may be a transient phenomenon. Fetal urine flow is 4–6 times greater before birth than after and is due to differences in renal vascular resistance, glomerular filtration, and concentrating ability. This high outflow contributes to ureteral dilatation. Another contributing factor includes increased compliance of the fetal ureter.

91.2.4 Pathophysiology

The pathophysiology of primary obstructed megaureters (POMs) has not been fully understandable yet. However, there is general agreement that the presence of an adynamic distal ureteral segment is the most common cause of primary obstructive megaureter. The presence of narrowed terminal portion of ureter will not convey the peristaltic wave or dilate enough to permit free passage of urine. This results in excess boluses of urine which coalesce and cause ureteral dilatation. The contraction waves become smaller and are unable to coopt the walls of dilated ureters. This along with infection could damage the renal parenchyma and could lead to irreversible renal damage similar to PUJ obstruction.

91.2.5 Diagnosis

91.2.5.1 Prenatal Diagnosis

The most intriguing question on prenatal evaluation is which children will require follow-up only and who will need surgery in order to rescue the renal function (Farrugia et al. 2014). In our database, we have analyzed 79 children with antenatal diagnosis of obstructive megaureter (Chertin et al. 2008). Antenatal SFU grade of hydronephrosis had no predictive value for the surgery in postnatal follow-up. However, those children who had ureteric diameter of more than 1.4 cm are more likely to require surgery postnatally.

91.2.5.2 Differential Diagnosis

Antenatally diagnosed ureteral dilatation needs further evaluation to confirm or exclude obstruction, reflux, or both. The clinician should confront the common clinical dilemma in pediatric antenatal hydronephrosis and must distinguish between those patients who will have deterioration in renal function while on surveillance protocol and therefore will benefit from early surgery and those who have nonobstructive hydronephrosis. In antenatally detected cases, ultrasonography should be performed between 3 and 5 days after birth to confirm antenatal findings. If no dilatation is seen, a repeat ultrasound should be performed after a few weeks as neonatal oliguria can mask dilatation. If dilatation persists on a repeat ultrasound, radionuclide scan is performed at the age of 4–6 weeks. In male infants with bilateral ureterohydronephrosis, MCUG should be performed for 72 h since birth to rule out posterior urethral valve. As stated previously, MRU has the ability to provide detailed information regarding anatomy, as well as renal function and drainage in a single study without the use of ionizing radiation.

Ultrasonography classically shows hydroureter and variable hydronephrosis, with hyperperistalsis of a lower ureter that terminates shortly above the bladder in a narrow, adynamic segment (Fig. 91.2a). However, the narrow segment may not always be visualized and therefore MCUG is necessary to exclude VUR. Contrast-enhanced voiding urosonography (CEVUS) is a dynamic imaging technique that enables the morphologic and functional evaluation of the entire urinary tract by introducing an ultrasonographic contrast agent into the bladder. CEVUS is most often indicated to detect VUR. It is highly sensitive while avoiding exposure to ionizing radiation.

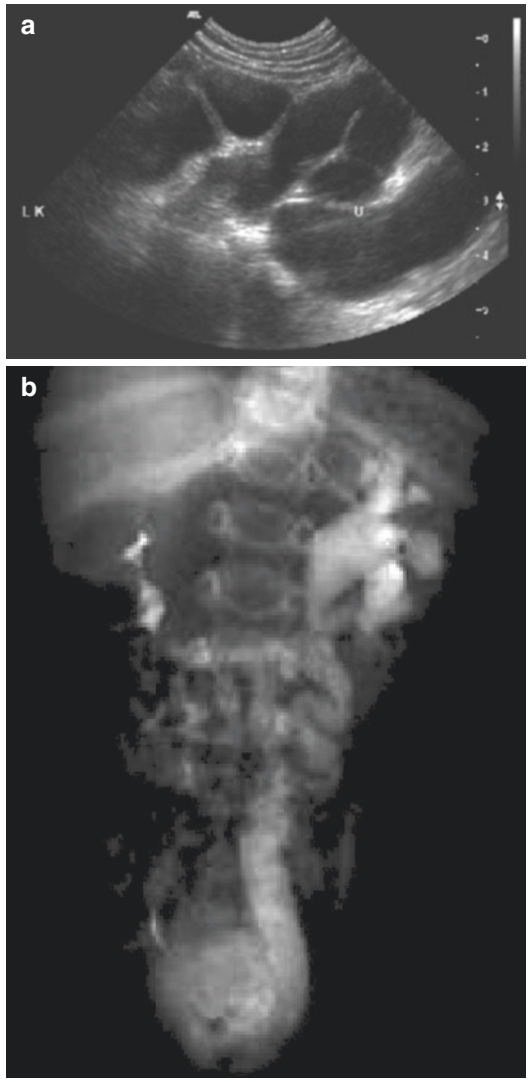

Fig. 91.2 (**a**) Longitudinal renal scan demonstrates severe left ureterohydronephrosis. (**b**) Intravenous urogram shows severe left ureterohydronephrosis

Intravenous Urography (IVP) may be necessary in equivocal cases to establish the diagnosis (Fig. 91.2b). It delineates the anatomy showing dilated, obstructed ureter. However, it is better to wait for a few weeks for renal maturation to allow concentration of contrast reliability. Occasionally, Whitaker Test and antegrade pyelography may be required to establish the diagnosis.

91.2.6 Management

It is being increasingly recognized that many antenatal and neonatal ureteral dilatations improve with time. Surgery is indicated in patients with progressive ureteral dilatation and deterioration in renal function (Di Renzo et al. 2013). In our series of the 79 children with antenatal diagnosis of hydronephrosis who led to postnatal confirmation of UJL obstruction, only 25 (31%) children required surgical correction over 16-year conservative follow-up (Chertin et al. 2008). Univariant analysis did not reveal statistical significance in those children who required surgical correction and in those who followed conservatively neither from the side of obstruction nor sex of the patient. However, those children who required surgery had ureteric diameter more than 1.4 cm, renal function less than 30%, and SFU Grades 3 and 4 of hydronephrosis.

Operation: There are various techniques of reimplanting the ureter in a non-refluxing manner after excision of adynamic, narrow segment. The initial approach to the ureter can be either intravesical, extravesical or combined. The most commonly used techniques for intravesical approach are Cohen's transtrigonal reimplantation and Politano Leadbetter operation. The basic principle of these operations is an excision of adynamic, obstructive terminal narrow portion of the ureter and reimplantation of the remaining ureter into the bladder in an anti-refluxing fashion. In those cases, a significant dilated tapering of the ureter is required.

Non-excisional techniques such as Folding (Kalikinski) or Plication (Star) of ureteral wall are also available. Although these techniques have the advantage of avoiding a suture line with potential urinary leakage, they are inappropriate for very dilated ureter as it reduces diameter by only 50% and in neonates it can become too bulky for the tunnel. In these cases, excisional tapering technique utilizing Hendren clamps where part of the ureteral wall is excised by using a knife and scissors is recommended.

Robot-assisted laparoscopic (RAL) surgery is a safe, minimally invasive technique that has become more widely used in pediatric urology over recent decades (Boysen et al. 2018; Andolfi et al. 2020).

With several advantages over standard laparoscopy, robotic surgery is particularly well-suited to reconstructive surgery involving delicate structures like the ureter. A robotic approach provides excellent access to and visualization of the ureter at all levels. We have recently published our experience with a novel surgical technique in which we performed robotic-assisted laparoscopic dismembered extravesical cross trigonal ureteral reimplantation (RADECUR). When reviewing the literature and in comparison to open and laparoscopic reimplantation for obstructive megaureter, success rate, operating time, and complications are comparable when considering RADECUR (Neheman et al. 2020).

In newborns and children younger than 1 year, ureter reimplantation could be very technically demanding and potentially threatening for bladder functional development, with high complication rate. With the advent of minimally invasive surgery back in 1998, the first report of endoscopic balloon dilatation for POM in children was published (Desgrandchamps 2001). Advantages of the endoscopic approach include no surgical incision, no violation of the bladder, no manipulation of the distal ureteral blood supply, and no need for prolonged catheterization. Endoscopic techniques include the use of guidewires, balloon catheters, and incisional uretrotomy.

However, the recent meta-analysis of the endoscopic management for persistent or progressive POM in children older than 12 months of age demonstrated modest success rates. In infants, it may best be utilized as a temporizing procedure. Approximately one-third of patients require surgical reintervention (Doudt et al. 2018).

91.2.7 Postoperative Course

In cases of the intravesical approach, the drain is removed after 24–48 h. Stents are removed after 7–10 days followed by suprapubic catheter. Ureteral reimplantation using extravesical approach can be performed without stenting. An indwelling urethral catheter is placed usually for 3–5 days to avoid urinary retention. Recently, we have started to remove the indwelling catheter on the following day after robotic surgery. Also, during open surgery while utilizing intravasical approach, there is no need to leave behind the drains and suprapubic catheter. We have learned that placement of JJ stents for the period of 2 weeks with indwelling urethral catheter for 3 days is safe and efficient and could significantly shorten hospital admission without compromising child safety and success of the surgery.

Complications: Wound infection, vesicoureteral reflux due to short tunnel with no effective flap valve mechanism, or obstruction due to a fibrotic distal end secondary to ischemia especially in children who underwent excisional type of ureteric remodeling.

Follow-up and Results: ultrasound is performed 3 months following surgery with radiologic studies at 6 months after repair in order to assess renal function and drainage. MCUG is performed at the time of radionuclide scan to rule out denovo reflux into reimplanted previously obstructed ureter. We recently published our data on long-term follow-up of renal function following ureter reimplantation. We demonstrated that successful ureteral reimplantation following antenatal diagnosis of ureterovesical junction (UVJ) obstruction showed an increase in relative renal function not only during short- and midterm follow-up, but also allows preserving the renal function throughout the puberty period (Neeman et al. 2020).

91.3 Conclusions

The majority of the children with antenatal diagnosed primary obstructive megaureters do not require surgical correction. When surgical intervention is required it appear that initial renal function <30%, ureteral diameter >1.2 cm, and SFU 3–4 are positive predictive factors for surgery. Surgery when indicated improves and maintains renal function in the long-term follow-up. Recent data demonstrate that robotic reimplantation is an emerging modality for UVJ obstruction correction.

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