

# CURRENT TRENDS IN THE MANAGEMENT OF POSTERIOR URETHRAL VALVES IN THE PEDIATRIC POPULATION

PAULOS YOHANNES AND MONEER HANNA

Posterior urethral valves (PUVs) are the most common congenital abnormalities causing bilateral renal obstruction. The widespread use of prenatal ultrasonography has contributed to an increase in the incidence and awareness of PUVs. The treatment of children with this anomaly has also evolved as radiographic imaging techniques and our understanding of the pathophysiology of obstructive uropathy has improved. Today, patients with PUVs who develop end-stage renal disease have the hope of undergoing renal transplantation; patients with PUVs represent 1% of those awaiting transplantation.<sup>1</sup> Urodynamic investigation has allowed us to treat incontinence secondary to associated bladder dysfunction effectively, and the development of smaller endoscopic instruments and newer valve ablation devices have helped minimize perioperative morbidity.

The mortality rate associated with PUVs has declined from 50% in the past few decades to less than 5%.<sup>2</sup> Renal hemodialysis, excellent broad-spectrum antibiotics, and improvements in neonatal intensive care units have contributed equally to the decline in mortality. According to Walker and Padron,<sup>3</sup> mortality from PUVs usually occurs in newborns with severe bilateral renal dysplasia and pulmonary hypoplasia who were stillborn or died shortly after birth, neonates who died of sepsis or electrolyte imbalances, or older children and adolescents who eventually had renal failure. Despite these advances, 24% to 45% of patients will have renal insufficiency during childhood.<sup>4-7</sup> Unfortunately, prenatal diagnosis of PUVs has not improved this rate.

PUVs are encountered most commonly in males; however, anecdotal cases have been reported in females. Urethral valves have a wide range of clinical and anatomic presentations. Although most patients are diagnosed in the prenatal and neonatal period, published reports regarding patients presenting in adolescence and the second decade of life lends credence to the idea that PUVs may be a spectrum of disease as suggested by Hendren<sup>8</sup> in 1971. The incidence is estimated to be between 1:3000 and 1:8000.<sup>1-8</sup>

Everyone agrees that to salvage renal function and maximize growth in infants with PUVs, obstruction of the urinary tract should be relieved at the earliest gestational age possible. Some believe that prenatal intervention is warranted if pulmonary hypoplasia or postnatal pulmonary insufficiency is to be avoided. Although controversial, prenatal intervention is technically difficult, and the ethical dilemma associated with it precludes its use in many surgical centers worldwide.

PUVs can be associated with hypospadias, ureteropelvic junction stenosis, imperforate anus, dysgenetic kidneys, double urethra, solitary kidney, crossed renal ectopia, congenital heart disease, and arguably, prune belly syndrome.

Three types of valves were described by Young and associates<sup>9</sup> in 1919. Type I valves originate distal to the verumontanum on the floor of the posterior urethra. The valve cusps diverge distally in an anterolateral orientation and fuse anteriorly in the midline. Type II valves are folds of tissue that run between the bladder neck and the verumontanum. Type III valves are located just distal to the verumontanum; they are often characterized by a diaphragm-like appearance with an opening located posteriorly. Type I valves remain the most common type, and type III valves are very rare. The true incidence of type II valves is not known because most of these patients are asymptomatic, and some investigators doubt their existence. Dewan<sup>10</sup> has advocated the presence of a common congenital posterior urethral obstruction morphology and termed this entity congenital obstructive posterior urethral membrane. This clinical observation sug-

*From the Division of Urology, Department of Surgery, Creighton University, Omaha, Nebraska; Division of Pediatric Urology, New York Hospital-Cornell, New York, New York; and Division of Pediatric Urology, Schneider Children's Hospital, Long Island Jewish Medical Center, New Hyde Park, New York*

*Reprint requests: Paulos Yohannes, M.D., Division of Urology, Department of Surgery, Creighton University, 601 North 30th Street, Suite 3822, Omaha, NE 68131*

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gests that the posterior urethral membrane is due to a membrane and not valves. It is believed that many patients appear to have a valve-type membrane because catheterization, undertaken to relieve obstruction, creates an opening in the membrane (type III).

The mechanism of obstruction to urinary flow between type I and type III valves is different. In type I valves, the flow of urine pushes the valve cusps shut like a wind pushes a sailboat. This allows the cusps to converge and obstruct urinary flow. On the other hand, most type I valves allow for a retrograde placement of a catheter, because this would open up the cusps and push them open laterally. Antegrade placement of the catheters, however, will invariably fail. Type III valves obstruct the flow of urine depending on the aperture of the diaphragm.

The clinical presentation of patients with PUVs depends on the degree of prenatal care, severity of renal dysplasia, and the type of valve. Patients in whom PUVs are diagnosed earlier in life, and soon after birth are at a greater risk of renal failure than are those diagnosed later in life. With prenatal sonography, most cases of hydronephrosis are picked up immediately, and the parents are given the informed option of prenatal intervention or intervention at the time of birth. If obstruction is severe, oligohydramnios is present and postnatal pulmonary failure is most likely. In addition, most cases of PUVs are associated with vesicoureteral reflux, and the degree of renal dysplasia due to reflux determines the extent of postnatal morbidity and mortality.

The symptoms associated with delayed presentation of PUVs include bedwetting, urinary tract infection, dribbling, hematuria, urinary retention, and, to a lesser degree, poor urinary stream. Interestingly, urinary stream is not a sensitive indicator of the presence of a valve. The stream can be strong if the bladder is overfilled; in addition, most adolescents do not give a history of poor stream as they may not have any other comparison.

The reference standard diagnostic modality of choice in patients with PUVs is the voiding cystourethrography. Often times, the anatomy of type I valves facilitates insertion of catheters to perform voiding cystourethrography (VCUG). VCUG can be done in a radiology suite without anesthesia. Real-time fluoroscopy allows visualization of detrusor and bladder neck activity. VCUG also allows the documentation of residual urine and vesicoureteral reflux. If hydronephrosis occurs without reflux, secondary ureterovesical junction obstruction should be suspected. Finally, differentiating the type of valve is not always possible on VCUG.

The role of ultrasonography in the evaluation of patients with PUVs is well defined. The degree of hydronephrosis, the irregularly thickened bladder wall, and the dilation of the posterior urethra have all been investigated and described by ultrasonography. Hulbert and coworkers<sup>11</sup> have reported on 28 infants with PUVs who underwent ultrasonography as their initial evaluation. The presence of clear corticomedullary differentiation was directly associated with a creatinine level of 0.8 mg/dL or less, and its absence was a bad prognostic sign. However, only 45% of patients with the absence of the junction developed end-stage renal disease. Therefore, although the presence of the corticomedullary junction is more suggestive of better renal function, the absence of it does not predict a poor prognosis as well. In addition, an association between vesicoureteral reflux and absent corticomedullary junctions was found.

After the presence of urethral valves is documented by VCUG, endoscopy is performed to identify the type of valve. A few decades ago, this was not possible; however, today, some argue in favor of immediate endoscopic primary valve ablation after stabilizing the renal function with small size catheter drainage for few days. This technique is safe and effective in the hands of the experienced pediatric urologist. Most valves do not cause obstruction to passage of the endoscope. In some cases, identification of type I valves can be tricky because, as the instrument is advanced, the retrograde flow of irrigation fluid pushes the valves open; therefore, some have advocated filling the bladder to capacity to close the valves shut or the use of a flexible endoscopy to visualize the valves in an antegrade fashion in patients with a temporary vesicostomy. Endoscopic examination often shows a prominent bladder neck with hypertrophy. The bladder is always trabeculated, and occasionally cellules and diverticula can be seen in severe cases.

Several options are available in the surgical treatment of infants with PUVs: primary valve ablation and observation, temporary vesicostomy and delayed valve ablation, and primary valve ablation with major upper tract reconstruction. Primary valve ablation was mostly abandoned in the era when pediatric cystoscopes were not available; most surgeons believed that instrumentation in the urethra was not only impossible in most neonates, but also resulted in significant strictures requiring lifelong treatment. Currently, however, better instruments have allowed us to treat the valves endoscopically using various modalities under direct vision, with minimal risk of developing dense urethral strictures.

Several studies have investigated the best timing and approach in the treatment of patients with

**TABLE I. Pediatric resectoscopes currently available on the market**

Manufacturer	Resectoscope Size (F)	Accessories
Wolf	9 and 11.5	Cutting, coagulating, and hook electrode
Circon	11 and 13	13F Cold knife, loop, and hook electrode 11F Hook electrode
Karl Storz	11 and 13	Cutting loop, angled Coagulating blunt electrode Hooke-shaped (ball and blunted) electrode

PUVs. Walker and Padron<sup>3</sup> compared primary valve ablation and temporary vesicostomy with delayed valve ablation. They concluded that vesicostomy does not have an advantage over primary valve ablation. In select cases in which patients have significant bilateral vesicoureteral reflux, however, vesicostomy may offer a slight advantage in relieving the pressure transmitted to the upper tracts.

Regardless of the approach used, one must keep in mind that the underlying renal dysplasia, high-grade bilateral reflux, and the noncompliant bladder are signs that will have a negative impact on therapy. On the same scale, a low nadir creatinine or glomerular filtration rate (estimated creatinine clearance), ascites, diverticulum, and unilateral reflux are good prognostic indicators.

On the contrary, Krueger and associates<sup>12</sup> have shown that temporary high urinary diversion protected the kidneys and promoted this approach as a first line of therapy. However, unless vesicoureteral obstruction coexists secondary to detrusor hypertrophy, or severe ureterectasis is persistent despite valve ablation, this method does not offer a better alternative than temporary vesicostomy, which makes reconstruction much easier than ureterostomy or pyelostomy.

The ability to ablate valves without direct vision has been criticized by several prominent pediatric urologists; the observation of the anatomy and the assurance that the valves are effectively ablated, as well as the possibility that this may falsely increase the incidence of valves, argues in favor of the endoscopic approach.<sup>13</sup> Various tools designed for valve ablation are commercially available. Urologists have tried to improve this technique to minimize the development of incontinence and urethral strictures.

Historically, valves were treated with open surgery. Now, valve ablation can be performed in a retrograde or antegrade fashion; the latter method, however, is mostly abandoned secondary to the ease of doing retrograde endoscopy and the risk of injuring the external sphincter in the antegrade fashion.<sup>14,15</sup> Furthermore, antegrade ablation of

the valves involves the increased morbidity of an open cystostomy.

Initially, miniature resectoscopes using the loop electrode were used.<sup>8</sup> These were later replaced by a Bugbee fulgurating electrode through a miniature McCarthy infant panendoscope.<sup>8</sup> A list of currently available pediatric resectoscopes is provided in Table I. Since then, the use of the "crochet hook," insulated diathermy hook (used under direct vision or fluoroscopic guidance), Whitaker hook, Fogarty balloon catheter, neodymium:yttrium-aluminum-garnet laser, Mohan's valvulotome, a modified venous valvulotome, or cold knife have all been described.<sup>13,16-22</sup>

Currently, most urologists will ablate the valve a few days after birth; however, some still believe that gradual dilation of the urethra for a few weeks is essential in those patients who do not have the right caliber urethra to allow passage of an endoscope. No consensus has yet been reached as to the type of catheter to be used or the length of catheterization after valve ablation.

The major complications of valve ablation, urinary incontinence and stricture, are determined mostly by the underlying noncompliant bladder and to a lesser degree by the experience of the urologist. Even though prospective randomized studies comparing the different types of valve ablation devices are lacking in published reports, it is doubtful that one system offers a clinically significant advantage over another. In addition, perineal urethrostomy, once advocated by Hendren<sup>8</sup> to circumvent the neonatal urethra, is no longer popular.

The incidence of complications after valve ablation has been reported to be between 5% and 25%.<sup>23,24</sup> Most have advocated avoiding bladder neck incision to minimize bladder neck contracture and incontinence. Valve ablation should be followed by close observation of renal function to see whether obstruction to the flow of urine has improved. Most infants will improve dramatically; others will require an additional procedure (temporary supravescical diversion) because of persistent, severe vesicoureteral reflux, a defunc-

tionalized bladder, or ureterovesical junction obstruction from detrusor hypertrophy. Finally, every effort should be maintained to prevent urinary tract infection.

In those patients with an extremely dilated upper tract, valve ablation should be followed by upper tract reconstruction. If not dealt with in this manner, urinary tract infection and sepsis secondary to stasis will ensue. In others, a period of observation after valve ablation can be instituted; during this period, upper tract function should be closely monitored by serum creatinine and/or radioisotope scans. If patients continue to show persistent urinary tract infection or fail to show improvement in renal function, upper urinary tract diversion should be performed. Ureterostomy or pyelostomy are undoubtedly more involved than the relatively simple Blocksom cutaneous vesicostomy. Upper tract urinary diversions should be done in such a way that it will make subsequent operations less difficult. The proximal ureter near the pelvi-ureteral junction is often chosen for ureterostomy as this ensures the best drainage. Finally, in contrast to studies by Krueger *et al.*,<sup>12</sup> studies by Duckett<sup>25</sup> and Close *et al.*<sup>26</sup> have shown that bladder dysfunction is directly related to proximal urinary diversion; therefore, unless the urologist has no other option, upper urinary tract diversion should be reserved for those patients with severely dilated upper tracts that do not respond to cutaneous vesicostomy.

Suprapubic catheters or nephrostomy tubes are all sound applications; however, they are associated with a high incidence of urinary tract infection, and their use for a prolonged time is to be discouraged. They can be used when anesthesia is contraindicated.

Studies evaluating the significance of persistently dilated upper urinary tract systems by Glassberg and associates<sup>27</sup> have classified three types of ureters. Type I ureters are unobstructed during bladder emptying and filling. Type II ureters are unobstructed with bladder emptying but obstructed with bladder filling. Finally, Type III ureters are obstructed during bladder filling and emptying. This classification can help urologists manage persistently dilated ureters after valve ablation. Most ureters that are of type I do not need any additional intervention. Furthermore, there remains little doubt that patients in the third category need to be converted to type II with cutaneous vesicostomy. Most patients fall under the type II category. Because type II ureters can be easily converted to type I ureters, these investigators concluded that temporary cutaneous vesicostomy should be the first choice in treating patients with severely dilated upper urinary tracts.

The option of ureteral tailoring to treat persistently dilated ureters has fallen out of favor. Ureteroneocystostomy in thick bladder walls has not been shown to produce better urinary drainage. Therefore, an ileal-interposition graft between the ureter and the bladder or bladder augmentation to produce a large capacity, low-pressure bladder is necessary to protect the kidneys.

The association between renal failure and linear growth retardation has been well recognized.<sup>12,28</sup> Acidosis, abnormal metabolism of calcium and phosphorus, vitamin D resistance, and caloric insufficiency have all been implicated in growth retardation. Growth failure is particularly more evident in infants who develop renal failure earlier in life. Krueger and associates<sup>12</sup> evaluated the growth pattern of 74 boys with a history of PUVs treated at The Hospital for Sick Children in Toronto, Ontario, Canada.<sup>12</sup> At an average follow-up of 7.4 years (from the time of diagnosis to initial treatment), they showed that growth potential improved as the age of presentation increased. Those patients who presented earlier in life did not grow as fast as their counterparts without the disease. Their results also bring out the controversy as to which early therapeutic measure will have the best effect on the growth rate overall. Because the growth potential is determined in the first few months of life, it is essential that the intervention modality of choice restore maximal renal function as soon as possible. Some argue that initial valve ablation may not offer maximal urinary drainage, leading to the continued destruction of nephrons and repeated episodes of infection. In reference to this, Krueger and associates<sup>12</sup> state that "The enhanced growth potential of the younger children treated by initial, temporary urinary diversion of the upper urinary tract is of particular significance when compared to the growth potential of those patients undergoing treatment by primary valve resection."

In another study, Reinberg *et al.*<sup>29</sup> evaluated a total of 19 patients with PUVs treated by various modalities. They did not find a difference in the growth rate among those patients treated by primary valve ablation or temporary cutaneous vesicostomy or higher urinary diversion.

Much effort has been placed in identifying the prognostic factors that predict end-stage renal disease in children with PUVs. Because the degree of renal dysplasia and time of presentation is invariably different, it is essential to identify these factors that help predict renal failure. In a review of 25 boys with PUVs by Tejani *et al.*,<sup>30</sup> the incidence of end-stage renal disease was 44%. In their study, the factors that were predictive of end-stage renal disease were the presence of high blood urea nitrogen,

late intervention, reflux nephropathy, and the presence of growth retardation.

The role of serum creatinine measurements in determining the response to treatment deserves special mention. Duckett<sup>25</sup> has emphasized the importance of a creatinine nadir of less than 0.8 mg/dL by 1 year of age. Williams *et al.*<sup>31</sup> has also found that a return of creatinine less than 1.0 mg/dL within the first year of life is predictive of a favorable outcome. This observation has also been supported by Connor and Burbige<sup>2</sup> in their series of 50 patients treated during a period of 10 years.

In a similar fashion, anatomic factors that play a positive role in protecting renal function in patients with PUVs have been identified by Rittenberg and associates.<sup>32</sup> These so called popoff valves include (a) the syndrome of PUVs, vesicoureteral reflux, and renal dysplasia; (b) large congenital-type bladder diverticula, and (c) urinary extravasation with or without urinary ascites.

The progression of renal failure and incontinence are lifelong issues that affect the pediatric population with PUVs. The incidence of urinary incontinence after valve treatment is between 15% and 38%.<sup>2,33-35</sup> If stress incontinence is included, the incidence rises to 70%.<sup>31</sup> Older series of patients had higher incidences of incontinence, because valve ablation accompanied resection of the bladder neck. As it became more evident that the hypertrophied bladder neck did not contribute to obstruction, pediatric urologists have stopped this practice, subsequently improving the incidence of incontinence secondary to sphincter incompetence.

Long-term urinary continence and renal function studies in neonates with PUVs by Connor and Burbige have identified bladder dysfunction and sphincter incompetence as the two primary reasons for urinary incontinence in their study; the incidence of incontinence, defined as the inability to remain dry for at least 3 hours, was 18%.<sup>2</sup> Urodynamic studies revealed 6 patients to have significant evidence of noncompliant, high-pressure "valve bladder"—a term coined by Mitchell in 1982. The evidence of upper tract deterioration in those patients with incontinence was high, as evidenced by worsening hydronephrosis and a decline in glomerular filtration rate.

Therapies to improve or cure incontinence include clean intermittent catheterization, double or triple voiding, fluid restriction, and anticholinergic medication. If all these measures fail to relieve upper tract pressure, augmentation cystoplasty should be performed. Patients with sphincter incontinence can be treated with artificial urinary sphincters (AMS 800).

Polyuria secondary to loss of urinary concentrating ability also contributes to urinary inconti-

nence.<sup>36,37</sup> Prospective studies have demonstrated that patients with valves develop acquired nephrogenic diabetes insipidus after valve ablation. Therefore, the inability to concentrate urine optimally leads to a relative increase in urine output that, in the presence of a small noncompliant bladder, indirectly contributes to incontinence.

The relationship between renal failure and bladder dysfunction is well established. Many studies, including the works of Mayo and Ansell,<sup>38</sup> have shown that as the thickened bladder gets full, it creates a secondary ureterovesical junction obstruction. Renal perfusion studies performed with a full bladder have confirmed this finding. Ureteral reimplantation is often associated with a poor outcome and does not always resolve the underlying problem of bladder dysfunction. Therefore, it is imperative that the "valve bladder," should be evaluated thoroughly and treated rapidly to delay progression to end-stage renal failure.

Urodynamic studies should be an essential component of the initial evaluation and follow-up of patients with PUVs. Numerous reports have described the urodynamic findings of the valve bladder.<sup>2,39,40</sup> This observation is especially important, because 75% of patients can develop bladder dysfunction after valve ablation. Videourodynamic studies can help assess incontinence secondary to an incompetent or a damaged external urinary sphincter, maldevelopment of the bladder neck region, uninhibited detrusor contractions, myogenic failure, high detrusor voiding pressures, persistent bladder neck obstruction, a small capacity, and a noncompliant bladder. The changing urodynamic pattern in the valve bladder has been studied by Holmdahl and associates.<sup>39</sup> They demonstrated that most bladders were hypercontractile with a low capacity in infants and smaller children; however, during the first 3 years of life after valve resection, the urodynamic pattern changed as the bladder capacity increased, hypercontractility disappeared, and bladder instability remained unchanged.

Four-hour voiding is a technique developed as a basic assessment of bladder dysfunction in young boys with PUVs. Studies by Holmdahl and coworkers<sup>7</sup> have shown that patients with PUVs void small amounts frequently and have a high residual volume. In addition, cystometry revealed a higher bladder capacity, as well as a higher voided and residual volume. Therefore, this noninvasive technique can be used to complement standard urodynamic testing for the follow-up of bladder dysfunction in patients with the valve bladder.

Patients with PUVs have impaired sexual and reproductive function secondary to cryptorchidism, vasal reflux, retrograde ejaculation, and decreased sexual libido and function due to renal failure. In a

review of 21 adults by Parkhouse and Woodhouse,<sup>41</sup> 4 of 9 men provided normal semen, and 2 were able to father children. Therefore, patients should be carefully counseled regarding their potential to father children. Modern reproductive assisting techniques such as in vitro fertilization and intracytoplasmic sperm injection can allow patients with PUVs to father children.

As mentioned above, patients with PUVs now live longer, and those that develop end-stage renal disease can undergo renal transplantation. Although 13% to 28% of children with PUVs develop end-stage renal disease, these patients consist of only 1% of the pool of patients awaiting renal transplantation.<sup>1</sup> Renal insufficiency can be secondary to renal dysplasia, vesicoureteral reflux, or progressive renal failure due to stasis and recurrent urinary tract infection. The long-term outcome with renal transplant was not as good until the role of "the valve bladder" was better defined. A few decades ago, the 5-year survival rate was reported to be 50% for valve patients versus 75% for their age-matched cohorts.<sup>42</sup> Since then, however, graft survival and renal function have been very similar. The incidence of urinary tract infection in children with PUVs after renal transplantation is also similar to control groups.<sup>43</sup>

In 1991, Diethelm and associates reported a follow-up of 18 patients with a history of PUVs who had undergone renal transplantation.<sup>4</sup> They determined that at 10 years, the difference in graft survival between the controls and patients with PUVs was not statistically significant. The 10-year mean serum creatinine level was also similar in both groups (2.3 versus 2.0 mg). In their 5-year follow-up study previously reported in 1991, however, the difference in the serum creatinine level was statistically significant; perhaps aggressive bladder training programs and antibiotic therapy can explain the difference. The most common cause of graft failure in both groups was chronic rejection.

The results of a study by Salomon *et al.*<sup>44</sup> also concur with these findings and report a 10-year graft survival rate of 54% in patients with PUVs. Anja *et al.*<sup>6</sup> and Ross *et al.*<sup>5</sup> have also reported similar findings with a 5-year graft survival rate of 50% and 59%, respectively. These findings are truly remarkable, because patients with PUVs have bladder dysfunction and are prone to recurrent urinary tract infection—both of which have a well-known adverse effect on renal graft function.<sup>1</sup>

#### REFERENCES

1. Indudhara R, Joseph DB, Perez LM, *et al*: Renal transplantation in children with posterior urethral valves revisited: a 10-year follow-up. *J Urol* 160: 1201–1203, 1998.
2. Connor JP, and Burbige KA: Long-term urinary continence and renal function in neonates with posterior urethral valves. *J Urol* 144: 1209–1211, 1990.
3. Walker RD, and Padron M: The management of posterior urethral valves by initial vesicostomy and delayed valve ablation. *J Urol* 144: 1212–1214, 1990.
4. Bryant JE, Joseph DB, Kohaut EC, *et al*: Renal transplantation in children with posterior urethral valves. *J Urol* 146: 1585–1587, 1991.
5. Ross JH, Kay R, Novick AC, *et al*: Long-term results of renal transplantation into the valve bladder. *J Urol* 151: 1500–1504, 1994.
6. Anja AM, Groenewegen AAM, Sukhai RN, *et al*: Results of renal transplantation in boys treated for posterior urethral valves. *J Urol* 149: 1517–1520, 1993.
7. Holmdahl G, Hanson E, Hanson M, *et al*: Four-hour voiding observation in young boys with posterior urethral valves. *J Urol* 160: 1477–1481, 1998.
8. Hendren WH: Posterior urethral valves in boys: a broad clinical spectrum. *J Urol* 106: 298–307, 1971.
9. Young HH, Frontz WA, and Baldwin JC: congenital obstruction of the posterior urethra. *J Urol* 3: 289–307, 1919.
10. Dewan PA: Congenital obstructing posterior urethral membrane (COPUM): further evidence for a common morphological diagnosis. *Pediatr Surg Int* 8: 45–50, 1993.
11. Hulbert WC, Rosenberg HK, Cartwright PC, *et al*: The predictive value of ultrasonography in evaluation of infants with posterior urethral valves. *J Urol* 148: 122–124, 1992.
12. Krueger RP, Hardy BE, and Churchill BM: Growth in boys with posterior urethral valves. *Symp Pediatr Urol* 1: 265–272, 1980.
13. Cromie WJ, Cain MP, Bellinger MF, *et al*: Urethral valve incision using a modified venous valvulotome. *J Urol* 151: 1053–1055, 1994.
14. Datta NS: Percutaneous transvesical antegrade ablation of posterior urethral valves. *Urology* 30: 561–564, 1987.
15. Zaontz MR, and Firlit CF: Percutaneous antegrade ablation of posterior valves in premature or underweight term neonates: an alternative to primary vesicostomy. *J Urol* 134: 139–141, 1985.
16. Whitaker RH, and Sherwood T: An improved hook for destroying posterior urethral valves. *J Urol* 135: 531–532, 1986.
17. Deane M, Whitaker RH, and Sherwood T: Diathermy hook ablation of posterior urethral valves in neonates and infants. *Br J Urol* 62: 593–594, 1988.
18. Abraham MK: Mohan's urethral valvulotome: a new instrument. *J Urol* 144: 1196–1198, 1990.
19. Biewald W, and Schier F: Laser treatment of posterior urethral valves in neonates. *Br J Urol* 69: 425–427, 1992.
20. Ehrlich RM, Shanberg A, and Fine RN: Neodymium: YAG laser ablation of posterior urethral valves. *Urology* 138: 959–962, 1987.
21. Tank ES: Cold knife ablation of urethral valves. *Society of Pediatric Urology Newsletter*, March 7, 1992, p 1.
22. Diamond DA, and Ransley PG: Fogarty balloon catheter ablation of neonatal posterior urethral valves. *J Urol* 137: 1209–1211, 1987.
23. Nijman RJM, and Scholtmeijer RJ: Complications of transurethral electro-incision of posterior urethral valves. *Br J Urol* 67: 324–326, 1991.
24. Myers DA, and Walker RD: Prevention of urethral strictures in the management of posterior urethral valves. *J Urol* 126: 655–657, 1981.
25. Duckett JW: Are "valve bladders" congenital or iatrogenic? *Br J Urol* 79: 271–275, 1997.
26. Close CE, Carr MC, Burns MW, *et al*: Lower urinary tract changes after early valve ablation in neonates and infants: is early diversion warranted? *J Urol* 157: 984–988, 1997.

27. Glassberg KI, Schneider M, Haller JO, *et al*: Observations on persistently dilated ureter after posterior urethral valve ablation. *Urology* 20: 20–28, 1982.
28. Reinberg Y, de Castano I, and Gonzalez R: Influence of initial therapy on progression of renal failure and body growth in children with posterior urethral valves. *J Urol* 148: 532–533, 1992.
29. Reinberg Y, de Castano I, and Gonzalez R: Prognosis for patients with prenatally diagnosed posterior urethral valves. *J Urol* 148: 125–126, 1992.
30. Tejani A, Butt K, Glassberg K, *et al*: Predictors of eventual end stage renal disease in children with posterior urethral valves. *J Urol* 136: 857–860, 1986.
31. Williams DI, Whitaker RH, and Barrett TM: Urethral valves. *Br J Urol* 45: 200–210, 1973.
32. Rittenberg MH, Hulbert WC, Snyder HM, *et al*: Protective factors in posterior urethral valves. *J Urol* 140: 993–996, 1988.
33. Peters CA, and Bauer SB: Evaluation and management of urinary incontinence after surgery for posterior urethral valves. *Urol Clin North Am* 17: 379–387, 1990.
34. Bauer SB, Dieppa RA, Labib KK, *et al*: The bladder in boys with posterior urethral valves: a urodynamic assessment. *J Urol* 121: 769–773, 1979.
35. Hoover DL, and Duckett JW: Posterior urethral valves, unilateral reflux and renal dysplasia syndrome. *J Urol* 128: 994–997, 1982.
36. Dineen MD, Duffy PG, Barratt TM, *et al*: Persistent polyuria after persistent posterior valves. *Br J Urol* 75: 236–240, 1995.
37. Gonzalez JM, and Suki WN: Polyuria and nocturia, in Marsy SG, & Glasscock RD (Eds): *Textbook of Nephrology*. 3rd ed. Baltimore, Williams & Wilkins, 1995, p 547.
38. Mayo ME, and Ansell JS: The effect of bladder function on the dynamics of the ureterovesical junction. *J Urol* 123: 229–231, 1980.
39. Holmdahl G, Sillen U, Bachelard M, *et al*: The changing urodynamic pattern in valve bladders during infancy. *J Urol* 153: 463–467, 1995.
40. Campaiola JM, Perlmuller AD, and Steinhardt GF: Non-compliant bladder resulting from posterior urethral valves. *J Urol* 134: 708–710, 1985.
41. Parkhouse HF, and Woodhouse CRJ: Long-term status of patients with posterior urethral valves. *Urol Clin North Am* 17: 373–378, 1990.
42. Reinberg Y, Gonzalez R, and Fryd D: The outcome of renal transplantation in children with posterior valves. *J Urol* 140: 1491–1493, 1988.
43. Mochon M, Kaiser BA, Dunn S, *et al*: Urinary tract infections in children with posterior urethral valves after kidney transplantation. *J Urol* 148: 1874–1876, 1992.
44. Salomon L, Fontaine E, Gagnadoux M, *et al*: Posterior urethral valves: long term renal function consequences after transplantation. *J Urol* 157: 992–995, 1997.