Serial voiding urosonography in posterior urethral valve diagnosis and management in pediatric patients

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ABSTRACT

Objectives. Report our experience with the use of contrast-enhanced serial voiding urosonography (SVU) for posterior urethral valve (PUV) patient diagnosis and management.

Materials and Methods. Descriptive retrospective study in 0- to 14-year-old patients with suspected PUV at SVU performed as a first contrast-enhanced urinary tract test with subsequent cystoscopic study. Variables were analyzed using SPSSv22.

Results. 18 patients were studied (median age: 6 months). Most patients (15) presented posterior urethral dilatation (mean diameter: 9.56 mm) and a >2 mm gap between proximal and distal urethra. 13 cases had bladder thickening and 9 had VUR. 15 PUV cases, 1 case of distal urethral mucocele, and 1 case of bladder diverticulum obstructing the urethra were diagnosed. Complete PUV resection was performed in 10 patients (66.6%) at the first cystoscopy. The control SVU detected one case of recurrence due to persistence of posterior urethral dilatation. The recurrence case and the 5 incomplete resection cases were treated with a second cystoscopy and resection. The youngest patients required a third resection and cutting balloon dilatation due to residual stenosis. Mean creatinine levels at diagnosis were 0.28 mg/dl.

Conclusions. Serial voiding urosonography (SVU) is a useful complementary test in pediatric patients with posterior urethral valve. Its dynamic nature and its advantages – absence of irradiation, safety, and high sensitivity – make it an ideal imaging test for PUV diagnosis and follow-up.

KEY WORDS: Voiding urosonography; Ultrasound cystography; Posterior urethral valves.

UROSONOGRAFÍA MICCIONAL SERIADA EN EL DIAGNÓSTICO Y MANEJO DE LAS VÁLVULAS DE URETRA POSTERIOR EN PACIENTES PEDIÁTRICOS

RESUMEN

Objetivos. Comunicar nuestra experiencia con la utilización de la urosonografía miccional seriada (UMS) para el diagnóstico y manejo de pacientes con válvulas de uretra posterior (VUP).

Material y método. Estudio retrospectivo descriptivo en pacientes entre 0 a 14 años con sospecha de VUP en UMS realizada como primera prueba contrastada de la vía urinaria y con estudio cistoscópico posterior. Las variables se analizaron utilizando SPSSv22.

Resultados. Fueron estudiados 18 pacientes (edad mediana de 6 meses). La mayoría de los pacientes (15) presentaban dilatación de la uretra posterior (diámetro medio de 9,56 mm) y diferencia entre uretra proximal y distal mayor de 2 mm. Trece casos tenían engrosamiento vesical y 9 RVU. Se diagnosticaron 15 casos de VUP, 1 caso de mucocele de uretra distal y 1 divertículo vesical que obstruía uretra. Se consiguió resección completa de las VUP en 10 pacientes (66,6%) en la primera cistoscopia. La UMS de control detectó un caso de resección incompleta por persistencia de dilatación de uretra posterior. Este caso y los 5 conocidos con resección incompleta se sometieron a una segunda cistoscopia y resección. El menor de los pacientes requirió una tercera resección y dilatación con balón de corte por estenosis residual. La creatinina media al diagnóstico fue 0,28 mg/dl.

Conclusiones. La urosonografía miccional seriada (UMS) es una prueba complementaria útil en pacientes pediátricos con válvulas de uretra posterior. Su carácter dinámico y ventajas: ausencia de irradiación, seguridad y alta sensibilidad; la convierten en una prueba de imagen ideal para el diagnóstico y seguimiento de VUP.

PALABRAS CLAVE: Urosonografía miccional; Ecocistografía; Válvulas uretra posterior.

INTRODUCTION

Urethral congenital obstruction is one of the most devastating abnormalities of the urinary tract and one of the life-threating pathologies in the neonatal period[(1)]. Posterior urethral valves (PUV) are membranous folds in the posterior urethral lumen and represent the most common

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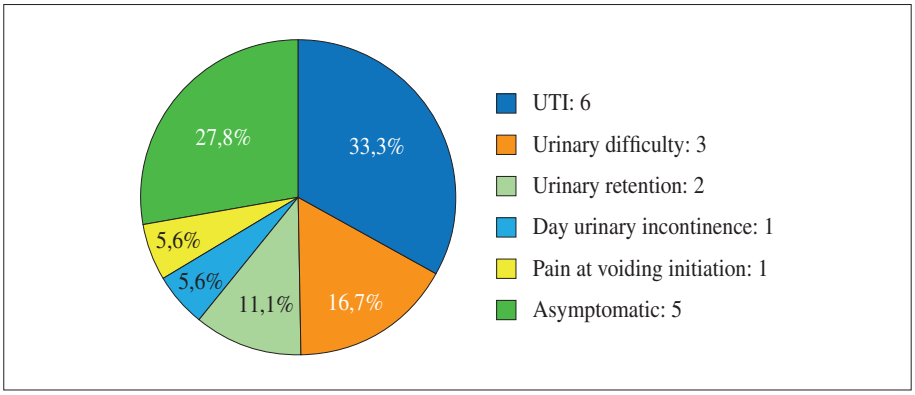

Figure 1. Circular chart of predominant clinical manifestations in all patients undergoing SVU.

urethral obstruction etiology in male newborns, with an incidence of 1 in 5,000 to 8,000[2].

Serial voiding cystography (SVC) is the preferred diagnostic study, and it is widely considered in the literature as the only imaging test establishing PUV diagnosis in a definitive fashion[1]. However, in recent years, serial voiding urosonography (SVU) has gained importance as a diagnostic method in pediatric urology.

The use of ultrasound signal enhancing agents for vesicoureteral reflux ultrasound study was first published in 1997 by Darge et al.[3]. Since then, various publications have demonstrated its equivalency with SVC for the study of the whole urinary tract in children[4,5], with the ultrasound advantages it provides over other imaging methods – it is easy to perform, it provides with real time images, and it does not involve ionizing radiation exposure.

SVU usefulness has been analyzed in various studies about the urethra in pediatric patients, and it has been concluded that it is a reliable imaging method, with sufficient sensitivity and specificity for PUV diagnosis[4,6]. However, there are few publications on clinical practice use in this pathology. Therefore, the objective of this work is to show our experience in PUV pediatric patient diagnosis and follow-up using SVU.

MATERIALS AND METHODS

Retrospective, descriptive, and qualitative study including all patients diagnosed with suspected lower urinary tract obstruction at SVU, carried out as the first contrast-enhanced urinary tract study, and subsequently undergoing cystoscopy from 2014 to 2018.

Patients diagnosed with PUV through complementary tests (ultrasound examination only, SVC, or cystoscopy) were excluded, even if SVU had been performed during follow-up.

In our healthcare facility, SVU is regarded as the imaging test of choice for upper and lower urinary tract study[7]. SVC is only used in exceptional and urgent cases. SVU is requested at the external consultation in all pediatric patients requiring a contrast-enhanced study of the urinary tract as a result of obstructive urinary tract symptoms, ultrasound thickening of the bladder wall, or recurrent UTI, among others. The diagnostic radiology department conducts the test while adapting the technique described by Duran et al.[4] to our hospital environment. The urethra is considered normal at SVU when contrast progression is continuous during voiding, owing to adequate urethral distension with homogeneous caliber. In children, the posterior urethra has a mean caliber of 6.4 ± 0.78 mm, and the anterior urethra has a mean caliber of 5.8 ± 0.91 mm; a caliber gap between the posterior and the anterior urethra of up to 2 mm is tolerated[8].

Patients with suspected urethral obstruction at SVU are scheduled for diagnostic-therapeutic cystoscopy. Clinical and imaging follow-up has been protocolized, requesting ultrasound examination one month following the procedure, and SVU three months after it.

Results were statistically analyzed using the SPSS software, version 22. For data presentation and analysis purposes, a descriptive statistics of each study variable was carried out. For the analysis of some important variables, only patients with PUV confirmation were considered.

RESULTS

During the study period, 198 SVUs were carried out in pediatric patients, among which 18 patients with signs suggestive of lower urinary tract obstruction at SVU, with no previous etiologic diagnosis.

Median age at SVU was 6 months (13 days-13 years). Patient age distribution was asymmetric, with most patients being under 1 year old, as discussed below. The most frequent clinical sign was urinary tract infection, found in 6 patients. Figure 1 features the predominant clinical manifestations in all patients.

Among diagnostic SVU findings, the state of the urethra, the bladder wall, and the presence of VUR were assessed. Figure 2 features the various categories the state

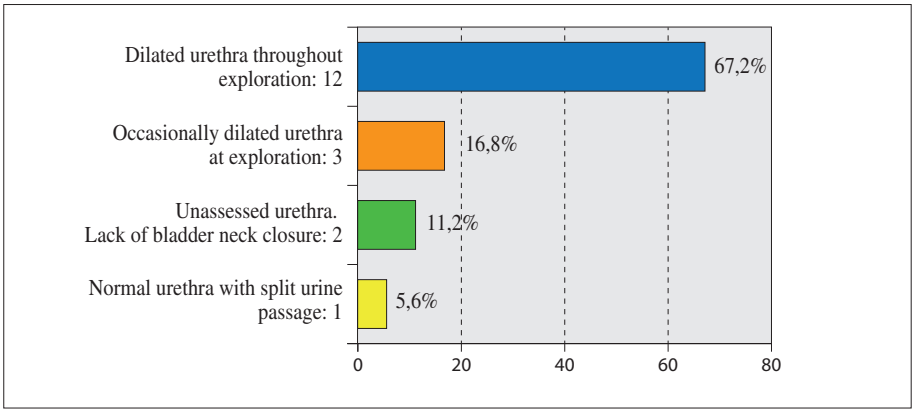

Figure 2. Bar chart of posterior urethral findings at diagnostic SVU.

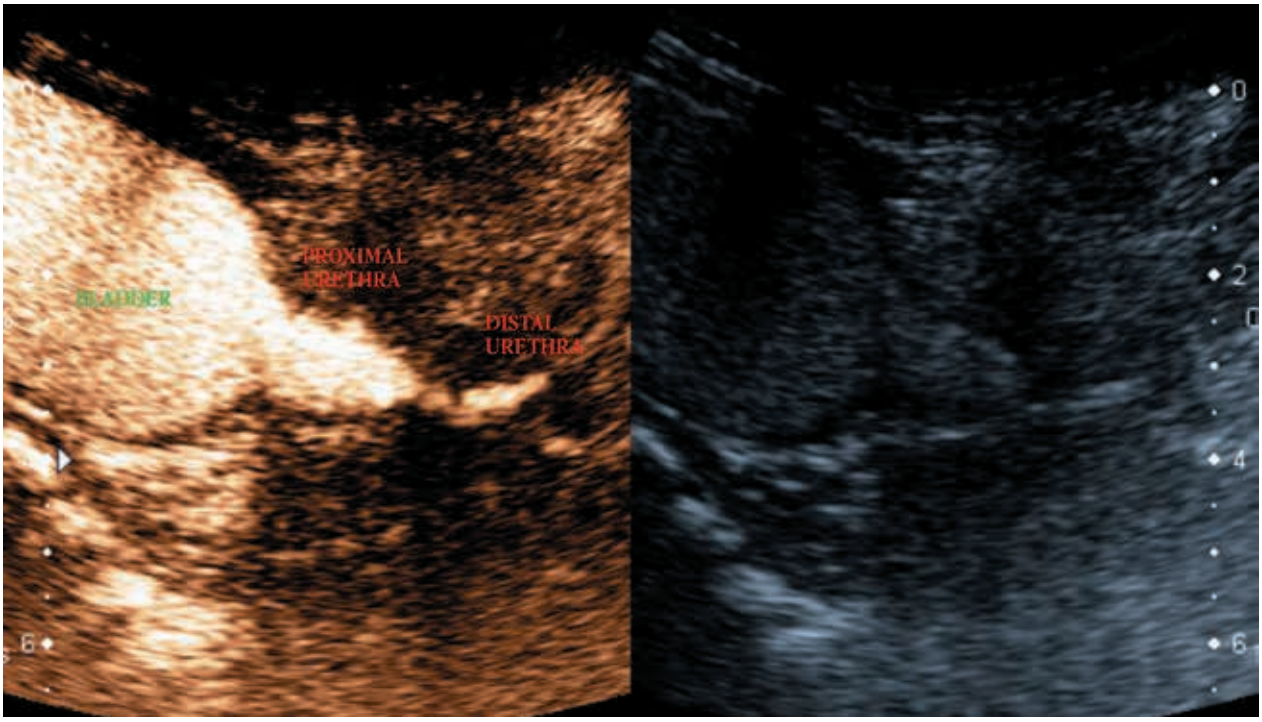

Figure 3. Proximal urethral dilatation and caliber gap with the distal urethra in a pathologic SVU.

of the posterior urethra was classified into at diagnostic SVU. Mean proximal urethral diameter was 9.56 mm, while mean distal urethral diameter was 3.34 mm. Therefore, the diameter gap between the proximal urethra and the distal urethra was 6.22 mm. SVU allows contrast progression to be dynamically analyzed during voiding, and the caliber gap between the dilated proximal urethra and the distal urethra to be evidenced, as it can be observed in Figure 3.

Regarding bladder findings, the bladder wall was thickened at SVU in 13 patients (72.2%), according to the radiologist. In addition, in some cases, the radiologist described increased bladder capacity and bladder neck dilatation throughout the study as findings suggestive of bladder obstruction. Furthermore, 9 patients had VUR at diagnostic SVU, with different degrees and laterality, as featured in Figure 4.

The first diagnostic and therapeutic cystoscopy following SVU with suspicion of lower urinary tract obstruction was performed at a median age of 9 months. Findings and treatments, arranged by age at the time of cystoscopy, are presented in Table 1. 15 patients were diagnosed with PUV, two of whom had history of Serial Voiding Cystourethrography (SVC), reported as normal regarding the lower urinary tract. The patient with anterior urethral mucocele also had a previous normal SVC.

Considering diagnostic cystoscopy as the reference test for urethral obstruction identification, SVU identified 17

Table 1. **First diagnostic-therapeutic cystoscopy results.**

Case	*Age*	*Findings*	*Treatment*
1	14 days	Type I PUV	Partial bougie electrofulguration
2	3 months	Type I PUV	Cold resection
3	4 months	Type I PUV	Partial bougie electrofulguration
4	5 months	Type I PUV	Partial bougie electrofulguration
5	6 months	Type III PUV	Cold resection
6	7 months	Type I PUV	Cold resection
7	7 months	Type I PUV	Cold resection
8	8 months	Type I PUV	Partial cold resection
9	9 months	Type I PUV	Cold resection
10	10 months	Type I PUV	Cold resection
11	11 months	Type III PUV	Cold resection
12	11 months	Type I PUV	Cold resection
13	1.3 years	Type I PUV	Partial cold resection
14	2.5 years	Type I PUV	Cold resection
15	3.8 years	Type I PUV	Cold resection
16	4.3 years	Giant bladder diverticulum	Open surgery removal
17	9.8 years	Anterior urethral mucocele	Electrofulguration
18	14 years	Normal urethra	

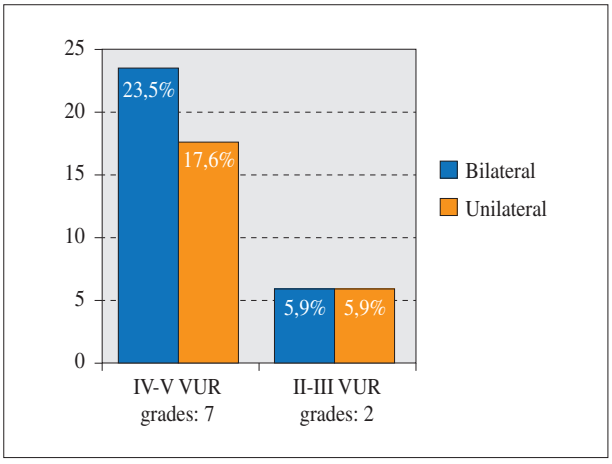

Figure 4. Column chart of patient VUR degree and laterality at diagnostic SVU.

Table 2. **SVU assessment vs. cystoscopy in urethral obstruction diagnosis.**

	Urethral obstruction	*Healthy*	*Total*
Positive	17	1	18
Negative	0	0	0
	17	1	18
	PPV: 94,4%	NPV: 100%	

of the 18 urethral obstruction cases (PPV: 94.4%), as it can be noted in Table 2.

Following the first PUV resection, control SVU was requested in 6 patients, carried out 8.6 months after the procedure on average. 4 patients (23.5%) had a normal caliber posterior urethra, 1 patient (5.9%) had reduced posterior urethral dilatation, and 1 patient (5.9%) had persisting dilatation, so incomplete PUV resection was suspected.

The patient with persisting posterior urethral dilatation at control SVU and the patients undergoing electrofulguration or partial resection at the first cystoscopy had a second resection cystoscopy performed. The results are featured in Table 3.

Only the youngest patient (Case 1) required a third resection, 5 months after the second, owing to the presence of annular residual scar valves, which underwent a new cold resection. In addition, this patient also had annular stenosis, treated using a dilatation and cutting balloon. No further remarkable complications were found in the rest of the series.

Mean creatinine levels at PUV diagnosis were 0.28 mg/dl. Only 1 patient, aged 1 year and 4 months at diagnosis, with a creatinine level of 0.78 mg/dl post resection of type I PUV, was included in stage 3 chronic renal insufficiency (renal glomerular filtration [RGF] = 55 ml/min/1.73 m^2).

Even though most (80%) PUV patients had no associated urological pathology, one patient with pyeloureteral junction stenosis (PUJS) and distal hypospadias was identified, another one with PUJS only, and one patient with pyeloureteral duplicity and ectopic ureter in the pos-

Table 3. Second PUV resection cystoscopy results.

Case	*Age at 2nd resection*	*Time from 1st resection*	*Findings*	*Treatment*
1	1 month	15 days	Residual PUV at hours 5, 7, and 12	Cold resection
3	1 year 3 months	9 months	Residual PUV at hours 5, 7, and 12	Cold resection
4	6 months	1 month	Residual PUV at hours 5, 7, and 12	Cold resection
5	1 year 6 months	1 year	Residual PUV at hour 12	Cold resection
8	9 months	1 month	Residual PUV at hour 12	Cold resection
13	1 year 8 months	4 months	Residual PUV at hours 5 and 7	Cold resection
	$\bar{x}$ = 11 months	$\bar{x}$ = 4.9 months		

terior urethra. This associated urological pathology has already received surgical treatment or is on a waiting list for surgery. Clinical and radiological follow-up was carried out both by pediatric surgery consultations and pediatric nephrology consultations for a mean 12.3 months.

DISCUSSION

In 2012, the European Society of Urogenital Radiology (ESUR) and the European Society of Pediatric Radiology (ESPR) included sonourethrography for the study of urethral abnormalities in their indication list for serial voiding urosonography (SVU)[9], since data consistent with SVC had been achieved, while avoiding ionizing radiation exposure[4,6,8,10]. The use of harmonic analysis software, which allows for contrast enhancing with the ultrasound signal color codification (mode B), and the use of convex probes provide with high quality morphologic and functional urethral images.

The highest-quality images are achieved in patients under 2 years of age thanks to the adequate ultrasound resonance of their tissues[8]. Most patients with suspected congenital lower urinary tract obstruction are included in this age band. However, in our experience, the technique is equally valid in older patients, since children diagnosed with PUV in our series were between 14 days old and 3.8 years old. Coincidentally, the three oldest patients had no PUV (Table 1).

SVU's main advantage over SVC lies in the fact it is a continuous dynamic and non-pulsating study, which allows the urethra and the bladder to be assessed in real time during the whole voiding process and in various voiding sequences. Information provided by SVU can even guide etiologic diagnosis towards lower urinary tract obstruction[10]. Even though most patients included in this study are PUV patients (Table 1), there are other urethral pathologies in our series which can reveal pathological findings in the contrast-enhanced ultrasound urethral assessment such as urethral mucocele or bladder diverticulum.

It is universally accepted that the normal appearance of the posterior urethra at SVC rules out the presence of PUV in children, thus making cytoscopic exploration unnecessary[11]. However, in their series of patients with late PUV diagnosis, Özen MA et al. found a poor correlation between the presence of PUV and SVC findings. In this group, SVC only diagnosed 10 (58.8%) out of 17 cases[12], so diagnostic cystoscopy should be preferred in these patients. Regarding VUR, there are various publications suggesting that SVU has a higher sensitivity for VUR diagnosis than SVC[13,14], and that it could provide a more reliable gradation of VUR degree[13,15-17], which has significant clinical implications in antibiotic prophylaxis or surgical treatment indication.

The studies considered by the ESUR and the ESPR in 2012[9] to incorporate the study of urethral abnormalities among SVU pediatric indications, as well as subsequent publications[4,7,18], include some patients diagnosed with and treated for PUV. However, ours is the first series studying patients with suspected urethral obstruction at SVU only. Diagnostic cystoscopy is the reference test in cases suggesting urethral obstruction. And as calculated according to Table 2, SVU has an acceptable predictive positive value for urethral obstruction diagnosis (94.4%) in this case series. We believe both non-PUV cases should not be removed from this calculation due to the fact they are equally pathological.

Real time voiding observation at SVU proves especially useful for the follow-up of patients undergoing posterior urethral valve resection[8]. In the control SVU of an asymptomatic patient, there was still a certain degree of proximal urethral dilatation – lower than before though –, but the passage of the contrast agent through the whole urethra and anterior urethral distension were normal, so it was considered to be part of progressive dilatation resolution following complete resection.

As it can be noted in Table 3, 6 of our patients required a second cystoscopy for PUV resection purposes. 5 cases corresponded to cystoscopies for second resection because the first was partial (Table 1), and 1 case corresponded to persistence identified by the control SVU following a seemingly complete resection in the first cystoscopy. Technical difficulties were encountered in the youngest patients. This is due to the fact that we have an 11.5 Fr

resectoscope, and in small size patients, it cannot be introduced in the distal urethra – even after meatus dilatation –, so a compact 9 Fr cystoscope and bougie electrofulguration are used, thus allowing for partial resection, which will be subsequently reviewed in a second procedure.

Urethral obstruction patient follow-up should be close so as to prevent renal, bladder, or sexual function alterations. The review by Deshpande in 2017 focuses on the strategies currently available to predict and manage PUV renal sequels in children – metabolic abnormalities, bladder dysfunction, and CRI[19]. The area which has seen most progress is renal function deterioration risk factor identification, which includes clinical data – such as the presence of more than 3 febrile UTIs[20] –, blood count data – such as baseline creatinine levels, lowest creatinine level following resection (nadir), creatinine clearance, proteinuria, and decreased glomerular filtration at one year of age[20-22] –, and ultrasound data – increased renal parenchyma echogenicity at baseline ultrasound examination, pathological corticomedullary differentiation, decreased estimated amount of renal parenchyma (total renal parenchymal area), and renal volume below the third percentile[20,22,23].

Bladder function could not be studied in depth due to the fact mean follow-up (12.3 months) was short, and our patients were too young. Bladder dysfunction is a frequent finding in PUV children (55%, range: 0-72%) which may occur even if urethral obstruction has been promptly and adequately treated[24]. Regular monitoring, adapted drug therapy, and assisted bladder voiding represent the basis of incontinence and bladder dysfunction treatment in valve bladder syndrome patients. For correct management, urodynamics should be carried out in all patients[25]. SVU may be combined with urodynamics to perform videourodynamics – as it is the case in our department[26]. This provides more information in a single procedure and leverages SVU advantages – absence of irradiation, safety, and high sensitivity – when it comes to diagnosing and treating PUV complications.

According to our experience, it can be concluded that the advantages of serial voiding urosonography (SVU) make it an ideal imaging test for PUV patient diagnosis and follow-up. In addition, its dynamic nature allows the voiding process to be assessed in real time, and urethral obstruction suspicion degree to be improved.

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