ORIGINAL ARTICLE

Clinical and urodynamics outcomes in pediatric primary bladder diverticula: a comparative study

Resultados clínicos y urodinámicos en divertículos vesicales primarios pediátricos: un estudio comparativo

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Abstract

Objective: *This study aimed to compare the effects of bladder diverticula smaller than 30 (SD) mm and larger than 30 mm (LD) on bladder functions and urodynamics.* **Materials and methods:** *Our retrospective analysis involved a cohort of 40 pediatric patients diagnosed with primary bladder diverticula.* **Results:** *The predicted mean bladder capacity (MBC) was 197.7 ± 95.8 mL, whereas the observed MBC was lower at an average of 170.1 ± 79.6 mL. This indicates that the observed MBC was 88.2 ± 12.9% of the predicted value (percentage). The mean diverticula diameter recorded was 33 ± 19.5 mm, and the diverticula to MBC ratio were calculated to be 0.25 ± 0.18. The distribution of urinary tract infections (UTIs) differed significantly between the groups ($p < 0.001$). Upper UT dilatation was significantly more common in the LD group (60%, n = 12) than in the SD group (15%, n = 3) ($p = 0.003$). The mean detrusor pressure (P[detrusor]) was significantly higher in the LD group (137.2 ± 24.1 cm H_2O) than in the SD group (63.9 ± 5.8 cm H_2O) ($p = 0.001$). In addition, the mean peak flow rate (Q_{max}) was significantly higher in the SD group (20.7 ± 7.9 mL/s) compared to the LD group (12.7 ± 3.8 mL/s) ($p < 0.001$).* **Conclusion:** *Bladder diverticula size is a significant factor in the clinical presentation and management of primary bladder diverticula in pediatric patients.*

Keywords: *Bladder. Diverticula. Vesicoureteral reflux. Urodynamic. Urinary tract infections.*

Resumen

Objetivo: *Este estudio tuvo como objetivo comparar los efectos de los divertículos vesicales menores 30 mm (SD), mayores 30 mm (LD) en las funciones y urodinámica de vejiga.* **Materiales y métodos:** *Nuestro análisis retrospectivo involucró una cohorte de 40 pacientes pediátricos diagnosticados con divertículos vesicales primarios.* **Resultados:** *Capacidad vesical media predicha (MBC) fue de 197.7 ± 95.8 mL, mientras que MBC observada fue menor con promedio de 170.1 ± 79.6 mL. Esto indica que MBC observada fue del 88.2 ± 12.9% del valor predicho (porcentaje). Diámetro medio de divertículos registrados fue de 33 ± 19.5 mm, y se calculó que relación entre los divertículos y la MBC era de 0.25 ± 0.18. Distribución de infecciones del tracto urinario (ITU) difirió significativamente entre grupos ($p < 0.001$). Dilatación del tracto urinario superior (UT) fue significativamente más común en grupo LD (60%, n = 12) que en grupo SD (15%, n = 3) ($p = 0.003$). Presión media del detrusor (P[detrusor]) fue significativamente mayor en grupo LD (137.2 ± 24.1 cm H_2O) que en grupo SD (63.9 ± 5.8 cm H_2O) ($p = 0.001$). Además, tasa de flujo máximo promedio (Q_{max}) fue significativamente mayor en grupo SD (20.7 ± 7.9 mL/seg) en comparación con grupo LD (12.7±3.8 mL/seg) ($p < 0.001$).* **Conclusiones:** *Tamaño de divertículos vesicales es factor significativo en presentación clínica, manejo de divertículos vesicales primarios en pacientes pediátricos.*

Palabras clave: *Vejiga. Divertículos. Reflujo vesicoureteral. Urodinámica. Infecciones del tracto urinario.*

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Introduction

About 1.7% of children are born with bladder diverticula, which are sac-like protrusions from the bladder wall. Diverticula of the bladder can be present at birth (primary bladder diverticula) or develop later in life (secondary bladder diverticula)[1,2]. Paraureteral diverticula, also known as Hutch diverticula, share a common etiology in which a defect in Waldeyer's fascial sheath plays a pivotal role in their development[3].

Hutch diverticula cause significant vesicoureteral reflux because they distort the ureterovesical junction[4,5]. Primary congenital diverticula have been linked to the connective tissue disorders known as Ehlers–Danlos types IV, V, and IX, which are said to cause the diverticula to rupture spontaneously[6,7]. Interestingly, a high prevalence of primary bladder diverticula has been linked to Menkes' kinky hair disease, a rare X-linked recessive disorder of copper metabolism[6,7].

Various genitourinary complications, including infections and voiding dysfunction, have been linked to bladder diverticula, which are primarily diagnosed through voiding cystourethrograms[8]. The main problem is that it is not known whether or not surgical intervention affects the frequency of associated infections or voiding dysfunction, and there are no established guidelines for the repair of primary pediatric bladder diverticula[8,9]. By discussing experiences with primary bladder diverticula in children, with an emphasis on the urinary tract infections (UTI) and voiding dysfunction that often accompany them.

This study aimed to compare the effects of bladder diverticula smaller than 30 (SD) mm and larger than 30 mm (LD) on bladder functions and urodynamics.

Materials and methods

Patients and groups

Our retrospective analysis involved a cohort of 40 pediatric patients diagnosed with primary bladder diverticula. All patients were selected from our hospital's patient database from the period between January 2020 and April 2023. The inclusion criteria encompassed patients aged < 18 years who had a confirmed diagnosis of primary bladder diverticula. Patients with secondary bladder diverticula or those with other significant genitourinary abnormalities were excluded from this study.

The following patient data were collected: patient age at the time of diagnosis, gender, the number of UTIs experienced, the presence of upper UT dilatation, renal impairment, vesicoureteral reflux, post-micturition residue (PMR), and whether the patient underwent surgery. Moreover, diverticula diameter, predicted mean bladder capacity (MBC), observed MBC, the percentage of predicted MBC, diverticula to MBC ratio, mean detrusor pressure (P[detrusor]), and mean peak flow rate (Q_{max}) were documented.

Patients were divided into two groups based on the size of their diverticula, with one group comprising those with diverticula < 30 mm in diameter, and the other with diverticula > 30 mm.

The diverticula diameter was determined through ultrasound examination. Predicted MBC and observed MBC were assessed through voiding cystourethrograms, which were also used to diagnose bladder diverticula and vesicoureteral reflux. PMR was evaluated through post-void ultrasound. The pressure-flow study was utilized to measure P(detrusor) and Q_{max}.

This study was conducted following the ethical standards of the Declaration of Helsinki, and it was approved by the Institutional Review Board of our hospital. Given the retrospective nature of the study (KAEK/2023.05.193), the requirement for individual informed consent was waived.

Statistical analysis

Data were analyzed using SPSS software (version 26.0). Continuous variables were presented as mean ± standard deviation and categorical variables as frequency and percentage. The independent *t*-test was used for the comparison of continuous variables between two groups, and the Chi-square test was utilized for categorical variables. A $p < 0.05$ was considered statistically significant.

Results

The study encompassed 40 patients with a mean age of 5.8 ± 3.8 years. The cohort consisted predominantly of males, making up 80% of the total patients (n = 32). The predicted MBC was 197.7 ± 95.8 mL, whereas the observed MBC was lower at an average of 170.1 ± 79.6 mL. This indicates that the observed MBC was 88.2 ± 12.9% of the predicted value (percentage). The mean diverticula diameter recorded was 33 ± 19.5 mm, and the diverticula to MBC ratio were calculated to be 0.25 ± 0.18. Half of the patients

(n = 20) had diverticula > 30 mm in diameter. The distribution of UTIs among patients was as follows: 7.5% of patients had no UTIs (n = 3), 42.5% had one UTI (n = 17), 17.5% had two UTIs (n = 7), 22.5% had three UTIs (n = 9), and 10% had four or more UTIs (n = 4). Further clinical observations revealed that 37.5% of patients (n = 15) had upper UT dilatation. Renal impairment was found in 7.5% of patients (n = 3), whereas 25% of the patients (n = 10) exhibited vesicoureteral reflux. Positive PMR was observed in 30% of patients (n = 12). The mean detrusor pressure (P[detrusor]) was 100.6 ± 40.9 cm H_2O, and the mean peak flow rate (Q_{max}) was found to be 16.7 ± 65.6 mL/s. Among the patient group, 27.5% (n = 11) underwent surgery as part of their treatment pathway (Table 1).

The study participants were divided into two equal groups, based on the size of their diverticula. Twenty patients (50%) had diverticula of < 30 mm, whereas the other 20 (50%) had diverticula larger than 30 mm. The mean age of patients in the smaller diverticula group was 5.3 ± 3.7 years, compared to 6.3 ± 3.9 years in the larger diverticula group (p = 0.439). In terms of gender, males made up 70% (n = 14) and 90% (n = 18) of the smaller and larger diverticula groups, respectively, although this difference was not statistically significant (p = 0.235). The predicted MBC was 183 ± 91.2 mL in the smaller diverticula group and 212.5 ± 100.3 mL in the larger group (p = 0.337). The observed MBC was 176.9 ± 87.1 mL in the smaller diverticula group, slightly higher than the 163.2 ± 72.9 mL in the larger group (p = 0.539). The observed MBC as a percentage of the predicted MBC was significantly higher in the smaller diverticula group 98.04 ± 8.7 than in the larger diverticula group 78.4 ± 8.01 (p < 0.002). The distribution of UTIs differed significantly between the two groups (p < 0.001). In terms of clinical observations, upper UT dilatation was significantly more common in the larger diverticula group (60%, n = 12) than in the smaller group (15%, n = 3) (p = 0.003). The rate of renal impairment was similar in both groups (p = 1.000). Vesicoureteral reflux and positive PMR were found exclusively in the larger diverticula group (50%, n = 10, and 60%, n = 12, respectively), with significant differences observed (p < 0.001 for both). The mean detrusor pressure (P[detrusor]) was significantly higher in the larger diverticula group (137.2 ± 24.1 cm H_2O) than in the smaller group (63.9 ± 5.8 cm H_2O) (p = 0.001). In addition, the mean peak flow rate (Q_{max}) was significantly higher in the smaller diverticula group (20.7 ± 7.9 mL/s) compared to the larger group (12.7 ± 3.8 mL/s) (p < 0.001). Finally, surgery was more prevalent in the larger diverticula group, with 55% of these patients (n = 11) undergoing surgery, compared to none in the smaller diverticula group (p < 0.001) (Table 2).

Table 1. Patients demographic

Variables	n (or mean)	% (or SD)
Age (year)*	5.8	3.8
Gender (M)	32	80
Predicted MBC (mL)*	197.7	95.8
Observed MBC (mL)*	170.1	79.6
Percentage of predicted MBC (%)*	88.2	12.9
Diverticula diameter (mm)*	33	19.5
Diverticula to MBC ratio*	0.25	0.18
Diverticula > 30 mm	20	50
Total UTI (n)		
Never	3	7.50
1 time	17	42.50
2 times	7	17.50
3 times	9	22.50
4 and more	4	10
Upper UT dilatation	15	37.50
Renal impairment	3	7.50
Vesicoureteral reflux	10	25
PMR (yes)	12	30
P (detrusor) cm H_2O*	100.6	40.9
Q_{max} (mL/s)*	16.7	5.6
Surgery	11	27.50

*mean/SD (standard deviation).
MBC: mean bladder capacity; PMR: post-micturition residue.

Discussion

Our study provides valuable insights into the clinical management and outcomes of pediatric patients diagnosed with primary bladder diverticula. It is notable that primary bladder diverticula are rare and generally associated with significant genitourinary complications including infections and voiding dysfunction[1,2,8].

The main finding of this study is the substantial differences observed between patients with smaller and larger diverticula. We found that those with larger diverticula (> 30 mm) experienced significantly more UTIs, higher instances of upper UT dilatation, greater

Table 2. Comparison of diverticula diameters

Variables	< 30 mm (n = 20) (%)	> 30 mm (n = 20) (%)	p-value
Age (year)*	5.3 ± 3.7	6.3 ± 3.9	0.439
Gender (M)	14 (70)	18 (90)	0.235
Predicted MBC (mL)*	183 ± 91.2	212.5 ± 100.3	0.337
Observed MBC (mL)*	176.9 ± 87.1	163.2 ± 72.9	0.539
Percentage of predicted MBC (%)*	98.04 ± 8.7	78.4 ± 8.01	< 0.002
Total UTI (n)			< 0.001
Never	3 (15)	0 (0)	
1 time	16 (80)	1 (5)	
2 times	1 (5)	6 (30)	
3 times	0 (0)	9 (45)	
4 and more	0 (0)	4 (20)	
Upper UT dilatation	3 (15)	12 (60)	0.003
Renal impairment	1 (5)	2 (10)	1.000
Vesicoureteral reflux	0 (0)	10 (50)	< 0.001
PMR (yes)	0 (0)	12 (60)	< 0.001
P (detrusor) cm H_2O*	63.9 ± 5.8	137.2 ± 24.1	0.001
Qmax (mL/s)*	20.7 ± 7.9	12.7 ± 3.8	< 0.001
Surgery	0 (0)	11 (55)	< 0.001

*mean/SD: Standard deviation; T-test; other items Chi-square test.
MBC: mean bladder capacity; PMR: post-micturition residue; UTI: urinary tract infection.

vesicoureteral reflux, higher PMR, increased detrusor pressure, lower peak flow rates, and were more likely to undergo surgery than those with smaller diverticula (< 30 mm). These findings emphasize the clinical importance of diverticula size in the presentation and management of the condition[10].

The association between bladder diverticula size and UTIs is particularly noteworthy. As our data suggest, UTIs are significantly more frequent in patients with larger diverticula. This is consistent with previous literature suggesting that urinary stasis within the diverticula facilitates bacterial growth, leading to an increased susceptibility to UTIs[2,8]. Moreover, it is well-established that UTIs are a common complication of bladder diverticula, particularly in children[2,10].

Our findings also demonstrated that patients with larger diverticula had significantly higher rates of upper UT dilatation and vesicoureteral reflux. Previous research has indicated that larger bladder diverticula can cause bladder outlet obstruction, which leads to increased intravesical pressure and can contribute to the development of upper UT dilatation and vesicoureteral reflux[5,10,11]. This further underscores the importance of bladder diverticula size in clinical outcomes.

The need for surgical intervention was another significant difference between the two groups. The larger diverticula group had a higher incidence of surgery compared to those with smaller diverticula. Surgery was more commonly needed in patients with larger bladder diverticula due to an increased likelihood of complications[11,12].

One limitation of our study is its retrospective nature, which may introduce selection bias. In addition, our sample size was relatively small, which might limit the generalizability of our findings. Despite these limitations, our study provides important information that could guide clinicians in the management of pediatric patients with primary bladder diverticula.

Conclusion

Our study suggests that bladder diverticula size is a significant factor in the clinical presentation and management of primary bladder diverticula in

pediatric patients. These findings highlight the need for further studies to establish clear guidelines for the management of this condition, particularly regarding the optimal time for surgical intervention.

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Conflicts of interest

The authors declare no conflicts of interest.

Ethical disclosures

Protection of human and animal subjects. The authors declare that the procedures followed were in accordance with the regulations of the relevant clinical research ethics committee and with those of the Code of Ethics of the World Medical Association (Declaration of Helsinki).

Confidentiality of data. The authors declare that they have followed the protocols of their work center on the publication of patient data.

Right to privacy and informed consent. The authors have obtained approval from the Ethics Committee for analysis and publication of routinely acquired clinical data and informed consent was not required for this retrospective observational study.

Use of artificial intelligence for generating text. The authors declare that they have not used any type of generative artificial intelligence for the writing of this manuscript nor for the creation of images, graphics, tables, or their corresponding captions.

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