Research Article

J Ped. Nephrology 2013 July;1(1):18-22.
http://journals.sbmu.ac.ir/jpn

Bladder Volume Wall Index in Children with Urinary Tract Infections

How to Cite This Article: Hooman N, Hallaji F, Mostafavi SH, Sharif MR, Tatarpoor P, Otukesh H. Bladder Volume Wall Index in Children with Urinary Tract Infections. J Ped. Nephrology 2013 July;1(1):18-22.

Nakysa Hooman,[1]*
Farideh Hallaji,[1]
Seyed- Hassan Mostafavi,[1]
Mohammad- Reza Sharif,[2]
Parvin Tatarpoor,[1]
Hassan Otukesh[1]

1Iran University of Medical Sciences, Tehran, Iran
2Kashan University of Medical Sciences, kashan, Iran

***Corresponding Author**
Nakysa Hooman
Ali-Asghar Children Hospital, Tehran-Iran
Email:
nakisa45@yahoo.com

Introduction: Few studies have focused on the correlation between bladder ultrasound and urinary tract infection. The aim of this study was to evaluate the bladder volume wall index in children with single or recurrent urinary tract infection.

Materials & Methods: This case-control study was conducted between March 2008 and December 2009. The study was performed on one hundred children (8 boys, 92 girls) aged 4-15 years with a history of urinary tract infection and thirty-nine (20 males, 19 females) age- matched healthy children who had negative urine culture one month before investigation. The kidneys, ureters, and bladder sonography were performed in all children. Bladder volume wall index was calculated for each child and the result of 70-130 was presumed normal. Student T-test, chi-square, likelihood ratio, and risk ratio were used. P-value <0.05 was considered significant.

Results: The mean bladder volume was 262.5 (±82) in recurrent urinary tract infection, 235 (±54) in single urinary tract infection, and 278 (±80) in controls (P<0.05). The bladder was thick (<70) in 37 (28 cases, 9 controls) and thin (>130) in 38 children (28 cases, 10 controls) (P>0.05). The median residual volume was not different between the two groups. The abnormal BVWI in children with vesicoureteral (VU) reflux was 75% as compared to 51% in those without VU reflux (P>0.05). There was no correlation between BVWI and age, gender, groups, vesicoureteral reflux status, or residual volume (P>0.05).

Conclusions: According to our findings, the bladder volume wall index is not sensitive enough to discriminate children who are prone to urinary tract infection.

Keywords: Urography; Urinary Tract Infections; Ultrasonography; Urinary Bladder

Received: 20-Dec-2012
Revised: 22-Jan-2013
Accepted: 02-Feb-2013

Running Title: Bladder Volume Wall Index in UTI

Introduction

Urinary tract infections are one of the most common infectious diseases in children. Ultrasound is an imaging modality routinely used for initial evaluation of children with urinary tract infections [1]. One of the indications for requesting voiding cystourethrogram is abnormal renal-bladder sonography or recurrent urinary tract infection (UTI) [2]. Few studies have investigated the correlation between the bladder abnormality in ultrasound and urinary tract infections [3-4].

The bladder volume wall index (BVWI), first introduced by Yeung *et al*, is a sonographic definition for the evaluation of bladder volume. According to the bladder volume wall index and urodynamic study findings, the bladders are classified to thick and small (BVWI<70), thin and large (>130), and normal (70-130) [4-7]. As this classification is used as a non-invasive tool for the evaluation of the patients with urinary tract

infections, we presumed that it could be useful in the detection of cases prone to recurrent urinary tract infections. However, we previously reported that BVWI had low sensitivity to detect children with lower urinary tract symptoms [8] or abnormal uroflowmetry [9].

Materials and Methods

Between March 2008 and December 2009, one hundred children (92 females, 8 males) aged 4-15 years with a history of urinary tract infection were enrolled in the study after obtaining consent from their parents. Thirty-nine age- matched children with no history of urinary symptoms were selected as controls.

The study was approved by the Ethics Committee of Iran University of Medical Sciences and followed the Institution's Review Board for Human Subjects Guidelines.

A through history and a complete physical exam were performed. Those with neurogenic bladder, urinary tract anomalies, or previous bladder or abdominal surgery were not included in the study. Urinary tract infection was defined as more than 10^5 single microorganisms grown in a sample urine culture obtained through the midstream method. Recurrent urinary tract infection was defined as either the history of at least two episodes of acute pyelonephritis, one episode of upper urinary tract infection and cystitis, or three episodes of cystitis [1]. Urine analysis and urine culture were performed for each child before further evaluation. In the case of urinary tract infection, bladder sonography was postponed for four weeks until urine culture results were negative.

A Ziemens Sonoline G40 sonography system was used for all patients with two 7.5-10 MHz linear and 5 MHz convex probes. At first in the supine oblique position, the maximum renal diameters were measured for each kidney; maximum length (L) in the longitudinal coronal oblique plane and mean corticomedullary thickness were measured in the supine or lateral decubitus position; maximum width (W) and AP diameter (D) were obtained in the axial or transverse plane and then the renal volume was calculated (Renal volume= L x W x D x 0.523). Total renal volume is the sum of right and left renal volumes. The age related expected bladder volume index (BVI) and BVWI were extracted for each patient from an available standard table [5]. The patient's bladder volume index (BVI) was calculated by multiplying the maximum AP and side to side internal diameters of the bladder (in mid-transverse plane) and the maximum dome to bladder outlet diameter (in mid-sagittal plane) in the supine position [4-8]. The post-void BVI was measured similarly after the child was asked to void completely. Then, the percentage of bladder emptying efficacy was calculated. At the next step, anterior, anterolateral and posterolateral wall thickness were measured in the mid-transverse view. The mean of these measurements represented post-void bladder mean wall thickness [4-9].

Subsequently, the bladder volume wall index (BVWI) was calculated through dividing the calculated BVI (cm^3) by mean bladder wall thickness (cm) [4-9]. This index was used to determine the BVWI% through dividing the calculated BVWI by the expected BVWI for age using the following equation [4-9].

$$\frac{BVI_{\max} - BVI_{empty}}{BVI_{\max}} x100 .$$

If the BVWI% was less than 70, it was classified as thick (low capacity, thick wall), between 70 to 130 was considered normal and more than 130 was regarded as thin (high capacity, thin wall) bladder [4-9].

Normal post-void residue was defined as the presence of greater than 20 ml post-void residual urine [10].

The data was presented as mean ± SD and frequency. Independent Student's t-test was used to compare means, ANOVA for comparing the differences between and within groups, Chi-square, likelihood ratio, and odd ration for any-rows x any-columns tables. Mann-Whitney test was used to compare non-parametric variables. P value less than 0.05 was considered significant.

Results

Out of 100 children with a history of UTI who were included in the study, fifty-five (3 boys, 52 girls) had RUTI and 45 (5 males, 40 females) had SUTI. Thirty-nine (20 males, 19 females) children who had no urinary tract symptoms were considered as the control group ($P<0.05$). The mean age of cases was 7.45 yr (±2.45 SD) vs. 8.2 (±2.6 SD) for the controls (p-value=0.12).

Table 1. Kidney Bladder parameters in Sonography in Healthy Children – percentile (n=39)

	5	25	50	75
Right kidney -length	70.20	81.10	88.50	94.20
Right kidney -wide	27.0	29.00	31.00	36.30
Right kidney - anteroposterior	30.00	34.40	40.30	42.20
Left kidney- length	71.40	87.10	90.30	99.00
Left kidney- wide	24.30	34.00	37.30	41.00
Left kidney - anteroposterior	31.40	35.00	40.40	47.90
full bladder	134.82	350.78	522.12	688.94
full bladder- length	56.71	66.35	76.55	100.50
full bladder -wide	40.55	59.38	67.40	76.42
full bladder -depth	52.00	69.58	97.65	109.50
empty bladder- length	13.96	24.20	35.35	48.03
empty bladder -wide	9.21	16.92	22.50	38.65
empty bladder -depth	8.74	18.45	26.95	39.55
bladder thickness - anterolateral diameter	1.90	2.50	3.15	4.00
bladder thickness -lateral diameter	1.99	2.58	3.45	4.25
bladder thickness - posteriolateral diameter	1.80	2.78	3.15	4.12
bladder thickness - mean diameter	2.02	2.71	3.36	4.00
Bladder volume wall Thickness	18.66	76.00	98.48	123.60
Post-void residue	0.00	5.00	13.45	24.95
right kidney volume	38.15	47.50	59.04	67.72
Left kidney volume	42.02	61.92	72.02	94.14
total kidney volume	85.68	108.79	129.31	154.56
bladder volume	180.00	217.50	252.30	321.15

Table 2. Kidney Bladder parameters in Sonography in Children with urinary tract infection – percentile (n=100)

	5	25	50	75
Right kidney -length	71.40	80.00	85.50	93.50
Right kidney -wide	26.48	29.15	32.70	36.05
Right kidney - anteroposterior	30.00	33.40	36.60	41.60
Left kidney- length	73.30	82.40	87.20	95.80
Left kidney- wide	28.00	33.15	35.90	41.30
Left kidney - anteroposterior	31.00	34.40	37.80	44.40
full bladder	142.98	348.64	492.48	735.94
full bladder- length	49.50	63.50	73.70	92.50
full bladder -wide	44.60	62.10	71.30	82.40
full bladder -depth	56.50	75.80	94.80	117.00
empty bladder- length	15.50	26.60	34.90	45.40
empty bladder -wide	11.50	23.60	30.80	44.40
empty bladder -depth	10.70	19.90	31.00	41.60
bladder thickness - anterolateral diameter	1.60	2.22	3.10	3.90
bladder thickness - lateral diameter	1.90	2.52	3.35	4.18
bladder thickness - posteriolateral diameter	1.90	2.40	3.30	4.18
bladder thickness - mean diameter	1.83	2.50	3.26	3.93
Bladder volume wall Thickness	35.18	66.09	96.32	140.35
Post-void residue	1.90	6.92	19.26	35.12
right kidney volume	35.41	42.96	55.10	69.11
Left kidney volume	36.70	50.87	64.83	78.71
total kidney volume	74.33	98.43	117.69	146.00
bladder volume	159.50	195.00	231.15	302.48

The mean bladder volume wall index was 98 (±81SD) in RUTI cases, 102(74 SD) in single UTI cases, and 103(±73 SD) in controls (P>0.05). Tables 1 & 2 show the quartile of kidney bladder sonography parameters in cases and controls. The median post-void residue was not different between cases (19 ml in RUTIs, 21 ml SUTI) and controls (14 ml) (P>0.05). There was no correlation Table 2- Kidney Bladder parameters in Sonography in Children with urinary tract infection – percentile (n=100) between BVWI, age, or gender (P>0.05). Standard voiding cystourethrogram was performed in 66 children with UTI, 41% of whom had vesicoureteral reflux. Of patients with VU reflux, 75% had abnormal BVWI (OR: 2.85, 95% CI: 1-8.7) (p-value=0.06). By dividing children to recurrent and single urinary tract infection, the odd ratio was calculated as 4.8 (95%CI:0.7 -33.7) for SUTI and 1.8 (95%CI:0.4-7.9) for RUTI (p-value>0.05).

Discussion

The majority of studies have focused on renal sonography parameters as a tool for the evaluation of patients with urinary tract infection. An observational study reported a change in the urinary tract infection policy in a decade in Australia. There was a higher rate of ultrasonography prescription for evaluation of urinary tract infection and lesser tendency to request invasive modalities [11]. Yeung et al. observed that their method of the measurement of BVWI had a good correlation with urodynamic evaluation [4-5]. This method measures the maximum capacity of the bladder to the expected bladder volume for age. In the conventional model of sonography, the maximum capacity of the bladder is not considered. Even a good association between BVWI and urodynamic evaluation can be a promising feasible method for ruling out the children with small or large bladder just by sonography and limit the necessity to employ invasive studies such as VCUG or UDS. Our previous study could not confirm the superiority of BVWI to Pediatric Lower Urinary Tract Scoring System to detect children with lower urinary tract symptoms [8]. In addition, we could not find any correlation between BVWI and uroflowmetry [9}. In contrast, Azhir et al used BVWI for the

evaluation of children with enuresis [12] and the responsiveness to therapy [13]. We tried to evaluate the ability of BVWI to detect children prone to urinary tract infection. Less attention has been paid to the bladder measurements on sonography of children with urinary tract infection. The bladder volume wall index (BVWI) is claimed to be highly correlated with urodynamic findings of thick, thin, or normal bladders [4,6]. However, no difference was detected in BVWI between case and control groups in our study. Liu *et al* evaluated the sonographic characteristics of the bladder in infants younger than 12 months with urinary tract infection and found that these infants had smaller bladder volumes, larger residual volumes, and thicker bladders than the controls [3]. According to the bladder volume wall index, the median anterolateral, posterolateral, and lateral wall thickness of the empty bladder are significantly lower in children with VU reflux. It may represent incomplete emptying of the bladder in this group. A few studies have shown that the bladder wall thickness varies minimally with age but is influenced by the bladder filling state; the upper limit of normal thickness is 3 mm when the bladder is distended and 5 mm when the bladder is empty [14-15]. A survey on healthy school-aged children showed a significant correlation between body mass index, age and the anterior and posterior thickness of the bladder wall but there was no significant correlation with the volume of bladder [16].

The limitations that we encountered during ultrasonography were that the measurement of BVWI consumes at least twice the time that is required for the conventional ultrasonography of the bladder, some children drink too much and presented with an over-distended bladder, and some children could not tolerate to fill the bladder completely as expected.

Conclusions

According to our findings, the bladder volume wall index is not sensitive enough to discriminate the children who are prone to recurrent urinary tract infection.

Acknowledgement

The study was supported by Iran University of Medical Science grant number 918 dated 2008. The abstract of this study was presented as poster in the 2nd congress of IrSPN held in Mashhad in 2011 [17].

Conflict of Interest

None declared

Financial Support

None declared

References

1- Mori R, Lakhanpaul M, Verrier-Jones K. Diagnosis and management of urinary tract infection in children: summary of NICE guidance. BMJ 2007;335:395-397.
2- Subcommittee on Urinary Tract Infection, Steering Committee on Quality Improvement and Management, Roberts KB. Urinary tract infection: clinical practice guideline for the diagnosis and management of the initial UTI in febrile infants and children 2 to 24 months. Pediatrics 2011;128(3):595-610.
3- Liu JX, Leung VY, Chu WC, Sreedhar B, Metreweli C, Yeung CK. Characteristics of the bladder in infants with urinary tract infections: an ultrasound study. Pediatr Radiol 2008;38:1084-1088.
4- Yeung CK, Sreedhar B, Leung YF, Sit KY. Correlation between ultrasonographic bladder measurements and urodynamic findings in children with recurrent urinary tract infection. BJU Int 2007;99: 651-655.
5- Leung VY, Chu WC, Yeung CK, et al. Normograms of total renal volume, urinary bladder volume and bladder wall thickness index in 3376 children with a normal urinary tract. Pediatr Radiol 2007;37:181-188.
6- Yeung CK, Sreedhar B, Leung VT, Metreweli C. Ultrasound bladder measurements in patients with primary nocturnal enuresis: a urodynamic and treatment outcome correlation. J Urol 2004;171:2589-2594.
7- Yeung CK, Chiu HN, Sit FK. Bladder dysfunction in children with refractory monosymptomatic primary nocturnal enuresis. J Urol 1999;162:1049-1054.
8- Hooman N, Hallaji F, Mostafavi SH, Mohsenifar S, Otukesh H, Moradi-Lakeh M. Correlation between Lower Urinary Tract Scoring System, Behavior Check List, and Bladder Sonography in Children with Lower Urinary Tract Symptoms. Korean J Urol 2011;52:210-215.
9- Mostafavi SH, Hooman N, Hallaji F, et.al. The correlation between bladder volume wall index and the pattern of uroflowmetry/external sphincter electromyography in children with lower urinary tract malfunction. J Pediatr Urol 2011; 8:367-374.
10- Chang SJ, Yang SS. Variability, related factors and normal reference value of postvo id residual urine in healthy kindergarteners. J Urol 2009;182:1933-1938.
11- South M. Radiological investigations following urinary tract infection: changes in Australian practice. Arch Dis Child 2009;94:927-930.
12- Azhir A, Nasseri F, Fazel A, Adibi A, Frajzadegan Z, Divband AH. Etiology and pathology of enuresis among primary s chool children in Isfahan, Iran. Saudi Med J 2007;28:1706-1710.
13- Azhir A, Gheissari A, Fragzadegan Z, Adebi A.New treatment protocol for primary nocturnal enu

resis in children according to ultrasound bladder me asurements. Saudi Med J 2008;29:1475-1479.

14- Jequier S, Rousseau O. Sonographic measurements of the normal bladder wall in children. AJR Am J Roentgenol 1987;149:563-566.

15- Kaefer M, Barnewolt C, Retik AB, Peters CA. The sonographic diagnosis of infravesical obstruction in children: evaluation of bladder wall thickness indexed to bladder filling. J Urol 1997;157:989-991.

16- Uluocak N, Erdemır F, Parlaktas BS, Caglar MK, Hasiloglu Z, Etikan I. Bladder wall thickness in healthy school-aged children. Urology 2007;69:763-766.

17- Hooman N, Mostafavi SH, Hallaji F, Otukesh H. Bladder Volume Wall Index In Children With Urinary Tract Infections. Iran J Kidney Dis 2011;5:7 (Abs.).