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Is a Low Sacral Ratio Associated with Primary Vesicoureteral Reflux in Children?

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Introduction: The association of sacral anomalies with fecal incontinence and lower urinary tract dysfunction is known. The sacral ratio is proposed as a tool for evaluation of sacral development. The aim of this cross-sectional study was to evaluate the prevalence and severity of vesicoureteral reflux in children with a low sacral ratio.
Materials and Methods: Six hundred and sixty nine children who were referred to a radiology clinic for a standard (fluoroscopic) VCUG to detect vesicoureteral reflux and other anomalies of the lower urinary tract after an episode of urinary tract infection were included in the study and their sacral ratios were measured.
Results: All children were younger than 14 years of age (mean 3.44±3.20). Of 669 children, 593 (88.6%) had normal sacral ratios out of whom 423 (71.3%) did not have VUR and 170 (28.7%) had VUR. Seventy-six (11.3%) children out of 669 cases had low sacral ratios; 49 (64.5%) of them had no VUR and 27 (35.5%) had VUR. There was no significant difference in the prevalence of VUR between children with and without a low sacral ratio (p value=0.217). Also, there was no significant difference or trend between a low sacral ratio and the severity of reflux (Chi2 for trend).
Conclusions: Although sacral anomalies may be related to some cases of VUR by producing lower urinary tract dysfunction, the sacral ratio is not associated with VUR.

Keywords: Sacral agenesis; Vesico-Ureteral Reflux; Urination Disorders; Anorectal Anomalies; child

Running Title: Sacral Ratio and Primary Vesicoureteral Reflux

Introduction

In 1995, Alberto Pena [1] proposed the sacral ratio (SR) as a reliable tool to evaluate sacral development. The SR is obtained by comparing the sacrum size with the fixed bony parameters of the pelvis. Pena proposed that the measurement of the SR would allow to establish the functional

prognosis in most children with anorectal malformations with a reasonable accuracy. However, there have been conflicting reports regarding the predictive value of the SR in identifying patients who are at risk of

incontinence. Demirbag et al [2] reported that they noticed a significant correlation between the sacral ratio and the continence score in their patients whereas Macedo et al [3] evaluated the SR in patients with anorectal malformations and concluded that the SR was of no practical value in identifying patients likely to have fecal incontinence. Sacral anomalies also may affect urinary function [4, 5]. Moreover, many factors are known in the pathogenesis of vesicoureteral reflux (VUR); voiding dysfunction may play an etiologic role in some of the children with VUR [6-12]. These clinical observations led us to consider that sacral anomalies may cause voiding dysfunction which may in return turn produce VUR in some children. In this study, we compared the prevalence of vesicoureteral reflux in normal children and in children with low sacral ratios.

Materials and Methods

About 700 children who had a history of urinary tract infection (UTI) for the first time and were referred to our radiology clinic for voiding cystourethrography (VCUG) between 2009 and 2011 were enrolled in this study. Because bowel preparation is not routinely performed before fluoroscopic VCUG especially in small children, the presence of gas and fecal material led to difficulty in visualization of the pelvic bones and measuring the SR in some films and the bones were obscured. We excluded these films and included only radiographs in which we could measure the SR accurately, so we here report the results of 669 patients. Also, we excluded patients with secondary VUR (due to posterior urethral valve, neuropathic bladder, etc.)

Reflux grading was performed according to the international reflux grading system [13]. The sacral ratio was measured as described by Pena et al [1], Torre et al [14] and Warne et al [15] mostly from anteroposterior and in some by lateral sacral radiography. Threeparallel lines were traced on each radiograph (Fig.):

1. Beween the uppermost aspect of each iliac crest
2. Between the lowest points of sacroiliac joints
3. Parallel to the two above-mentioned lines touching the lowest radiologic visible point of the sacrum.

The sacral ratio is calculated by dividing the distance between the two lower line (B) by the distance between the two upper lines (A) [1,14,15]. A sacral ratio of 0.74 is considered normal in the anteroposterior view. Sacral ratios lower than 0.52 in either AP or lateral views are considered abnormal [14].

SPSS13 software (SPSS Inc., Chicago, IL) was used for data analysis. In this cross-sectional study Chi-square was used to compare the frequency of the variables between groups and Chi square for trend was used for detecting the trends. P values less than 0.05 were considered significant.

Results

All of the children were younger than 14 years. The mean age of the participants ±SD was 3.44±3.20. Four hundred and twelve children (61.6%) were male and 256 (39.4%) were female. For the detection of VUR in girls, some physicians prefer radionuclide VCUG over fluoroscopic VCUG [16,17]; therefore, the number of girls who were referred to our radiology clinic for fluoroscopic VCUG was lower than boys. Three hundred and thirteen children (46.8%) were younger than 2 years, 170 (25.4%) were 2-5 years, 151 (22.8%) were 5-10 and 35 (5.%) were 10-14 years old. Table 1 shows the prevalence of low sacral ratio in different age groups. Comparison of different age groups showed a significant difference in the prevalence of low sacral ratio among these four groups (P value= 0.006). Table 2 shows the correlation of children's age and the prevalence of VUR; the prevalence of VUR decreased with an increase in children's age (Chi2 for trend, P-value<0.05).

Among 669 children, 593 had normal sacral ratios of whom 423 (71.3%) had no VUR and 170 (28.7%) had VUR (93 case had unilateral and 77 cases had bilateral VUR). Of 669 cases, 76 had low sacral ratios; 49(64.5%) had no VUR and 27 (35.5%) had VUR (14 cases had unilateral and 13 cases had bilateral VUR). There was no significant difference in the prevalence of VUR between children who had or did not have a low sacral ratio (p value = 0.217).

We also evaluated if there was a relationship between the presence of low sacral ratio and the severity of VUR. The reflux grade in

children with normal and abnormal sacral ratios is shown in Table 3. There was no significant relationship or trend between the presence of low sacral ratio and severity of reflux (Chi2 for trend).

Discussion

Activation, coordination, and integration of various parts of the bladder sphincter complex involve both the central somatic and the autonomic nervous system through three sets of peripheral nerves: sacral parasympathetic, thoracolumbar sympathetic and sacral somatic nerves. All three nerves (hypogastric, pelvic and pudendal nerves) carry both motor and sensory nerves [5]. Bony abnormalities of the spine may affect the bladder function; in particular, neurogenic bladder dysfunction will result if the sacral neural segments S2 to S4 are involved [18]. Patients with sacral anomalies may manifest with upper or lower motor lesions. The upper motor lesion is characterized by detrusor hyperreflexia, exaggerated sacral reflexes, absence of voluntary control over the sphincter, and detrusor sphincter dyssynergia [4]. VUR has been seen in children with hyperreflexia with or without dyssynergia [4]. Sacral nerve stimulation has been used for the treatment of voiding dysfunction [19, 20]. It has been found that the number of sacral vertebrae correlates with the final functional outcome in these children very well. However, it is often difficult to count the number of sacral vertebrae accurately, particularly in patients with a dysmorphic sacrum with fused vertebrae or hemivertebrae. The sacral ratio as proposed by Pena may be a simple method for the evaluation of the sacrum. Torre et al compared normal children and those with anorectal malformation (ARM) and found a wide range of normal values for the SR and stated that patients should not be considered to have a true pathology unless the SR is below 0.52 either in the AP or lateral view [14]. In 2004, Macedo et al reported the results of SR measurements in children with ARM. Although the SR was different in patients with sacral agenesis, it was not different in continent, partially continent, or incontinent patients. They concluded that the SR was of no practical value in identifying patients likely to have fecal incontinence [3]. Warne et al questioned the validity of SR measurement as a method for detecting sacral anomalies. Four investigators (one radiologist, two urologists, and one surgical fellow student) studied the sacral radiographs of 50 children and measured the SR. Although the SR had good inter- and intra-observer repeatability, the variability of the values among similar patients was noticeable, suggesting that this single value is of limited value in discriminating a normal from an abnormal sacrum [15].

It has long been known that a significant proportion of children with VUR have voiding dysfunction [5-12] and the opposite is true - that is reflux can be demonstrated in many children with bladder dysfunction. Voiding dysfunction plays a role in the etiology of congenital VUR [4,9- 12]. Increased intravesical pressure seems to be the primary factor for inducing reflux in idiopathic lower urinary tract dysfunction [21]. Also, voiding dysfunction may be responsible for the perpetuation of reflux and development of renal scaring [12]. Treatment of voiding dysfunction is effective in the management of some cases of VUR [22-25].

The sacral ratio has already been studied in children with VUR. Kajbafzadeh et al compared sacral ratio in children with VUR and normal children. [26] and reported that the sacral ratio was lower in children with VUR than normal children. Also, they observed a correlation between the degree of skeletal sacral anomaly and uroflowmetry findings in children with VUR. In this study, we did not find a significant difference in the prevalence of VUR between children with normal and low SRs. Moreover, the grade of VUR was not different between children with normal and low sacral ratios.

Conclusions

Although sacral anomalies may be related to some cases of VUR by producing lower urinary tract dysfunction,

1. The sacral ratio is of limited value in discriminating a normal from an abnormal sacrum (15).
2. The sacral ratio is of no practical value in identifying patients likely to have fecal incontinence (3), which may also be true for the lower urinary tract function.
3. The low sacral ratio is not associated with VUR.

Table 1. The prevalence of low sacral ratio in different age groups

Age category	Short Sacrum	Normal Sacrum	Total
under 2 years	24 (7.7%)	289 (92.3%)	313 (100)
2-5 years	27 (15.9)	143 (84.1%)	170 (100%)
5-10 years	17 (11.3%)	134 (88.7%)	151 (100%)
10-14 years	8 (22.9)	27 (77.1%)	35 (100%)
total	76 (11.4%)	593 (88.6%)	669 (100%)

Table 2. Relation between age of the children and presence of VUR

Age Category	Without reflux	Unilateral or bilateral reflux	Total
Under 2 years	206 (65.8%)	107(34.1%)	313 (100%)
2-5 years	122 (71.8%)	48(28.2%)	170(100%)
5-10	113 (74.8%)	38(25.2%)	151 (100%)
10-14 years	28 (80.0%)	7 (20%)	35 (100%)
total	472 (70.6%)	197 (29.4%)	669 (100%)

Table 3. The reflux grade in children with normal and abnormal sacral ratio

Reflux grade	Right kidney		Left kidney	
	Normal Sacral ratio N=642	Abnormal sacral ratio N=76	Normal Sacral ratio N=642	Abnormal sacral ratio N=76
No reflux	500(80.1%)	60(78.9%)	500(80.1%)	53(69.7%)
Grade I	32(5.1%)	2(2.6%)	8(1.3%)	1(1.3%)
Grade II	56(9.0%)	7(9.2%)	81(13.0%)	12(15.8 %)
Grade III	18(2.9%)	3(3.9%)	18(2.9%)	4(5.3%)
Grade IV	9(1.4%)	3(3.9%)	7(1.1%)	0(0%)
Grade V	9(1.4%)	1(1.3%)	10(1.6%)	6(7.9%)

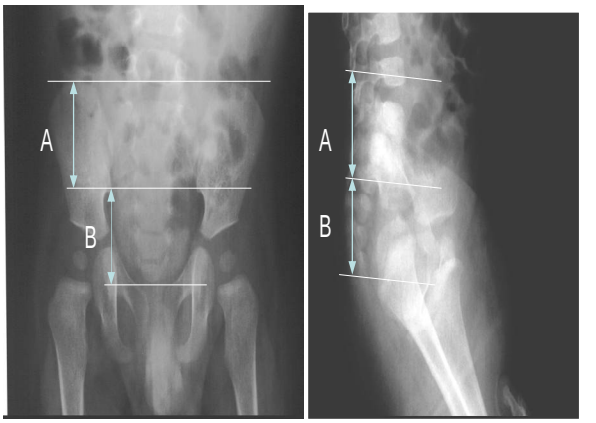

Figure 1. The SR is obtained by the ratio of two distances B/A

Conflict of Interest

None declared

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None declared

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