Original article

Morphometry of the pelvic ureter

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Abstract

Introduction: Morphometric features of the pelvic ureter such as length and obliquity of the intravesical part are important in etiology of vesicoureteric reflux (VUR). Although differences in morphometry of the ureter may underlie the observed sex disparity in the frequency of vesicoureteric reflux, there is scarcity of comparative data on the organization of the pelvic ureter. This study aimed at determining sex differences in the structure of the pelvic ureter. **Materials and Methods:** This was a descriptive cross – sectional study carried out at the Department of Human Anatomy University of Nairobi, Kenya. Eighty-eight ureters from black adult Kenyans (48 male and 40 female) were studied. Length and angle at which intravesical ureter lies to the bladder was measured in millimeters and degrees respectively. Data were analyzed using SPSS (Version 16.0, Chicago Illinois) for means and standard deviations. Sex differences in morphometry were determined using the Student's t test. A value $p \leq 0.05$ was considered statistically significant. Pearson's correlation test was used to test for correlation between length and angle. A Two-tailed test was used to test for significance of the correlation co-efficient. A p – value < 0.01 was considered significant. **Results:** The mean intravesical length of pelvic ureter in males was 18.69 mm compared to 14.81 mm in females (p – value of <0.001). The angle at which ureters lay to the bladder was 26.75° in males and in females 29.10° (p – value of 0.018). **Conclusion:** The pelvic ureter displays sex differences in morphometry with the intravesical segment being longer with a more oblique course in males. These features could underlie the higher female predisposition to VUR.

Keywords: ureter, length, angle, vesicoureteric reflux, sex.

1 Introduction

The pelvic ureter is that part which extends from the pelvic brim to the urinary bladder. It consists of a juxta and intravesical segments with the latter having an oblique course through the bladder wall and measuring 10-19 mm long in adults (HUTCH, 1962).

The intravesical part is responsible for the active and passive components for prevention of vesicoureteric reflux (VUR) (KING, KAZMI and BELMAN, 1974; RADMAYR, FRITSCH, SCHWENTNER et al., 2005). The latter is as a result of its oblique course and length through the bladder wall (THOMSON, DABHOIWALA, VERBEEK et al., 1994) giving rise to a valvular mechanism at the vesicoureteric junction (VUJ) (RADMAYR, FRITSCH, SCHWENTNER et al., 2005; CARR, WALTON and DONE, 1992). Refluxing ureters, have therefore been shown to have a shorter intravesical length and a less oblique intravesical course (NOBLE, CHRISTMAS, CHAPPLE et al., 1992). Accordingly, sex differences in morphometry of the intravesical ureter may underlie the higher frequency of vesicoureteric reflux in females as opposed to males (EL-KHATIB, BECKER and KINCAID-SMITH, 1990; BUCKLEY, GEOGHEGAN, O'BRIEN et al., 1974). However, comparative morphometric data on the pelvic ureter are scarce and this study therefore aimed at comparing the length and angle of implantation of the intravesical ureter between males and females.

2 Materials and Methods

Material for this study was obtained from 88 black Kenyan cadaveric hemipelvises (48 male; 40 female: age range 30-50 years) at the Department of Human Anatomy, University of Nairobi, Kenya. Prosections with any form of urinary bladder abnormalities such as bladder wall trabeculation and nodulation or ureteric pathology were excluded from the study. Measurements of intravesical length and angle at which the ureter lies to the bladder were taken by two observers and averages obtained for the two sets of values. For intravesical length, a probe was inserted through the internal ureteric orifice and length of the intravesical ureter was marked and measured using a rule to the nearest 0.5 mm. The angle at which the ureter lies to the bladder (Q) was measured using a protractor as an angle subtended between a horizontal plane through the interureteric ridge and a diagonal axis passing through the intravesical ureter (Figure 1).

Data were analyzed using SPSS version 16.0.for means ± standard deviations. Student's t test, at 95% confidence interval was used to test for significant differences in the intravesical ureter length and the angle at which the intravesical ureter lies to the bladder with regards to sex. A p – value of < 0.05 was considered significant. Pearson's correlation test was used to test for association between

mean length and mean angle. A Two-tailed test was used to test for significance of the correlation co-efficient. A p – value < 0.01 was considered significant. The data are presented in tables and box plots.

3 Results

One hundred and twelve ureters from fifty six individuals were available for this study. Twenty four were excluded from the study: ten due to difficulty in identification of internal ureteric orifice and fourteen due to obvious pathologies of the ureters and bladder. Eighty eight were therefore studied. The pelvic ureters, in all cases, were bilateral muscular tubes extending from the pelvic brim to the urinary bladder wall. The ureters coursed within the pelvic cavity to pierce the posterior wall of the urinary bladder and traverse the bladder wall to terminate at the internal ureteric orifice.

The mean length of the intravesical ureter was 16.99 mm (standard deviation 3.459, range 9 mm-25 mm.) It was longer in males with a mean value of 18.81 mm (standard deviation of 3.266, range 9 mm-25 mm.) compared to 14.80 mm (standard deviation of 2.198 and range 10 mm-19 mm) in females (Figure 2). This difference in length between the sexes was statistically significant (p-value < 0.001) (Table 1).

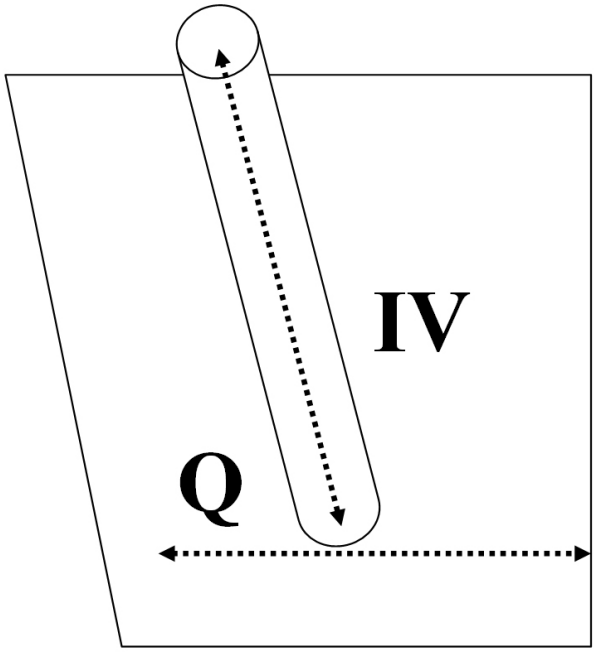

Figure 1. Schematic diagram showing a hemi-section of the posterior bladder wall at the trigone. The angle Q was measured in between the horizontal (↔) and diagonal (↖↘) axes subtended for intravesical ureter (IV).

The ureter entered the bladder at a mean angle of 27.59° (standard deviation of 4.770°, range 20°-40°). In males, this angle was narrower with a mean of 26.50° (standard deviation of 5.251°, range 20°-40°) in comparison to females mean 28.90° (standard deviation of 3.781°, range 20°-39°) (Figure 3). The difference in angle Q between sexes was statistically significant (p-value 018) (Table 2).

Pearson's correlation test was applied to test for correlation between mean length and angle and a value of –0.333 was found. The strength of this correlation was statistically significant (p – value 0.002).

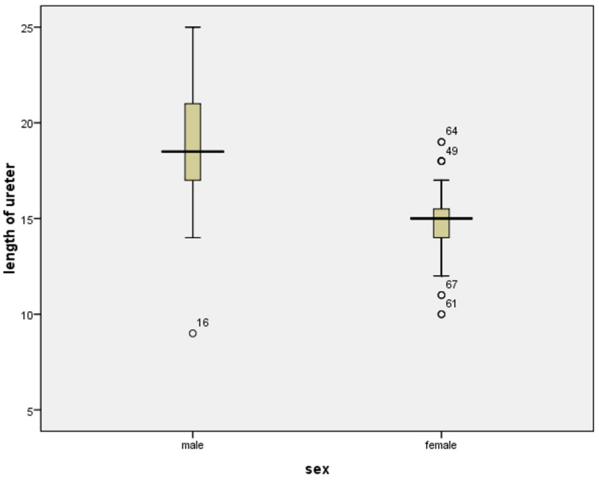

Figure 2. Box plot of sex dimorphism in length of intravesical ureter.

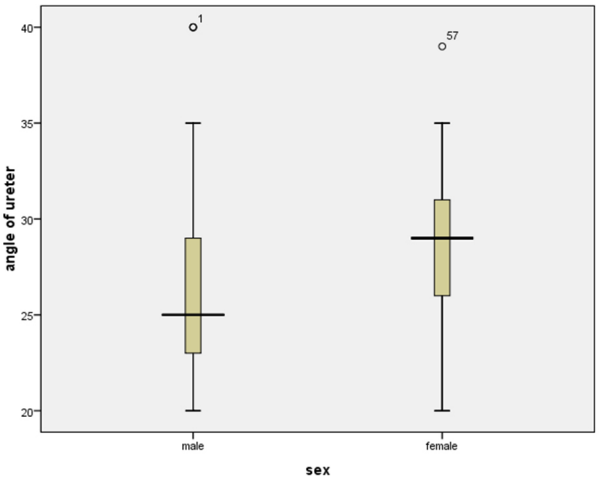

Figure 3. Box plot of sex dimorphism in angle at which the ureter lies to the bladder.

Table 1. Intravesical ureter length.

	Sex	N	Mean	Std. Deviation	Range	p-value
length of intravesical ureter	Male	48	18.81 mm	3.266	9-25 mm	<.001
	Female	40	14.80 mm	2.198	10-19 mm	

Table 2. Angle at which the ureter entered the bladder (Q).

	Sex	N	Mean	Std. Deviation	Range	P-value
Angle of the ureter to the bladder (Q)	Male	48	26.50°	5.251	20-40°	0.018
	Female	40	28.90°	3.781	20-39°	

4 Conclusion

Morphometry of the pelvic ureter has been implicated in etiology of vesico-ureteric reflux (CARR, WALTON and DONE, 1992). This condition has demonstrated disparity based on sex (EL-KHATIB, BECKER and KINCAID-SMITH, 1990). This study therefore proceeded to describe differences in the pelvic ureter structure that probably underlie this disparity. Indeed observations in the current study revealed differences in morphometry of the pelvic ureter between males and females.

The mean length was 16.90 mm. This value is within the range of 10-19 mm reported by Hutch (1962). It is however lower than 23 ± 0.6 mm reported by Roshani, Dabhoiwala and Verbeek et al. (1999). Similarity with Hutch's findings can probably be attributed to use of the same methodology. On the other hand, the difference between findings of the current study and those of Roshani, Dabhoiwala and Verbeek et al. (1999) may be explained by the nature of the specimens used and the methodology, that is fresh autopsy ureters bathed in physiological saline as opposed to formalin fixed samples used in the current study and Endoluminal ultrasonography (ELUS) for measurement of length.

Length of the intravesical ureter constitutes part of the passive anti reflux mechanism (ROSHANI, DABHOIWALA, VERBEEK et al., 1996). In males, this length averaged 18.96 mm compared to 14.81 mm in females. Relatively shorter intravesical lengths have been reported in refluxing ureters (CARR, WALTON and DONE, 1992; MURAWSKI, MYBURGH, FAVOR et al., 2007). This could imply that a shorter intravesical ureter in females compared to their male counterparts accounts for their predisposition to VUR.

The mean angle at which the intravesical ureter lies to the bladder in the current study was 27.84°, a value was much higher than 11 ± 0.5° reported by Roshani, Dabhoiwala and Verbeek et al. (1999). The latter calculated this angle as a function of bladder wall thickness and intravesical ureteric length. A notable observation of the current study was that females had a wider angle implying a more oblique course of the intravesical ureter as opposed to males.

The oblique course of the intravesical ureter forms part of the passive anti reflux mechanism (ROSHANI, DABHOIWALA, VERBEEK et al., 1996). This is achieved through neutralization of the force tending to separate the ureteral roof from floor. This force is due to the increased surface of the bladder wall due to distension with urine (PEREMANS, 1966). Consequently, the wider angle is less efficient at preventing VUR (NOBLE, CHRISTMAS, CHAPPLE et al., 1992).

A negative correlation was found between length and angle Q of the intravesical ureter hence an increase in length would result in a decrease in angle Q. A literature report has correlated the propensity to reflux in the Pax2 1Neu+/– mouse with a shortened intravesical ureter that has lost its angulated entry into the bladder wall (MURAWSKI, MYBURGH, FAVOR et al., 2007). In combination with a shorter intravesical length, a wider angle Q could, in part, explain the predisposition of females to VUR.

The limitations of this study included tissue shrinkage that occurs in cadaveric specimen. This may have affected measurements taken. However, the shrinkage factor was the same for all specimens included as only cadaveric specimen were used in this study

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