Urol Res (2005) 33: 199–202
DOI 10.1007/s00240-004-0461-3

ORIGINAL PAPER

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Direct ureteric length measurement from intravenous pyelography: does height represent ureteric length?

Received: 24 March 2004 / Accepted: 22 November 2004 / Published online: 25 February 2005

Abstract Ureteric length is the most important factor for determining the ideal length of a ureteric stent. In most of the literature, ureteric length is estimated according to a patient's height. We investigated the reliability of a patient's height as a measure of ureteric length. We measured the actual length of the ureteric trace (ALUT) and the linear distance (LD) from the ureterorenal junction to the ureterovesical junction by intravenous pyelography (IVP), using a 15 min view. A total of 203 patients (100 men, 103 women, 406 ureters) with normal findings were studied, and ALUT, LD and height were measured. The mean patient height was 164.3 ± 8.3(SD) cm. Mean ALUTs of the right and left ureters were 23.4 ± 1.9 cm and 24.4 ± 2.0 cm, respectively, and the mean LDs of the right and left ureters were 22.1 ± 1.9 cm and 22.9 ± 2.0 cm, respectively. Height was significantly correlated with the ALUTs of both sides, but these were not linear ($r^2 = 0.024$ right, 0.059 left). However, LD showed significant linear correlations with the ALUTs of both sides ($r^2 = 0.879$ right, 0.884 left). Two formulas to estimate the ALUT from LD were suggested: right ALUT = 0.94×right LD + 2.6, left ALUT = 0.96×left LD + 2.4. Our results demonstrated that patient height does not provide a reliable estimate of ureteric length. LD by IVP is preferable to patient height when estimating the ureteric length.

Keywords Ureter · Length · Stent · Height

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Introduction

A double J ureteric stent is usually placed to prevent or relieve ureteric obstruction. In particular, the advent of extracorporeal shock wave lithotripsy (ESWL) and the more recent explosion of endourologic techniques have dramatically increased the number of indications for indwelling ureteric stents [1, 2, 3, 4, 5]. However, patients may experience complications such as pain, urinary frequency, hematuria, infection, stent fragmentation and migration [6, 7, 8, 9, 10, 11, 12], and many of these complications are related with ureteric stent length. A stent which is too long may cause symptoms of trigonal irritation and one which is too short may migrate [13]. Therefore, the choice of correct ureteric stent length is most important for reducing stent associated complications.

The selection of ureteric stent length must be individualized, based on the patient's ureteric length. Ureteric length for each patients has been calculated using three different methods according to previous reports: (1) estimation from a formula based on the patient's height [14], (2) direct measurement of the ureter itself using a guidewire [15], and (3) measurement of the distance from the ureteropelvic junction to the ureterovesical junction either by retrograde pyelography or intravenous pyelography (IVP) [13]. Of these methods, direct measurement with a guidewire cannot be used routinely. Pilcher and Patel [14] reported that patient height is a more reliable guide to ureteric stent length than direct ureteric measurement. However, Breau and Norman [16] reported that ureteric length should be measured directly from an x-ray to select the optimal stent length. Clinically, the majority of urologists and radiologists use the patient's height to estimate ureteric length. However, the reliability of this method as an estimate of ureteric length has not been confirmed.

In this study, we investigated the reliability of using a patient's height for determining the correct length of the ureteric stent, and developed a more accurate method.

Patients and methods

A total of 203 patients (406 ureters) with normal IVP findings were studied. There were 100 men and 103 women with an age range of 17–83 years. Normal IVP findings were confirmed independently by a radiologist and an urologist. The underlying indications for IVP were not considered.

We measured the actual length of the ureteric trace (ALUT) and the linear distance (LD) on IVP with a 15 min view, which showed the whole ureter well. ALUT was measured by tracing the ureter from the ureterorenal junction, i.e. from the point where the ureter crosses the medial border of the kidney contour to the ureterovesical junction, and by measuring the length of the trace with a flexible ruler. LD was taken as the straight length between the same points. Ten percent was deducted from the measurements obtained to account for radiographic magnification. Sex, height, weight and age were compared with the measured ALUT and LD values.

Data were analyzed using SPSS 10.0 (SPSS, Chicago, Ill.). Significant differences were determined using the Student's *t*-test, and correlations between variables were determined by linear regression analysis. A *P* value below 0.05 was considered significant.

Results

Mean patient height was 164.2 ± 8.3 cm (SD, range 140–185 cm). The mean ALUTs of the right and left ureters were 23.4 ± 1.9 cm and 24.4 ± 2.0 cm, respectively, and the mean LDs of the right and left ureters were 22.1 ± 1.9 cm and 22.9 ± 2.0 cm. The right ALUT was 1.0 cm shorter than the left ($P < 0.05$) (Table 1). Patient height was significantly correlated with the ALUTs of both sides ($P < 0.05$), but these correlations were not linear. The r^2 value was 0.024 for the left side and 0.059 for the right side (Fig. 1a, b). Weight, sex and age were not found to affect either ALUT or LD.

The ALUT and LD of both sides were found to be linearly correlated. By linear regression analysis, the r^2 of ALUT and LD were 0.879 for the right side and 0.884 for the left (Fig. 2a, b). ALUT could be calculated from LD using the linear equation:

$$\text{Right ALUT} = 0.94 \times \text{right LD} + 2.6.$$

$$\text{Left ALUT} = 0.96 \times \text{left LD} + 2.4.$$

Table 1 The actual length of the ureteric trace (ALUT) and linear distance (LD) taken from a 15 min view intravenous pyelography

	Right ($n = 203$)		Left ($n = 203$)	
	Mean ± SD	Range	Mean ± SD	Range
ALUT (cm)	23.4 ± 1.9	17.3–28.7	24.4 ± 2.0	17.6–31.5
LD (cm)	22.1 ± 1.9	16.7–28.1	22.9 ± 2.0	15.0–28.7

Discussion

Choosing the correct length for a ureteric stent is important for preventing stent associated complications. However, there is no standardized method for determining the ideal ureteric stent length in spite of its common use. Clinically, most urologists and radiologists use the patient's height to decide upon the ideal ureteric stent length due to simplicity to use. However, this method proved unreliable in the present study due to lack of linearity.

In the present study, ALUT was measured from the ureteric trace taken from an IVP. Thus, it represents the normal ureter length, or at least is linearly correlated with the normal ureteral length. The most exact way to measure ureteral length is the method of using cadaver ureters, but this is rarely useful clinically. We considered that tracing ureters in an AP view would not be different from real ureteral length, as ureters are located in the narrow retroperitoneal space and are directed lineally in a lateral view.

Ureteral measurement using guidewire is a relatively exact method. However, the guidewire used in the

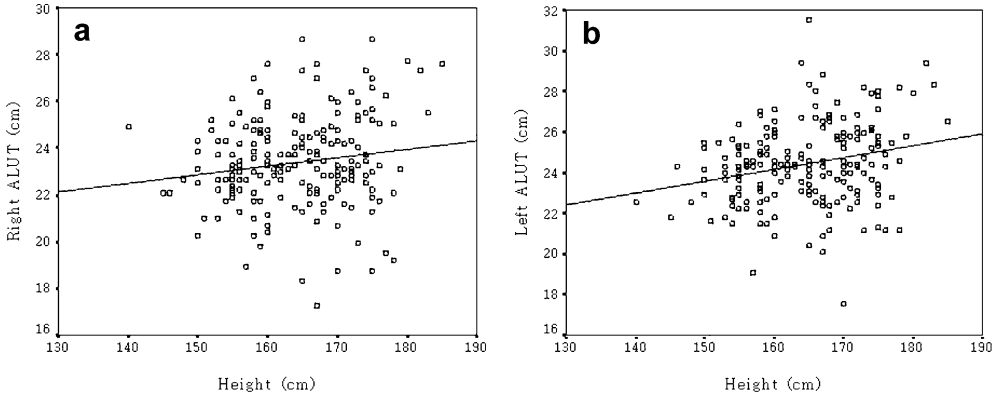

Fig. 1 Correlation between patient height and actual length of the ureteric trace (*ALUT*) from a normal intravenous pyelography of 15 min. **a** Correlation with height and right ALUT ($P < 0.05$, $r^2 = 0.024$). **b** Correlation with height and left ALUT ($P < 0.05$, $r^2 = 0.059$)

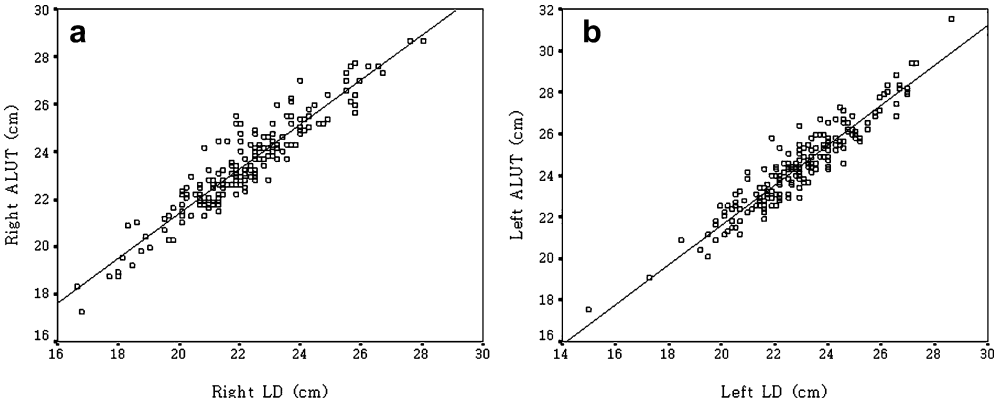

Fig. 2 The correlation between actual length of the ureteric trace (*ALUT*) and linear distance (*LD*) on a normal intravenous pyelography of 15 min. **a** Correlation between the right ALUT and the right LD ($P < 0.05$, $r^2 = 0.879$). **b** Correlation between the left ALUT and the left LD ($P < 0.05$, $r^2 = 0.884$)

measurement makes highly curved ureters straight and ureteral length is underestimated [14]. Therefore, tracing the ureters viewed on IVP film is an ideal method and represents the patient's actual ureteral length. Moreover, it is very bothersome to use a guidewire to estimate ureteral length for stenting, while our method is very easy to apply.

However, ALUT can provide an overestimation, particularly if the ureter is dilated or highly convoluted [14]. In addition, the ALUT measurement is limited to the clinical setting due to the need for a flexible ruler and associated measurement variability. For these reasons, LD is more useful. LD can be measured directly with a common rigid ruler on IVP film. Also, in the case of a dilated or highly convoluted ureter, ALUT can be deduced using a simple linear equation from the LD value. It should be noted that the calculated value is not the real ALUT, and maybe shorter than this. However, this value is useful for predicting the decompressed ureter length. After insertion of a ureteric stent, the dilated ureter could be decompressed so that hydronephrosis and convolutions disappear. Therefore, there is a tendency to overestimate ALUT when choosing an ideal length of stent in a clinical situation. However, the LD value is unchanged, and thus an overestimate of the ureteric length may be avoided.

Most of formulas for choosing the length of a ureteric stent based on patient height come from data on Caucasians. However, there are many other races and each has a different height and body habitus. For example, Asians are shorter and have a relatively longer trunk than Caucasians [17]. This means that there is a possibility that Asians have a longer ureter than Caucasians for a given height. The height based formula does not take into account such racial differences. However, LD is an individualized method, and is not limited by such considerations. Therefore, LD is very useful independently of race, sex and individual characteristics.

In the present study, we measured ALUT from the ureterorenal junction to the ureterovesical junction. The ureteropelvic junction is difficult to identify in the non-dilated ureter on a normal IVP. However, the ureterorenal junction is a clear and objective reference point. In addition, there is merit in that the proximal curl of the stent must be located proximally to the ureterorenal junction.

Our study has a limitation. Our results have not been verified in a clinical situation. Our study suggests that the stents chosen should cause less irritation, fewer migration events and other complications than stents chosen by the traditional method of using the patient's height. To prove this, a randomized prospective study is currently underway.

In conclusion, our results demonstrate that patient height does not provide a reliable estimate of ureteric length due to the lack of linearity between the two. We believe that LD based on IVP is preferable to patient height for the estimation of ureteric length.

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