ESTIMATING MALE URETERAL LENGTH WITH MATHEMATICAL MODELS: CADAVERIC STUDY

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ABSRACT
Prior determination of ureteral length before placement of stent helps in pre operation planning for urological surgery. This is an opportunity to select appropriate length of stent. There are evidences of increase in the use of ureteric stents as a result of frequent obstruction of the ureter. This experimental research was carried out on dissected seven male cadavers with measurement of two ureters and eight anthropometric dimensions from each subject. The statistical analysis used includes, mean, correlation coefficient, regression and simulation. There was high correlation coefficient between ureteral length (y) and four out of the considered eight anthropometric measurements: Supra orbital notch to medial malleolus τ = 0.954; waist circumference τ = 0.914; Anterior supra iliac spine to lateral malleolus τ = 0.887; acromion to lateral malleolus τ = 0.796. Use of mathematical equation and anthropometric measurement of patient will by- pass traditional use of x-ray to evaluate ureteral length when considering the length of the stent to be used by Urologist. Each of the four generated models predicts appropriate length of ureter, thereby reduces cost, within limited time that gives conveniences and comfort to the patient.

Key words: Ureteral stent, Anthropometry, Ureter, and Mathematical model.

INTRODUCTION
In certain urological conditions that obstruct ureter like hydronephrosis, the use of ureteral double J (DJ) stent placement procedure by Urologist is still a common surgical solution (Mannar, 1970; Mardis *et al*., 1982; Smedley *et al*.,1988 and Ramsey *et al*., 2010). Ureteric stents placement has probably increased in numbers with the technological advances in the ureteroscopes (Joshi, 2012), knowing that frequent use of X-ray to determine ureteral length can be contraindicated in some conditions, as it can affect DNA structures (Nakano,1994 ; Liang *et al*., 2007). In addition, too long stent can result to irritative bladder symptoms which may occur in patients' daily activities (Chew *et al*., 2007).

The alternative way to determine ureteral length is therefore necessary, as previous study has indicated that too long stent is associated with higher morbidity and newer technologies need to be developed to reduce patient discomfort in future (Jansen *et al*., 2012).

In this present study, the course of ureter was related to tips of transverse processes of lumbar vertebrate 2-5, sacroiliac joint and spines (Moore *et al*.,2011;Kulkarni, 2012), as shown in fig 1.

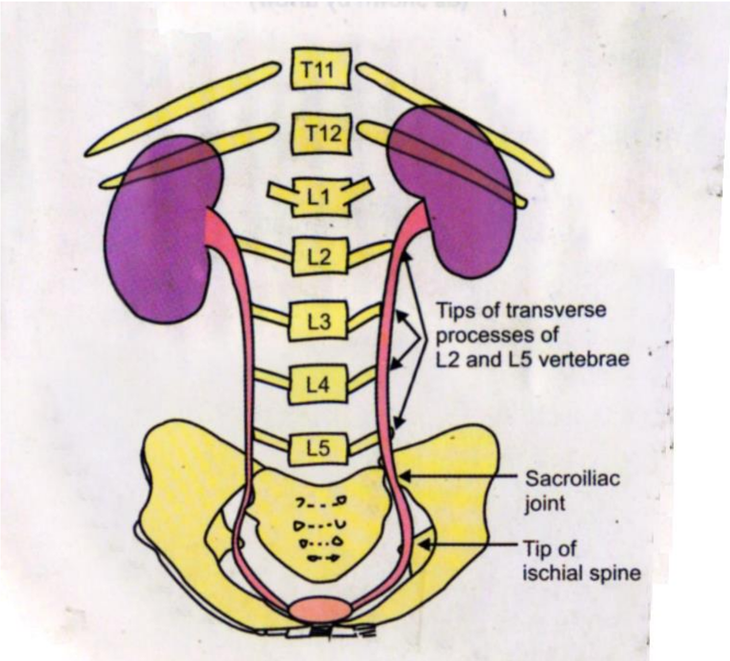

Fig. 1: Course of Ureters in Abdominal and Pelvic Cavites (Kulkarni, 2012)

Fig 2: Current Stents Designs (Josh, H. B. 2012)

The aim of this present study is to establish model that will predict male ureteral length. This is a further recommendation of a previous study (Bozzin *et al*, 2014). The model will be clinically available to select stent prior ureteral stent placement (Janssen *et al*; 2012),for male, as shown in fig 2. The link established between physical data and respective ureteral length is an alternative safe procedure to by-pass x-ray in double J stent placement (Mannar, 1970 ;Smedley *et al*., 1988 ; Bebel and Winterkorn, 1993).

MATERIALS AND METHODS

This study commenced with approval from Lagos University Teaching Hospital Research and Ethics Committee. The research involved anthropometry procedure, which includes measurement of physical heights, body girth or circumference, bone-diameter, and ureteral length (fig 1.) with reference to anatomical landmarks (Cater and Auckland,1994). The anthropometry procedure is a process that is noninvasive, while collection and analysis of data are within limited time (WHO, 1995). Anthropometry deals with measurement of variant physical dimension, visceral organs, in size, shape length and weight as related to gene, nutrition and environment (Cater and Auckland, 1994; Alan *et al*., 2001 ; Malina and Bourchard, 2004).

The seven formalin-infused subjects were purposefully selected, for linearity of their physical body, by avoiding cadaver with bending leg, neck and other part of the body. Seven male cadavers dissected, to approach the fourteen ureters in retroperitoneal positions, also ureters were also observed in pelvic cavity(fig 1), penetration urinary bladder *(*Moore *et al*., 2011 and Kulkarni, 2012). This arrangement is also explained by Guyton (2006), for the *functional* relevance of the ureter, as shown in fig 1.

The following measurements were carried out and the statistical analysis was performed using the statistical Package SPSS Version 20.0.

X_A – Supraorbital notch – Lateral malleolus.
X_B – Acromion – Lateral malleolus.
X_C – First lumbar vertebre – Tip of coccyx.
X_D – Anterior Superior Iliac Spine – Lateral Malleolus.
X_E – Pubic symphysis – Medial Malleolus .
X_F – Left acromion – Right Acromion.
X_G – Anterior Superior Iliac Spine (left-right) Length.
X_H – Waist Circumference.
y – Length of Ureter.

The regression equation established was $y = BX + C$
Where(y) dependent variable is the length of ureter to be predicted.

$X_{A\text{-}H}$ = independent variables as the anthropometric measurement as mentioned above.
C = is constant which indicates the value of y when $x = 0$.
B = indicates the gradient or rate of change of ureteral length (y) per 1cm of anthropometric change (x).

The collected data was regressed with statistical model using SPSS 20.0 version.

RESULT

The ureters were observed within renal fascia, in the retroperitoneal abdominal cavity, running into the pelvic cavity, as shown in fig 1. to penetrate urinary bladder. The data on anthropometric measurement and ureteral length obtained are shown in table 1. Table 2. shows data on regression analysis of dependent variable, ureteral length (y) against independent variables, anthropometric measurement (X_A to X_H), indicating details of correlation co-efficient (R), coefficient of determination (R^2), std error of estimate, slope (B) and constant (C). Regression of ureteral length (y) against $X_{B,}$ $X_{D,}$ $X_{H,}$ and X_A gave positive or significant relation in ascending order of R and R^2 and descending order of Std error of estimation at level of 0.05.while correlation coefficient of y against $X_{C,}$ $X_{E,}$ $X_{C,}$ X_G. are not significant.

Table 1: Statistical Analysis of length of ureters(y) and physical heights(x)

Parameter	N	Mean (cm)	SD	Max (cm)	Min(cm)
X_A	7	164.57	1.55	171	159
X_B	7	149.36	1.75	157	141
X_C	7	31.21	0.46	32	29
X_D	7	96.00	2.87	102	85
X_E	7	88.71	1.71	92	87
X_F	7	38.28	1.10	41	34
X_G	7	23.85	0.70	26	23
X_H	7	75.71	2.90	83	61
Y	7	25.98	0.33	27	24.5

Table 2: Regression analysis of ureteral length(y) against physical heights(x)

xxx	R	R^2	Adjusted R^2	Std error of estimate	Sig	C	B	H	Sig
X_A	0.95	0.910	0.891	0.29919	0.001*	-8.625	0.210	Ho rejected	Significant
X_B	0.79	0.634	0.560	0.60219	0.032*	2.365	0.158	Ho rejected	Significant
X_C	0.73	0.536	0.444	0.67748	0.061	8.52	0.562	Ho accepted	Not Significant
X_D	0.88	0.786	0.743	0.46004	0.008	14.142	0.125	Ho rejected	Significant
X_E	0.61	.381	0.257	0.78290	0.140	15.2	0.122	Ho accepted	Not Significant
X_F	0.15	-.024	0.171	0.98296	0.740	25.284	0.056	Ho accepted	Not Significant
X_G	0.15	0.025	0.170	0.98245	0.735	25.759	0.008	Ho accepted	Not Significant
X_H	0.91	0.836	0.794	0.44624	0.011 *	17.99	0.107	Ho rejected	Significant

* = significant at $P < 0.05$

DISCUSSION

Previous study has indicated presentation of patients with urinary frequency and urgency with stent that is longer than necessary (Ho *et al* 2008). Likewise research studies had revealed necessity to improve stent quality in the following areas: type of material like polymer (Lennon *et al*., 1995; Joshi *et al*., 2005; Lee *et al*., 2005; Davenport *et al*., 2006); diameter of the stent (Erturk *et al* 2003; Chew *et al*., 2007); shape of the stents (Dunn *et al*., 2000; Lingeman *et al*., 2009), placement position (Al-kanari *et al* 2007) and the size of the length (Ho *et al*., 2008). In addition numerous studies have also been conducted in attempt to identify the ideal stent in respect of material, shape and size but with little or no definite conclusion (Joshi, 2012).

The two previous articles had revealed that the physical height could not be a proper link to ureteral length (Shah & Kulkarni, 2005; Paick *et al* 2003). But the further study of Bozzin (2014) has established a mathematical model to predict ureteral length of female which confirmed link between physical data and length of the ureter. The research study (Bozzin *et al* 2014) therefore recommended for further research to develop mathematical model to predict male ureteral length, which is the aim of this present study.

Bozzin (2014) in their work used x-ray to estimate the ureteral length. To improve on the study (Bozzin et al 2014), this present research study engaged the used of cadaveric study to develop link relationship with positive outcome of four different anthropometric measurements out of eight measurements as mentioned in the method.

Four out of the eight anthropometric measurements are significant as indicated in table 2. XA has the highest correlated coefficient (R= 0.95) and correlation coefficient of determination (R^2 = 0.91 and the least standard error of estimate (0.299). This indicated that mathematical equation for X_A has the best quality to predict the ureteral length as indicated in Table 2. in this study. Although any of the other three (X_H, X_D, X_B) physical data and its equation can also be used in condition the linear physical measurement (X_A) is not possible. The following mathematical models can predict male ureteral length (y) separately when considering different physical measurement (X_A, X_B, X_D, X_H).

$y = -8.62\ 5 + 0.0210X_A$

$y = 2.365 + 0.158X_B$

$y = 14.143 + 0.125X_D$

$y = 17.799 + 0.107X_H$

This present study presented four different equations as against one equation from Bozzni (2014), study.

CONCLUSIONAND RECOMMENDATION

This present study has proffered definitive conclusion to predict the length of ureter from single measurement of any of the four physical data at the patient's bed side. This tools is also referred to as point of care testing (POCT) to select appropriate length of ureteric stent for male patient. This work also recommends more quality research work on other physical characters of ureteric stents and pharmacological agents from multidisciplinary approaches for making ureteric stents comfortable for patient when stent is in placed and after removal.

ACKNOWLEDGMENT

We acknowledge and appreciate the efforts of the laboratory staff of Gross Anatomy and Anatomic and Molecular Pathology, College of Medicine, University of Lagos for their professional assistants during the use of cadavers for this research. We also appreciate consultancy services from Department of Mathematics University of Lagos for their input.

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ADDRESS OF PRINCIPAL INVESTIGATOR: DEPT. OF ANATOMY, CMUL.
DATE OF RECEIPT OF VALID APPLICATION: 26-11-14

This is to inform you that the research described in the submitted protocol, the consent forms, and all other related materials where relevant have been evaluated and are exempted from full review by the Lagos University Teaching Hospital Health Research Ethics Committee (LUTHHREC).

All informed consent forms used in this study must carry the HREC assigned number and duration of HREC approval of the study. In multiyear research, endeavor to submit your annual report to the HREC early in order to obtain renewal of your approval and avoid disruption of your research.

The National code for Health Research Ethics requires you to comply with all institutional guidelines, rules and regulations and with the tenets of the code including ensuring that all adverse events are reported promptly to the HREC. No changes are permitted in the research without prior approval by the HREC except in circumstances outlined in the code. The HREC reserves the right to conduct compliance visits to your research site without previous notification.

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