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Predicting Female Ureteral Length: A Mathematical Model

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Abstract

Aim: Ureteral double J stent placement is a common urological procedure. There are many conditions that lead to a stent placement and some of them, mainly in pregnant female patients, have the contraindications of using X-ray. This study has the aim of proposing a mathematical model able to predict ureteral length finding a correlation between different physical data.

Materials and methods: Between June 2007 and July 2009, 100 female patients who underwent ureteral stent placement were enrolled in this study. Patients with septic conditions, history or evidence of TCC, congenital and acquired kidney or ureteral malformations, and previous ureteral surgery were not enrolled. Physical data for each patient were obtained (age mean 55.8 yrs range 18-89 SD 15.27, height mean 173 cm. range 160-182 SD 6.31, weight mean 75.33 kg range 62-94 SD 8.81). During the procedure, a previous ureteral retrograde pyelography was performed to individualize the pyeloureteral junction. Ureteral length was calculated using a graduated ureteral catheter (ureteral length obtained between 24 and 27 cm). The length was read in cystoscopy looking at the ureteral orifice while the catheter tip reached the pyeloureteral junction. The collected data were analyzed.

Results: A correlation between ureteral length and height of the patients was found. The following mathematical model is able to predict ureteral length starting from the patient's height: Result: y=0.151712487 (height expressed in cm) ± 0.12; Correlation Coeff: r = 0.973, Residual Sum of Squares: rss=5.285. No correlation was found with patient's age and weight.

Discussion and conclusion: Knowing with a good approximation the length of the ureter to be cannulated gives the possibility to choose in advance the proper one to be used. Patient's height correlates with her ureteral length.

A cost reduction can be obtained avoiding an intraoperative X-ray control. An X-ray free ureteral stenting procedure can be described (using just ultrasound control) mainly in pregnant women.

Abbreviations: PUJ: Pieloureteral Junction; TCC: Transitional Cell Carcinoma; DJ: Double J; SD: Standard Deviation; CT: Computerized Tomography

Introduction

Ureteral DJ stent placement is a common urological procedure usually performed to solve a situation of hydronephrosis [1-3]. Often it is an urgent or a semi-urgent procedure and the technique is well known and easily performed by any Urologist [4]. The combined use of an endoscopic and an X-ray control makes the procedure safe and with a very low risks rate [5].

Nevertheless there are many conditions that lead to a stent placement and some of them, mainly in pregnant female patients, have the contraindications of using X-ray. X-ray use risks to cause an induction of alterations in DNA of the patient, even if male, or of the fetus [6,7].

This study has the aim of proposing a mathematical model able to predict ureteral length finding a correlation between different physical data, thus leading to a safe ureteral placement even if without X-ray control.

Materials and Methods

Between June 2007 and July 2009, 100 female patients who underwent ureteral stent placement (normal ureteral catheter, Double J stent or Single J stent) were enrolled in this study. All of the female patients were informed about the procedure and signed a proper consent form [8].

We definitely excluded from the study, and from any data collection, patients with septic condition such as documented CT pyelonephritis, patients with history of TCC of the bladder or evidence of it during the preliminary cystoscopy, previous positive urinary culture and secondary evidence of a infectious conditions such as fever, tachycardia and abnormalities during micturition. *This decision was taken because of the abnormalities induced by this situations, mainly because any evidence of inflammatory disease could alternate ureteral length and its linearity*. We also excluded patients with a known history or a new CT scan evidence of congenital and acquired kidney or ureteral malformations [9]. Due to a very large number of patients selected and in order to minimize any other bias influencing the study we also do not consider patients with a previous ureteral surgery even if only endoscopic, mainly because of the scar tissue that can be found inside. At least one hour before the surgical procedure of stent placement physical data (age, height and weight) for each patient were obtained.

To insert the catheter we used the most common technique described by Marmar [1]. After a preliminary cystoscopy, the selected ureteral orifice was focused, and then cannulated with a stiff wire to allow us to place a common graduated ureteral catheter. A previous

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ureteral retrograde pyelography (68 Kv, 300 mA), before the ureteral catheterization, was performed to assess the position of the pyeloureteral junction (PUJ).

An ureteral graduated catheter was then inserted aiming the pyeloureteral junction PUJ. With the proximal tip at that level the ureteral length was read in cystoscopy looking at the ureteral orifice while the catheter tip reached the pyeloureteral junction.

At the end of the procedure we also measure the X-ray exposure for each patient.

The collected data were analyzed with an online regression tool from www.xuru.org using the linear least squares fittings. The analysis performed was controlling any kind of correlations between the ureteral and one of the variables or a couple of variables or the variables at all.

A post operative follow up was conducted in this study group with 24 hours of hospitalization.

Results

The preliminary cystoscopy performed in each of the patients selected reveals no evidence of incidental TCC and the endoscopic of the ureteral placement were performed with no complications. The successive retrograde pyelography showed visible abnormalities in the upper urinary tract in 43 patients so they were not enrolled in the study.

The exposure mean time for each procedure was 3.2 sec. The data obtained are shown in table n°1 and n°2 (age mean 55.8 yrs range 18-89 SD 15.27, height mean 173 cm. Range 160-182 SD 6.31, weight mean 75.33 kg range 62-94 SD 8.81).The statistical analysis finds out a correlation between ureteral length and height of the patients. The simplest relation was found using the height only, the following mathematical model is able to predict ureteral length starting from patient's height and restricted to the range of 161 and 181 cm (Tables 1 and 2).

y (expected ureteral length) = 0.151712487 (height expressed in cm) ± 0.12

Correlation Coeff: r=0.973

Residual Sum of Squares: rss=5.285

No correlation were found with patient's age and weight even if used as variables related to the height and used alone.

Discussion

The cohort used is selected to grant a naïve sample to analyze, thus to be free from any bias and any other conditions able to alter the results obtained.

We expected a female population with a lower mean height. This was caused mainly by the exclusion criteria that selected a younger and higher population. On the other hand a younger population is the right one to be considered for an X-ray free stent placement in case of pregnancy.

The statistical analysis firmly underlines how the height of the patient strictly correlates with her ureteral length and do not correlate with any others of the variables controlled in study.

No complications were observed in the postoperative period.

To our knowledge this is the first analysis that leads to a mathematical model able to predict ureteral length. The possibility to have only

Patient	Age	Weight (kg)	Height (cm)	Ureteral length (cm)
1	21	71	174	26.5
2	44	62	172	26
3	57	82	177	27
4	59	75	164	25
5	67	68	161	24
6	59	73	168	25.5
7	60	68	179	27
8	30	94	181	27
9	66	85	178	27
10	23	77	176	26
11	74	82	181	27
12	23	62	170	25
13	51	73	164	24
14	46	75	164	25
15	67	68	162	24
16	59	73	168	25.5
17	73	68	179	27
18	48	93	181	27
19	66	85	178	27
20	57	77	176	26
21	38	71	172	27
22	48	62	174	26.5
23	57	82	175	27.5
24	62	75	166	25.5
25	67	68	159	24.5
26	73	73	170	25
27	63	68	177	26.5
28	55	94	183	26.5
29	55	85	176	26
30	45	77	178	27
31	66	71	176	27
32	69	61	178	26
33	71	82	181	26.5
34	62	75	179	25
35	58	68	168	24.5
36	72	73	161	25
37	60	68	164	26
38	66	94	177	26.5
39	65	85	172	27
40	18	77	174	26.5
41	23	71	175	27
42	44	63	170	26
43	48	83	176	26.5
44	42	75	166	25
45	67	68	163	24.5
46	58	72	170	26
47	62	67	177	26.5
48	42	93	180	27
49	78	86	179	26.5
50	39	78	176	26
51	81	72	173	26.5
52	49	62	174	26.5
53	54	82	176	27
54	59	75	165	25
55	67	66	160	24
56	64	73	169	25.5

57	33	68	180	27
58	37	94	181	26.5
59	79	87	178	26.5
60	76	77	176	26.5
61	27	73	174	26.5
62	72	62	173	26.5
63	68	82	177	27
64	66	75	164	25.5
65	66	66	162	24.5
66	65	70	167	26
67	59	65	179	26.5
68	47	91	178	27
69	44	88	181	27
70	39	64	176	26.5
71	80	73	175	26
72	33	65	172	26
73	57	82	177	27
74	59	82	165	24
75	58	68	161	25
76	89	71	168	25.5
77	69	68	179	27
78	49	92	181	26.5
79	62	79	178	26.5
80	37	77	176	26
81	29	75	175	26.5
82	59	65	173	26.5
83	57	85	176	27
84	47	74	165	25
85	76	67	162	24
86	50	71	167	25.5
87	61	66	178	27
88	54	90	180	27
89	66	83	177	27
90	42	77	177	26
91	68	82	175	26.5
92	44	69	171	26
93	34	81	178	27
94	59	77	163	25
95	48	72	162	24.5
96	63	64	169	26
97	85	91	178	27
98	76	69	182	26.5
99	54	70	177	26.5
100	38	80	175	26

Table 1: Data obtained per patient.

Patient (enrolled -excluded)	100-43
X-ray Exposure Time	mean 3.2 sec SD 0.8
Age	mean 55.8 yrs range 18-89 SD 15.27
Height	mean 173 cm range 160-182 SD 6.31
Weight	mean 75.33 kg range 62-94 SD 8.81

Table 2: Data obtained, summary.

one variable that takes part in ureteral length calculation makes the procedure simple and friendly to be calculated by the surgeon before the procedure.

Previously two articles stated that height could not be a proper indicator for ureteral length.

The first paper by Shah, using a group of only 25 patients (a quarter of the one considered in this study) has a statistical level of confidence much more inferior to this study. The study also does not exclude patients with previous diseases of the upper urinary tract and this choice can lead to alterations of data analysis. Nevertheless the aim of our study is to find out a rational for x-ray free ureteral catheter placement procedure (mainly for pregnant women), aim that is not the one for the considered manuscript.

The second paper by Paick does not use ureteral catheterization to define length, but it is only a retrospective analysis based on intravenous pyelography. There are no exclusion criteria to avoid any bias that could come from different urological situations, one above all is surely benign prostatic hyperplasia in men. This paper, mainly in its material and methods section, describes a situation that the Urologist will never face during a ureteral catheter placement. Situation that is one of the first issues considered in our study. Besides this Paick concludes that ureteric linear distance estimates ureteral length as we state in our material and methods section.

Many are the conditions that lead to a stent placement and many are the disease that can be caused by X-ray exposure [10,11]. X-ray control is able to determine a correct pig tail placement of the proximal tip of the ureteral catheter. X-ray lead to many other pathological conditions as DNA fragmentation, cancer inductions, retroperitoneal fibrosis [6,7,12,13]. Their use during pregnancy is strictly reserved to selected cases assuming anyway the risk of inducing abnormalities, childhood cancers like acute lymphoblastic leukemia or causing abortion [14-16].

There was no evidence of any implemented x-ray exposition of the patients and operators so the procedures did not add any X-ray induced.

Knowing ureteral length in advance can be the door to pass avoiding x-ray in this procedure; certainly the procedure needs a technique validation and the key can be the use of an US kidney control during the endoscopic placement [17-19].

Certainly this needs that the catheter correctly inserted is able to reach and overtake the PUJ, but this can be easily done knowing the ureteral length in advance.

Knowing with a good approximation the length of the ureter to be stented gives the possibility to choose in advance the model to be used instead of trying to get the right one. This also avoid the risk of placing a too long catheter that leads, in some cases, to an over active bladder syndrome.

A cost reduction can also be obtained avoiding any intraoperative X-ray control. This cost reduction comes mainly from the fact that X-ray technician is no more requested, allergic patients will not need a cortisone pre medication and future X-ray exposure complications are not considered for this procedure.

The big advantage in an X-ray free procedure remains with no doubt for pregnant women cases as explained before.

Conclusion

Patients' height do correlate with their ureteral length and the mathematical model is able to predict with a good approximation the expected height.

Given this we will also be able to establish a ultrasonographic-endoscopic (X-ray free) technique for ureteral placement that can find its main application in pregnant and fertile women.

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