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Original article

Significance and clinical value of the transitional zone volume (TZV) or index (TZI) in assessing the degree of lower urinary tract obstruction: Revisited

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Abstract
Introduction: A lot of diagnostic tools are present for assessing the degree of LUTs. Pressure-flow studies are invasive and cannot be justified in all patients suffering from LUTs. From here came the clinical importance of searching for another clinical tool, to help in assessing the degree of LUTS.
Objective: The aim of this work was to evaluate the significance and clinical value of the TZI, which has been a point of debate over the last decade.
Patients and methods: Between November 2011 and November 2012, sixty-two male patients above the age of 45 years were included in the study. They were divided into 3 groups (obstructed, retention and control groups). Assessment included IPSS, physical examination, DRE, labs, uroflowmetry, pressure flow studies, TRUS and a pelvic ultrasound for PVR. The transitional zone index (TZI) was calculated as being the transitional zone volume/whole gland volume ratio of the prostate. The whole gland volume, adenoma volume and TZI were compared in each group to each specific symptom, total IPSS, PSA, PdetQmax and Qmax.
Results: No statistically significant correlation was found between the IPSS and the volume measurements, whether between the IPSS and whole gland volume or the IPSS and the TZV or TZI in the obstructed group and the control group. However, when dividing patients according to their TZI into two groups utilizing a TZI of 0.5 as a cutoff value, a possibility existed that patients might be more accurately classified into obstructed and non-obstructed.

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Conclusion: Estimating the transition zone volume during TRUS is a reasonable way to obtain the required information about the TZI. Calculating the TZI could not be directly correlated with any of the different parameters, making the clinical value of such an index questionable. The observation that the obstructed and the retention groups both had a TZI above 0.5 deserves further research that can help in the classification of patients into obstructed and non-obstructed.

The absolute indications for surgery in BPH are objective, namely refractory urine retention despite adequate medical treatment, recurrent or persistent urinary tract infections, recurrent gross hematuria of prostatic origin, pathophysiological changes of the kidneys and bladder calculi secondary to obstruction. However, a very large number of patients do not meet those absolute indications. They undergo surgery for a relative indication, usually severe LUTs not responding to medical therapy, the magnitude of which is purely subjective and may be related to the degree of tolerance of each patient.

A lot of diagnostic tools are present for assessing the degree of LUTs; they include symptom assessment questionnaires (as the IPSS), uroflowmetry, post-voiding residual urine and pressure flow studies. The combined use of those tools may achieve a more complete clinical picture. In 1979, Abrams and associates used pressure-flow plots in addition to flow rate measurement. They found that in about half of the patients with LUTS, a correct classification into obstructed and non-obstructed can be achieved by Qmax alone. The addition of the detrusor pressure at Qmax allowed correct classification in two-third of patients. The remaining one-third of patients were assessed by the pressure flow plot. In many patients, both detrusor pressure and Qmax were low, denoting a decompensating detrusor muscle as the source of the low Qmax [1]. Pressure-flow studies are invasive and cannot be justified in all patients suffering from LUTs. From here came the clinical importance of searching for another clinical tool that is already performed in many BPH patients, to help in assessing the degree of LUTs in such patients.

The aim of this work was to evaluate the significance and clinical value of the TZI, which has been a point of debate between different respectable authors over the last decade. The importance of such work was derived from the will of developing and highlighting an objective tool which can be calculated from an investigation which is not considered invasive and is already done to many prostatic patients [Trans-rectal ultrasonography (TRUS)]. We hoped that revealing such a tool would aid in the assessment and proper management of prostatic patients complaining of LUTS.

Patients and methods

This work was carried out in the urology department at Cairo University hospitals between November 2011 and November 2012. Sixty-two male patients above the age of 45 years were included in the study. They were divided into 3 groups.

The first group included 20 patients complaining of LUTs but not in retention (the obstructed group). All patients in this group had an IPSS above 7. The second group included 22 patients in retention, which was considered the far end of the scale of urinary obstruction (the retention group). The third group was the control group which included 20 patients above 45 years not complaining of LUTs; all patients in this group had an IPSS below 7. We excluded all patients who had serious mental illness or with any physical or mental difficulty rendering them not able to answer questionnaires. Patients with bladder pathology such as stones, tumors and neurogenic bladder or patients with previous surgery for BPH, as well as patients with cancer prostate or prior pelvic irradiation were also excluded. Patients on medications with known interference on the functioning of the lower urinary tract such as alpha-blockers, anti-cholinergic and diuretics were also excluded.

A score was obtained from every patient after being invited to answer the questions from the International Prostate Symptom Score (IPSS) developed by the American Association of Urology. Besides the IPSS score, a complete medical and surgical history was also obtained. Physical examination was done including a DRE. Urine analysis, urine culture and PSA were included as the standard labs for every patient. All patients underwent a uroflowmetry, pressure flow studies, a trans-rectal ultrasound (TRUS) for measurement of the prostate size and a pelvic ultrasound for estimation of the post-voiding residual urine. Flowmetry was done as a primary investigation after history taking and was only included when the voided volume was over 100cc. A urodynamic investigation (pressure-flow study) was done to determine mainly the detrusor pressure at maximum flow (PdetQmax). The Qmax from the free flowmetry was the value included during our statistical analysis.

DRE and trans-rectal ultrasound were done with the patient in the left lateral decubitus. Serial sonograms were obtained for both the transverse and longitudinal views of the prostate. In the transverse view, the image with the widest prostate diameter was used to calculate the laterolateral (T) and the anteroposterior diameter (AP). The craniocaudal (L) dimension was calculated in the longitudinal view. Dimensions were taken from the prostate gland as a whole and from the adenoma (transition zone) to calculate the whole gland volume and the transitional zone volume. The transitional zone index (TZI) was calculated as being the transitional zone volume/whole gland volume ratio of the prostate. Many formulas can be used to assess the prostate and transition zone volume. Most formulas assume that the gland conforms to an ideal geometric shape: either an ellipse ($\pi/6 \times$ transverse diameter $\times$ AP diameter $\times$ longitudinal diameter), sphere ($\pi/6 \times$ transverse diameter, or a prolate (egg shaped) spheroid ($\pi/6 \times$ transverse diameter $\times$ AP diameter). In our study, we utilized the ellipse formula. Data were statistically described in terms of mean standard deviation, median and range. Correlations between different parameters were obtained using Spearman's correlation coefficient. All statistical calculations were done using computer programs SPSS (Statistical Package for the Social Science; SPSS Inc., Chicago, IL, USA) version 15 for Microsoft Windows.

Table 1 Summary of descriptive statistics.

	The obstructed group		The retention group		The control group	
	Mean	Median	Mean	Median	Mean	Median
Incomplete emptying	1.7	1.5			0.35	0
Frequency	2.05	2			1	1
Intermittency	2.4	2.5			0.3	0
Urgency	1.45	1			0.25	0
Weak Stream	3.15	3			0.55	0
Straining	1.55	1.5			0.2	0
Nocturia	2.8	3			0.85	0.5
IPSS	15.1	15			3.45	3.5
PSA	2.43	2.05	10.01	6.05	5.7	1.65
DetQmax	82.9	72.5	71.09	53	58.65	56.5
Qmax	8.8	8.4			12.27	12.95
Whole gland	35	29.5	78.9	64.5	26.25	25.5
Adenoma	20.56	15.5	56.15	46.5	10.55	10.35
TZI	0.57	0.56	0.68	0.69	0.39	0.41

Results

The mean age of the patients in the first group (20 patients) was 62.5, the mean age of patients in group 2 (22 patients) was 67.32 and the mean age of patients in the control group (20 patients) was 54.9. A summary of the IPSS score, prostate volume measurements, Qmax and PdetQmax is shown in the following tables for the first and third groups. However for group two, only their prostate volume measurements and PdetQmax are shown, as patients were catheterized with no voiding symptoms or flow available (see Table 1).

The whole gland volume, adenoma volume and TZI were compared in each group to each specific symptom, total IPSS, PSA, PdetQmax and Qmax, except for group 2 (retention group) where the comparison was done only to the PSA and PdetQmax (see Table 1).

A summary of the statistical values of the different prostatic volumes in each of the 3 groups is seen in Table 1. A correlation between whole gland volume, transition zone volume and transition zone index with the different parameters in the 3 given groups can be seen in Table 2.

Discussion

A known clinical fact is that the total prostatic gland volume poorly correlates with the degree of LUTs. However Kaplan et al. suggested that this lack of correlation may partially be due to measuring the wrong part of the prostate [2]. As described by McNeal, BPH is secondary to hyperplasia of the transition zone with a minor contribution from the central zone and periurethral glands. In 1997, Kaplan et al. suggested that increased transition zone index was significantly associated with a progressively worsening AUA symptom score, peak urine flow and detrusor pressure at peak urine flow and they stated that on using a transition zone index cutoff of 0.5, there was a highly significant difference in the previous parameters compared to lower cutoff points ($p = 0.001$). This explains how patients with small prostates and high transition zone index may have more symptoms than those with large prostates and lower transition zone index [2]. The results of Kaplan were very contradicting when compared to the Lepor group study; who stated that there was a weak correlation between the IPSS versus the transition zone volume and the transition zone index. The only statistically significant correlation found was between the peak flow rate versus the transition zone volume and transition zone index [3], taking into consideration that in the Kaplan study, all patients had a pressure flow done, which was not the case in the Lepor study, thus neglecting an important objective tool. However in the Lepor work, the pairwise relationship between the prostate volumes and the IPSS score and peak flow rate was measured after classifying the patients into obstructed and non-obstructed, providing the study with a control group, thereby giving the results a higher credibility. Another study by Witjes claimed that there was a statistically significant but moderate correlation between prostate volume, TZ volume and TZ index and Qmax and voided volume. The correlation between TZ volume, TZ index and Qmax was slightly higher than with prostate volume. However, there was no control group in this study. These results were not disagreeing with the earlier conclusion of Kaplan, who assumed that the TZ index may serve as useful proxy for evaluating worsening obstruction. However, the author claims that the TZ volume and total prostate volume alone are equally useful [4]. Kurita in 1998 found that the strongest relationship with the AUA symptom score was for the TZ volume. The decrease in the peak flow rate was significantly correlated with all the indices, in the order of TZ index, TZ volume and total prostate volume. The postvoid residual urine volume also showed a significant correlation with these indices. The TZ index had the strongest correlation with both the peak flow rate and the postvoid residual urine volume [5]. A more recent and larger study by Franciosi et al. on 223 patients concluded that there is a weak correlation between the severity of LUTS and the different volumes of the prostate gland (TV, TZV) and the TZI [6]. However, this study also lacked the presence of a control group and the concomitant evaluation of free flowmetry or urodynamic studies depriving this study from any objective clinical tool. The performance of different cutoff values for the TZI in detecting acute urinary retention was studied by the author. As the cutoff value increased, the specificity increased and the sensitivity decreased. He determined the cutoff value for the TZI as the value that provided almost equivalent sensitivity and specificity, and had the highest efficiency. This TZI value proved to be 0.65. Using it, the TZI detected acute urinary retention in 57 of the 64 patients (89%) and had a positive predictive value of 63%.

In our study, we tried to provide a control group and to do pressure flow studies for all patients, as an objective clinical tool. We also tried to revisit the idea of using the TZI as a cutoff point to identify

Table 2 Correlation between prostate volume, TZI and TZV and different parameters.

	Obstructed group Spearman's correlation coefficient, r (p)			Catheterized group Spearman's correlation coefficient, r (p)			Control group Spearman's correlation coefficient, r (p)		
	Prostate volume	TZ volume	TZ index	Prostate volume	TZ volume	TZ index	Prostate volume	TZ volume	TZ index
Incomplete emptying	0.158 (0.506)	0.149 (0.53)	0.094 (0.692)				0.353 (0.127)	0.368 (0.111)	0.009 (0.97)
Frequency	0.04 (0.866)	0.119 (0.617)	0.085 (0.722)				0.102 (0.67)	0.137 (0.566)	0.038 (0.873)
Intermittency	0.006 (0.979)	0.04 (0.882)	0.085 (0.722)				0.317 (0.174)	0.326 (0.16)	0.184 (0.437)
Urgency	0.009 (0.969)	0.12 (0.613)	0.12 (0.620)				0 (1.0)	0 (1)	0.144 (0.544)
Weak Stream	0.082 (0.73)	0.12 (0.62)	0.374 (0.104)				1.138 (0.872)	0.18 (0.939)	0.17 (0.474)
Staining	0.28 (0.231)	0.294 (0.208)	0.093 (0.695)				0.354 (0.126)	0.368 (0.11)	0.299 (0.2)
Nocturia	0.14 (0.555)	0.051 (0.83)	0.298 (0.201)				0.011 (0.965)	0.145 (0.542)	0.97 (0.685)
IPSS	0.002 (0.994)	0.084 (0.724)	0.245 (0.297)				0.367 (0.111)	0.301 (0.197)	0.034 (0.888)
PSA	0.392 (0.088)	0.418 (0.066)	0.263 (o.262)	0.685 (0)	0.734 (0)	0.548 (0.008)	0.361 (0.118)	0.313 (0.18)	0.205 (0.387)
DetQmax	0.359 (0.12)	0.122 (0.608)	0.25 (0.295)	0.61 (0.787)	0.113 (0.62)	0.27 (0.219)	0.202 (0.392)	0.208 (0.38)	0.13 (0.586)
Qmax	0.131 (0.582)	0.074 (0.757)	0.027 (0.911)				0.113 (0.636)	0.005 (0.984)	0.073 (0.759)

the likehood of the patients being obstructed or not. On comparing the three different groups, we found no statistically significant correlation between the IPSS and the volume measurements, whether between the IPSS and whole gland volume for the obstructed group ($r = 0.002$) and the control group ($r = 0.367$) or between the IPSS and the TZV in the obstructed group ($r = 0.084$) and the control group ($r = 0.501$) and the IPSS and the TZI in the obstructed group ($r = 0.245$) and the control group ($r = 0.034$). These results confirm the results of the Lepor study and are completely contradictory to the earlier work done by Kaplan and colleagues. Our results were nearly matching to those of Witjes study who found no significant correlation between the IPSS and the different prostatic volumes, apart for question 7 in the IPSS (nocturia). He also found a marginally significant correlation with TZV and a statistically significant correlation with the TZI, which we were not able to demonstrate. We found no significant correlation between the different prostatic volumes and the Qmax in the obstructed and the control group. For the obstructed group, the r and p values that we obtained when comparing the Qmax with the different prostatic parameters were 0.131 and 0.582 for the PV, 0.074 and 0.755 for the TZV and 0.27 and 0.911 for the TZI. These values do not agree with the Kaplan results, who found a weak, moderate and strong correlation between the Qmax and the PV ($r = -0.20$), TZV ($r = -0.34$) and TZI ($r = -0.71$) respectively [2]. When trying to compare the Det Qmax with the different prostatic volumes in the 3 groups, no significant correlation was obtained. This is also contradicting Kaplan who noted a weak correlation between PV and Det Qmax ($r = 0.13$), a stronger correlation with the TZV ($r = 0.20$) and an even better correlation with the TZI ($r = 0.43$). Witjes found a moderate correlation between prostate volumes and the results of the pressure- flow studies. One of the explanations for such differences in the results among our study and the previously mentioned two studies might be due to the fact that a large number of patients (especially in the catheterized group) were not able to void during the pressure flow studies. In such patients, we recorded the maximum detrusor pressure they were able to generate as their Det Qmax. In the catheterized group, it was noted that patients who were able to void, had a higher Det Qmax than those who failed. However, the main value of the pressure flow studies in such cases was to exclude the presence of a neurogenic element in the patients' symptoms. Although our study failed to show any significant correlation for the TZI with all the other parameters studied (Table 2), an observation can be made that both the obstructed and the retention groups had a mean TZI above 0.5 (0.57 and 0.68 respectively), while the control group had a mean TZI of 0.39 (Table 1).

No correlation could be demonstrated between TZI and the total IPSS or the different obstructive and irritative symptoms or between the TZI and the Qmax and detrusor pressure at Qmax (Table 2). Although no linear correlation was found between the TZI and the other different parameters, the observation that the obstructed and the retention groups both had a TZI above 0.5 deserves further research. The two main drawbacks of this study are the limited sample size and the difference in the mean age of the three different groups.

Conclusion

Estimating the transition zone volume during TRUS is a reasonable way to obtain the required information about the TZI. Calculating the TZI could not be directly correlated with any of the

different parameters, making the clinical value of such an index questionable. The observation that the obstructed and the retention groups both had a TZI above 0.5 deserves further research that can help in the classification of patients into obstructed and non-obstructed.

Authors' contributions

M Magdi: Inception of study idea, performance of TRUS procedures and collection and analysis of data.

Mohamed El Ghoneimy: Inception of study idea, performance of urodynamic procedures, drafting the initial manuscript draft, and writing the final manuscript, and corresponding author (submission of manuscript; response to reviewers comments and drafting the revisions).

Mohamed Abdel Rassoul: Planning of study design, performance of chart review and data collection and analysis, performance of statistical analysis, and revision of final manuscript.

Hany El Fayoumy: Sharing in planning of study design, drafting the patients and methods section of the manuscript, and revision of final manuscript.

A Abdel Hakim: Sharing in planning of study design and revision of final manuscript.

Conflict of interest

None.

Source of funding

None.

Ethical committee approval

The study submitted for publication is an observational study based on retrospective review of patients' charts. According to institutional policy, this type of study does not require consent from patients and does not necessitate Ethical committee approval.

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