Transition zone volume measurement – is it useful before surgery for benign prostatic hyperplasia?

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Key words: *benign prostatic hyperplasia; transrectal ultrasound; transition zone volume.*

Summary. *Objective. The aim of this study was to estimate the equivalence and correlation between transition zone volume, measured by transrectal ultrasound, and removed prostate tissue weight in surgically treated patients due to benign prostatic hyperplasia.*

Material and methods. This study involved 168 patients with histologically confirmed benign prostatic hyperplasia. Of these patients, 120 underwent transurethral resection of the prostate and 48 – open prostatectomy. The weights of the specimens were compared with the corresponding volumes of the transition zone. Equivalence and correlation between transition zone volume and removed tissue weight were analyzed.

Results. The mean (standard deviation, range) transition zone volume was 25.43 mL (±13.19, 5–61.6) in the transurethral resection group and 76.1 mL (±42.97, 13–275.8) in the open operation group. The mean removed tissue weight was 22.9 g (±13.41, 5–66) and 73.96 g (±44.96, 18–280), respectively, in the transurethral resection and open operation groups. The correlation between removed tissue weight and transition zone volume was stronger in the open operation group than it was in the resection group ($r=0.957$, $P<0.001$ vs. $r=0.878$, $P<0.001$). There was a significant difference between transition zone volume and resected tissue weight ($P=0.001$). However, in the open operation group, there was an agreement between transition zone volume and enucleated tissue weight ($P=0.263$).

Conclusions. A significant correlation was detected between removed tissue weight and transition zone volume. There is a significant difference between volume measurement and resected tissue weight while enucleated tissue weight was in agreement with transition zone volume when an open prostatectomy was performed.

Introduction

Pathological and morphological studies have proven that an enlargement of the prostate, in the event of benign prostatic hyperplasia (BPH), is due to the enlarged transition zone (TZ). In such a case, there is no significant growth of peripheral and central zones because "adenoma" compresses them. Although McNeal developed a new appreciation to the prostate and the zones of its anatomy more than three decades ago (1), the clinical importance of TZ has only been raised recently. The background for such investigations involves the possibility to differentiate a borderline between the transition and other zones during examination by transrectal ultrasound and calculate its volume using the formula of prolate ellipsoid (2).

The importance of transition zone was studied and confirmed in many aspects: impact on duration, complications and effectiveness of surgical treatment; choice of medical BPH treatment modalities; more accurate detection of prostate cancer; bladder outlet obstruction and severity of symptoms; prediction of acute urinary retention (3–8) and other aspects.

There is another very interesting aspect, especially from a practical point of view, associated with the transition zone – TZV correlation with the weight of surgical specimens removed during surgery. Indications for transurethral prostatic resection (TURP) and an open operation depend mostly on prostate size. According to the prostate development theory, described by McNeal, removed tissue weight during surgery depends on the transition zone. In such circumstances, it is very important to know if the preoperative investigation of the transition zone is correct and the measured volume is the same as the removed weight of the specimen.

The usefulness of a transitional zone investigation before an operation seems unquestionable in most cases, but there are conflicting data regarding the

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agreement between TZV and removed tissue weight (TW) (9, 10). Some authors suggest minimizing observed underestimations by applying additional formulas (11). However, all these studies included a limited number of patients, and their conclusions are unreliable.

The aim of this study was to investigate correlation and adequacy between TZV and TW in a large group of patients. The patients involved in this study underwent TURP, as the most used procedure in surgical BPH treatment, and open operations. This was meant to assure that the measured volume range and study population would be similar to real life.

Material and methods

This study involved 168 patients who had been operated on for BPH during the period of February 2002 to February 2004 (the study was approved by the Regional Ethical Committee, and all the patients provided written consent). The diagnosis of BPH was based on history, symptoms (International Prostate Symptom Score), physical findings, urinary flow rate (Qmax), post-void residual volume, and transrectal ultrasound measurements. There were 120 patients who underwent transurethral resection of the prostate, and 48 underwent open prostatectomy. Benign prostatic disease was confirmed histologically.

All patients underwent transrectal ultrasound before surgery, which was performed with the ultrasound device model, SIEMENS Sonoline SI-250 (Germany), with a 5–7.5 MHz transrectal probe. The transition zone was scanned in transverse and sagittal planes with the subject in the left lateral decubitus position. The width of the transition zone was measured between the inner part of the capsule, the height – from the bladder neck to the clear inferior limit, and the length – from the inner part of the capsule to the clear limit of the transition zone at the verumontanum. TZV was calculated using the formula for a prolate ellipsoid: width × length × height × 0.52. TZV was compared with the weight of the surgical specimen. The specific weight of the prostate is ~1.0; *i.e.*, volume (mL) equals weight (g) (12). All inadequacies of volume measurements were registered.

Statistical analysis was performed using software, Statistica 5.0 and SPSS 12.0 for Windows (Statistical Package for Social Sciences Chicago, Illinois, USA). Calculations of the mean, range, and standard deviation were performed. Mean values were compared using independent and paired samples *t* test, Mann-Whitney U and Wilcoxon W test. Correlation was assessed using Pearson's coefficient and simple linear regression. For all statistical tests, $P<0.05$ was considered significant.

Results

The mean (SD, range) age of patients was 69 years (±7.56, 45–92). The mean TPV was 63.9 mL (±40.99, 16–326.7), the mean TZV was 39.9 mL (±34.19, 5–275.8), and the mean surgical specimen weight was 37.5 g (±35.09, 5–280). The difference between measured TZV and resected TW was significant (39.9 *vs.* 37.5, P=0.001). Removed TW constituted 94% of TZV and 58.7% of TPV. TW strongly correlated with TZV (r=0.968, $P<0.001$). Overestimation of TZV (TZV>TW) was found in 96 (57.14%) cases, and the mean difference thereof was 8.06 mL (±5.96, 1–29). Underestimation of TZV (TZV<TW) was in 55 (32.74%) cases with a mean difference of 6.74 mL (±6.08, 1–25.3). Overestimated volume was slightly higher than underestimated volume, 8.06 *vs.* 6.74 mL, P=0.035 (Mann-Whitney test, (Table)). In 17 (10.12%) cases, TZV was equal (±1 mL) to removed TW. The value of TZV was different than TW in 151 of 168 cases, and the mean of all incorrect volume measurements (over- and underestimations) was 6.81 mL (±6.15, 1–29.06).

In the TURP group (n=120), the mean TPV was 46.46 mL (±17.68, 16–90.2), the mean TZV was 25.43 mL (±13.19, 5–61.6), and the mean resected TW was

Table. **Adequacy between the measurements of prostate volume and removed tissue weight in groups of different treatment modalities**

Group	TPV/TW (%)	TZV/TW (%)	Overestimation/Underestimation
All patients (n=168)	63.9/37.5 (59)***	39.9/37.5 (94)**	8.06/6.74*
TURP (n=120)	44.7/22.9 (51)***	25.43/22.9 (90)**	6.38/4.83**
Open operation (n=48)	107.4/73.9 (69)***	76.1/73.9 (97)	13.4/9.85

TPV – total prostate volume; TW – removed tissue weight; TZV – transition zone volume; overestimation – (TZV>TW); underestimation – (TW>TZV); TURP – transurethral resection of the prostate. *P<0.05, **P<0.01, ***P<0.001.

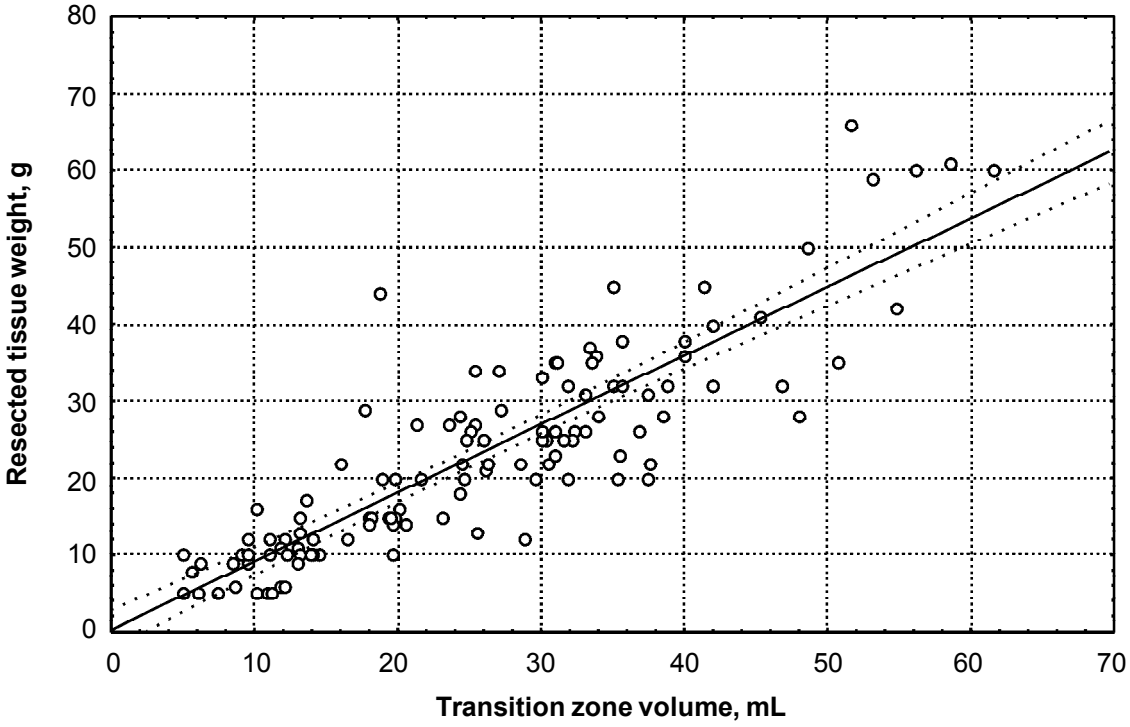

Fig. 1. **Correlation (r=0.878) between resected tissue weight and transition zone volume in transurethral resection group (n=120)**

22.9 g (±13.41, 5–66). The difference between measured TZV and resected TW was significant (25.43 *vs.* 22.9, P<0.01). Resected TW constituted 90% of measured TZV. The correlation between TW and TZ (Fig. 1) was very strong, r=0.878, P<0.001. Underestimation of TZ was in 34 (28.3%) cases and overestimation in 73 (60.8%). Resected TW was equal to TZV in 13 (10.9%) cases. Overestimated volume in this group, the same as in all the cases under study, has a tendency of being higher than underestimated volume is (6.38±4.39 *vs.* 4.83±4.76, P=0.007 (Table)). There was a strong correlation between TZV and overestimated volume detected (r=0.50, P<0.01). Underestimated volume has no such correlation. Of the overestimations in that group, 70% were up to 7 mL and 17% were more than 10 mL. Incorrect measurements were detected in 107 of 120 cases.

In the group of patients who underwent open surgery (n=48), the mean TPV was 107.41 mL (±49.7, 28–326.7), the mean TZV was 76.1 mL (±42.97, 13–275.8), and the mean resected TW was 73.96 g (±44.96, 18–280). The difference between estimated TZV and enucleated TW did not reach a significant level (P=0.263). Enucleated TW constituted 97.2% of TZV and 68.9% of TPV. The correlation between TW and TZV (Fig. 2) was stronger than it was in the TURP group (r=0.957, P<0.001). Overestimation was detected almost at the same rate as underestimation was – in 23 (47.9%) and 21 (43.7%) cases, respectively. There was no significant difference between the means of the over- or underestimations of volume (13.4±7.17 *vs.* 9.85±6.81, P=0.06, (Table)). There was no correlation between over- or underestimations and TZV or enucleated TW. TZV was equal to enucleated TW in 4 (8.3%) cases. Incorrect measurements were detected in 44 of the 48 cases.

Discussion

The investigation of the transition zone in BPH patients is very important in several aspects. It can predict the response to conservative treatment or predict progression of the disease and its complications. In cases of surgical BPH treatment, the main interest regarding the transition zone is its correlation with operation time, complications, and even treatment efficacy (13, 14). One of the main practical points of view regards the agreement between TZV and removed TW.

The decision regarding which modality of surgery to choose depends on the projected amount of tissue that needs to be removed. Generally, when suspected TW is more than 50–60 g, an open operation is recommended. Another very important aspect is the skill for performing one or other modality of operation. In the very extensive study by Mebust *et al.*, resected TW was less than 30 g in 73% of 3885 cases of TURP. Some of the reasons for the complications, described

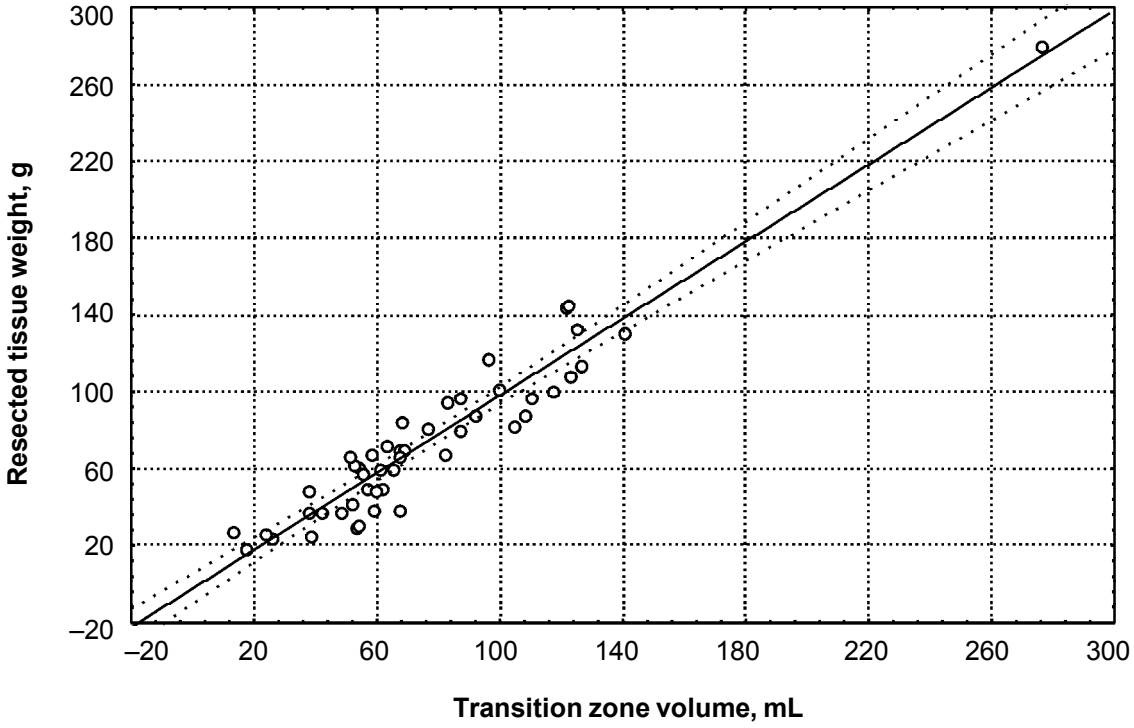

Fig. 2. **Correlation (r=0.957) between enucleated tissue weight and transition zone volume in open prostatectomy group (n=48)**

by these authors, were a prostate volume >45 mL and the duration of operation exceeding 90 min (15). Such reasons are all directly related to the skills and technique involved in performing the surgery. Last but not least, concomitant diseases, constitution and the age of the patients play significant roles on the decision for surgery modality. The amount of removed tissue depends on TZV, because 90% and 97% of the transition zone were removed, respectively, during transurethral resection and open operation. There is no way to check if all the removed tissue belongs to the transition zone alone, and only the open adenomectomy, as the most "radical" BPH surgery technique, can confirm this indirectly.

In studies where TZV and removed TW have been investigated, a strong correlation between these two parameters was detected. This present study reports similar results: a significant correlation between TZV and resected TW was found in the TURP group (r=0.878), in the open operation group (r=0.957), and in all investigated cases (r=0.968, P<0.001). Nonetheless, does this mean that measured volume was similar to the removed weight? This point was not noticed in all the studies (3), and where it was noticed, the presented results are conflicting. Baltaci *et al.* investigated 50 patients with BPH, who underwent an open prostatectomy, and did not find agreement despite a significant correlation between enucleated tissue weight and TZV (9). The same conclusions were published other study, which compared 37 cases of removed adenoma weight with TZV (11). On the other hand, Zlotta *et al.* presented an agreement between their radiological investigation and anatomical findings (10). In the earlier published data by the authors herein, there was no significant difference detected between TW and TZV either (16).

The data of this study are controversial in respect to measured volume and removed weight; therefore, these call for a broader discussion. In the TURP group, significant disagreement was detected between the mean TZV and resected TW (25.43 *vs.* 22.9, P=0.01). Meanwhile, in the open operation group, there was no real difference (76.09 *vs.* 73.96, P=0.263). There are two possible explanations for this. The first regards the difference in specificity between the small and large volume prostate measurements, and the other regards the way the prostate tissues were removed (operation modality). It is known that prostatic tissues shrink and lose weight due to electrocoagulation during transurethral resection (17). Additionally, anatomical studies have presented that from 2.08% to 36.84% of prostate tissues, part of which belong to TZ, are usually localized outside the verumontanum (18), the lower border of resection during TURP. Therefore, part of those tissues could not be resected during the operation. The last but not least reason is

that it is quite difficult to distinguish borderlines between prostate zones during transurethral resection. All of aforementioned irregularities are avoided during an open operation. That can explain why a significant difference between TZV and TW was detected in the transurethral resection group in this study.

Transrectal ultrasound, like any investigation, has its limitations. Height and width in the transverse plane are usually not difficult to measure. However, sometimes, there is a problem in precisely measuring the length of TZ in the sagittal plane. Diffuse calcifications between TZ and the peripheral zone, small and very large TZ, usually with an unclear borderline between zones and the hypoechoic triangle zone at the apex of the gland may impede accurate measurement. Not all the problems mentioned are specific to small or large prostates alone. However, these, according to the experience of the authors herein, could not have influenced the precision of volume measurements of the large or small prostates. Three reasons allow a presumption that the controversial results in groups are due to the operation mode. One is the same over and underestimations rate (47.9% *vs.* 43.7%). Further, the mean of over- and underestimated volumes is not statistically different (13.4 *vs.* 9.85, P=0.06). Finally, no significant correlation was detected between the mean incorrect measurements volume and TZV or TW in the open operation group. The exact opposite data, found for the TURP group – twice more overestimations than underestimations, a significantly greater overestimated volume, and significant correlation with TZV ($r=0.50$, $P<0.01$) – substantiate the presumption regarding the operation mode. The reason that the difference between TZV and TW was estimated in the TURP group is due to the aforementioned limitations of transurethral resection, not the specificity of measurement.

Usefulness of TZV measurement before open operation was proven by the data presented in this study. Over- and underestimations occur at the same rate and volume. TZV before transurethral resection should be assessed in light of the following precautions: overestimations occur two times more frequently, and the mean volume, 6.38 mL, is significantly different from the mean underestimation. Despite a significant TZV and TW disagreement in the transurethral resection group, the transition zone measurement before TURP should not be ignored, especially bearing in mind the aforementioned reasons for that disagreement.

Conclusions

The data presented in this study show that there is a strong correlation between transition zone volume determined by transrectal ultrasound and removed prostate tissue weight. Adequacy between transition zone volume, calculated using the ellipsoid formula, and tissue weight depends on operation modality. Resected tissue weight is significantly less than transition zone volume due to some specificity of transurethral prostatic resection, while enucleated tissue weight during an open operation is in agreement with measured transition zone volume.

Tranzitorinės zonos tūrio išmatavimas. Ar jis naudingas prieš chirurginį gerybinės prostatos hiperplazijos gydymą?

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Raktažodžiai: gerybinė prostatos hiperplazija, transrektinis ultragarsinis tyrimas, tranzitorinės zonos tūris.

Santrauka. *Darbo tikslas.* Nustatyti tranzitorinės zonos tūrio, išmatuoto transrektinio ultragarsinio tyrimo metu, atitikimą ir koreliaciją su operacijos metu pašalintų prostatos audinių svoriu pacientams, sergantiems gerybine prostatos hiperplazija.

Tyrimo medžiaga ir metodai. Į tyrimą įtraukti 168 pacientai, kuriems histologiškai po operacijos patvirtinta gerybinė prostatos hiperplazija. Transuretrinė prostatos rezekcija atlikta 120 pacientų, atvira operacija – 48. Pašalinta prostatos audinių masė buvo palyginta su tranzitorinės zonos tūriu. Analizuotas ultragarsinių ir operacinių duomenų atitikimas bei koreliacija.

Rezultatai. Vidutinis tranzitorinės zonos tūris (standartinis nuokrypis, pasiskirstymas) buvo 25,43 ml (±13,19, 5–61,6) transuretrinės rezekcijos grupėje ir 76,1 ml (±42,97, 13–275,8) – atvirų operacijų grupėje. Vidutinis pašalintų audinių svoris – 22,9 gr. (±13,41, 5–66) ir 73,96 gr. (±44,96, 18–280) atitinkamai endoskopinių ir atvirų operacijų grupėse. Koreliacija tarp atviros operacijos metu pašalintų audinių svorio bei tranzitorinės zonos tūrio buvo stipresnė nei tarp endoskopinės operacijos metu pašalintų audinių bei išmatuoto tranzitorinės

zonos tūrio (r=0,957, <0,001 *vs.* r=0,878, p<0,001). Nustatytas reikšmingas skirtumas tarp pašalintų audinių svorio ir echoskopinių matavimų (p=0,001) endoskopinės operacijos metu, o atvirų operacijų grupėje šis skirtumas nereikšmingas (p=0,263).

Išvados. Nustatyta reikšminga koreliacija tarp pašalintų audinių svorio ir tranzitorinės zonos tūrio nepriklausomai nuo operacijos tipo. Reikšmingas skirtumas nustatytas tarp endoskopinės operacijos metu pašalintų audinių svorio ir tranzitorinės zonos tūrio, o atviros operacijos metu pašalintų audinių svoris atitinka echoskopinius tranzitorinės zonos tūrio matavimus.

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