Arab Journal of Urology (2014) 12, 256–261

Arab Journal of Urology
(Official Journal of the Arab Association of Urology)

www.sciencedirect.com

ORIGINAL ARTICLE

Predicting the resected tissue weight from a digital rectal examination and total prostate specific antigen level before transurethral resection of the prostate

Ahmed M. Harraz, Ahmed El-Assmy *, Mohamed Tharwat, Ahmed M. Elshal, Ahmed R. El-Nahas, Tamer S. Barakat, Mohamed M. Elsaadany, Samer El-Halwagy, El Housseiny I. Ibrahiem

Urology and Nephrology Center, Mansoura University, Mansoura, Egypt

Received 9 April 2014, Received in revised form 29 August 2014, Accepted 18 September 2014
Available online 11 November 2014

KEYWORDS

PSA;
TURP;
Prostate volume;
Resected tissue weight;
DRE

ABBREVIATIONS

AUC, area under the curve;
BMI, body mass index;
ROC, receiver operating characteristic;

Abstract ***Objective:*** To determine the use of the prostate specific antigen (PSA) level and digital rectal examination (DRE) findings to estimate the resected tissue weight (RTW) before transurethral resection of the prostate (TURP).

Patients and methods: We retrospectively analysed 983 patients who underwent TURP between December 2006 and December 2012. The primary outcome was the RTW required for clinical improvement, and was not associated with re-intervention. Age, PSA level, body mass index (BMI) and DRE findings were correlated and modelled with the RTW. The DRE result was defined as DREa (small vs. large) or DREb (small vs. moderate vs. large) according to the surgeon's report. Equations to calculate RTW were developed and tested using receiver operating characteristic (ROC) curve analyses.

Results: There were significant correlations between PSA level ($r = 0.4$, $P < 0.001$) and RTW, whilst BMI and age showed weak correlations. The median (range) RTW was 45 (7–60) vs. 15 (6–60) g for small vs. large prostates (DREa)

* Corresponding author. Tel.: +20 50 2262222; fax: +20 50 2263717.
E-mail address: a_assmy@yahoo.com (A. El-Assmy).

Peer review under responsibility of Arab Association of Urology.

ELSEVIER Production and hosting by Elsevier

http://dx.doi.org/10.1016/j.aju.2014.09.006

RTW, resected tissue weight;
PV, prostate volume

($P < 0.001$), respectively. Similarly, the median (range) RTW was 11 (6–59) vs. 26.2 (6–60) vs. 42 (7–60) g in small vs. moderate vs. large prostates (DREb) ($P < 0.001$), respectively. Using PSA level and DREb (model 3) there was a significantly better ability to estimate RTW than using PSA and DREa (model 2) or PSA alone (model 1) based on ROC curve analyses. The equation developed by model 3 (RTW = 1.2 + (1.13 × PSA) + (DREb × 9.5)) had a sensitivity and specificity of 82% and 71% for estimating a RTW of > 30 g, and 84% and 63% for estimating a RTW of > 40 g, respectively.

Conclusions: The PSA level and DRE findings can be used to predict the RTW before TURP.

Introduction

Although new technologies are increasing dramatically TURP continues to be the referent for all procedures treating obstructive LUTS in men. Before surgery an estimation of prostatic volume (PV) is mandatory as it is related to disease progression, unfavourable outcomes, surgical guidance and is a good estimate of the response to surgery [1,2]. The most reliable method to calculate PV is by TRUS [3,4]. Nevertheless, there are many concerns about the results of TRUS. It has been shown that the measured PV can vary with the experience of the operator, the size of the prostate and the presence of a third lobe [5,6]. In addition, conventional bi-dimensional ultrasonography has been shown to be less accurate than three-dimensional ultrasonography [6].

The relationship between PSA level and TRUS-measured PV was assessed in many previous publications. This strong relationship was confirmed in patients in China [7], Korea [8,9], Taiwan [10] and Netherlands [11]. Even in a large population of patients undergoing screening, PSA levels correlate well with the PV measured by a DRE [12]. In addition, recently the metabolic syndrome and obesity have been shown to influence both PSA levels and PV to a great extent [13–16]. Therefore, it was suggested that for an accurate estimation of PV, PSA measurements and obesity indices should be included [13,17].

TRUS-based measurements of PV have shown a strong correlation with resected tissue weight (RTW) [18,19], as during TURP only adenomatous tissue is resected. Although the RTW might not be an indicator of the degree of clinical improvement after TURP [20], it might be an indicator of further prostatic growth and the need for re-treatment [21,22]. Furthermore, predicting the RTW might aid adequate surgical planning before surgery. As there are no previous studies that have correlated PSA level or obesity indices with RTW, in the present study we determined the utility of preoperative variables for estimating the RTW before TURP.

Patients and methods

After obtaining internal review board approval, we retrospectively reviewed our electronic databases for patients who underwent surgery for obstructive LUTS related to BPH between December 2006 and December 2011 and who had completed ⩾6 months of follow-up (983 men). Only patients who had a standard monopolar TURP were included. Patients were excluded if they had undergone any surgical procedure other than TURP (37) and those with missing data for PSA or RTW (207). For the purpose of obtaining an homogenous data distribution, patients with a PSA level of > 20 ng/mL (31) and a RTW of > 60 (18) were also excluded. All patients with a preoperative PSA level of > 4 ng/mL had biopsy-confirmed BPH before surgery.

For each patient the electronic database was reviewed for their demographics, including, age, presentation, associated medical comorbidity and BMI. Each patient had a DRE before TURP, carried out by the surgeon. The approximate size of the prostate was reported as 'mild enlargement' if the size was the same as the distal phalanx of the index finger, 'marked' if the boundaries could not be felt digitally, and 'moderate' for any other sizes. Preoperative laboratory investigations included measurements of the preoperative total PSA, serum creatinine and haemoglobin levels. A flow curve and postvoid residual urine volume were routinely assessed before surgery. The TRUS-measured PV was not routinely obtained in every patient.

All patients underwent a standard monopolar TURP, with documented resection of most of the adenomatous tissue. Patients with documented tunnelling only or with incomplete removal of the adenoma were excluded. After resection the removed adenomatous tissue was compressed and immediately weighed before being examined histopathologically. Patients were maintained on quinolone antibiotics for 2 weeks after removal of the urethral catheter. To confirm any clinical improvement, all patients had their postvoid residual estimated and a flow curve assessed at least once during the follow-up.

Table 1 Demographics for the 693 patients undergoing TURP.

Variable	Mean (SD) or *n* (%)
Age (years)	65 (7.3)
Presentation	
LUTS	549 (79.2)
Catheterised	119 (17.2)
Haematuria	25 (3.6)
Diabetes mellitus	82 (11.8)
Hypertension	181 (26)
BMI (kg/m^2)	28.2 (4.7)
PSA (ng/mL)	4.5 (3.9)
Preop haemoglobin (g/dL)	13.8 (1.6)
DRE	
Mild	287 (41.4)
Moderate	370 (53.4)
Marked	32 (4.6)
Not reported	4 (0.5)
Vesical stones	121 (17.5)
Postop haemoglobin (g/dL)	12.7 (4.5)
RTW (g)	22 (13)

The primary outcome was the RTW that was associated with alleviating obstructive LUTS and that was not associated with further prostatic re-intervention at least within the 6 months after surgery. Therefore, any patients requiring re-intervention for residual adenoma within the next 6 months were excluded (seven).

Statistical analysis

The correlation between age, serum PSA level, BMI and RTW was investigated using the Pearson correlation coefficient. The median RTW was compared between subcategories of DREa and DREb using the Mann–Whitney *U*-test and Kruskal–Wallis test, respectively. Variables showing a significant correlation with RTW were entered into a linear regression model to construct an equation to estimate the RTW. As the DRE was reported to be associated accurately with large prostates of > 50 g [23], the DRE category was entered twice in two different models together with PSA level, after combining mild and moderate prostates as 'small' vs. 'large' prostates (DREa), and as 'mild, moderate' vs. 'marked enlarged' prostates (DREb). The predicted values of the derived equations were compared with the actual values of RTW at different thresholds using the receiver operating characteristic (ROC) curve.

Results

In all, 693 patients met the study inclusion criteria within the specified period. The patients' demographics are shown in Table 1. The RTW showed no correlation with age (r = 0.07, P = 0.05) or BMI (r = 0.07, P = 0.04), but there was a moderately positive significant correlation with PSA level (r = 0.4, P < 0.001). The median (range) RTW was significantly higher in patients with large vs. small prostates (DREa), at 45 (7–60) g vs. 15 (6–60) g, respectively (P < 0.001). Similarly, the median RTW differed significantly between small vs. moderate vs. large prostates (DREb), at 11 (6–59) vs. 26.2 (6–60) vs. 42 (7–60) g, respectively (P < 0.001). Therefore, equations to estimate the RTW were developed based on three regression models using preoperative PSA level alone as a predictor (model 1), PSA and DREa (model 2), and PSA and DREb (model 3) as predictors (Table 2). Model 1 explained only 16.4% of the variance of RTW values whilst adding DRE findings increased the predictive ability of the model to 29% and 34% for models 2 and 3, respectively.

After constructing ROC curves for the three models (Fig. 1A and B), the model 3 equation showed the best predictive ability for a RTW of > 30 g, with an area under the curve (AUC) and 95% CI of 0.8 (0.790–

Table 2 Linear regression models for predicting RTW after TURP.

Independent variables	Coefficient	SE	$r_{partial}$	t	P
Model 1					
Constant	15.708				
PSA	1.400	0.120	0.405	11.64	< 0.001
Equation: RTW = 15.708 + (1.400 × PSA)					
Model 2					
Constant	−3.792				
PSA	1.315	0.115	0.401	11.452	< 0.001
DREa	19.037	2.161	0.319	8.810	< 0.001
Equation: RTW = (1.315 × PSA) + (19.037 × DREa) − 3.792					
DREa: small = 1 and large = 2					
Model 3					
Constant	1.239				
PSA	1.133	0.109	0.368	10.379	< 0.001
DREb	9.534	0.715	0.453	13.342	< 0.001
Equation: RTW = 1.239 + (1.133 × PSA) + (DREb × 9.534)					
DREb: small = 1, moderate = 2, large = 3					

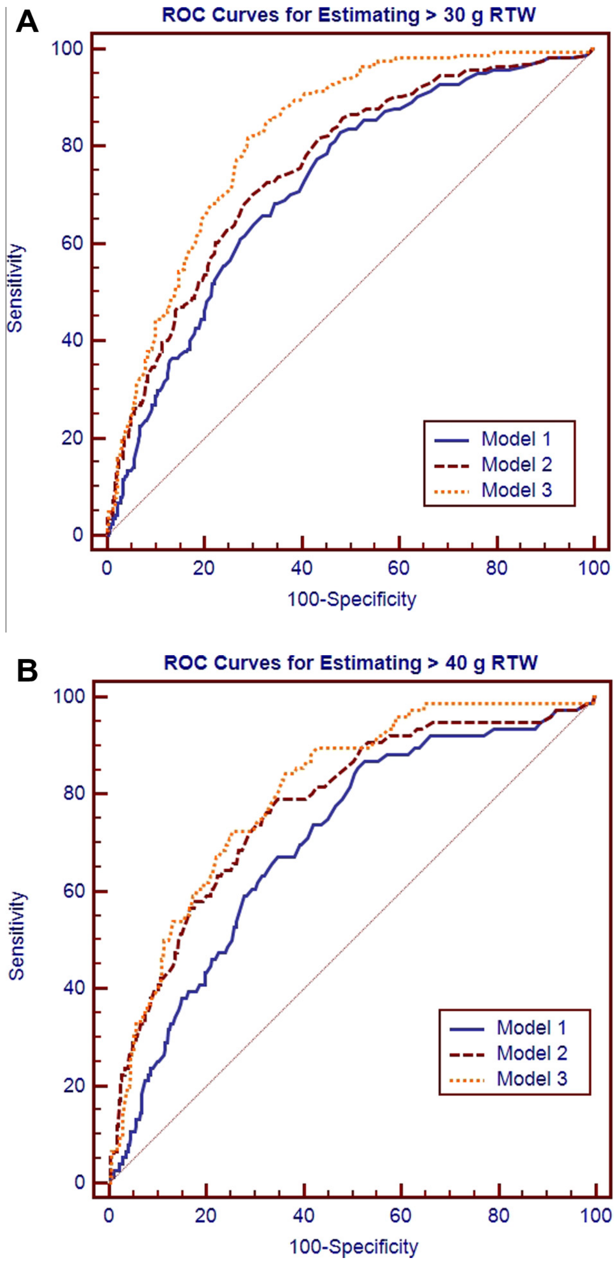

Figure 1 ROC curves for the three models for (A), estimating a RTW of >30 g, and (B), of >40 g.

0.849) ($P < 0.001$), with a sensitivity of 82% and specificity of 71% at a threshold estimated RTW of >23.5 g. On comparing the three models, the difference between the areas of model 1 and 2 (95% CI) was 0.036 (0.013–0.058) ($P = 0.001$), and the difference between models 2 and 3 (95% CI) was 0.064 (0.04–0.089) ($P < 0.001$).

Similarly, the model 3 equation had significantly the best predictive ability when compared to models 1 and 2 for estimating a RTW of >40 g, with an AUC of 0.8 (0.771–0.832) ($P < 0.001$), with a sensitivity of 84% and specificity of 63% at the same threshold value. On comparing models 1 and 2, the difference (95% CI) between areas was 0.071 (0.028–0.114) ($P = 0.001$), and the difference in areas between models 2 and 3 was 0.029 (−0.003–0.062) ($P = 0.08$). Table 3 shows the results of the ROC curves.

Table 3 Comparison of the ROC curves of models predicting RTW from PSA level and DRE.

RTW	AUC	SE	95% CI	P
RTW >30 g				
Model 1 (PSA)	0.720	0.022	0.685–0.754	<0.001
Model 2 (PSA + DREa)	0.756	0.021	0.723–0.788	<0.001
Model 3 (PSA + DREb)	0.821	0.017	0.790–0.849	<0.001
RTW > 40 g				
Model 1 (PSA)	0.702	0.031	0.666–0.736	<0.001
Model 2 (PSA + DREa)	0.773	0.029	0.740–0.804	<0.001
Model 3 (PSA + DREb)	0.803	0.025	0.771–0.832	<0.001

Discussion

The RTW and not the total PV is the actual determinant of operating time and consequently it is directly related to the perioperative complication rates [24]. Therefore, predicting the RTW might be important in surgical planning before TURP. In the present study there was a moderately significant positive correlation between the preoperative serum PSA level and DRE, and the RTW after TURP, whilst age and BMI had very weak correlations. In addition, adding the DREb gave a significantly better performance of the model for estimating the RTW than using PSA alone or PSA and DREa as predictors.

The relationship between age, total PSA level, obesity indices and TRUS-measured PV was reported previously [14,25]. Nevertheless, age and BMI were weakly correlated with RTW in the present study. During TURP only obstructing adenomatous tissue is removed, with sparing of the peripheral and prostatic capsular tissues. Therefore, this eliminates to a major extent the effect of age and BMI on PV. Furthermore, as the RTW is not necessarily correlated with PV, the expected effect of age and BMI is reduced.

Although a preoperative estimation of PV is essential, there is a debate as to whether the total PV is an indicator of how much tissue should be resected during TURP. Park et al. [21] compared 85 patients with a mean PV of 59.7 g and mean RTW of 11.2 g vs. 178 with a mean PV of 69.9 g and mean RTW of 24 g. Hakenberg et al. [20] reported 138 men who underwent TURP, in whom the mean PV was 49 g and the mean RTW was 24.7 g. However, the RTW was shown to correlate significantly with transitional zone volume as measured by TRUS. Aus et al. [24] reported a significant positive correlation between the RTW and transitional zone volume before and after TURP. In another report, Alkan et al. [19] described a strong correlation between the estimated and resected volumes. Milonas et al. [18] compared the RTW of adenomas removed by TURP and open prostatectomy with corresponding TRUS measurements, found a strong correlation between adenomas enucleated during open prostatectomy, with a weak correlation with adenomas removed by TURP.

Another issue to be addressed is how much RTW is needed to achieve a clinical improvement. Hakenberg et al. [20] correlated the RTW with the clinical outcome as measured by symptom scores after TURP, and found that the RTW was negatively correlated with symptom scores, and that there was no significant correlation between the ratio of RTW to PV and the change in symptom scores. The authors declared that early symptomatic improvement was dependent on the RTW, but the relationship was weak because of possible other confounding variables. They also admitted that the completeness of resection is not mandatory for the optimum clinical outcome. Park et al. [21] compared the outcome between patients who had a RTW ratio of $>50\%$ and $<50\%$, and found no statistically significant difference in the clinical outcome even after stratification according to PV. Those authors suggested that a complete resection might not be mandatory for an optimal clinical improvement. Furthermore, a limited resection might be enough for patients with larger prostates.

The DRE has been shown to predict large prostates (>50 g) [23]. In the present study our routine daily practice was used to define the DRE findings regarding the PV in the context of BPH. Although subjective our definition of prostatic enlargement depends on extreme values to minimise the bias between surgeons. All our reported findings were the records of the senior surgeon operating on the patient. In addition, the very large prostate and the very small were defined first and then any size in between was deemed ‘moderate’. Two models were used that included the DRE finding, one assessed by ‘small vs. large’ prostates to minimise the bias if the three-level classification was used. Model 3 including a DRE defined as ‘mild vs. moderate vs. marked’ enlargement and showed the largest AUC and the best ability to discriminate a RTW of >30 g and >40 g.

The present study has several limitations; first, the outcome defined as the RTW is not consistent across different patients and mainly depends on surgeon volume, as some surgeons prefer to resect the whole adenoma and others do not. Nevertheless, our general policy is to resect the whole adenomatous tissue up to the capsule. Second, the definition of DRE findings is subjective, but our policy to depend on extreme observations might minimise any bias related to the DRE measurement. Third, the study was retrospective and thus had all the limitations related to this design. Fourth, we had no internal validation arm for the provided equations and hence further validation is required. Finally, our equation did not account for surgeon volume, as an experienced surgeon can resect more tissue than a trainee. Nevertheless, the study described the experience of TURP over a 6-year period and therefore it was difficult to assess the accurate volume for each surgeon.

However, to the best of our knowledge this is the first reported study to correlate the RTW with preoperative variables. We believe that the findings of the current study might be beneficial in clinical practice to allow an approximate estimate of the RTW before TURP, and therefore aid better surgical planning for optimising the outcome of the procedure.

In conclusion, the RTW can be predicted from PSA level before TURP, and this prediction is improved after adding the finding of a DRE. These equations could be used for better surgical planning before TURP. Further studies are needed to validate these findings.

Conflict of interest

None.

Source of funding

None.

References

[1] Nickel JC. Benign prostatic hyperplasia: does prostate size matter? *Rev Urol* 2003;**5**(Suppl. 4):S12–7.
[2] Bergdahl S, Aus G, Lodding P, Norlén L, Hugosson J. Transrectal ultrasound with separate measurement of the transition zone volume predicts the short-term outcome after transurethral resection of the prostate. *Urology* 1999;**53**:926–30.
[3] Grossfeld GD, Coakley FV. Benign prostatic hyperplasia. Clinical overview and value of diagnostic imaging. *Radiol Clin North Am* 2000;**38**:31–47.
[4] Kijvikai K. Digital rectal examination, serum prostatic specific antigen or transrectal ultrasonography. The best tool to guide the treatment of men with benign prostatic hyperplasia. *Curr Opin Urol* 2009;**19**:44–8.
[5] Choi YJ, Kim JK, Kim HJ, Cho KS. Interobserver variability of transrectal ultrasound for prostate volume measurement according to volume and observer experience. *AJR Am J Roentgenol* 2009;**192**:444–9.
[6] Giubilei G, Ponchietti R, Biscioni S, Fanfani A, Ciatto S, DI Loro F, et al. Accuracy of prostate volume measurements using transrectal multiplanar three-dimensional sonography. *Int J Urol* 2005;**12**:936–8.
[7] Mao Q, Zheng X, Jia X, Wang Y, Qin J, Yang K, et al. Relationships between total/free prostate-specific antigen and prostate volume in Chinese men with biopsy-proven benign prostatic hyperplasia. *Int Urol Nephrol* 2009;**41**:761–6.
[8] Lee SE, Chung JS, Han BK, Moon KH, Hwang SI, Lee HJ, et al. Relationship of prostate-specific antigen and prostate volume in Korean men with biopsy-proven benign prostatic hyperplasia. *Urology* 2008;**71**:395–8.
[9] Shim HB, Lee JK, Jung TY, Ku JH. Serum prostate-specific antigen as a predictor of prostate volume in Korean men with

lower urinary tract symptoms. *Prostate Cancer Prostatic Dis* 2007;**10**:143–8.
[10] Chang YL, Lin AT, Chen KK, Chang YH, Wu HH, Kuo JY, et al. Correlation between serum prostate specific antigen and prostate volume in Taiwanese men with biopsy proven benign prostatic hyperplasia. *J Urol* 2006;**176**:196–9.
[11] Bohnen AM, Groeneveld FP, Bosch JL. Serum prostate-specific antigen as a predictor of prostate volume in the community: the Krimpen study. *Eur Urol* 2007;**51**:1645–52.
[12] Pinsky PF, Kramer BS, Crawford ED, Grubb RL, Urban DA, Andriole GL, et al. Prostate volume and prostate-specific antigen levels in men enrolled in a large screening trial. *Urology* 2006;**68**:352–6.
[13] Yang HJ, Doo SW, Yang WJ, Song YS. Which obesity index best correlates with prostate volume, prostate-specific antigen, and lower urinary tract symptoms? *Urology* 2012;**80**: 187–190.
[14] Nakanishi Y, Masuda H, Kawakami S, Sakura M, Fujii Y, Saito K, et al. A novel equation and nomogram including body weight for estimating prostate volumes in men with biopsy-proven benign prostatic hyperplasia. *Asian J Androl* 2012;**14**:703–7.
[15] Byun HK, Sung YH, Kim W, Jung JH, Song JM, Chung HC. Relationships between prostate-specific antigen, prostate volume, and components of metabolic syndrome in healthy Korean men. *Korean J Urol* 2012;**53**:774–8.
[16] Kim JM, Song PH, Kim HT, Moon KH. Effect of obesity on prostate-specific antigen, prostate volume, and international prostate symptom score in patients with benign prostatic hyperplasia. *Korean J Urol* 2011;**52**:401–5.
[17] Kaplan SA. Re: A novel equation and nomogram including body weight for estimating prostate volumes in men with biopsy-proven benign prostatic hyperplasia. *J Urol* 2013;**190**:197.
[18] Milonas D, Matjosaitis A, Jievaltas M. Transition zone volume measurement – is it useful before surgery for benign prostatic hyperplasia? *Medicina (Kaunas, Lithuania)* 2007;**43**:792–7.
[19] Alkan I, Turkeri L, Biren T, Cevik I, Akdas A. Volume determinations by transrectal ultrasonography in patients with benign prostatic hyperplasia. Correlation with removed prostate weight. *Int Urol Nephrol* 1996;**28**:517–23.
[20] Hakenberg OW, Helke C, Manseck A, Wirth MP. Is there a relationship between the amount of tissue removed at transurethral resection of the prostate and clinical improvement in benign prostatic hyperplasia. *Eur Urol* 2001;**39**:412–7.
[21] Park HK, Paick SH, Lho YS, Jun KK, Kim HG. Effect of the ratio of resected tissue in comparison with the prostate transitional zone volume on voiding function improvement after transurethral resection of prostate. *Urology* 2012;**79**:202–6.
[22] Goel A, Kumar A. Re: Park et al. Effect of the ratio of resected tissue in comparison with the prostate transitional zone volume on voiding function improvement after transurethral resection of prostate (Urology 2012; 79: 202–206). Urology 2012; 79: 747; author reply 747–748.
[23] Bosch JL, Bohnen AM, Groeneveld FP. Validity of digital rectal examination and serum prostate specific antigen in the estimation of prostate volume in community-based men aged 50–78 years. The Krimpen Study. *Eur Urol* 2004;**46**:753–9.
[24] Aus G, Bergdahl S, Hugosson J, Norlen L. Volume determinations of the whole prostate and of adenomas by transrectal ultrasound in patients with clinically benign prostatic hyperplasia: correlation of resected weight, blood loss and duration of operation. *Br J Urol* 1994;**73**:659–63.
[25] Berges R, Oelke M. Age-stratified normal values for prostate volume, PSA, maximum urinary flow rate, IPSS, and other LUTS/BPH indicators in the German male community-dwelling population aged 50 years or older. *World J Urol* 2011;**29**:171–8.