CANADIAN JOURNAL OF UROLOGY

Tech Science Press

Doi:10.32604/cju.2026.072379
ARTICLE

Prostate volume on transrectal ultrasound: comparing ultrasounds performed by urologists to radiologists

Marie-Elise Henckes, Ben Van Cleynenbreugel*
Department of Development and Regeneration, KU Leuven, Leuven, Belgium

HENCKES ME, CLEYNENBREUGEL BV. Prostate volume on transrectal ultrasound: comparing ultrasounds performed by urologists to radiologists. *Can J Urol* 2026;33(4):811–817.

Objectives: *This study aims to assess the precision of transrectal ultrasound (TRUS) measurement of the prostate volume when performed by a urologist compared with a radiologist. To date, no prior research has directly compared the accuracy of prostate volume measurements between these two groups.*
Methods: *A retrospective study was conducted using data from 307 men who underwent enucleation of the prostate between 2020 and 2022 in two Belgian hospitals (University Hospital Leuven and Maria Middelares Hospital [Ghent]). A comparison was made between the prostate volume measured on ultrasound pre-operatively and the measured resected volume after enucleation. We compared these differences in volume in men who had their ultrasound performed by a urologist (N = 114), those who had it performed by a radiologist (N = 175), and those who had an MRI pre-operatively as a measurement (N = 18).*

Results: *A multivariate regression to predict measured prostate volume was performed with age, estimated prostate volume, and pathology result as predictors, which was significant at* $\alpha = 0.05$, $F(3, 302) = 168.104$, $p < 0.001$, $R^2_{Adjusted} = 0.686$. *Adding the imaging modality (ultrasound performed by a urologist or radiologist, or MRI) to the base model did not significantly improve the prediction of measured prostate volume, F-change(3, 299) = 0.367, p = 0.777. Seven outliers were identified (|Z-score| > 2), of which six measurements were performed by resident urologists (N = 19) and one by a certified urologist (N = 95).*
Conclusion*: This study demonstrates no evidence that prostate volume measurements performed by radiologists using ultrasound are more accurate than those performed by urologists. The higher number of outliers among resident urologists likely reflects the well-known learning curve associated with prostate ultrasound and highlights the importance of standardized training.*

Key Words: prostate hyperplasia, transrectal ultrasound, observer variation, urology, radiology

Introduction

In patients for whom pharmacological treatment is ineffective or who develop complications (e.g., urinary retention, bladder stone formation, urinary tract infections, etc.), prostate surgery is considered the standard therapeutic approach for Benign Prostatic Hyperplasia (BPH).[1] Historically, prostate volume estimation played a crucial role in determining the appropriate surgical intervention. Prior to the introduction of laser-based treatments for BPH, a commonly used threshold was 80 cc. In cases where the prostate volume was anticipated to be less than 80 cc, a transurethral resection of the prostate (TURP) was typically performed, whereas open prostatectomy was recommended for larger glands.[1–4] With the introduction of laser enucleation techniques, however, there is no longer a definitive upper limit regarding prostate size, and the choice of surgical technique now largely depends on surgeon expertise.[5–9]

Prostate enucleation is a surgical approach aimed at removing the entire adenoma obstructing urinary

Received date 25 August 2025
Accepted for publication 24 February 2026
Published online 21 August 2026

*Corresponding Author: Ben Van Cleynenbreugel.
Email: ben.vancleynenbreugel@uzleuven.be

flow through the urethra. Previous studies report that the volume of prostate tissue removed during enucleation typically ranges from 51% to 70.4% of the total prostate volume.[10–12] Although enucleation is increasingly considered size-independent, accurate estimation of prostate volume remains an essential component of surgical planning, as it significantly influences operative duration.[7,13–16] The most utilized method for prostate volume estimation is transrectal ultrasound (TRUS). Magnetic resonance imaging (MRI) has been shown to provide superior accuracy in prostate volume assessment; however, it is less readily available and more costly.[17–19]

In Belgium, transrectal ultrasounds are predominantly performed by urologists, with the University Hospital of Leuven representing one of the few exceptions, where these procedures are conducted by radiologists. As far as we know, no studies have directly compared the accuracy of prostate volume estimation between urologists and radiologists. This study seeks to compare the prostate volume as measured by either a urologist or a radiologist with the actual tissue volume removed during laser enucleation.

Methods

Study population

Following approval from the Ethics Committee of the University Hospital of Leuven (No. S69155) and the Ethics Committee of the Maria Middelares Hospital (Ghent) (No. MMS 2024.007), a list was compiled of all patients who underwent laser enucleation between 1 January 2020, and 31 December 2022. Data were retrospectively collected from electronic patient records, yielding an initial cohort of 387 patients (155 from Ghent and 232 from Leuven). In the Ghent cohort, 35 patients were excluded, including 15 duplicate entries, while 45 patients were excluded from the Leuven cohort. A detailed list of exclusions is provided in Table 1.

To be eligible for inclusion, prostate volume had to be determined via ultrasound or magnetic resonance imaging (MRI) within 12 months prior to surgery. When prostate volume was reported as a range (e.g., 60–65 mL), the lower value was used for analysis. The identity of the clinician performing the ultrasound had to be clearly documented; otherwise, the patient was excluded.

Surgical technique

Laser enucleation was performed using either the holmium laser (HoLEP) or the thulium laser (Tm:YAG;ThuLEP). All procedures were carried out by three experienced urologists, each of whom had been performing enucleations prior to 2020. Both en bloc and three-lobe techniques were used, depending on surgeon preference.

Ultrasound technique

Prostate volume was calculated using the ellipsoid volume formula: $V(\text{cm}^3) = \frac{\pi}{6} \times \text{length (cm)} \times \text{width (cm)} \times \text{height (cm)}$. Prostate dimensions (length, width, and height) were obtained during transrectal ultrasound (TRUS) or on MRI imaging. Given that this is a retrospective study, urologists and radiologists may employ different techniques in executing the procedure.

Different ultrasound systems were used in the two participating hospitals. At Maria Middelares Hospital (Ghent), a BK Medical BK5000 system (BK Medical, Herlev, Denmark) was employed, whereas in the University Hospital Leuven, a Canon Aplio i800 (Canon Medical Systems, Tochigi, Japan) was used.

Statistical analysis

Descriptive statistics were used to summarize demographic and clinical characteristics. Categorical variables are reported as frequencies (percentages). Owing to the absence of prior data addressing this research question, a formal a priori power analysis could not be performed.

To compare prostate volume measurements between subgroups (i.e., between ultrasound performed by urologists vs. radiologists), we used multiple linear regression. The assumption of homoscedasticity was checked by a scatterplot. The model summary of the multiple linear regression can be found in Table 2. The primary outcome variable was resection weight, while estimated prostate volume was included as a predictor in the regression model, along with operator type. The null hypothesis stated that ultrasound measurements performed by urologists would differ significantly in accuracy from those performed by radiologists.

Outliers were identified using scatterplot analysis to mitigate the risk of falsely rejecting the null hypothesis due to extreme values. Statistical significance was defined as a p-value < 0.05. All statistical analyses were conducted using IBM SPSS Statistics (version 29.0.1.0; IBM Corp., Armonk, NY, USA).

Results

A total of 307 patients were included in the final analysis. Of these, 114 patients (37%) underwent TRUS

TABLE 1. **Exclusion criteria**

Maria Middelares Hospital (Ghent)	**Details**
Total patients	155
Excluded due to double inclusion	15
Excluded due to no surgery carried out	17
Excluded due to only partial resection	1
Excluded due to no measurement of volume on pathology	2
Final included patients	120
University Hospital Leuven	**Details**
Total patients	232
Excluded due to double inclusion	2
Excluded due to only partial resection	1
Excluded due to no measurement of volume on pathology	2
Excluded due to no knowledge who performed ultrasound	15
Excluded due to ultrasound/MRI carried more than 1 year before	14
Excluded due to conversion to TURP	6
Excluded due to pre-operative change to REZUM	1
Final included patients	187

TABLE 2. **Model summary**

Model	**Statistics**				**Change of statistics**				
	R	**R^2**	**Adjusted R^2**	**Std error of the estimate**	**R^2 change**	**F change**	**Df1**	**Df2**	**Sig. F change**
Model 1	0.831	0.690	0.686	26.74526	0.690	168.104	4	302	<0.001
Model 2	0.831	0.691	0.684	26.82968	0.001	0.367	3	299	0.777
Model 3	0.831	0.691	0.683	26.86671	0.000	0.176	1	298	0.675

Note. Model 1. Predictors: (Constant), Outliers, Age_Patient, Anatomopathology (APO) result, Measured volume; Model 2. Predictors: (Constant), Outliers, Age_Patient, APO result, Measured volume, Resident Urology, MRI, Radiologist; Model 3. Predictors: (Constant), Outliers, Age_Patient, APO result, Measured volume, Resident Urology, MRI, Radiologist, Interaction urology resident.

performed by a urologist, while 175 patients (57%) underwent TRUS conducted by a radiologist. In 18 patients (6%), prostate volume estimation was based exclusively on MRI. Among the urologist-performed TRUS examinations, 19 (17%) were conducted by urology residents, with the remainder performed by staff urologists. Patients' characteristics are summarized in Table 3.

The mean resected prostate volume was 53.5 g, compared with a mean preoperative estimated volume of 80.5 g on imaging, corresponding to an average resection of 66% of the estimated prostate volume. These findings are consistent with previously reported enucleation efficiency rates, which range from 51% to 70.4% of total prostate volume (5,6,1). Subgroup-specific resection volumes are presented in Table 4.

Multiple regression analysis revealed that the estimated prostate volume from imaging was the strongest predictor of actual resected volume ($B = 0.690$, $p < 0.001$; see Table 5). No statistically significant difference in estimation accuracy was observed between TRUS performed by urologists and radiologists ($B = -2.067$, $p = 0.613$), nor between TRUS performed by urologists and MRI-based estimations ($B = 2.531$, $p = 0.716$). After adjustment for age and pathology findings, prostate volume estimation accuracy appeared comparable across modalities and operator specialties.

TABLE 3. **Patients' characteristics**

Characteristics	Total	Ultrasound–Urologist	Ultrasound–Radiologist	MRI
Number, n (%)	307 (100%)	114 (37%)	175 (57%)	18 (6%)
Mean age (years)	70	72	70	67
HoLEP, n (%)	271 (88%)	114 (100%)	141 (81%)	16 (89%)
ThuLEP, n (%)	36 (12%)	0 (0%)	34 (19%)	2 (11%)
Pathology report, n (%)				
Positive	37 (12%)	7 (6%)	29 (16%)	1 (6%)
Negative	272 (88%)	107 (94%)	146 (84%)	17 (94%)

TABLE 4. **Prostate volumes**

Volume	Urologist	Urologist resident	Radiologist	Radiologist resident	MRI
Expected volume	78.45 g	90.79 g	83.15 g	80.34 g	89.41 g
Resected volume	49.98 g	50.95 g	52.83 g	49.70 g	59.17 g
Expected volume/ resected volume	64%	56%	64%	62%	66%

TABLE 5. **Coefficients of the multiple linear regression**

Predictors	Unstandardized coefficients		Standardized coefficient beta	*t*	Significance	95% confidence interval for Beta		Correlations		
	Beta	Standard error				Lower limit	Upper limit	Zero-order	Partial	Part
(constant)	−41.569	13.577	/	−3.064	**0.002**	−68.314	−14.878	/	/	/
Age_patient	0.374	0.194	0.064	1.924	0.055	−0.009	0.756	0.222	0.111	0.062
APO result	−4.812	4.618	−0.034	−1.042	0.298	−13.900	4.275	−0.047	−0.060	−0.034
Measured volume	0.820	0.040	0.690	20.647	**<0.001**	0.742	0.898	0.746	0.767	0.664
Outliers	115.204	10.464	0.362	11.042	**<0.001**	94.949	136.135	0.437	0.539	0.355
Res Urology	−0.593	4.073	−0.006	−0.146	0.884	−8.608	7.423	0.018	−0.008	−0.005
MRI	2.531	6.956	0.012	0.364	0.716	−11.158	16.219	0.034	0.021	0.012
Radiologist	−2.067	4.087	−0.021	−0.506	0.613	−10.111	5.977	−0.037	−0.029	−0.016
Interaction Urology Res	3.347	7.973	0.017	0.420	0.657	−12.343	19.038	0.116	0.024	0.014

Note. APO result = measured weight of the enucleated prostate; Measured volume = pre-operative prostate volume measurement on TRUS/MRI; Res Urology = resident urology measured prostate volume. Bold p-values are <0.05, which means statistical significance.

In a subset of patients who underwent both MRI and TRUS, direct comparisons were possible. In the Maria Middelares cohort (n = 17), where TRUS was performed by urologists, the mean prostate volume was 94.94 g on MRI and 85.12 g on ultrasound, while the mean resected (pathological) volume was 51.55 g. Ultrasound, therefore, underestimated MRI-derived volume by approximately 11%, and both imaging modalities overestimated resected volume by 65%–85%. In the University Hospital Leuven subgroup (n = 6), where TRUS was performed by radiologists, mean MRI volume (70.0 g) and ultrasound volume (69.3 g) were nearly identical, with both exceeding the resected volume (37.2 g) by approximately 85%.

Outlier analysis identified seven cases with a Z-score greater than 2. Of these, six were associated with TRUS performed by urology residents (N = 19), and one by a staff urologist (N = 95), indicating a potential association between limited experience and reduced measurement accuracy. The presence of outliers was independently associated with a significant impact on the regression model (B = 115.204, $p < 0.001$).

Discussion

This study evaluated the accuracy of TRUS in estimating prostate volume prior to laser enucleation, with particular emphasis on whether the operator specialty—urologist vs. radiologist—affected measurement precision. Additionally, TRUS-based estimates were compared with MRI-based measurements, which are often considered more accurate but are less accessible in routine clinical practice.[11,18,20]

No statistically significant difference in prostate volume estimation accuracy was observed between ultrasounds performed by urologists and those performed by radiologists. Furthermore, MRI was not associated with superior predictive accuracy compared with TRUS. This suggests that, despite differences in training and imaging routines, both radiologists and urologists can perform TRUS with comparable precision in estimating prostate volume.

Previous studies comparing TRUS measurements with prostatectomy specimens have demonstrated that, although TRUS may systematically underestimate prostate volume—particularly in larger glands—the correlation with true specimen volume remains strong and clinically acceptable. Terris and Stamey showed a high correlation between TRUS-estimated volume and prostatectomy specimen volume despite absolute differences, supporting the use of TRUS as a reliable preoperative tool rather than an exact volumetric measurement.[21] Similar findings were reported by Park et al., who demonstrated correlation coefficients of approximately 0.83 between TRUS volume and specimen volume following radical prostatectomy.[22]

Although MRI is often regarded as the gold standard for prostate volume estimation, it did not demonstrate superior accuracy compared with TRUS performed by urologists in this cohort.[18,23] In paired MRI and TRUS measurements, radiologist-performed ultrasound appeared to yield prostate volume estimates more closely aligned with MRI than those obtained by urologists.[17–19,24] However, the small number of patients with paired imaging limits the reliability of these observations and underscores the need for validation in larger prospective studies. Despite limited MRI availability in this cohort, the findings support the continued reliance on TRUS for routine preoperative planning, even in settings with restricted access to advanced imaging.

The observation that six out of seven outliers were measurements performed by urology residents likely reflects a learning curve associated with TRUS, as previously reported in literature on procedural training.[25] Although this subset was small (N = 19), it highlights the need for structured training and quality assurance, especially in teaching hospitals.[25]

Previous studies suggest that inter-observer variability may contribute more to discrepancies in prostate volume estimation than the imaging modality itself.[25] Bates et al. demonstrated that inter-observer variation in TRUS volume measurements was significantly greater than intra-observer variation, indicating that operator technique and experience play a dominant role in measurement variability.[26] This supports the present finding that specialty background alone does not determine accuracy, provided adequate training is achieved.

The strengths of this study include a large sample size and inclusion of two independent institutions, enhancing generalizability. However, several limitations should be acknowledged. The retrospective design introduces potential selection and documentation bias. A prospective study in which both a radiologist and a urologist perform TRUS on the same patient using the same equipment would provide a more rigorous comparison. This, however, would require an additional transrectal examination, potentially limiting patient participation.

An alternative design comparing imaging-based prostate volume estimates with specimens obtained during radical prostatectomy could provide a more accurate reference standard. This would have to be a prospective study design since it would involve removing the peri-prostatic fat and the seminal vesicles before weighing the specimen to make the comparison more exact.

The absence of standardized protocols across operators and institutions (e.g., in measurement technique or imaging interpretation) may further contribute to variability. In a prospective study design, this limitation could be addressed by implementing a standardized protocol for prostate ultrasound measurement. Additionally, some degree of adenoma loss following morcellation is unavoidable and may vary depending on the technique used to collect the morcellated tissue. Very small tissue fragments may pass through the filter or remain in the collecting bags, while others may be retained within the tubing connecting the morcellator to the collecting bag. Furthermore, resected tissue was weighed after formalin fixation, which may have influenced the measured tissue weight.

Despite these limitations, this study provides meaningful initial evidence regarding the accuracy of prostate volume estimation by urologists and radiologists in routine clinical practice.

Conclusions

This study found no evidence that prostate volume measurements obtained by radiologists using ultrasound are more accurate than those obtained by urologists. This implies a comparable quality of prostate volume estimation across the operator specialties.

The higher proportion of outliers among measurements performed by urology residents reflects the known learning curve associated with prostate ultrasound and underscores the need for standardized training. Further prospective studies are warranted to validate these findings and minimize potential confounding factors.

Acknowledgement

We would like to thank the physicians from Maria Middelares Hospital (Ghent) and University Hospitals Leuven who contributed to this study through the performance of their ultrasound examinations and prostate enucleation procedures.

Funding Statement

The authors received no specific funding for this study.

Author Contributions

Marie-Elise Henckes was responsible for all aspects of the research and the writing of the manuscript. Ben Van Cleynenbreugel contributed to the conceptualization of the study and critically reviewed the manuscript. All authors reviewed and approved the final version of the manuscript.

Availability of Data and Materials

All data are available for critical evaluation.

Ethics Approval

Ethical approval was obtained prior to data collection from both the Ethics Committee of University Hospitals Leuven (No. S69155) and the Ethics Committee of the Maria Middelares Hospital (Ghent) (No. MMS 2024.007). Since this is a retrospective study, no informed consent is needed.

Conflicts of Interest

The authors declare no conflicts of interest.

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