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Original article

Comparison of prostate volume measured by transrectal ultrasound and magnetic resonance imaging: Is transrectal ultrasound suitable to determine which patients should undergo active surveillance?

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Abstract

Objectives: To compare prostate volume obtained by transrectal ultrasound (TRUS) and endorectal MRI (eMRI) to assess the reliability of TRUS in determining prostate-specific antigen (PSA) density.

Materials and methods: Data for 2,410 patients diagnosed with localized prostate cancer (CaP) and treated with radical retropubic prostatectomy (RRP) at the University of Pennsylvania Health System between 1991 and 2005 was reviewed. Of these patients, 756 had both a preoperative TRUS and eMRI of the prostate performed. Prostate size was estimated using the prolate ellipsoid formula (height $\times$ width $\times$ length $\times$ $\pi/6$); maximal height or antero-posterior (A-P) diameter was determined using a midsagittal view for TRUS and an axial view for eMRI. Pearson's correlation, linear regression, and paired *t*-test were performed to compare prostate volumes estimated via both imaging modalities.

Results: Average prostate size measured with TRUS and eMRI correlated significantly with one another ($R = 0.801$; $P < 0.0001$), demonstrating a strong linear relationship ($y = 0.891x + 2.622$, $R^2 = 0.642$). Comparison of PSA density also demonstrated a strong linear relationship ($y = 0.811x + 0.053$, $R^2 = 0.765$). Average prostate volume differed by 1.7 ml (TRUS relative to eMRI), which was statistically significant based on a paired *t*-test ($P < 0.001$). Upon stratification of patients into three groups based on average TRUS volume ($\leq$30, >30–60, and >60 ml), significant correlation (0.318, 0.564, 0.650) and difference between volumes (−2.1, 4.0, 5.1 ml; $P < 0.0001$, $P < 0.0001$, $P < 0.05$ TRUS relative to eMRI) was maintained.

Conclusions: Prostate volume estimations with TRUS and eMRI are highly correlated. It is therefore, reasonable to conclude that in the hands of an experienced sonographer, TRUS is not only an efficient and economical examination, but also an accurate and reproducible modality to estimate prostate size.

Keywords: Active surveillance; Prostate volume; PSA density; MRI; Transrectal ultrasound

1. Introduction

Active surveillance (AS) is an increasingly popular option for men with low-risk prostate cancer (CaP). Prostate-specific antigen (PSA) density is often employed as a key criterion in determining a patient's eligibility for AS. Transrectal ultrasound (TRUS) is classically used to determine prostate volume to calculate PSA density, as it is less expensive and time intensive than MRI, and requires less personnel and space to operate; however, TRUS volume can be user-dependent, which in turn could influence treatment decisions [1]. At our institution, endorectal MRI (eMRI) is preferable to MRI with a body coil as it better demonstrates prostatic and periprostatic anatomy as well as pathologic disease [2,3]. Although the role of eMRI in low-risk CaP patients is not established, it has been increasingly used in this population to help guide treatment decisions with regard to definitive intervention or AS.

Research has demonstrated that there is a strong correlation among the various prostate volumes estimated via TRUS, CT, and MRI [4,5]. It has also been shown though that typically, TRUS underestimates (10%–16%) and CT

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Table 1
Clinical characteristics of the patients

Number	756
Mean age at diagnosis, years (IQR)	59.9 (9.0)
Mean preoperative PSA, ng/ml (IQR)	7.5 (4.1)
Clinical stage (%)	
T1a	1 (0)
T1b	0 (0)
T1c	429 (57)
T2a	193 (26)
T2b	27 (4)
T2c	53 (7)
T3a	2 (0)
T3b	0 (0)
Unknown	51 (7)
Clinical Gleason score (%)	
≤6	523 (69)
7	177 (23)
8–10	35 (5)
Unknown	21 (3)

IQR = interquartile range; PSA = prostate-specific antigen.

and MRI overestimate (up to 30%) prostate size [1,6–8]. More recently, the accuracy of prostate volume calculation has taken on greater importance with the increased popularity of AS. To date, though, there are very few studies comparing prostate volumes calculated using TRUS and eMRI. The goal of this study, therefore, was to assess the reliability of TRUS in determining prostate volume compared with that of eMRI.

2. Materials and methods

With our institution's Internal Review Board approval, we performed a retrospective evaluation of a prospectively maintained database at the University of Pennsylvania. The database contains 2,410 patients diagnosed with localized CaP and treated with radical retropubic prostatectomy (RRP) at the University of Pennsylvania Health System between 1991 and 2005. Of these patients, 756 had both a preoperative TRUS and eMRI of the prostate performed. Endorectal MRI was performed at the discretion of the treating urologist before surgery.

Preoperative prostate volume was first assessed via TRUS. To calculate prostate size, the prostate was measured in three dimensions with volume estimated using the prolate ellipsoid formula (height × width × length × π/6); dimensions were determined based upon maximal height or antero-posterior (A-P) diameter on midsagittal image. The prostate volume was calculated by the attending radiologist performing the TRUS study.

eMRI of the prostate was performed shortly after TRUS for preoperative staging. Prostate volume via eMRI was also estimated using the prolate ellipsoid formula, with dimensions determined based upon maximal A-P diameter on axial image. The prostate volume was calculated by the attending radiologist reading the eMRI.

Patient data collected and analyzed included patient age, preoperative PSA, PSA density, clinical stage, clinical Gleason score, TRUS volume, and eMRI volume.

2.1. Statistical analysis

Preoperative prostate volumes estimated with TRUS and eMRI were compared using Pearson's correlation, linear regression, and paired *t*-test; $P < 0.05$ was considered statistically significant. All statistical analyses were performed with GraphPad Prism 5 (San Diego, CA).

3. Results

A total of 756 patients underwent preoperative TRUS and eMRI before treatment of their CaP between 1991 and 2005. The mean age was 59.9 years (IQR 9.0), with a mean preoperative PSA of 7.5 ng/ml (IQR 4.1). Table 1 shows all remaining clinical characteristics, including clinical stage and Gleason score.

Table 2 shows statistical comparison between TRUS and eMRI-based prostate volumes for the entire group. The average prostate size measured with TRUS and eMRI were 40.0 ml (range 9.0–172.0) and 38.3 ml (range 9.0–244.0), respectively, which correlated significantly with one another ($R = 0.801$; $P < 0.0001$), demonstrating a strong linear relationship ($y = 0.891x + 2.622$, $R^2 = 0.642$) as shown in Fig. 1. While the difference in average prostate volume was only 1.7 ml, this difference was statistically significant based on a paired *t*-test ($P < 0.001$). Of note, comparison of PSA density, calculated based upon presurgical PSA, also demonstrated a strong linear relationship ($y = 0.811x + 0.053$, $R^2 = 0.765$) as shown in Fig. 2.

Table 3 shows further analysis of TRUS and eMRI-based prostate volumes when stratifying patients into three groups according to average TRUS volume: (1) ≤30 ml ($n = 297$), (2) >30–60 ml ($n = 355$), and (3) >60 ml ($n = 104$). Pearson's correlation coefficients for the three groups were 0.318, 0.564, and 0.650, respectively, with all values reaching statistical significance ($P < 0.0001$). The difference in average prostate size was −2.1, 4.0, and 5.1 ml for TRUS relative to eMRI for all three groups, respectively, with all differences significant based on a paired *t*-test ($P < 0.0001$, $P < 0.0001$, $P < 0.05$).

Table 2
Correlation between prostate volume measured by TRUS and eMRI

	Mean, ml (range)	R[a]	Mean diff, ml	SE	*P*-value[b]
TRUS volume	40.0 (9.0–172.0)				
eMRI volume	38.3 (9.0–244.0)	0.801	1.7	0.5	<0.001

TRUS = transrectal ultrasound; eMRI = endorectal MRI.
[a] Pearson's correlation coefficient.
[b] Student's *t*-test (paired).