Prostate Cancer Volume Estimation by Combining Magnetic Resonance Imaging and Targeted Biopsy Proven Cancer Core Length: Correlation with Cancer Volume

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Purpose: Multiparametric magnetic resonance imaging often underestimates or overestimates pathological cancer volume. We developed what is to our knowledge a novel method to estimate prostate cancer volume using magnetic resonance/ultrasound fusion, biopsy proven cancer core length.

Materials and Methods: We retrospectively analyzed the records of 81 consecutive patients with magnetic resonance/ultrasound fusion, targeted biopsy proven, clinically localized prostate cancer who underwent subsequent radical prostatectomy. As 7 patients each had 2 visible lesions on magnetic resonance imaging, 88 lesions were analyzed. The dimensions and estimated volume of visible lesions were calculated using apparent diffusion coefficient maps. The modified formula to estimate cancer volume was defined as the formula of vertical stretching in the anteroposterior dimension of the magnetic resonance based 3-dimensional model, in which the imaging estimated lesion anteroposterior dimension was replaced by magnetic resonance/ultrasound targeted, biopsy proven cancer core length. Agreement of pathological cancer volume with magnetic resonance estimated volume or the novel modified volume was assessed using a Bland-Altman plot.

Results: Magnetic resonance/ultrasound fusion, biopsy proven cancer core length was a stronger predictor of the actual pathological cancer anteroposterior dimension than magnetic resonance estimated lesion anteroposterior dimension ($r = 0.824$ vs 0.607, each $p < 0.001$). Magnetic resonance/ultrasound targeted, biopsy proven cancer core length correlated with pathological cancer volume ($r = 0.773$, $p < 0.001$). The modified formula to estimate cancer volume demonstrated a stronger correlation with pathological cancer volume than with magnetic resonance estimated volume ($r = 0.824$ vs 0.724, each $p < 0.001$). Agreement of modified volume with pathological cancer volume was improved over that of magnetic resonance estimated volume on Bland-Altman plot analysis. Predictability was more enhanced in the subset of lesions with a volume of 2 ml or less (ie if spherical, the lesion was approximately 16 mm in diameter).

Conclusions: Combining magnetic resonance estimated cancer volume with magnetic resonance/ultrasound fusion, biopsy proven cancer core length improved cancer volume predictability.

Key Words: prostatic neoplasms, biopsy, magnetic resonance imaging, tumor burden, prognosis

Abbreviations and Acronyms

3D = 3-dimensional
ADC = apparent diffusion coefficient
AP = anteroposterior
DWI = diffusion weighted imaging
MCV = MRI estimated cancer volume
mp = multiparametric
MR = magnetic resonance
MRI = magnetic resonance imaging
MR/US = magnetic resonance/ultrasound
PCV = pathological cancer volume
PSA = prostate specific antigen
RP = radical prostatectomy
T2w = T2-weighted
TRUS = transrectal ultrasound

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* Financial interest and/or other relationship with EDAP.

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MULTIPARAMETRIC MRI is a highly accurate method to visualize clinically significant cancer.[1,2] Index cancer volume determined by MRI may be helpful to plan treatment, particularly to identify tumor margins for image guided focal therapy and select better candidates for active surveillance.[3] DWI is sensitive to visualization of tissue structures at the microscopic level and ADC calculated from DWI was reported to be promising to determine cancer volume.[4–8]

However, even combinations of all mp-MRI sequences often underestimate or overestimate the pathological volume of a cancer. Such inaccurate measurements have estimated moderate correlation coefficients that vary from 0.55 to 0.90 based on PCV and MRI measured lesion volume.[1,3,5–10] Therefore, improved precise estimates of cancer volume may need to consider additional parameters, which may allow for adjustments or modifications to MRI data to match more closely the actual pathological volume of a cancer.[7] Several reports have suggested that targeted biopsies using mp-MRI provide significantly greater cancer core length and higher Gleason scores for MR visible lesions than random biopsies.[11–13] They may enhance accurate risk stratification through improved cancer characterization.[14–16]

Accordingly we hypothesized that combining MRI measured volume with targeted biopsy proven cancer core length may improve our ability to estimate cancer volume. In this study using RP as the reference standard we first evaluated the accuracy of mp-MRI to estimate cancer volume in each patient in whom cancer was confirmed by MR/US fusion targeted biopsy. We then further identified a novel modification formula to improve the estimated cancer volume combined with MRI and targeted biopsy proven cancer core length, and compared that estimate with the MRI based estimation.

MATERIALS AND METHODS

This study was approved by the local institutional review board. From 2010 to 2014 we enrolled 81 consecutive patients with increased PSA who sequentially underwent certain procedures, including 1) prebiopsy MRI, 2) MR/US fusion targeted biopsy of a MRI suspicious lesion and 3) robot-assisted RP as primary treatment. Figure 1 shows a flow chart of patients in this study. The median interval between prebiopsy MRI and biopsy was 3 days (range 0 to 116), and between MRI and RP it was 52 days (range 13 to 171). The table lists the characteristics of the 81 patients. Since 7 patients each had 2 visible cancers on MRI, a total of 88 visible lesions were analyzed.

MRI was performed using a 3 Tesla MR-750 MRI scanner (GE®) and a 16-channel phased array body coil. T2w and DWI sequences were used to generate ADC maps with or without dynamic contrast enhanced MRI. Before biopsy MRI was assessed by a radiologist (SP) who had experience with reviewing prostate MR in more than 150 cases. All MR/US fusion targeted biopsies were performed with the patient under local anesthesia by an experienced urologist (OU) who had performed more than 150 cases with the Urostation®.

All RP specimens were assessed by the modified Stanford technique. The gland was cut perpendicularly every 3 to 5 mm in sections from apex to base. Both ends of the 5 to 8 mm distal section of the apex and base were

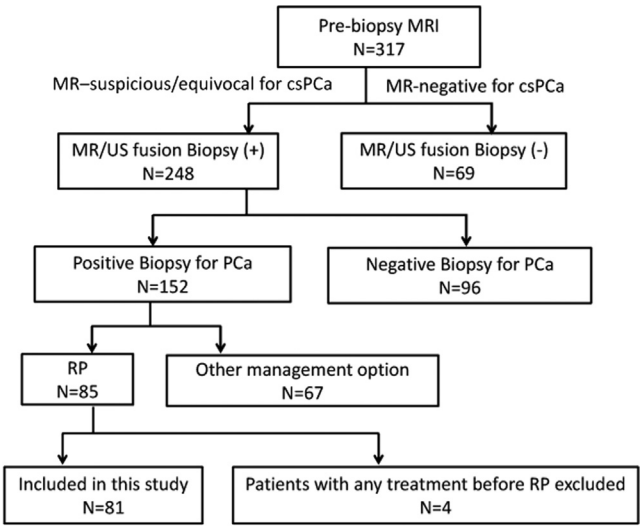

Figure 1. Number of men included in study. *cs*, clinically significant. *PCa*, prostate cancer.

Characteristics of patients and pathological characteristics of MR/US biopsy proven cancers

No. pts/No. lesions	81/88*	
Median age (range)	64	(46–83)
Median ng/ml PSA (range)	7.4	(2.2–25.0)
Median ml pathological prostate vol (range)	44.8	(18.0–137.0)
No. clinical stage (%):		
cT1c	67	(82.7)
cT2a–c	14	(17.3)
No. pathological stage (%):		
pT2a, b	11	(13.6)
pT2c	49	(60.5)
pT3a	17	(21.0)
pT3b	4	(4.9)
No. Gleason score (%):		
3 + 3	21	(23.9)
3 + 4	48	(54.5)
4 + 3	9	(10.2)
4 + 4	2	(2.3)
3 + 5	4	(4.5)
4 + 5	4	(4.5)
No. Ca location (%):		
Peripheral zone	65	(73.9)
Transition zone	23	(26.1)
PCV (ml):		
Median (range)	0.75	(0.01–8.97)
No. less than 0.2 (%)	22	(25.0)
No. 0.2–less than 0.5 (%)	12	(13.6)
No. 0.5–less than 2.0 (%)	37	(42.0)
No. 2.0 or greater (%)	17	(19.3)
Median ml MCV (range)	0.5	(0.06–6.20)

* Seven patients each had 2 MR/US fusion targeted biopsy proven lesions.