Detection and Characterization of Prostate Lesions Using Real-Time Shear Wave Elastography: A prospective, diagnostic , and bicentric study

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Disclosures

- RGB and JMC received equipment grants from SuperSonic Imagine.

Purpose

- To prospectively evaluate the diagnostic performance of real-time Shear Wave Elastography (SWE) in detecting and characterizing prostate lesions in patients with high and/or rising PSA and/or abnormal DRE.

Introduction

- Prostate Cancer is the most commonly diagnosed malignancy in men (excluding skin cancer). ~ 240,000 new cases per year in the USA.
- The screening standard has been a combination of DRE and PSA.
- Abnormality triggered a TRUS guided 12-core sextant biopsy.
- Two major drawbacks
  - Substantial number of unnecessary biopsies with no or indolent cancer
  - High false negative rate.

Introduction

- Multi-parametric MRI (MP-MRI) is increasing used for detection and staging. While MP-MRI sensitivity is high, its specificity remains low.
- Conventional TRUS has limited sensitivity and specificity.
- CEUS is currently under evaluation.

Introduction

- Shear wave elastography (SWE) recently shown promise in detection of PC
- In SWE a push pulse is used to generate shear waves within tissue. The shear wave speed is proportional to the stiffness of the tissue.
- Early studies have demonstrated a high sensitivity and specificity for detection of PC.

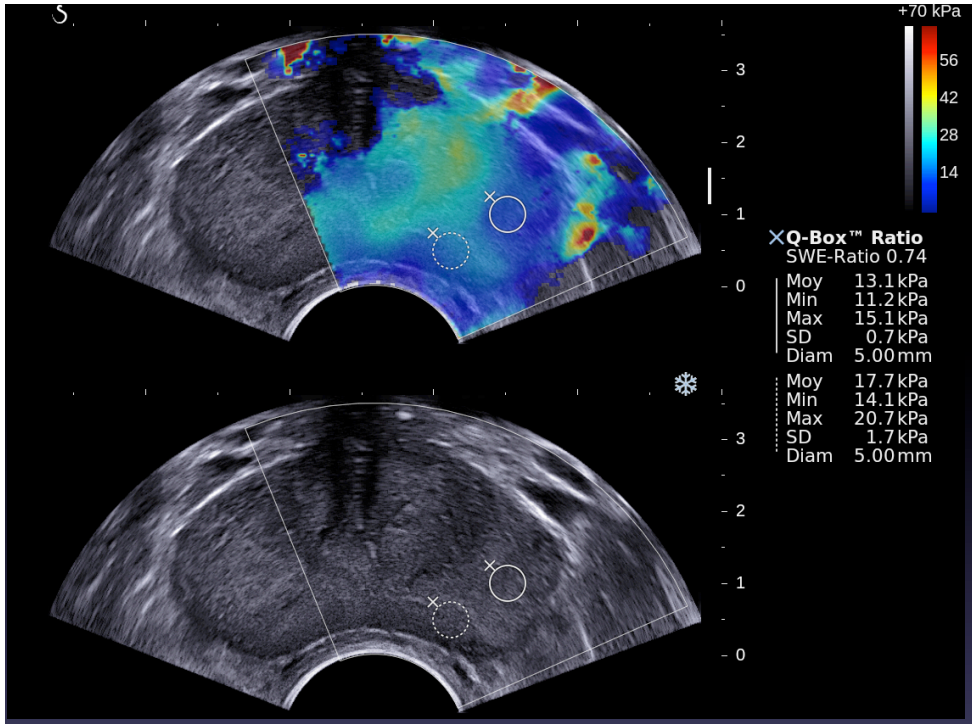
Barr RG, Memo R, Schaub CR. UQ 2012;28:13-20.

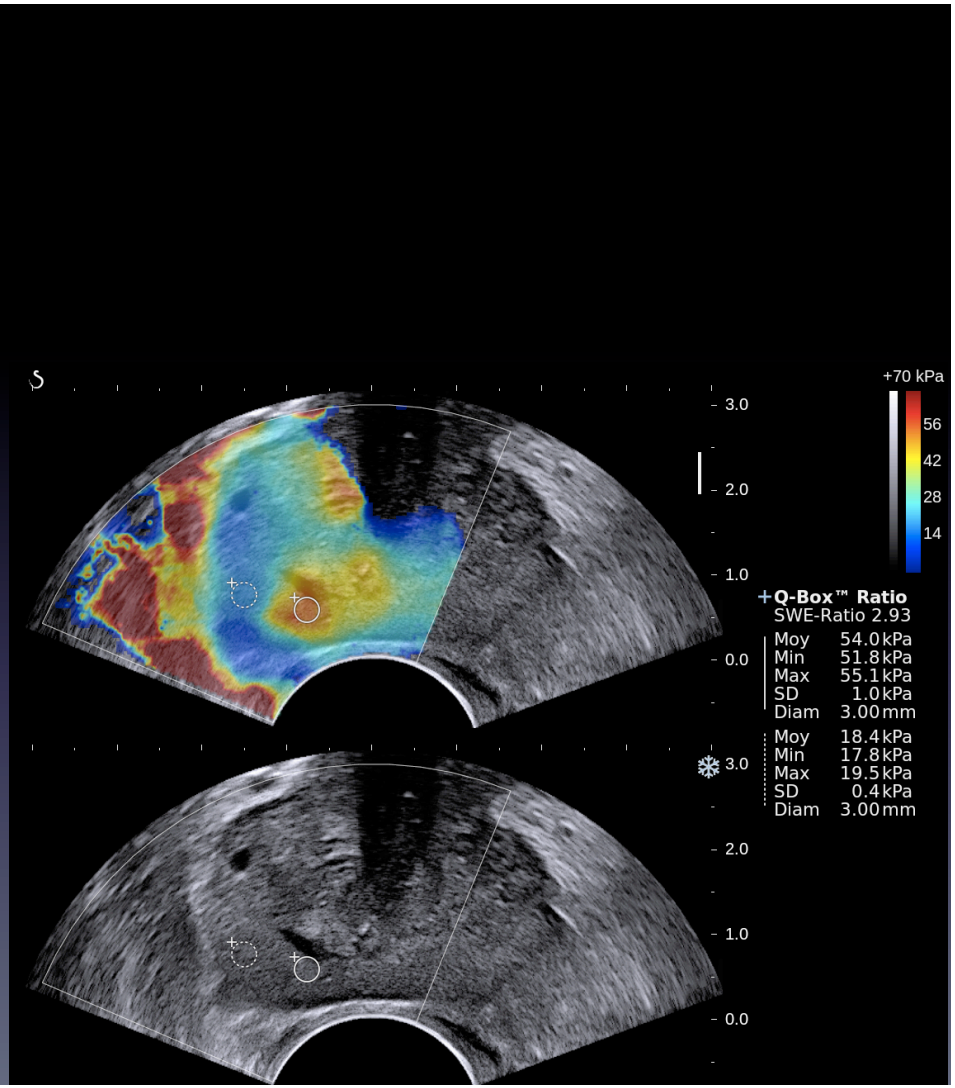
Materials and Methods

- IRB approved, HIPPA compliant
- 2 sites (Necker Hospital, Paris, FR.; Southwoods Imaging Center, Youngstown, Ohio).
- 184 patients scheduled for TRUS biopsy for abnormal PSA (>4.0)/ increasing PSA, and/or abnormal DRE
- Complete B-mode and color Doppler study of prostate
- Followed by SWE

Materials and Methods

- SWE performed with a SuperSonic Imagine US system using a SE12-3 endocavity transrectal probe.
- Exams performed by one of two radiologists with >3 years experience with SWE
- Exams performed
  - Patient in left lateral position
  - No applied pressure
  - Penetration setting
  - Scale set to max of 70-90 kPa
  - Probe held still for 3-4 sec for measurement
  - Entire gland evaluated.


+70 kPa
56
42
28
14
Q-Box™ Ratio
SWE-Ratio 0.74
Moy 13.1 kPa
Min 11.2 kPa
Max 15.1 kPa
SD 0.7 kPa
Diam 5.00 mm
Moy 17.7 kPa
Min 14.1 kPa
Max 20.7 kPa
SD 1.7 kPa
Diam 5.00 mm


+70 kPa
56
42
28
14
Q-Box™ Ratio
SWE-Ratio 2.93
Moy 54.0 kPa
Min 51.8 kPa
Max 55.1 kPa
SD 1.0 kPa
Diam 3.00 mm
Moy 18.4 kPa
Min 17.8 kPa
Max 19.5 kPa
SD 0.4 kPa
Diam 3.00 mm

Materials and Methods

- TRUS-guided biopsy performed by one of three physicians with at least 20 years experience in performing TRUS prostate biopsies.
- Biopsies performed under US guidance wit 18-gauge Tru-Cut needle
- Minimum of 12 biopsies with paramedian and lateral cores for each sextant. Additional cores taken for suspicious areas. Locations documented.

Materials and Methods

- Pathology performed for each specimen.
- Gleason score and prostatic intraepithelial neoplasia were recorded for each specimen.
- The length of each biopsy and length of adenocarcinoma tissue was recorded.

Statistical Analysis

- Continuous variables expressed as means and SD.
- The relationship between elasticity and each variable was assessed using Pearson's correlation Coeficient
- Elasticity values and elasticity ratios of malignant and benign regions were compared using unpaired Student's t-test.
- Differences among more than 3 groups were analyzed using analysis of variance (ANOVA)
- ROC curves were plotted.
- PPV, NPV, Se, Spe, and AUROC were estimated with 95% confidence levels.

Results

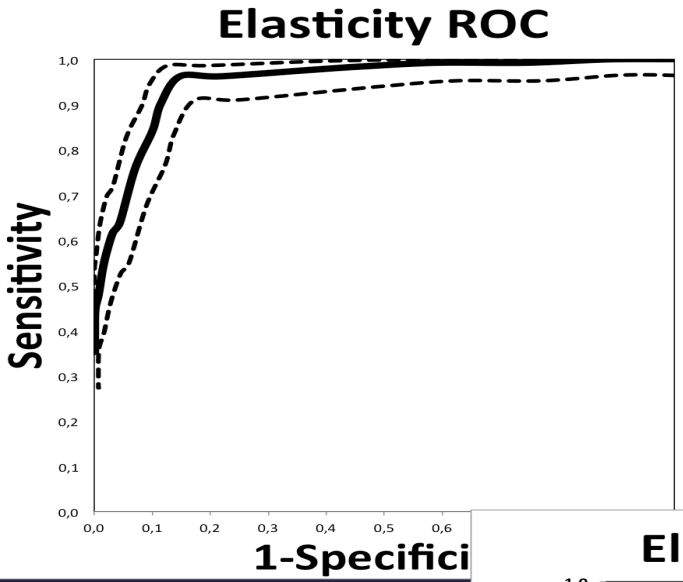
Characteristic	Overall recruitment	Center 1	Center 2	P value
Number of patients (Total; patients with cancer; Incidence %)	184; **70; 38 %**	106; **49; 46 %**	78; **21; 30 %**	0.60
Age, mean, (SD; range)	65.1 (7.6; 51-86)	65.8 (7.6; 51-86)	64.2 (7.4; 46-79)	0.15
PSA in ng / ml, mean, (SD; range)	7.4 (6.6; 0.2-60)	9.1 (7.3; 0.4-60)	4.7 (3.7; 0.2-18.6)	<0.0000001
Prostate Volume in ml, mean, (SD; range)	52 (26.4; 12.9-159)	54.9 (24.1; 15-125)	48.0 (29.1; 12.9-159)	0.09
Number of Biopsies (Systematic; targeted)	1176 (1039; 137)	703 (566; 137)	473 (473; 0)	0.46
Positive Biopsies (Systematic; targeted)	**188 (133; 55)**	**137 (82; 55)**	**49 (49; 0)**	
Negative Biopsies (Systematic; targeted)	988 (906; 82)	566 (482; 82)	424 (424; 0)	
Positive Biopsy Rate (Systematic; targeted)	**16% (15%; NA)**	**19% (15%; 40%)**	**10% (10%; NA)**	
Number of Gleason 3, 4 and 5 biopsies (Considered as non significant PC)	2	2	0	0.40
Number of Gleason 6 biopsies over 3 mm? (Systematic; targeted), % of cancer patients	**36 (33; 3NA), 19%**	**17 (14; 3), 12%**	**19 (19; 0NA), 39%**	
Number of Gleason 7 biopsies (Systematic; targeted), % of cancer patients	**132 (83; 49NA), 71%**	**97 (58; 49), 71%**	**25 (25; 0NA), 51%**	
Number of Gleason 8 biopsies (Systematic; targeted), % of cancer patients	**14 (11; 3NA), 7%**	**9 (6; 3), 7%**	**5 (5; 0NA), 10%**	
Number of Gleason 9 biopsies (Systematic; targeted) % of cancer patients	**6 (6; 0NA), 3%**	**6 (6; 0), 4%**	**0 (0; 0NA), 0%**	

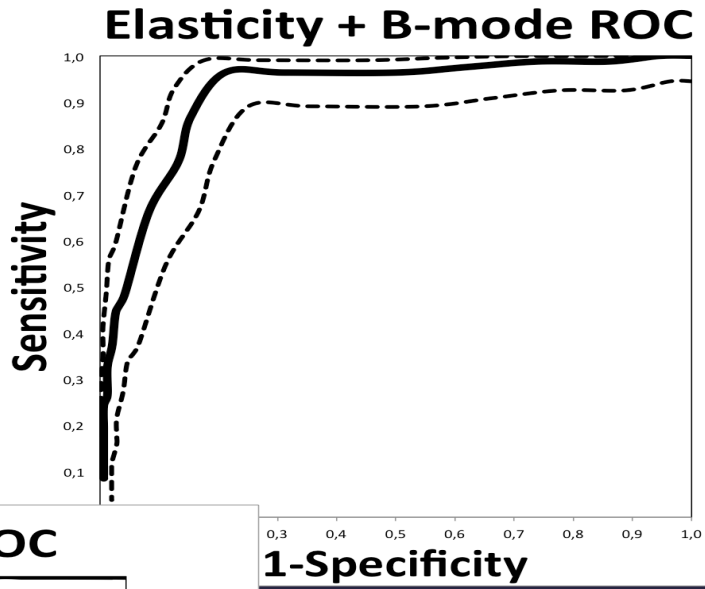
Results

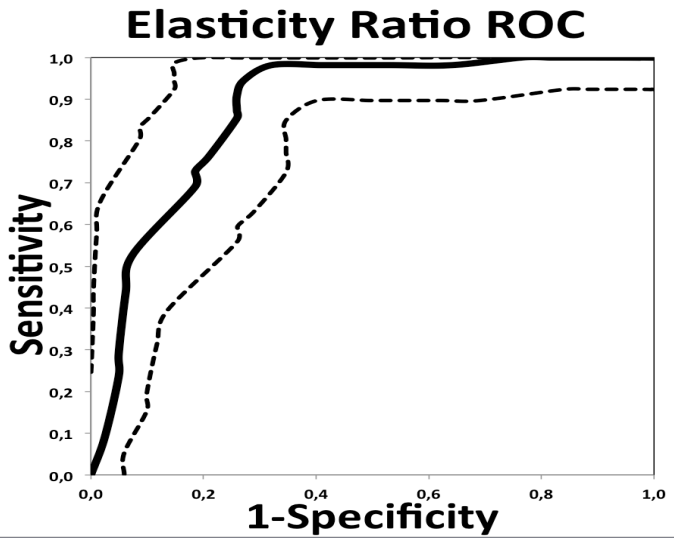
- 184 patients
- 1176 peripheral zones biopsies
  - 1039 sextants
  - 137-targeted lesions
- Positive biopsies rate of targeted biopsies 40%(55/137)
- Positive biopsy rate of sextant biopsies 15% (133/906).
- Based on ROC curves a kPa cutoff value of 35 kPa (3.42m/s) was used to differentiate benign from malignant lesions.

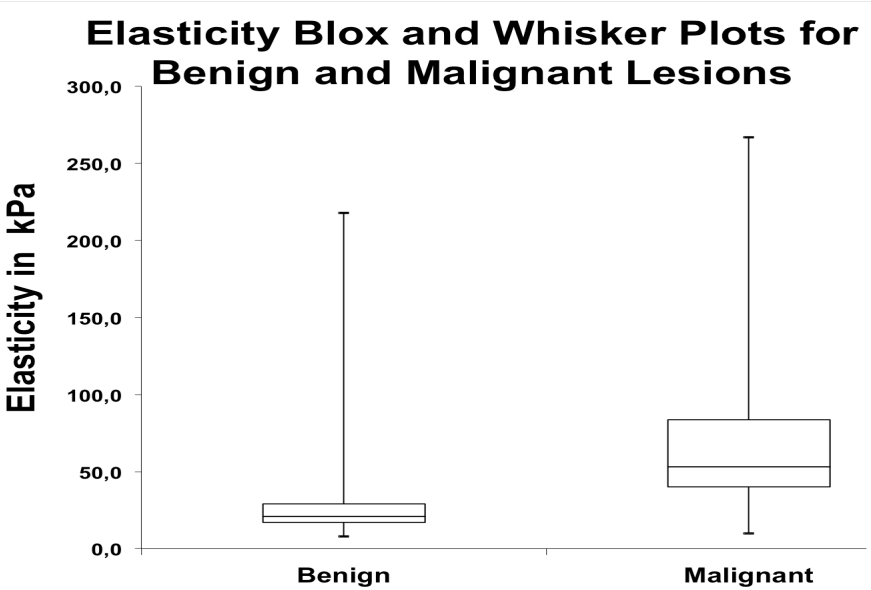
Results

	Sens	Spec	PPV	NPV	AUROC
B-mode	0.35 0.28-0.44	0.9 0.87-0.92	0.44 0.35-0.53	0.86 0.83-0.88	NA
Elasticity: 35kPa	0.95 0.91-0.99	0.85 0.83-0.87	0.44 0.39-0.51	0.99 0.98-1.00	0.95
B-mode and Elasticity	0.96 0.89-0.99	0.79 0.75-0.82	0.44 0.37-0.51	0.99 0.97-1.00	0.91
Ratio: 1.5	0.98 0.89-0.99	0.68 0.56-0.78	0.68 0.56-0.77	0.98 0.89-1.00	0.90

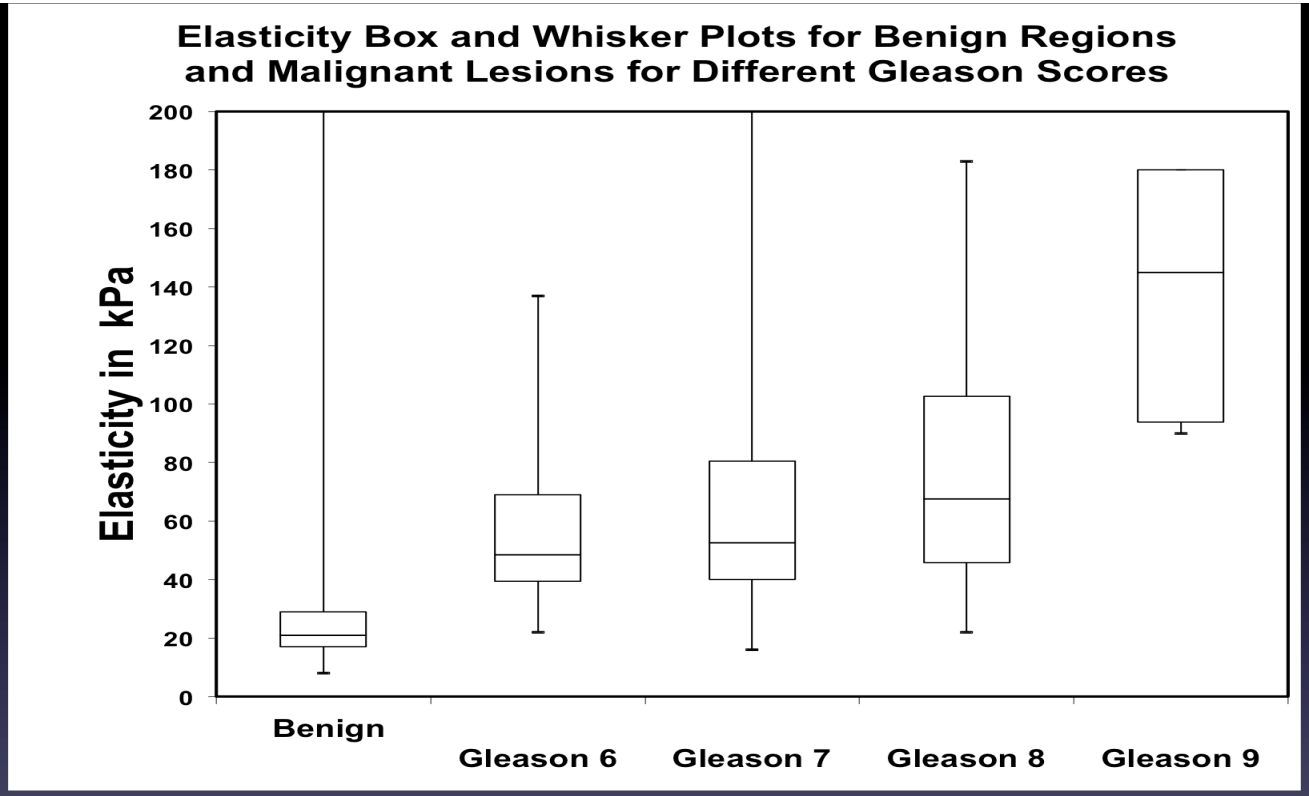

Elasticity ROC
Sensitivity
1-Specifici
1,0
0,9
0,8
0,7
0,6
0,5
0,4
0,3
0,2
0,1
0,0
0,0
0,1
0,2
0,3
0,4
0,5
0,6


Elasticity + B-mode ROC
Sensitivity
1-Specificity
1,0
0,9
0,8
0,7
0,6
0,5
0,4
0,3
0,2
0,1
0,3
0,4
0,5
0,6
0,7
0,8
0,9
1,0


Elasticity Ratio ROC
Sensitivity
1-Specificity
1,0
0,9
0,8
0,7
0,6
0,5
0,4
0,3
0,2
0,1
0,0
0,0
0,2
0,4
0,6
0,8
1,0


Elasticity Blox and Whisker Plots for Benign and Malignant Lesions
Elasticity in kPa
300,0
250,0
200,0
150,0
100,0
50,0
0,0
Benign
Malignant

Elasticity Ratio Blox and Whisker Plots for Benign and Malignant Lesions
Elasticity Ratio
10,0
9,0
8,0
7,0
6,0
5,0
4,0
3,0
2,0
1,0
0,0
Benign
Malignant



P value G6/G789	0.01
P value G67/G89	0.001
P value G678/G9	<0.0000001

Conclusions

- Shear Wave Elastography provides a high sensitivity (114/119, >95%, 95% CI: 0.91 - 0.99) for prostate cancer detection together with a very high negative predictive value (775/780, >99%, 95% CI: 0.98 - 1.00).
- Prostate Cancer stiffness increases with Gleason score and therefore are strongly linked with prostate cancer aggressiveness especially for elevated Gleason scores (≥ 7).

Conclusions

- If systematic biopsies were performed only in stiff areas detected by Shear Wave Elastography, the positive biopsy rates would have increased from 15% (133/906) to 48% (128/266).
- Shear Wave Elastography might help decrease the number of biopsies thanks to its high negative predictive value (775/780, >99%).