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ORIGINAL ARTICLE

Exploring the anatomical factors influencing testes elasticity via ultrasound shear wave elastography: Preliminary results

Yun-Yong Lin[1], Lin Mao[1], Jin Li, Zhi-Min Zhu, Yan-Hua Luo, Xiao-Hua Zhou, Shao-Dong Qiu*, Fei Chen*

Department of Ultrasound, The Second Affiliated Hospital of Guangzhou Medical University, Guangzhou 510260, China

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KEYWORDS
Shear wave elastography;
Ultrasonography;
Testes elasticity

Abstract
Purpose: The aim of this study is to evaluate the anatomical factors influencing elasticity values of normal testicular parenchyma using shear wave elastography (SWE).
Methods: This study examined 68 healthy male volunteers (117 testes in which standard transverse axis ultrasonography views could be obtained) via conventional scrotal ultrasonography and SWE. Both the mean (E_{Mean}) and standard deviation (E_{SD}) elasticity values were acquired.
Results: In the standard transverse axis view of the rete testis at the mid-lateral edge of the testes, the E_{Mean} values in 2 mm the testicular parenchyma from the rete testis and the testicular capsule at the same level as the rete testis were all significantly larger than in the central zone ($P < 0.001$, $P < 0.001$, respectively). The E_{Mean} value in the testicular parenchyma 2 mm from the testicular capsule on the line formed approximately 45° below the horizontal line of the rete testis was significantly larger than in the rete testis approximately 45° above the horizontal line ($P < 0.001$). In two standard transverse axis views, the E_{SD} values in other regions were significantly larger than those in the central zones (all $P < 0.001$). Also, the E_{Mean} values in the transmediastinal arteries were larger than those of the surrounding normal testicular parenchyma ($P < 0.001$).
Conclusion: Based on SWE, factors including the testicular capsule, the density of testicular fibrous septa, the depth of the Q-Box^{TM}, and the transmediastinal artery may influence the testes elasticity measurement.

* Corresponding authors.
E-mail addresses: qiushandongqsd@126.com (S.-D. Qiu), flylycn@126.com (F. Chen).
[1] These authors contributed equally to this study.

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PALABRAS CLAVE
Elastografia de onda de cisalhamento;
Ultrassonografia;
Elasticidade dos testículos

Exploração dos factores anatómicos que influenciam a elasticidade dos testes através da elastografia de onda de cisalhamento por ultrassons: resultados preliminares

Resumo
Objectivo: Avaliar os factores anatómicos que influenciam os valores de elasticidade do parênquima testicular normal usando a elastografia de onda de cisalhamento (SWE).
Métodos: Este estudo examinou 68 voluntários saudáveis do sexo masculino (117 testes em que foi possível obter vistas de ultrassonografia de eixo transversal padrão) através de ultrassonografia escrotal convencional e SWE. Foram adquiridos tanto os valores de elasticidade média (EMean) como de desvio-padrão (ESD).
Resultados: Na vista padrão do eixo transversal do teste rete na borda média-lateral dos testes, os valores EMean em 2 mm do parênquima testicular do teste rete e a cápsula testicular ao mesmo nível que o teste rete eram todos significativamente maiores do que na zona central ($p < 0{,}001$, $p < 0{,}001$, respectivamente). O valor EMean no parênquima testicular a 2 mm da cápsula testicular na linha formada aproximadamente 45° abaixo da linha horizontal do testículo reticular era significativamente maior do que no testículo reticular aproximadamente 45° acima da linha horizontal ($p < 0{,}001$). Em duas vistas de eixo transversal padrão, os valores ESD em outras regiões eram significativamente maiores do que os das zonas centrais (todos $p < 0{,}001$). Além disso, os valores EMean nas artérias transmediastinais eram maiores do que os do parênquima testicular normal circundante ($p < 0{,}001$).
Conclusão: Com base no SWE, factores incluindo a cápsula testicular, a densidade do septo fibroso testicular, a profundidade da Q-Box™ e a artéria transmediastinal podem influenciar a medição da elasticidade dos testículos.

Introduction

Elastography, first described by Ophir et al. (1991) for its potential application in the noninvasive assessment of the mechanical characteristics of tissues, has, in recent years, undergone rapid development.[1,2] Shear wave elastography (SWE), as one of the elastographic techniques, can quantify the modulus of elasticity or Young's modulus, which represents the stiffness of tissues. SWE has significant advantages compared with strain elastography, such as high repeatability.[3] SWE has been widely used in liver fibrosis, breast tumors, and thyroid nodules.[4,5] However, there are few studies on testicular diseases. In patients with complete testicular torsion, a higher Young's modulus was reported in the central and border areas of torsional testes than in those of normal testes.[6] Elsewhere, an experiment conducted by Zhang et al.[7] on rabbits demonstrated that the SWE method might be utilized for testicular spermatogenesis evaluation after torsion.

There is a need to elucidate the elasticity values of normal testicular parenchyma and limitations in elasticity measurements when interpreting SWE on testicular pathology. Previous studies found that the peripheral zones of normal testicular parenchyma are stiffer than the central zones. For instance, a single study reported 6.73 ± 1.27 as the strain rate between the central and peripheral zones of normal testicular parenchyma.[8] Besides, the mean values of shear wave velocity were similar in the inferior and superior parts of the testicle (1.15 m/s) but were significantly lower in the central part (0.90 m/s).[9] Measurements using elastography between normal testicular parenchyma's central and peripheral zones differ. Nevertheless, an understanding of the elasticity of testes is limited, and the mechanism of different elasticity values in different zones of normal testicular parenchyma remains unclear. Moreover, the measurement point requires standardization.[5] This prompted us to analyze anatomical factors influencing the elasticity values of normal testicular parenchyma measured by SWE.

Materials and methods

The Research Ethics Committee of our institution approved this study. Informed consent was obtained from participants before the examination.

Study participants

This study enrolled 68 healthy male volunteers (with 117 testes in which standard transverse axis ultrasonography views could be obtained). The study was conducted from May 2020 to October 2020. The standard transverse axis view of the testicle was defined as the rete testis located at the mid-lateral edge (Fig. 1A) or middle zone of the posterior lateral edge (Fig. 1B). In some parts of the testes, the above two standard transverse axis views could be obtained by changing the position of the ultrasonic probe. However, despite the change of the probe position, in the vast majority of cases, only the standard transverse axis view of the rete testis at the mid-lateral edge of the

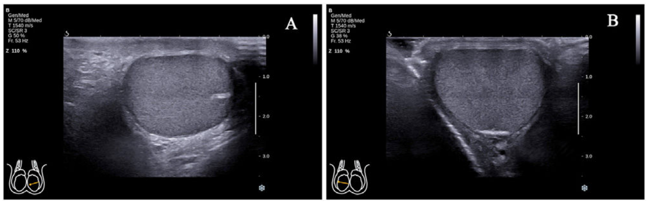

Figure 1 Standard transverse axis view of the testicle. The rete testis of the left testicle (A) is located at the mid-lateral edge. The rete testis of the right testicle (B) is located in the middle zone of the posterior lateral edge.

testes could be obtained. The exclusion criteria included: (1) presence of testicular, epididymal, or spermatic cord diseases; (2) history of testicular, epididymal, or spermatic cord diseases, including male infertility; (3) presence of sex hormone abnormality, including testosterone (TES), luteinizing hormone (LH) and follicle stimulating hormone (FSH); (4) Abnormal spermiogram data; (5) failure to obtain a standard transverse axis view regardless of the change in probe position.

Ultrasonographic examination

Volunteers were put in a supine position to perform scrotal ultrasonography (US). Images of conventional US and SWE were obtained using an Aixplorer ultrasound scanner (SuperSonic Imagine, Aix-en-Provence, France) with a 4–15 MHz linear transducer. First, we confirmed the absence of testicular, epididymal, and spermatic cord diseases and the possibility of obtaining a standard transverse axis view using conventional US. Second, the volumes of the testes were measured in three dimensions and calculated according to the formula: length × width × height × 0.523.[9] Third, SWE was performed using the penetration mode with an elasticity range of 0 to 90 kPa. The diameter of the measurement sampling box (Q-Box™; SuperSonic Imagine) was 2 mm, which we used to measure elasticity values. The locations of the Q-Box™ were as follows.

1. In the standard transverse axis view of the rete testis at the mid-lateral edge of the testes, there were (1) testicular parenchyma 2 mm from the rete testis at the same level as the rete testis (the propagation direction of the shear wave was approximately 0° with the testicular lobular septum; the following will be abbreviated as angle values; Fig. 2A); (2) testicular parenchyma 2 mm from the testicular capsule at the same level as the rete testis (0°; Fig. 2B); (3) testicular parenchyma at half of the distance from the rete testis to the testicular capsule at the same level as the rete testis (0°; Fig. 2C); (4) testicular parenchyma 2 mm from the testicular capsule on the line that formed approximately 45° below the horizontal line of the rete testis (45°; Fig. 2D); (5) testicular parenchyma 2 mm from the testicular capsule on the line that formed approximately 45° above the horizontal line of the rete testis (45°; Fig. 2E); (6) the rete testis (Fig. 2F).
2. In the standard transverse axis view of the rete testis at the middle zone of the posterior lateral edge of the testes, there was (7) testicular parenchyma at half of the distance from the rete testis to the testicular capsule on the vertical line of the rete testis (90°; Fig. 3A); (8) testicular parenchyma 2 mm from the testicular capsule on the line that formed approximately 45° to the right side of the vertical line of the rete testis (45°; Fig. 3B); (9) testicular parenchyma 2 mm from the testicular capsule on the line that formed approximately 45° to the left side of the vertical line of the rete testis (45°; Fig. 3C); (10) the rete testis (Fig. 3D).

A trained sonographer with three years of experience conducted all US examinations. Without any compression on the scrotal surface, the Q-Box™ was maintained at the above positions for at least 3 s to generate stable elastic images. Both the E_{Mean} and E_{SD} values were recorded. Two experienced sonographers analyzed the US images (with 5 and 15 years' experience) in consensus. Notably, the values of the E_{Mean} and E_{SD} represented the averages of three Q-Box™ measurements at each position.

Statistical analysis

All statistical data were analyzed using SPSS 18.0 software (IBM, Armonk, NY, USA). Continuous variables were expressed as mean ± standard deviation (SD) or median and interquartile range where appropriate. Continuous parameters were checked for the normality of distribution using the Shapiro–Wilk test and compared using the unpaired *t*-test or Mann–Whitney *U* test with normal and non-normal distributions, respectively. The association of the testicular volume with the E_{Mean} value in the central zones of normal testes was evaluated using regression analysis. Furthermore, Spearman's rank correlation coefficient was used to evaluate the association between the two groups. $P < 0.05$ was considered statistically significant.

Results

Characteristics of study participants

A total of 68 healthy male volunteers aged 19–57 years (median age, 28.00; interquartile range, 25.25–32.50) were included in the analysis. This study excluded 19 testes that failed to show a standard transverse axis view despite changing the probe position; thus, 117 normal testes (left testicle, $n = 55$; right testicle, $n = 62$) were included. Hormone profile and spermiogram data of study participants are shown in Table 1. The testes were symmetric ovoid structures with medium homogeneous echogenicity and no hydrocele. Color Doppler showed the star-like or cord-like blood flow in the testes. The spectral waveform of the intratesticular arteries characteristically had a normal low-resistance pattern. Among them, in 28 testes, we obtained two standard transverse axis views by changing the position of the ultrasonic probe, whereas in 76 testes, only the standard transverse axis view of the rete testis at the mid-lateral edge of the testes was acquired. Additionally, in 13 testes, only the standard transverse axis view of the rete testis at the middle zone of the posterior lateral edge was obtained.

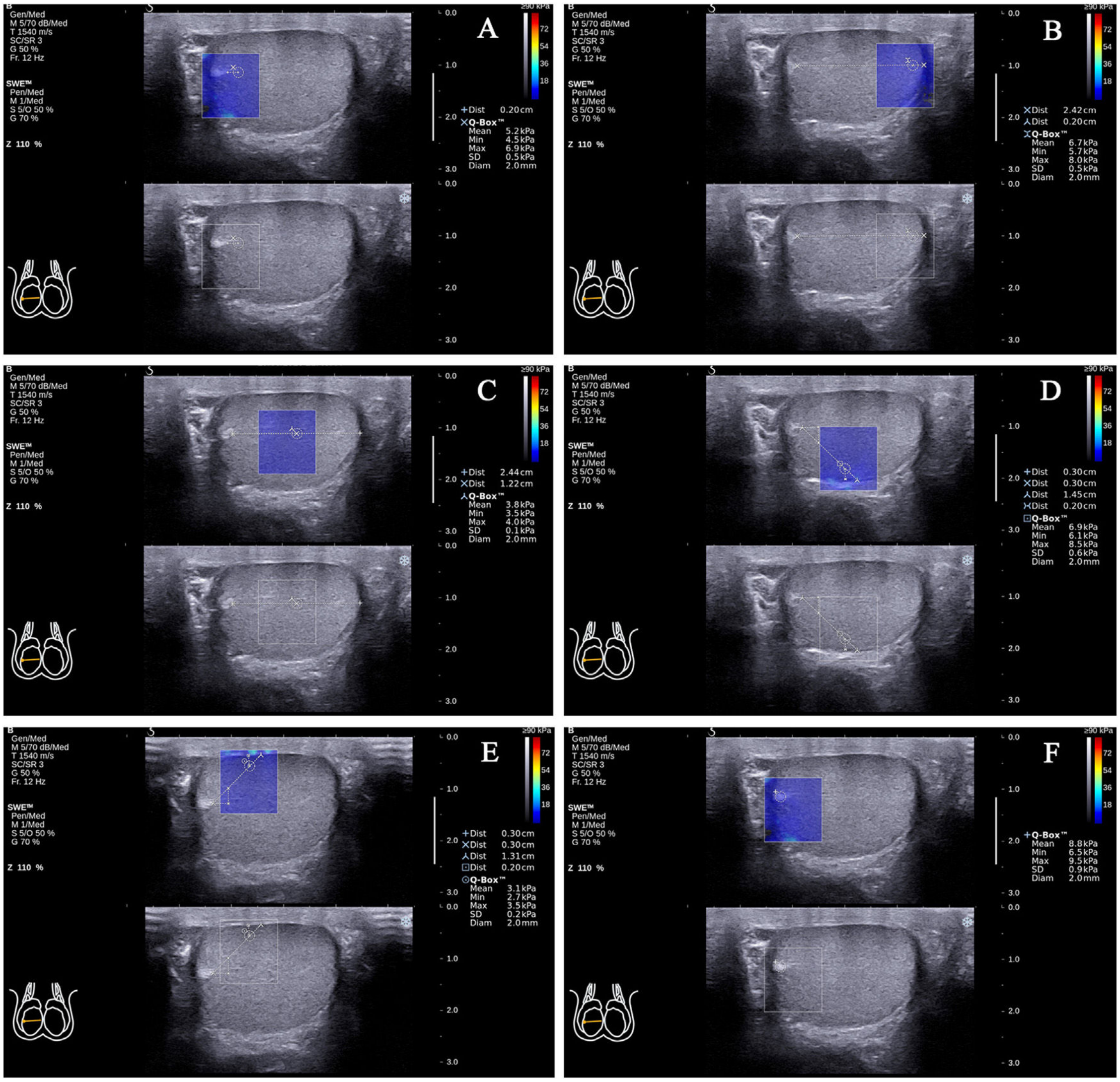

Figure 2 The locations of the Q-Box^{TM} in the standard transverse axis view of the rete testis at the mid-lateral edge of the right testicle. The location of the Q-Box^{TM} (A) is testicular parenchyma 2 mm from the rete testis at the same level as the rete testis. The location of the Q-Box^{TM} (B) is testicular parenchyma 2 mm from the testicular capsule at the same level as the rete testis. The location of the Q-Box^{TM} (C) is testicular parenchyma at half of the distance from the rete testis to the testicular capsule at the same level as the rete testis. The location of the Q-Box^{TM} (D) is testicular parenchyma 2 mm from the testicular capsule on the line that formed approximately 45° below the horizontal line of the rete testis. The location of the Q-Box^{TM} (E) is testicular parenchyma 2 mm from the testicular capsule on the line that formed approximately 45° above the horizontal line of the rete testis. The location of the Q-Box^{TM} (F) is the rete testis.

SWE measurements in different zones of normal testes

Elasticity values in different zones of normal testes measured by SWE are summarized in Table 2. In the standard transverse axis view of the rete testis at the mid-lateral edge of the testes, the E_{Mean} values in regions 1, 2, and 6 were significantly larger than those in region 3 (5.00 ± 1.15 versus 2.97 ± 0.59 kPa, 5.05 ± 1.13 versus 2.97 ± 0.59 kPa, 10.07 ± 2.52 versus 2.97 ± 0.59 kPa; P < 0.001, P < 0.001, P < 0.001, respectively). The E_{Mean} value in region 4 was significantly larger than in region 5 (6.29 ± 1.26 versus 4.66 ± 0.73 kPa; P < 0.001). Compared with region 3, the values of E_{SD} in other regions, including regions 1, 2, 4, 5, and 6 were significantly larger (0.60 [0.30–0.80] versus 0.20 [0.10–0.20] kPa, 0.50 [0.40–0.80] versus 0.20 [0.10–0.20] kPa, 1.20 [0.80–1.58] versus 0.20 [0.10–0.20] kPa, 0.60 [0.40–1.08] versus 0.20 [0.10–0.20] kPa, 1.75 [0.83–2.30] versus 0.20 [0.10–0.20] kPa; P < 0.001, P < 0.001, P < 0.001, P < 0.001, P < 0.001, respectively).

In the standard transverse axis view of the rete testis at the middle zone of the posterior lateral edge of the testes, the E_{Mean} value in region 10 was significantly larger than in region 7 (12.88 ± 2.73 versus 2.92 ± 0.53 kPa; P < 0.001). No significant difference in the E_{Mean} value was reported between regions 8 and 9 (5.91 ± 1.08 versus 5.45 ± 1.47 kPa; P = 0.107). Compared with region 7, the E_{SD} values in other

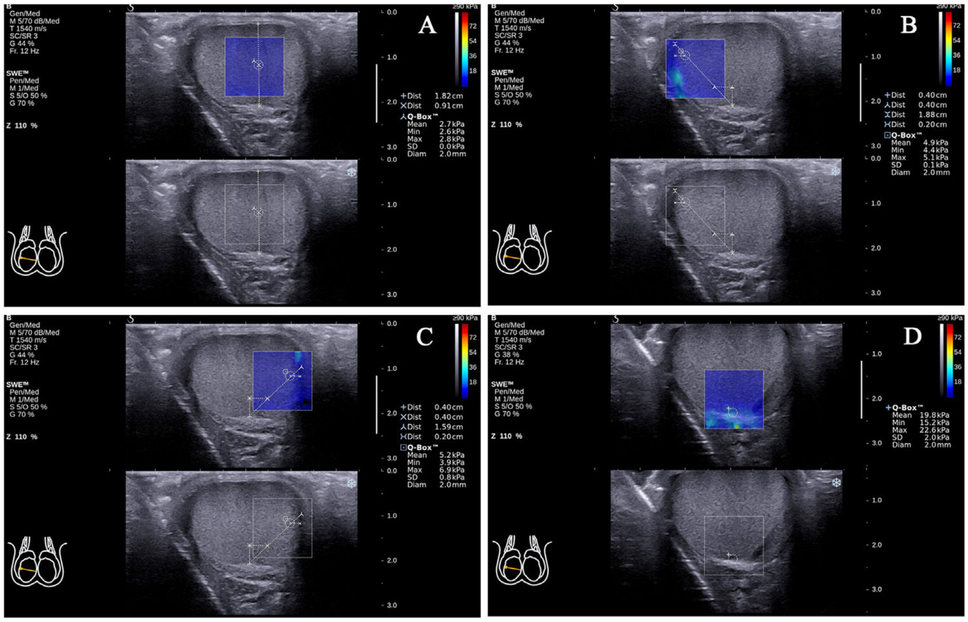

Figure 3 The locations of the Q-Box^{TM} in the standard transverse axis view of the rete testis at the middle zone of the posterior lateral edge of the right testicle. The location of the Q-Box^{TM} (A) is testicular parenchyma at half of the distance from the rete testis to the testicular capsule on the vertical line of the rete testis. The location of the Q-Box^{TM} (B) is testicular parenchyma 2 mm from the testicular capsule on the line that formed approximately 45° to the right side of the vertical line of the rete testis. The location of the Q-Box^{TM} (C) is testicular parenchyma 2 mm from the testicular capsule on the line that formed approximately 45° to the left side of the vertical line of the rete testis. The location of the Q-Box^{TM} (D) is the rete testis.

Table 1 Hormone profile and spermiogram data of study participants.

Characteristic	Study participants	Normal reference interval
n	68	...
Hormone profile		
TES, nmol/L	20.65 (19.52–21.62)	5.54–25.17
LH, U/L	2.60 (1.85–3.25)	0.8–7.6
FSH, U/L	2.86 (2.03–3.99)	0.7–11.1
Spermiogram data		
Semen volume, ml	3.33 (2.97–3.87)	2–5
PH	7.6 (7.5–7.7)	7.2–8.0
Sperm motility (A + B)	59.68 (57.09–63.71)	≥50%
Sperm concentration, mil/ml	65.79 (57.86–85.95)	>20
Defective sperm rate	12 ± 4	≤30%
Liquefaction, min	18 (12–25)	<40

Data are expressed as mean ± SD or median (interquartile range). TES indicates testosterone; LH, luteinizing hormone; FSH, follicle stimulating hormone; PH, potential of hydrogen; A, grade A ratio; B, grade B ratio; mil, million.

regions, including regions 8, 9, and 10, were significantly larger (0.90 [0.55–1.10] versus 0.20 [0.10–0.30] kPa, 0.60 [0.40–0.80] versus 0.20 [0.10–0.30] kPa, 0.90 [0.65–1.40] versus 0.20 [0.10–0.30] kPa; $P < 0.001$, $P < 0.001$, $P < 0.001$, respectively).

In addition, the E_{Mean} value in region 3 in the standard transverse axis view of the rete testis at the mid-lateral edge of the testes was comparable with region 7 in the standard transverse axis view of the rete testis at the middle zone of the posterior lateral edge of the testes (2.97 ± 0.59 versus 2.92 ± 0.53 kPa; $P = 0.625$). The E_{Mean} value in region 10 was significantly larger than in region 6 (12.88 ± 2.73 versus 10.07 ± 2.52 kPa; $P < 0.001$).

During the SWE examination, there were 25 cases of standard transverse axis views that showed a transmediastinal artery entering through the mediastinum and coursing toward the periphery of the testicular gland (25/117, 21.4%; Fig. 4A, B). The E_{Mean} value in the transmediastinal arteries was larger than in the surrounding normal testicular parenchyma (9.51 ± 3.79 versus 4.16 ± 1.21 kPa; $P < 0.001$).

Table 2 Elasticity values in different zones of normal testes.

Standard transverse axis view	The locations of the Q-Box™	n	E_{Mean} (kPa)	E_{SD} (kPa)
The rete testis located at mid-lateral edge	Region 1	104	5.00 ± 1.15*	0.60 (0.30–0.80)*
	Region 2	104	5.05 ± 1.13*	0.50 (0.40–0.80)*
	Region 3	104	2.97 ± 0.59	0.20 (0.10–0.20)
	Region 4	104	6.29 ± 1.26†	1.20 (0.80–1.58)*
	Region 5	104	4.66 ± 0.73	0.60 (0.40–1.08)*
	Region 6	104	10.07 ± 2.52*	1.75 (0.83–2.30)*
The rete testis located at middle zone of the posterior lateral edge	Region 7	41	2.92 ± 0.53	0.20 (0.10–0.30)
	Region 8	41	5.91 ± 1.08	0.90 (0.55–1.10)§
	Region 9	41	5.45 ± 1.47	0.60 (0.40–0.80)§
	Region 10	41	12.88 ± 2.73‡,§	0.90 (0.65–1.40)§

Data are expressed as mean ± SD or median (interquartile range).
Region 1: Testicular parenchyma 2 mm from the rete testis at the same level as the rete testis.
Region 2: Testicular parenchyma 2 mm from the testicular capsule at the same level as the rete testis.
Region 3: Testicular parenchyma at half of the distance from the rete testis to the testicular capsule at the same level as the rete testis.
Region 4: Testicular parenchyma 2 mm from the testicular capsule on the line that formed approximately 45° below the horizontal line of the rete testis.
Region 5: Testicular parenchyma 2 mm from the testicular capsule on the line that formed approximately 45° above the horizontal line of the rete testis.
Region 6: The rete testis.
Region 7: Testicular parenchyma at half of the distance from the rete testis to the testicular capsule on the vertical line of the rete testis.
Region 8: Testicular parenchyma 2 mm from the testicular capsule on the line that formed approximately 45° to the right side of the vertical line of the rete testis.
Region 9: Testicular parenchyma 2 mm from the testicular capsule on the line that formed approximately 45° to the left side of the vertical line of the rete testis.
Region 10: The rete testis.
* $P < 0.001$ vs Region 3.
† $P < 0.001$ vs Region 5.
‡ $P < 0.001$ vs Region 6.
§ $P < 0.001$ vs Region 7.

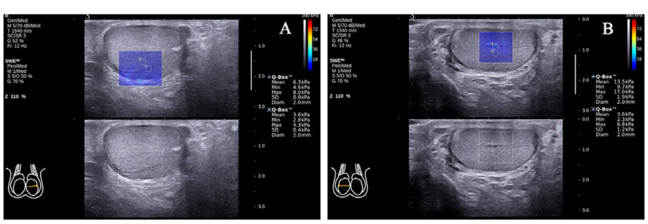

Figure 4 Transmediastinal arteries in two standard transverse axis views. The E_{Mean} value in the transmediastinal artery of the left testicle (A) was larger than the surrounding normal testicular parenchyma (6.30 versus 3.60 kPa). The E_{Mean} value in the transmediastinal artery of the right testicle (B) was larger than the surrounding normal testicular parenchyma (13.50 versus 3.60 kPa).

The association between the testicular volume and SWE measurement in the central zones of normal testes

Measurements of the diameter and volume of testes are shown in Table 3. We reported no correlation between the testicular volume and the E_{Mean} value in the central zones of all normal testes ($r = -0.034$, $P = 0.719$).

Discussion

Following previous reports, the peripheral zones of normal testicular parenchyma were stiffer than the central zones.[8,9] However, the mechanism of different elasticity values in various zones of normal testicular parenchyma is still unclear. In this study, through assessment and comparison of the elasticity values in different zones in the standard transverse axis views of normal testes using SWE, we could reveal the anatomical factors influencing the elasticity values of normal testicular parenchyma.

In the standard transverse axis view of the rete testis at the mid-lateral edge of the testes, the E_{Mean} value in the testicular parenchyma 2 mm from the testicular capsule at the same level as the rete testis was significantly larger than the testicular parenchyma at half of the distance from the rete testis to the testicular capsule at the same level as the rete testis. In these two regions, both the depth and angle between the propagation direction of the shear wave and the testicular lobular septum (approximately 0°) were approximately the same. This study, therefore, suggests that the testicular capsule critically influences the elasticity values of normal testicular parenchyma, and the normal testicular parenchyma is stiffer in the subcapsular area.

Table 3 Measurements of diameter and the volume of testes.

	n	L (cm)	W (cm)	H (cm)	V (cm^3)
Right testes	62	4.03 ± 0.31	2.61 ± 0.32	1.85 ± 0.28	9.63 (8.23–11.49)
Left testes	55	3.93 ± 0.34	2.58 ± 0.27	1.92 ± 0.28	10.20 (8.56–11.61)
All testes	117	3.98 ± 0.33	2.59 ± 0.29	1.88 ± 0.28	10.00 (8.47–11.51)

Data are expressed as mean ± SD or median (interquartile range). L, length; W, width; H, height; and V, volume. V is calculated according to the formula: $L \times W \times H \times 0.523$.

Besides, in the standard transverse axis view of the rete testis at the mid-lateral edge of the testes, the E_{Mean} value in the testicular parenchyma 2 mm from and at the same level as the rete testis was significantly larger than in the testicular parenchyma at the same level as and at half of the distance from the rete testis to the testicular capsule. The rete testis is a network of epithelium-lined spaces embedded in the fibrous stroma of the mediastinum. Notably, numerous fibrous septa radially extend into the testis from the mediastinum, splitting it into around 250–400 lobules, each composed of 1–3 seminiferous tubules.[10] The E_{Mean} value in the rete testis was also significantly larger than in the testicular parenchyma at the same level and at half of the distance from the rete testis to the testicular capsule. This observation concurs with the previously reported findings.[11] Thus, the current study suggests that the elasticity values of normal testicular parenchyma may be affected by the density of testicular fibrous septa; the closer the rete testis, the denser the testicular fibrous septa and the stiffer the testicular parenchyma.

In the standard transverse axis view of the rete testis at the middle zone of the posterior lateral edge of the testes, we found no significant difference in the E_{Mean} values between testicular parenchyma 2 mm from the testicular capsule on the line that formed approximately 45° to the right side of the vertical line of the rete testis and that formed approximately 45° to the left side of the vertical line of the rete testis. However, in the standard transverse axis view of the rete testis at the mid-lateral edge of the testes, the E_{Mean} value in the testicular parenchyma 2 mm from the testicular capsule on the line that formed approximately 45° below the horizontal line of the rete testis was significantly larger than in the testicular parenchyma 2 mm from the testicular capsule on the line that formed approximately 45° above the horizontal line of the rete testis. The propagation directions of the shear wave in these 4 regions were all approximately 45° with the testicular lobular septum. In addition, the E_{Mean} value in the rete testis in the standard transverse axis view of the rete testis at the middle zone of the posterior lateral edge of the testes was significantly larger than in the rete testis in the standard transverse axis view of the rete testis at the mid-lateral edge of the testes. Therefore, this study suggests the depth of the Q-Box™ may affect the elasticity values of normal testicular parenchyma. However, further investigation should clarify how depth influences elasticity values of normal testicular parenchyma measured by SWE.

Based on a previous study, the median stiffness value in the mid-region of the kidney (shear wave 90° to the pyramid axis) was significantly lower than at the upper pole of the kidney (shear wave 0° to the pyramid axis).[12] However, in this study population, we report no significant difference in the E_{Mean} values between the central zones in two standard transverse axis views. The propagation direction of the shear wave in the central zone in the standard transverse axis view of the rete testis at the mid-lateral edge of the testes was approximately 0° with the testicular lobular septum. Whereas that of the standard transverse axis view of the rete testis at the middle zone of the posterior lateral edge of the testes was approximately 90°. This observation reveals that the angle between the propagation direction of the shear wave and the testicular lobular septum in the central zone of normal testicular parenchyma was not significantly correlated with the elasticity values.

In two standard transverse axis views, the E_{SD} values in other regions were significantly larger than those in the central zones. Thus, this study suggests that the measurement of elasticity values in the central zones is the most stable and reproducible. Besides, the E_{Mean} values in the transmediastinal arteries were larger than those of the surrounding normal testicular parenchyma. Therefore, the elasticity measurement of diffuse testicular lesions should choose the central zones and avoid the transmediastinal artery.

In this study population, no correlation between the testicular volume and the E_{Mean} values in the central zones of normal testes was reported, an observation that is consistent with a previous study.[9] This may have been attributed to the idea that our study population only includes adults but no children (children have immature and small-sized testes that may affect SWE measurements). Therefore, further investigation should clarify how immature testicular volume influences elasticity values of normal testicular parenchyma measured by SWE.

There were some limitations to this study. First, a relatively limited study population was evaluated. Second, the present study could not provide histological data to explain the results but only inferred. Third, this study was conducted using one type of commercially available equipment; thus, the results might vary according to the type of equipment and algorithm used for elastography. Fourth, a single US examiner may represent bias. Finally, we did not analyze which factor had the greatest influence on the elasticity measurements of normal testicular parenchyma.

Conclusion

This study demonstrated that the testicular capsule, density of testicular fibrous septa, depth of the Q-Box™, and the transmediastinal artery are potential factors influencing testes' elasticity measured by SWE. These factors should be considered in the elasticity measurement of focal testicular lesions. Moreover, the elasticity measurement of diffuse testicular lesions should choose the central zone and avoid the transmediastinal artery.

Ethical disclosures

Protection of human and animal subjects. The authors declare that no experiments were performed on humans or animals for this study.

Confidentiality of data. The authors declare that they have followed the protocols of their work center on the publication of patient data.

Right to privacy and informed consent. The authors have obtained the written informed consent of the patients or subjects mentioned in the article. The corresponding author is in possession of this document.

Authors' contributions

Conception and design of the research: Shao-Dong Qiu, Fei Chen.

Acquisition of data: Yun-Yong Lin, Lin Mao, Jin Li, Zhi-Min Zhu, Yan-Hua Luo.

Analysis and interpretation of the data: Yun-Yong Lin, Shao-Dong Qiu, Fei Chen.

Statistical analysis: Yun-Yong Lin, Jin Li, Fei Chen.

Obtaining financing: None.

Writing of the manuscript: Yun-Yong Lin, Lin Mao, Shao-Dong Qiu, Fei Chen.

Critical revision of the manuscript for intellectual content: Xiao-Hua Zhou, Yun-Yong Lin, Fei Chen.

All authors read and approved the final draft.

Ethics approval

This study was conducted with approval from the Ethics Committee of The Second Affiliated Hospital of Guangzhou Medical University. This study was conducted in accordance with the declaration of Helsinki.

Consent for publication

All participants signed a document of informed consent.

Availability of data and materials

We declared that materials described in the manuscript, including all relevant raw data, will be freely available to any scientist wishing to use them for non-commercial purposes, without breaching participant confidentiality.

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Conflict of interests

The authors declare that they have no competing interests.

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