UDC 616.65-006.6-073.4

Elements of shear wave elastography classification at prostate cancer

V.F. Korobko

SI "Institute of Nuclear Medicine and Diagnostic Radiology of NAMSof Ukraine"

Prostate cancer is still one of the leading problems in oncourology [1]. Visual methods for malignant tumors of this localization detection are still insufficient in sensitivity and specificity, that requires the search for new approaches to improve this disease diagnostics.

One of such methods is elastography with the possibility to determine the rigidity of prostate pathologically altered areas and to compare it with the elastic properties of healthy tissues [2]. It is known that malignant tumors in most cases have higher rigidity than the unaffected parenchyma of the organ. Currently, 2 types of elastography are applied: compression elastography and shear wave elastography. The first method is based on mechanical pressure on the zone of interest with subsequent evaluation of the objects' compressibility under the probe. It is the compression elastography that is mostly often applied to determine the elastic properties of focal lesions of various organs, including prostate [3, 8].

The second method – shear wave elastography – measures the mechanical wave induced by the probe velocity spreading. As more rigid areas conduct the wave much faster, then the wave's speed can be applied for the evaluation of the elastic properties of organs and tissues. Shear wave elastography method found wide application in the diagnosis of diffuse liver diseases and became the alternative to puncture biopsy for the hepatic fibrosis stage determination. In prostate diseases rigidity measurement with shear wave is used much less often [7].

The aim of the study – to study the possibilities of shear wave elastography in prostate malignant tumors.

Material and investigation methods

18 patients aged from 54 to 72 years with established diagnosis of prostate cancer were investigated. The parameters of the prostate-specific antigen (PSA) of the blood were in the range of 9-24 U/l. To confirm the diagnosis, 11 patients underwent puncture biopsy.

All patients underwent prostate US examination by transabdominal and transrectal access with color and energy Doppler. Both methods of elastography were applied on the ultrasound scanner RADMIR "ULTIMA" to study pancreas elastic properties. Elastograms with "well-established" image were considered the most correct, with a relative error in the control window of no more than 15%. At the same time, it was necessary to make the comparison with gray-scale image in order to exclude the influence of calcification, fibrosis foci, etc. on the elastography parameters. When high-rigidity zones were detected, a comparison with symmetrical area of the opposite lobe was fulfilled (Fig. 1).

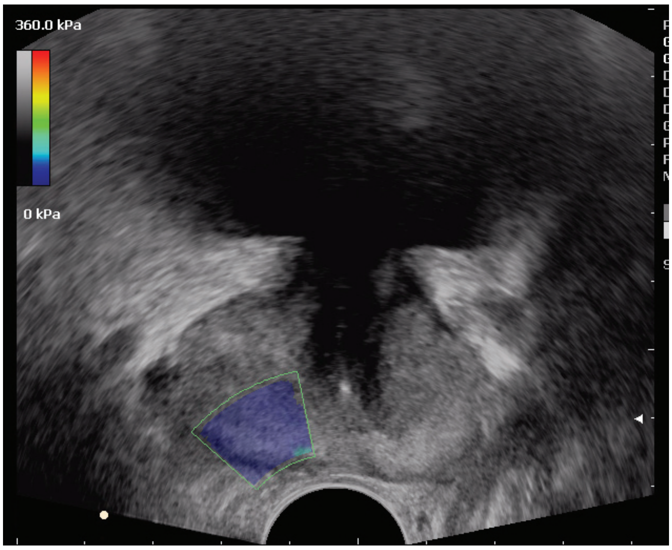

Fig. 1. *Shear wave elastogram of the normal prostate.*

Results and their discussion

Since pancreas malignant tumors in most cases have poor compressibility during compression and high shear wave velocity, then on the elastograms they are encoded as zones of increased rigid-

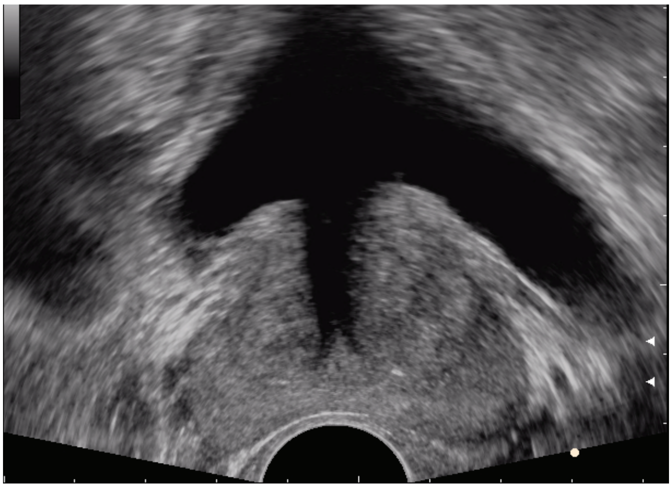

Fig. 2. *Prostate echogram at transrectal gray-scale US. Signs of moderately expressed benign prostatic hyperplasia. Visible focal pathology is absent.*

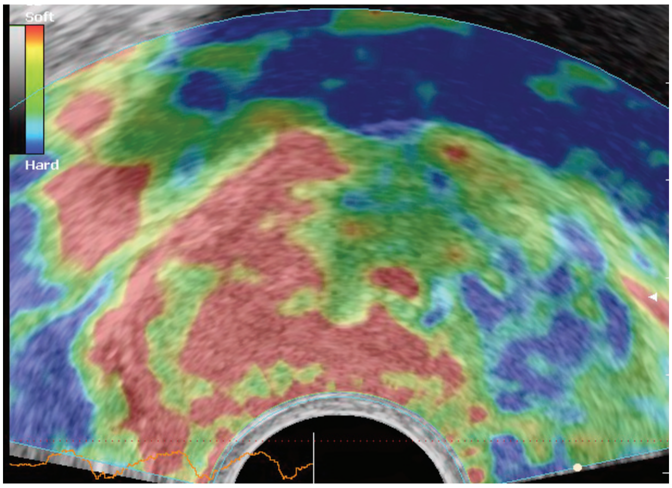

Fig. 3. *Compression elastography demonstrates in prostate right lobe the site of increased rigidity, charted in blue.*

ity. Among 18 patients investigated in grey-scale mode, 11 had typical ultrasound tumor picture with hypoechoic area in the peripheral zone (61 %). In 2 patients, the tumor node was determined in the transition zone, that caused the difficulty in data interpretation in terms of differential diagnosis with benign prostate hyperplasia. In 5 (27%) investigated patients, the ultrasound picture differed little from the normative one and did not allow to suspect convincingly the prostate cancer.

With application of compression elastography, prostate neoplasm was diagnosed in 15 patients (83 %). In shear wave elastography mode, malignant tumor was detected in 16 patients (88 %). As the result of shear wave elastograms analysis, three types of images characteristic for prostate cancer were identified.

The first type of shear wave elastograms was characterized by the appearance of high rigidity areas, charted in red (at compression elastography such areas are traditionally charted in blue). The Young's modulus of rigidity was in the range of 158-330 kPa. The healthy parenchyma stiffness of the prostate was 48-79 kPa. In the presence of fibrosis, the Young's modulus reached 82-98 kPa. High rigidity appeared in calcification foci – from 90 to 220 kPa. The first type of elastogram was established in 13 patients (72 %).

Clinical observation 1. Patient K., 64 years, was directed for investigation by urologist because of the increased PSA level to 12 U/l (Fig. 2-5).

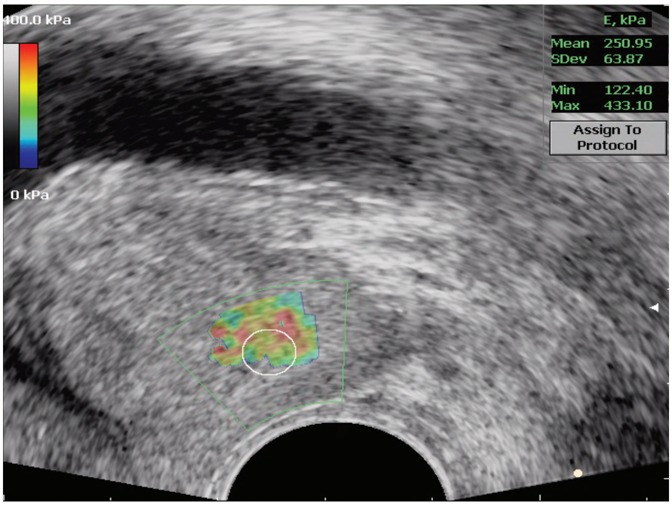

Fig. 4. *Shear wave elastography in prostate right lobe demonstrates high rigidiry area (red color), 250 kPa.*

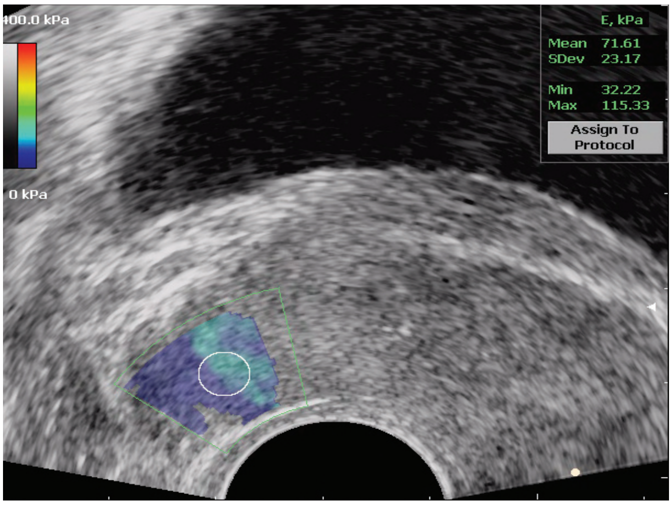

Fig. 5. *Shearing wave elastography of the healthy prostate left lobe shows the normal rigidity of the parenchyma (blue-blue color), 71 kPa.*

Clinical observation 2. Patient B., 54 years old, PSA level is 9 U/l (Figure 6, 7)

The second type of shear wave elastograms was determined in patients with very high rigidity of the tumor node, when the shear wave is not capable to cause the affected tissue deformation, so it was not stained on the monitor. In such cases, the symptom of a “black hole” or “bitten apple” appears [4]. The symptom of the “black hole” was also described in breast cancer [2].

Clinical observation 3 (Fig. 8-9).

Clinical observation 4. This elastographic type was observed in 3 patients (17 %) (Fig. 10).

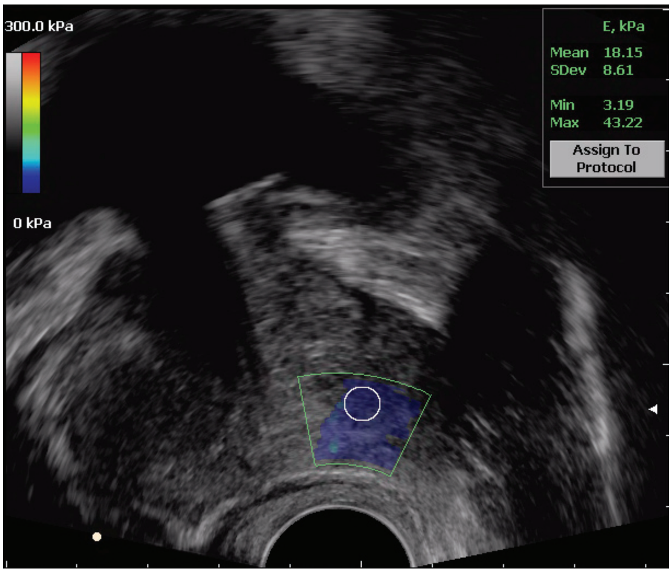

Fig. 6. *Shear wave elastography of the prostate right lobe demonstrates the organ tissue rigidity (blue),18 kPa.*

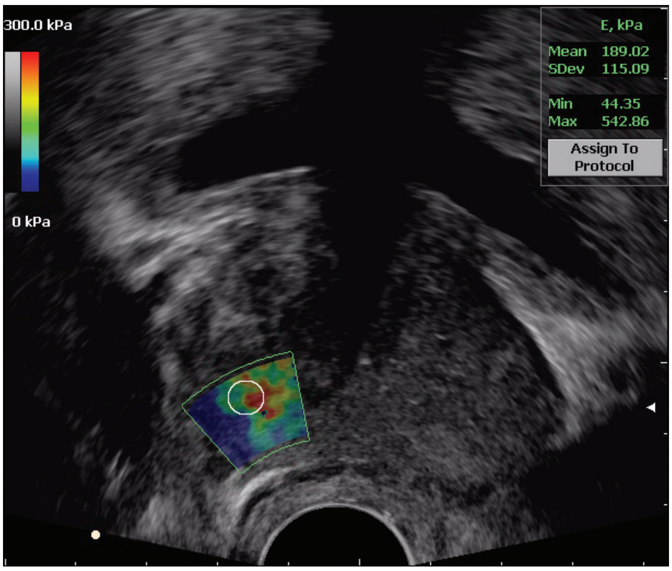

Fig. 7. *Shear wave elastography in the prostate left lobe shows high rigidity area (red), 189 kPa.*

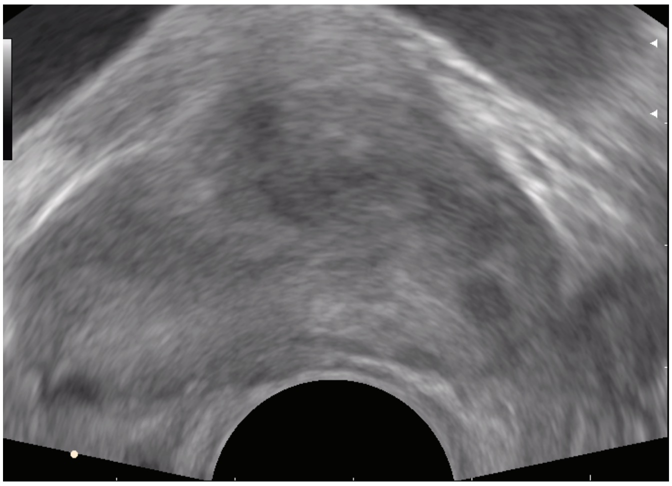

Fig. 8. *Solitary hypoechogenic node is identified in the right lobe.*

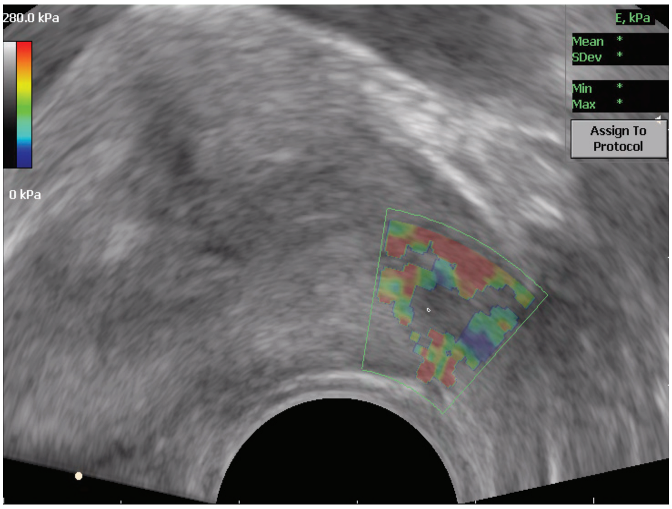

Fig. 9. *In shear wave mode, the colored pixels in the affected area are not detected (“black hole” symptom).*

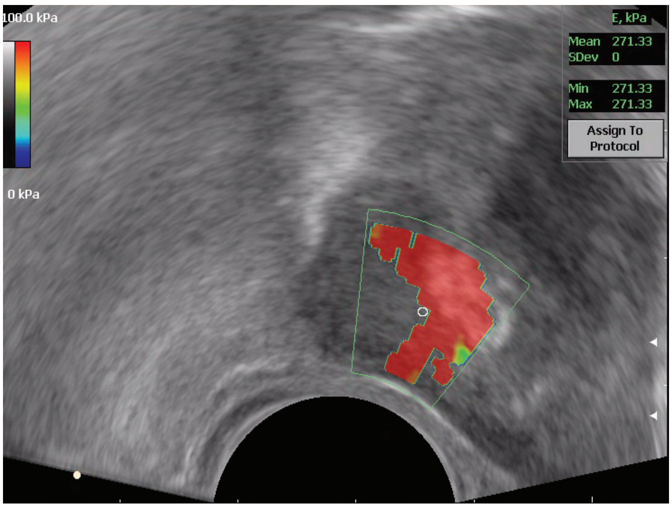

Fig. 10. *Symptom of “bitten apple” at pancreas left lobe cancer.*

The third type of shear wave elastograms corresponded to the image of unmodified prostae tissue. Therefore, in 2 patients (11 %) shear wave elastography and compression elastography did not confirm the diagnosis. Apparently, when interpreting the parameters of shear wave elastography, one should follow the rule: **"not every tumor node has high rigidity and not every high rigidity is malignant tumor"**.

It should be noted that the researchers also point to the high diagnostic efficiency of shear wave elastography in the diagnosis of cancer of this localization. However, in this case, slightly different parameters of pancreas parenchyma rigidity are given both in the norm and in the pathology. Thus, the authors [5] indicate the following 95 % confident interval of rigidity of healthy pancreas = 5,0-23,0 kPa. The difference from our data in this case is explained by the relatively young age of the selected control group (the age of patients was 25-35 years). Our contingent was presented by patients older than 54 years, and, as is known, the elasticity of the prostate gland decreases with age due to small-focal fibrosis, calcification and stagnant phenomena, which was reflected in higher rigidity prostate parenchyma parameters in patients. Other researchers [5] note that the parenchyma rigidity index e in the investigated area of more than 53 kPa should cause suspicion of malignant degeneration of the prostate tissue. It is considered [8] that the Young's rigidity modulus of more than 35 kPa is just the indication for prostate puncture biopsy.

The uncertainty in the elastograms' interpretation is due to the fact that all these data were obtained from the Aixplorer (Supersonic Imagine, France), which has slightly different elastogram analysis characteristics than those found with the RADMIR "ULTIMA" scanner.

Conclusion

Shear wave elastography is enough sensitive method for prostate malignant tumors detection. Three types of shear wave elastograms characteristic for this disease were determined.

Literature

1. Возианов А. Ф. Опухоли мочеполовой системы / А. Ф. Возианов, И. А. Клименко, С. А Возианов // Справочник по онкологии. – К.: Здоров´я, 2008. – 502 с.
2. Зыкин Б. И. Эластография: анатомия метода / Б. И. Зыкин, Н. А. Постнова, В. Е. Медведев // Променева діагностика, променева терапія. – 2012. – №2-3. – С. 107-113.
3. Мухомор А. И. Диагностика рака предстательной / А. И. Мухомор // Лучевая диагностика, лучевая терапия. – 2012. – №4. – С. 84-93.
4. Пат. 81254 Україна, МПК А61В 8/08 (2006.01). Спосіб діагностики злоякісних пухлин передміхурової залози / І. М. Дикан, О. В. Поліщук, В. Ф. Коробко, Т. А. Глобенко, С. Г. Мазур; заявитель ДУ „Інститут ядерної медицини та променевої діагностики НАМН України". – № 201215090; заявл. 28.12.2012; опубл. 10.02.2015, Бюл. № 3.
5. Митьков В. В. Ультразвуковая эластография сдвиговой волны у больных с подозрением на рак предстательной железы / В. В. Митьков, А. К. Васильева, М. Д. Митькова // Ультразвуковая и функциональная диагностика. – 2012. – № 5. – С. 18-29.
6. Ультразвуковая эластография сдвиговой волной в диагностике рака предстательной железы (ретроспективное исследование) / А. В. Амосов, Г. Е. Крупинов, Ю. В. Лернер [и др.] // Ультразвуковая и функциональная диагностика. – 2016. – № 4. – С.10-17.
7. Эластография сдвиговой волны: возможности дифференциальной диагностики очаговых и диффузных изменений различных органов и тканей / Н. А. Постнова, А. Ю. Васильев, Б. И. Зыкин [и др.] // Вестник рентгенологии и радиологии. – 2011. – № 2. – С. 29-34.
8. Brock M. Comparision of reai-time elastografy with grey-scale ultrasonography for detection of organ-confined prostate cancer and extracapsular extension: a prospective analysis using whole mount sections after radical prostatectomy / M. Brock, F. Sommer // BJU Int. – 2011. – Vol. 108. – P. 217.
9. WFUMB Guidelines and Recommendations on the Clinical Use of Ultrasound Elastography / Ultrasound in Med. & Biol. – 2017. – Vol. 43. – № 1. – P. 1-3.

ELEMENTS OF SHEAR WAVE ELASTOGRAMS' CLASSIFICATION AT PROSTATE CANCER

V.F. Korobko

Purpose – to study the possibility of shear wave elastography application in prostate cancer.

Materials and methods. Shear wave elastography with fixation of stiffness indices of healthy and injured parts of the organ was performed in 18 patients with confirmed diagnosis of prostate cancer.

Conclusions. The application of shear wave elastography has made it possible to expand the possibilities of traditional gray-scale scanning for the detection of malignant neoplasm in prostate gland. The main types of elastographic images for this disease were determined.

Key words: prostate cancer, shear wave elastography, Young's modulus of rigidity/ stiffness.

ЕЛЕМЕНТИ КЛАСИФІКАЦІЇ ЕЛАСТОГРАМ ЗСУВНОЇ ХВИЛІ ПРИ РАКУ ПЕРЕДМІХУРОВОЇ ЗАЛОЗИ

В.Ф. Коробко

Мета – вивчити можливості застосування еластографії зсувної хвилі у випадках раку передміхурової залози.

Матеріали та методи. У 18 хворих з підтвердженим діагнозом раку передміхурової залози проводилася еластографія зсувної хвилі з фіксуванням показників жорсткості здорових і уражених ділянок органу.

Висновки. Використання еластографії зсувної хвилі дозволило розширити можливості традиційного сірошкального сканування при виявленні пухлини передміхурової залози. Визначено основні типи еластографічних зображень при цьому захворюванні.

Ключові слова: рак передміхурової залози, еластографія зсувної хвилі, модуль жорсткості Юнга.

ЭЛЕМЕНТЫ КЛАССИФИКАЦИИ ЭЛАСТОГРАММ СДВИГОВОЙ ВОЛНЫ ПРИ РАКЕ ПРЕДСТАТЕЛЬНОЙ ЖЕЛЕЗЫ

В.Ф . Коробко

Цель – изучить возможности применения эластографии сдвиговой волны при раке предстательной железы.

Материалы и методы. У 18 больных с подтверждённым диагнозом рака предстательной железы проводилась эластография сдвиговой волны с фиксированием показателей жесткости здоровых и пораженных участков органа.

Выводы. Использование эластографии сдвиговой волны позволило расширить возможности традиционного серошкального сканирования при выявлении рака предстательной железы. Определены основные типы эластографических изображений для этого заболевания.

***Ключевые слова**:* рак предстательной железы, эластография сдвиговой волны, модуль жесткости Юнга.

Патенти

СПОСОБ УЛЬТРАЗВУКОВОЙ ДИАГНОСТИКИ ЛИТОГЕННОСТИ ПУЗЫРНОЙ ЖЕЛЧИ

RU 2402274; Гибадулина И.О., Гибадулин Н.В., Белобородова Е.В., Белобородова Э.И., Останко В.Л. Способ ультразвуковой диагностики литогенности пузырной желчи, заключающийся в осуществлении ультразвукового сканирования желчного пузыря, отличающийся тем, что определяют количественные ультразвуковые параметры состояния содержимого желчного пузыря путем построения ультразвуковой амплитудной гистограммы содержимого полости желчного пузыря в области дна, тела и шейки как до введения желчегонного стимулятора, так и спустя 40 мин после введения желчегонного стимулятора, с последующим определением индекса эхоплотности пузырной желчи, который рассчитывают по формуле $D=H_{стим.}/H_{исх.}$, где $H_{исх.}$ - среднеарифметическое значение ультразвуковой амплитудной гистографии содержимого полости желчного пузыря до введения желчегонного стимулятора, $H_{стим.}$ - среднеарифметическое значение ультразвуковой амплитудной гистографии содержимого полости желчного пузыря после введения желчегонного стимулятора, и при индексе эхоплотности пузырной желчи менее 1,3 - определяют нормальное состояние пузырной желчи, при индексе эхоплотности пузырной желчи, равном или более 1,3, - определяют литогенное состояние пузырной желчи.