Penile Sonoelastography for the Localization of a Non-Palpable, Non-Sonographically Visualized Lesion in a Patient with Penile Curvature from Peyronie's Disease

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ABSTRACT

Introduction. Sonoelastography is an emerging ultrasound-based technique that allows characterization of tissue stiffness.

Aim. The aim of this report is to present a case of significant penile curvature with a non-palpable, non-sonographically visualized plaque that was demonstrable with sonoelastography.

Methods. A 60-year-old male presented with significant left penile curvature during erections. The penis was evaluated with physical exam followed by B-mode and color Doppler ultrasound. No evidence of plaque was identified with these modalities. Shear wave sonoelastography was pursued to further characterize the patient's Peyronie's disease.

Results. An area of increased tissue stiffness that correlated with the site of maximum curvature was identified with shear wave sonoelastography and used to target intralesional injection therapy.

Conclusion. Sonoelastography provides an additional way to characterize, localize, and deliver therapy to a lesion in patients with Peyronie's disease and is particularly useful when palpation and B-mode ultrasonography have failed to demonstrate a plaque. **Richards G, Goldenberg E, Pek H, and Gilbert BR. Penile sonoelastography for the localization of a non-palpable, non-sonographically visualized lesion in a patient with penile curvature from Peyronie's disease. J Sex Med 2014;11:516–520.**

Key Words. Ultrasound; Diagnostic Testing; Sonoelastography; Peyronie's Disease; Penile Curvature

Introduction

The formation of fibrous scar in the tunica albuginea of the phallus is referred to as *induratio penis plastica* and chronic inflammation of the tunica albuginea, but it is most commonly known as Peyronie's disease. The eponymous Francois Ginot de la Peyronie, who described the condition in 1743, was the personal physician to King Louis XV of France [1]. Peyronie's disease is an inflammatory process, histologically characterized by chronic lymphocytic and plasmacytic infiltration, leading to fibrosis of the tunica albuginea of the phallus and penile curvature during erection [1]. The fibrosis is usually detectable as an indurated plaque by palpation or by radiographic findings [2,3]. Peyronie's disease is common, with reports of it affecting 3–9% of men [2,4], yet there is speculation that the prevalence is much higher because of men underreporting their symptoms [1,4]. Although it may be precipitated by traumatic intercourse or injury, up to 70% of cases do not stem from an inciting event, and the exact pathophysiology leading to the disease is unknown [5].

Palpation of pathology by the physician as part of a physical examination is an integral part of the evaluation of a patient, with firm lesions often a sign of pathology. In Peyronie's disease, assessment of the deformity through physical examination is imperative. Assessments of curvature are best made with pharmacostimulated erections [6–8]. Penile curvature is sometimes present without a palpable plaque [2,3]. Ultrasound is the primary imaging technique in the evaluation of

Peyronie's penile pathology and has a role in demonstrating calcifications in lesions and, with duplex studies, identifying potential concomitant vascular compromise [2,6,7]. Case series have reported the detection of penile plaques with B-mode ultrasonography in 39% to 97% of cases [3,9]. Investigation into magnetic resonance imaging (MRI) as an alternative to ultrasonography has not found that MRI provides a significant advantage over ultrasound or palpation, and unlike ultrasound, MRI is unable to identify calcification in penile plaques [10]. Sonoelastography (tissue elasticity imaging) is an emerging ultrasound modality designed to evaluate the stiffness of biological tissues and allows inferences to be made about pathology in the same manner as palpation [11].

Case

A 60-year-old man with a history of atrial fibrillation and testosterone deficiency presented with a complaint of left penile curvature during erections. The curvature had been stable for the 3 years prior to presentation and has interfered with his ability to have sexual intercourse. He denies any inciting incidents correlating with the onset of his curvature. On physical examination, he has a normal appearing flaccid phallus without palpable plaques.

B-mode and color Doppler ultrasound of the phallus with pharmacostimulation revealed a 45° left curvature at the mid-phallus without calcifications or abnormal echogenicity of the tunica albuginea or cavernosal bodies. The images were obtained at 12 MHz with a linear array transducer (SuperLinear™ SL 15–4, bandwidth 4–15 MHz, SuperSonic Imagine, Aix-en-Provence, France) with an ultrasound platform capable of also performing shear wave sonoelastography (Aixplorer®, SuperSonic Imagine).

Shear wave sonoelastography was then performed. An area of increased relative tissue stiffness was demonstrated localized to the left mid-corporal body correlating to the area of maximum curvature (Figure 1). Sonoelastography generates a color display corresponding to tissue stiffness that is superimposed over ultrasound images within an elastogram box. In this case, the red color represents tissue that is firmer and blue is tissue that is less firm. The transverse views demonstrate the firm region on the left side of the penis at the mid-shaft location of the curvature (Figure 1B) that is not present in the images from the proximal or distal shaft (Figure 1A and C). When the elastogram box is superimposed over the mid-shaft longitudinal penile images, the firm tissue is demonstrated on the left (Figure 1E) but not on the right (Figure 1D). This region involves not only the tunica albuginea but also the underlying cavernosal tissue as well.

The patient is considering, but has not pursued, intralesional therapy. Without a palpable plaque and in the absence of demonstrable B-mode ultrasound evidence of plaque, the area visualized on the sonoelastography study can be used to target intralesional injections.

Discussion

Sonoelastography uses ultrasonic techniques to determine differences in relative tissue elasticity, a measure of tissue stiffness (also known as Young's modulus) [11]. When a compressive stress is placed on tissue, a degree of deformation (strain) occurs. The amount of deformation is inversely proportional to the stiffness of the tissue. Furthermore, the amount of stress required to deform the tissue is directly proportional to the stiffness of the tissue. Young's modulus is thus the quotient of the relationship between the stress (the dividend) and the strain (the divisor) [12,13].

There are two modalities that are frequently used to induce stress in a tissue with ultrasound. Real-time sonoelastography employs manual compression of the tissue with the ultrasound probe to produce a stress on the tissue [12,14]. If the tissue has a uniform stiffness, then the strain is uniform. If there is a variable elasticity of the tissue, then there will be variations in the strain that can be detected by the ultrasound probe. Real-time sonoelastography takes advantage of variations in the tissue deformation in this way to demonstrate the relative differences in tissue stiffness. These differences are displayed with a color scale overlying their location on the ultrasound image [12].

Shear wave sonoeslastography enlists another type of stress, shear stress, to determine elasticity [13]. Shear stress arises when a surface of a material is subjected to stress in a direction parallel to that surface and the opposite surface is held in place by an opposing force. A stress induced at a certain location in tissue will deform the tissue in that location and, because the tissue around it is held in place by the opposing force of friction and normal forces of adjacent tissue structure, a shear stress is generated. One might imagine a block of gelatin sitting on a plate. When a finger is placed on the upper surface of the block and moved in any direction, the upper surface of the block is dragged

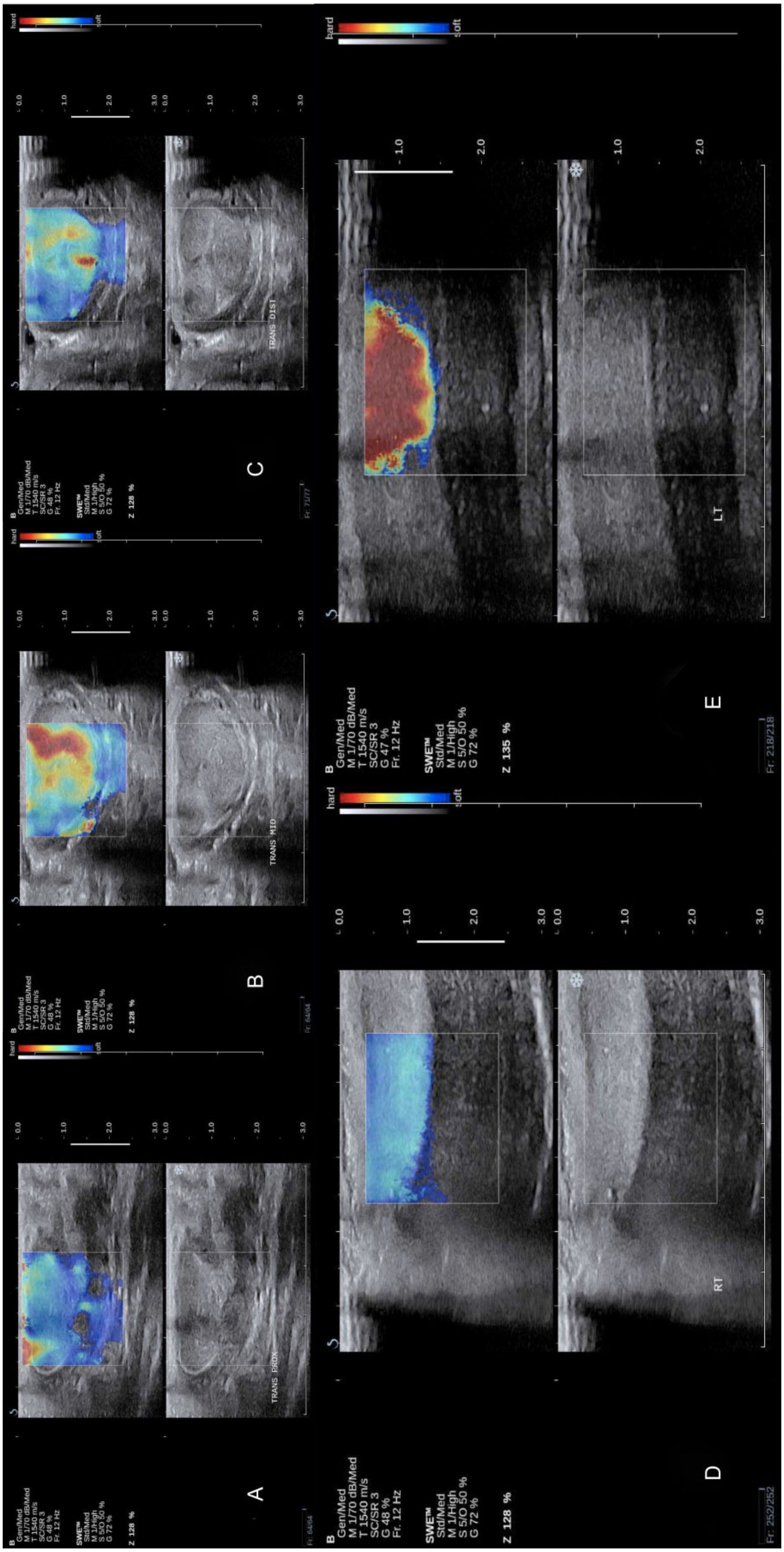

Figure 1 Sonoelastograms (scaled with red [more firm] and blue [less firm]) superimposed over transverse B-mode ultrasound images of the (A) proximal, (B) mid-, and (C) distal phallus. Sonoelastograms superimposed over parasagittal views of the (D) right and (E) left cavernosal bodies.

and displaced in that direction. The lower surface remains in place on the plate. The whole block is subjected to torque across the length of the block that extends from the plate to the finger. The degree of resistance to this type of deformation a material exhibits is reflected in its shear modulus. The shear stress can also propagate radially from the location of its source through the surrounding tissue in the same manner as waves propagate radially away from the site where a pebble hits the surface of a body of water [13]. These waves are shear waves. The tissue deformations generated by these waves can be detected by ultrasound receivers with very fast acquisition speeds [15,16]. The ultrasound transducers are uniquely constructed to generate these shear wave but also can be used for more traditional diagnostic ultrasound [12,13,15,16].

The speed at which shear waves propagate is inversely proportional to the square root of the medium's density and directly proportional to the square root of its elasticity [12,13]. Thus, the more stiff (the greater the shear modulus), the faster the shear waves travel. It is this relationship and the notion that tissue density has little variability within an organ that allow the stiffness of tissue to be determined by calculation of the speed of shear wave propagation through the tissue. This is the principle employed in shear wave sonoelastography to determine elasticity. The elasticity is displayed on the ultrasound images as a color scale [16].

Tissue stiffness determined by compressive waves generated by the ultrasonographer during real-time sonoelastography comes with a degree of intersonographer variability as the stress generated in this fashion cannot be consistently reproduced. It is dependent on how hard each sonographer compresses the tissue. Thus, relative elasticity differences can be determined (as all the tissue examined is subjected to the same stress), but quantitative measurements of elasticity that can be compared between exams cannot be made with the current techniques used for real-time sonoelastography. Shear wave sonoelastography does not share this limitation. Shear wave propagation can be reproducibly measured and calculated by the ultrasound software, and tissue density remains relatively constant in specific tissue types. Shear wave sonoelastography has the advantage of being comparable over different exams and quantitative with the current state of the technology [15].

Sonoelastography has been evaluated in breast, thyroid prostate, lymph node, and testicle tissue for its ability to discriminate benign and malignant lesions [12,14,17–19]. Real-time sonoelastography in combination with B-mode ultrasound has been used in a series of 74 patients with Peyronie's disease to identify firm lesions in 93% of the series, as opposed to 86% that had lesions identified with a protocol of palpation and ultrasound [20]. Moreover, in the subpopulation without a palpable plaque (15/74), only five had lesions that were detectable on B-mode ultrasound alone. Lesions demonstrated in all five were identified as firm with sonoelastography. Out of the 10 patients where non-palpable lesions were also not demonstrated with B-mode ultrasonography, firm lesions were detected in 5 when sonoelastography was added to the evaluation [20].

In this case, the addition of sonelastography served to support the diagnosis of Peyronie's disease when physical exam and duplex ultrasound with pharmacostimulation failed to demonstrate evidence of a plaque. Although the patient has not, as of the time of this report, elected to pursue treatment of his curvature, it allows us to offer the patient a manner in which to localize the delivery of intralesional treatment should he pursue this option. We believe that the use of penile sonoelastography is most helpful in the select group of men with Peyronie's disease that have no palpable plaque and the absence of B-mode ultrasonographic findings consistent with Peyronie's disease. It may be particularly beneficial when intralesional treatment is desired, as it provides an additional way to localize a lesion to deliver therapy when palpation and B-mode ultrasonography have failed to demonstrate a plaque. Given the profound psychological impact that this disease may have [21] and the significant patient dissatisfaction rates with more invasive techniques like graft procedures [22] make the availability of this option particularly relevant to this subgroup of patients.

In addition, the sonoelastographic images may demonstrate changes in the tissue that extend beyond those that can be demonstrated on B-mode ultrasound. Specifically, there is a potential with sonoelastography to demonstrate changes not simply limited to the tunica albuginea but also to the cavernosal body as well. This coincides with previous reports indicating the evidence of fibrosis extension into cavernosal tissue in Peyronie's disease [23–25]. The application of this technology to clinical practice is currently limited by its relatively limited availability compared with B-mode ultrasonography.

We have used sonoelastography of the phallus to locate lesions that might be amenable to treatment with injectable agents. To our knowledge, this is the first reported use of penile shear wave sonoelastography to characterize Peyronie's disease. Sonoelastography is an exciting new innovation in the evaluation of patients with Peyronie's disease, and further investigation is needed to investigate the clinical applications of this technology.

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