SEXUAL MEDICINE REVIEWS REVIEWS

Pathophysiology and Grayscale Ultrasonography of Penile Corporal Fibrosis

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ABSTRACT

Introduction: Penile corporal fibrosis may occur secondary to explantation of an infected penile prosthesis, severe penile trauma, refractory low-flow priapism, Peyronie's disease, or chronic intra-cavernous injection of vasoactive drugs. Other etiologies of corporal fibrosis, presenting primarily with erectile dysfunction, can develop in chronic smokers, hypertensive patients, alcoholics, diabetics, and after radical prostatectomy. Corporal erectile tissue fibrosis is a significant pathophysiologic component of erectile dysfunction; however, current ultrasound-based penile imaging protocols do not directly assess it.

Objective: To determine if grayscale ultrasonography (US) is a suitable imaging modality to identify and assess penile corporal erectile tissue fibrosis.

Methods: A PubMed literature review was performed for studies that detailed ultrasonographic methods and findings of pathologies causing penile corporal fibrosis. Our main outcome measure was the ultrasonographic findings of pathologies causing penile corporal fibrosis.

Results: Grayscale US demonstrates the capability to detect and localize the fibrotic changes of the corpora cavernosa. Ultrasonographic findings capture penile corporal tissue heterogeneity including diffuse, circumscribed, or localized patterns.

Conclusion: Overall, grayscale US may be a useful and convenient imaging modality to assess penile corporal fibrosis secondary to explantation of an infected penile prosthesis, priapism, penile trauma, chronic intra-cavernous injection of vasoactive drugs, diabetes, Peyronie's disease, and vascular disease. While limited by the skill and knowledge of the US operator, the combined knowledge of pathophysiology and US may help clinicians identify and manage the underlying etiology of penile corporal fibrosis. **Kim J, Drury R, Morenas R et al. Pathophysiology and Grayscale Ultrasonography of Penile Corporal Fibrosis. Sex Med Rev 2021;XX:XXX–XXX.**

Key Words: Grayscale; Ultrasound; Imaging; Penile Fibrosis

INTRODUCTION

Ultrasonography (US) is the primary imaging modality used for patients with penile conditions such as erectile dysfunction (ED), Peyronie's disease (PD), penile trauma, and priapism. While patients are typically given a preliminary diagnosis based on history and physical examination, imaging is often required to confirm the diagnosis or to assess the extent of the condition. Ultrasound and magnetic resonance imaging are mostly used, but other techniques such as retrograde urethrography and computed tomography are performed in indicated cases. Currently, penile duplex Doppler ultrasonography (PDDU) is the gold standard for evaluating etiology of ED based on hemodynamic parameters. Alternatively, standard grayscale US imaging is used to scan for non-vascular abnormalities such as fibrosis, plaques, or tunica albuginea (TA) defects.

Penile fibrosis, particularly the formation of plaques of the TA in patients with PD, has been well-studied[1]; however, the fibrosis of the corpora cavernosa is a highly prevalent sequela of various etiologies. Corporal fibrosis results from the loss of smooth muscle cells and the increase of collagen deposition. In fact, the composition of cavernosal tissue changes physiologically with age. In men between ages 41 and 60 years old, the abundance of smooth muscle cells reduces to 40%, and reduces to about 35% in men over 60.[2]

Cases of penile corporal fibrosis may occur secondary to explantation of an infected penile prosthesis, severe penile trauma, refractory low-flow priapism, PD, or chronic intra-cavernous injection of vasoactive drugs.[3–8] Other etiologies of penile corporal fibrosis, presenting primarily with ED, can

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develop in chronic smokers, hypertensive patients, alcoholics, diabetics, and after radical prostatectomy.[1,9,10] Corporal erectile tissue fibrosis is a significant pathophysiologic component of ED; however, current US-based penile imaging protocols do not directly assess it.

In this article, we review the literature to determine if grayscale US is a suitable imaging modality to identify and assess penile corporal erectile tissue fibrosis.

Examination Technique

To examine for penile fibrosis, high-frequency sonographic equipment must be utilized. Ultrasound is applied directly to the penis using a linear transducer probe. Currently, linear transducers have maximum frequency of 12−15 Mhz; however, a minimum frequency of 7.5 Mhz is required. Imaging parameters should be set to the highest spatial resolution, using high-definition zoom and tissue-specific presets when available. It should be noted that a higher frequency setting and real-time spatial compounding will allow for better spatial and contrast resolution, allowing for greater detection of low-grade fibrosis.[11]

To perform this procedure, the patient is first placed in the supine position with his penis reflected dorsally on the anterior abdominal wall. Towels may be placed on the sides of the penis to stabilize it. Then, ultrasound gel is placed on the surface of the penis. Grayscale, or B-mode, images in the longitudinal and transverse planes are obtained by applying the transducer at the level of the glans and moving down to the base of the penis. Additionally, the ultrasound probe may be applied transperineally to assess the base of the penis. Examination of the penis is performed when the penis is flaccid for assessment of penile prosthesis, priapism, and trauma. For evaluation of erectile dysfunction and PD, intracavernosal injection of a vasoactive substance, such as prostaglandin E1, is indicated. In such cases, 10−20 micrograms of prostaglandin E1 is injected laterally into the corpus cavernosum using a 0.5 inch, 27 to 30-gauge needle.

Normal Anatomy

The penile shaft is composed of 3 cylindrical erectile bodies: 2 corporal cavernosa and 1 corpus spongiosum. In particular, the corpora cavernosa are made up of smooth muscle cells, loose areolar tissue, blood vessels, nerves, and collagen fibers. The composition of cavernosal tissue varies with age; in healthy young men, collagen fibers comprise about 48% of cavernosal tissue, while smooth muscle cells make up about 46%.[2,12]

Transverse grayscale US images of the normal penis will display the corpora cavernosa and corpus spongiosum as homogeneous cylindrical structures. The TA and Buck's fascia will appear as 1 thin echogenic line surrounding the corpora as if they were both stuck together. The cavernosal arteries will appear as a pair of dots on transverse scans, and they will appear as linear or narrow tubular structures on longitudinal scans. Dorsal vessels will appear as anechoic structures that are seen on the dorsal aspect of the penis (Figure 1).

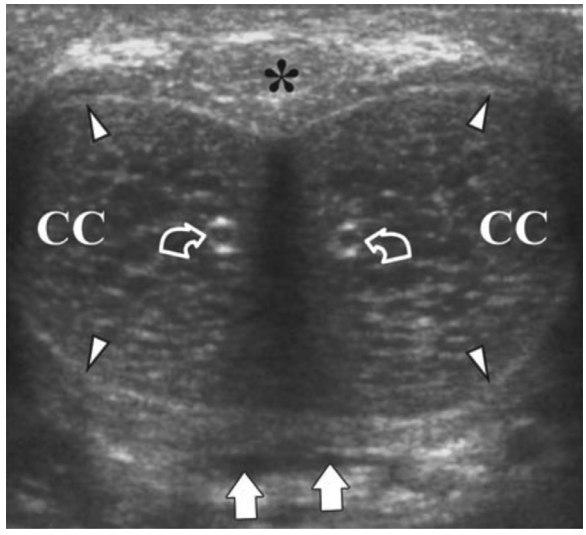

Figure 1. Normal penile anatomy displayed by transverse ultrasonography image shows the corpora cavernosa and the corpora spongiosum (*). The cavernosal arteries are identified by the curved arrows, the dorsal vessels are identified by the solid arrows, and the tunica albuginea is identified by the arrowheads. (Image used with permission from Radiographic Society of North America: Bertoloto M, et al. *RadioGraphics* 2009;29:477−493.

Inflatable Penile Prosthesis

For nearly half a century, inflatable penile prosthesis (IPP) has been associated with high patient satisfaction rates. Indications for IPP placement include ED, PD, and phalloplasty.[13] Though rare, postoperative complications of IPP include prosthesis infection, erosion, and mechanical failure.[14-17] Infection is a significant cause of IPP-associated corporal fibrosis, and the greatest concern of IPP placement.[21] Risk of IPP infection increases based on the number of subsequent IPP surgeries.[18-20] One study reported operative infection rates for IPP placement was 2.1% and 6.5% for primary placement vs secondary or revisional IPP surgery, respectively.[21] However, some estimate a much lower post-surgical infectious rate.[22] Adamsky et al found that, out of 10,847 IPP placements, 228 (2.1%) required explantation within 3 months due to infection.[23] Failure to promptly explant an infected IPP can cause substantial corporal fibrosis.[24] The incidence of corporal fibrosis secondary to IPP infection and explantation has not been reported in the literature.

The treatment of IPP complications may involve prosthetic explantation and potential replacement.[25] Even with strategies to mitigate scarring, IPP implantation and explantation may cause fibrosis of the penile corpora.[24,26] Wound healing after original IPP implantation or revisional IPP surgery or explantation involves expansion of the extracellular matrix, including increased myofibroblast production of collagen.[27]

Grayscale US is a useful tool in assessing penile fibrosis following IPP placement or removal. The identification of severe

cavernosal fibrotic changes is necessary for choosing the appropriate surgical technique.[28,29] Complete fibrosis of the corpora may render some surgical techniques for IPP re-implantation unsuccessful.[30] In cases of severe fibrosis, the standard technique for IPP re-implantation involves creation of large corporotomy incisions to remove fibrotic tissue with subsequent graft usage to cover resected corporal walls.[7,9] However, alternative operative approaches have also proven successful. For example, Ghanem et al utilized corporeal counter incisions for re-implants to avoid perforation of the urethra or corpora.[28] Out of 17 patients with severe corporal fibrosis, only 1 had intraoperative crural perforation that was subsequently fixed. Montague and Angermeier used a technique called corporeal excavation, which allowed nearly complete removal of intracorporeal fibrotic tissue in all 9 patients.[29] Additional approaches by Shaeer et al utilize intraoperative penoscopy and ultrasound to aid in the removal of fibrotic cavernosa.[31,32] However, these revised techniques cannot be utilized if the fibrosis is not first identified.

If a patient's history and physical exam increase the index of suspicion of post-surgical fibrosis, US-based findings may aid in confirming the diagnosis. On US, penile surgery causes a distinct area of circumscribed fibrosis.[33] Circumscribed fibrosis presents as an area of echogenic tissue that is inhomogeneous in appearance.[34] In other words, as the provider runs the US probe longitudinally along the erect penis, certain transverse views of the penis will show increased echogenicity and thickness. Normal, non-fibrosed sections of the penis will have a regular thickness and echogenicity. These circumscribed areas of fibrosis indicate where prior incisions or infections caused localized fibrosis within the corpora. It should be noted that circumscribed fibrosis is distinct from diffuse fibrosis, which shows the entire circumference and length of the corpora having increased echogenicity and thickness.

Ischemic Priapism

Priapism is a non-sexual erection that is persists for more than 4 hours). There are 3 main forms of priapism: ischemic (low-flow, veno-occlusive), nonischemic (high-flow, arterial), and stuttering (recurrent or intermittent).[35] More than 95% of priapism episodes are ischemic.[36] Ischemic priapism occurs when there is occlusion of penile venous outflow. Halted penile venous outflow causes vascular congestion, preventing oxygenated blood from flowing into penile arteries.

Untreated ischemic priapism is a medical emergency that results in hypoxia and subsequent acidosis.[37] If blood flow is restored within 24 hours, approximately 50% of patients will recover normal erectile function without irreversible corporal fibrosis.[38,39] If blood flow is restored beyond 24−72 hours after initial occlusion, though pain and erection resolve, irreversible fibrosis and impotency may occur.[36] Though a rare condition in the general population, certain populations, such as patients with sickle-cell disease or disseminated malignancies, have a higher incidence of veno-occlusive priapism.[40] In sickle cell patients, the lifetime probability of experiencing ischemic priapism ranges from 29% to 42%.[41,42]

Though usually a clinical diagnosis, US allows providers to determine the extent of damage from ischemic priapism. Bertolotto outlined these progressive changes.[43] During the initial periods of ischemic priapism, the echogenic appearance of the corpora cavernosa remains normal. Blood stasis may be visualized as gravity-dependent blood sedimentation along the floor of the cavernosa, producing a fluid-fluid level. As the ischemia and acidosis progresses, increased echogenicity within the corpora represents tissue edema. After significant time has passed, fibrotic changes occur, visualized on US as wide echogenic alterations to the corpora. Additionally, diffuse corporal fibrosis from long-standing ischemic priapism may appear as hyperechogenic, ill-defined areas along the cavernosal arteries, replacing the normal sinusoid structure (Figure 2).[33]

Penile Trauma

Penile trauma is a relatively rare occurrence.[44] In general, penile trauma can be broken into 2 categories based on the state of the

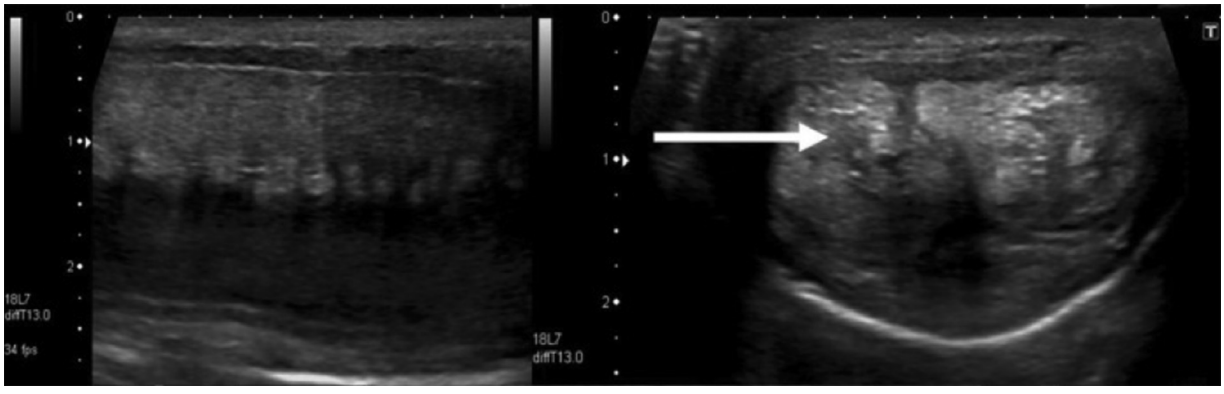

Figure 2. Long-standing ischemic priapism displayed by longitudinal ultrasonography (left) and transverse (right) images. The arrow identifies echogenic, distorted cavernosa reflecting significant corporal fibrosis. Image has been modified from the original source and used with permission: Halls JE, et al. *Br J Radiol*. 2012;85 Spec No 1(Spec Iss 1):S79-S85.

penis (ie, erect vs flaccid).[45] Trauma to an erect penis usually results from the sudden bending of the erect penile shaft, as may happen during foreplay, intercourse, or masturbation.[46] This sudden bending can rupture the TA, also known as a penile *fracture*. Rapid identification and surgical treatment of penile fractures is needed to lower one's risk of post-traumatic penile fibrosis.[47] Trauma to a flaccid penis may cause a variety of penile pathologies, including high-flow priapism from blunt or penetrating cavernosal artery injury, extratunical or cavernosal hematomas with uninjured TA following blunt trauma, and repetitive microtrauma and chronic deoxygenation of crura in "saddle-based" sports (eg, long-distance biking, horseback riding).[33,46,48-51]

Trauma-based penile pathologies may lead to irreversible fibrosis through several mechanisms. In comparison with ischemic priapism, nonischemic priapism is usually the result of blunt trauma and is not considered a medical emergency.[42,52] Blunt trauma causes a lesion to develop in a cavernosal artery, allowing blood to flow into the corpora. This increases corporal blood flow and causes only a *partial* erection. However, because penile venous outflow remains patent, complete vascular occlusion is prevented. In rare circumstances, high-flow priapism can lead to complete tumescence, significantly increasing one's risk of penile fibrosis.[40,45] Additionally, even without progression to low-flow priapism, select case studies have shown distal corporal fibrosis following high-flow priapism.[53] In saddle-based sports, chronically low oxygen tension from compression of the cavernosal arteries against the perineum is hypothesized to induce cavernosal expression of transforming growth factor (TGF)- β1.[33,54] Elevated TGF- β1 causes penile fibrosis through increased connective tissue synthesis.[55]

In post-traumatic fibrosis, US provides key diagnostic information. Depending on the injury, US may reveal diffuse, circumscribed, or proximal cavernosal fibrosis.[33] Diffuse cavernosal fibrosis occurs in trauma with low oxygen tension levels, such as in the rare circumstance that high-flow priapism results in complete erection.[40,45] On US, instead of normal cavernosal sinusoidal tissue surrounding the arteries, diffuse fibrosis appears as hyperechogenic areas that are ill-defined. These changes will be seen longitudinally along the penile vasculature as the provider runs the US probe lengthwise along the erect penis. Additionally, US allows providers to determine the extent of ischemic progression (see low-flow priapism section.) Circumscribed cavernosal fibrosis may result from healed extra- or intracavernosal hematomas or ruptured TA.[33,43,46,56] On US, this may appear as an echogenic, inhomogeneous lesion along the penile septum.[34] Transverse US scans can also help identify circumscribed post-traumatic scars in the cavernosum (Figure 3).[33] Proximal cavernosal fibrosis occurs in situations such as the saddle-based sports. On US, the penile crura may have a coarse echotexture from sinusoidal spaces that are irregular and large with thick echogenic walls.

Intracavernosal Injections

Approximately 1 out of 3 men have ED that is refractory to oral phosphodiesterase-5 inhibitors, warranting treatment with intracavernosal injections (ICI) and/or other second-line agents.[57,58] Compared with oral medications, ICI have a known time of onset, making them a desirable option. However, ICI involves self-injection, which is a deterrent for some patients. To

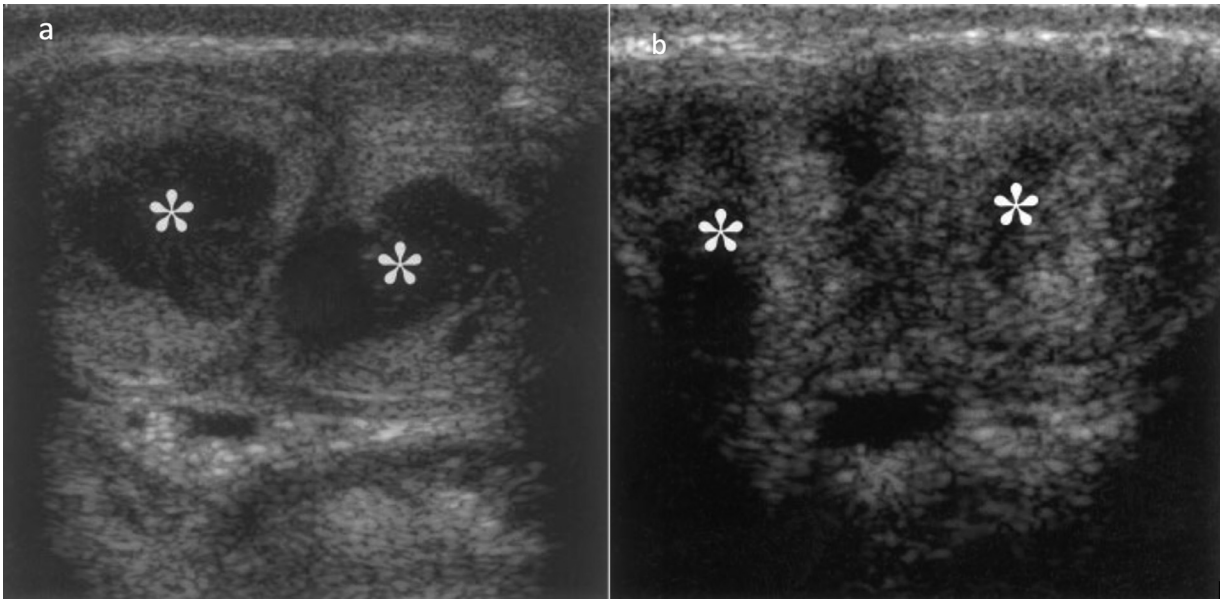

Figure 3. Circumscribed fibrosis secondary to high-flow priapism (a) Transverse ultrasonography displays bilateral cavernous hematomas (*) at the base of the penis (b) 6 months later, transverse ultrasonography displays inhomogeneity of corpora cavernosa due to fibrotic changes (*) Image used with permission from the Radiological Society of North America: Bertoloto M, et al. *RadioGraphics* 2003;23:495–503.

administer an ICI, the user self-injects medication into their corpora cavernosa. The medication subsequently causes corporal smooth muscle relaxation, leading to an erection.[59] Papaverine and prostaglandin E-1 are some of the most commonly used ICI medications.[60]

Most of the penile fibrosis associated with ICI comes from their potentially severe sequela. On rare occasions, ICI can cause low-flow priapism. In fact, some estimate that 5% of patients who inject themselves with papaverine develop ischemic priapism.[61] The risk is significantly smaller with papaverine and prostaglandin E-1 injections.[62] ICI may also act as a means of admitting bacteria into sterile penile tissue, leading to cavernositis.[63] Additionally, as ICI causes minor bleeding following injection, proper post-injection pressure is needed to prevent hematoma formation.[64] Low-flow priapism, cavernositis, and hematomas are all significant risks for penile fibrosis. Lastly, the repetitive microtrauma itself from injecting into the corpora cavernosa may cause fibrosis.[65] To this point, some studies suggest that the most common cause of post-traumatic cavernosal fibrosis is repeated ICI usage.[45,66,67]

When fibrosis occurs following ICI-induced cavernositis and/or low-flow priapism, diffuse cavernosal fibrosis may be seen on US.[33,65] Fibrosis from repeated ICI use microtrauma appears on US as circumscribed, heterogeneously echogenic nodules within the corpora.[33,45] These circumscribed nodules are especially common in frequent users of ICI and those who develop hematomas from improper post-injection pressure.[33] Furthermore, for reasons still unknown, some patients who utilize ICI develop distal, segmental penile fibrosis that may be visualized on US.[68]

Diabetes

Diabetes is one of the primary risk factors for ED, with an estimated 25−75% of men with type II diabetes complaining of some degree of ED.[69] In addition to its association with ED, penile fibrosis is commonly seen in patients with diabetes. Extended hyperglycemic states are often associated with the damage of the cavernosal vessels, which eventually leads to penile fibrosis.[70] Though no epidemiologic studies have explicitly stated the incidence of penile fibrosis in patients with diabetes, studies have shown overactivation of fibrotic pathways in association with diabetes.[69]

In diabetic patients, diffuse chronic insults that occur throughout the corpora and penile artery walls elicit cellular alterations.[1] Penile fibrosis associated with diabetes frequently manifests as decreased smooth muscle and increased extracellular connective tissue within the corpus cavernosum.

The capability of grayscale US to detect the diffuse fibrotic changes of the corpora cavernosa secondary to diabetes depends on the extent of tissue damage.

On grayscale US, patients with diabetes usually present with normal appearance of the corpora cavernosa or with subtle alterations. These subtle alterations may present as a slight increase in echogenicity and larger lacunar spaces with thickened walls.[33] In some patients, calcifications in the wall of the cavernosal arteries can be identified on longitudinal scan.[71]

Peyronie's Disease

PD is a condition characterized by shortening and curvature of the penis due to the presence of dense fibrous plaques within the TA. The prevalence of diagnosed PD in men in the United States is estimated to range from 0.5% to 9%.[72] It should be noted that patients with PD may develop secondary corporal fibrosis, overruling the notion that penile fibrosis is limited to the TA. The incidence of corporal fibrosis in PD patients is not well-studied. However, data from the PROPPER study of men with PD undergoing IPP placement showed that 51.2% of patients had corporal fibrosis at the time of operation.[73] ED is found in approximately 20% of patients with PD.[74]

It is largely accepted that PD-associated penile fibrosis is the result of an inflammatory process in which there is chronic leukocytic infiltration of the TA. While the exact cause of this process is unknown, it is hypothesized that penile microtraumas can occur during intercourse, causing delamination of the TA.[75] This proliferation of local fibroblasts triggers excessive collagen deposition within the extracellular matrix and causes fibrosis that may extend into the corpus cavernosum.

When a patient presents with PD, conventional grayscale US may prove effective in examining less common fibrotic manifestations of PD, such as corporal fibrosis.

On US, corporal fibrosis is identified as coarsened, usually hyperechoic, heterogenous regions within the corpora.[76] A rare presentation of PD has been published in a Korean case report of a fibrotic lesion involving the corpus cavernosum without TA.[77] US of the fibrotic nodule demonstrated a heterogenous echogenic mass located in the left corpus cavernosum at the level of the penoscrotal junction. Grayscale US examination can be useful to determine the extent of fibrosis involving the corpora cavernosa, which is important in formulating appropriate treatment strategies.[43] Severe corporal fibrosis may alter the surgical approach with IPP placement (refer to Inflatable Penile Prosthesis section).

Vascular Disease

Vasculogenic ED describes reduced blood flow to the penis during arousal, due to either atherosclerosis or endothelial dilation dysfunction. It is thought that this cause of impotence is a manifestation of the same process from which cardiovascular disease results. Vasculogenic ED is frequently associated with penile fibrosis, as evidence has consistently shown an associated increase in extracellular matrix tissues within the corpus cavernosum in such cases.[10] In young, healthy patients, the corpus cavernosum is composed of approximately 40−52% smooth muscle. However, the corpus cavernosum is composed of only 10−25% smooth muscle in patients with penile arteriogenic impotence.[70]

This results in an increased collagen content within the cavernosum, and blood flow to the cavernosum can be further inhibited.

Patients with vasculogenic ED will often present on US with increased fibrotic tissue within the cavernosum. Echogenicity of the cavernosa is reduced in the areas around the cavernosal arteries.[78] These variants in echogenicity are indicative of overactivation of the fibrotic processes and disruption of the trabecular network within the vessels. Visualizing these changes within the cavernosum is extremely valuable to clinicians, as it is heavily associated with vasculogenic ED. Thus, using grayscale US can indicate which treatment option is most appropriate, and prevent further proliferation of the fibrotic tissue.

DISCUSSION

Grayscale US is a widely implemented imaging modality that has untapped potential to assess penile corporal fibrosis. Compared to computed tomography and magnetic resonance imaging, US can be performed rapidly, conveniently, and economically by the urologist at the bedside. The use of grayscale US has already been adopted as a non-invasive method to characterize fibrosis and tissue heterogeneity in hepatic cirrhosis and chronic liver disease.[79,80] As it stands, Doppler US is already routinely utilized in clinically assessing ED. PDDU indirectly assesses corporal fibrosis based on hemodynamic findings such as peak systolic velocity, end-diastolic velocity (EDV), and resistive index. However, PDDU cannot localize lesions of discrete penile fibrosis and may miss early fibrosis that is not detectable by changes in EDV, which may only be detectable in advanced stage of disease. Future directions for this interesting application of grayscale US include the development of a standardized protocol to assess penile corporal tissue heterogeneity and the incorporation of developing technologies such as ultrasound elastography (USE) to assess penile fibrosis.

More specifically, grayscale US findings may be correlated to PDDU EDV to detect patients with positive findings that may have not been identified with a hemodynamics-focused PDDU. Goldstein et al developed a system to classify penile grayscale US images by severity of corporal fibrosis in men who presented with ED.[81] Currently, elevated EDV is used clinically to suggest corporal veno-occlusive dysfunction as the underlying etiology of ED. However, the group found that adding corporal fibrosis severity grading to PDDU protocol added positive findings in 35% of patients with ED who may have otherwise been misdiagnosed with intact veno-occlusive function. In such cases, grayscale US may aid detection of early ED by assessing corporal fibrosis.

In addition, USE is currently being investigated as a promising modality to assess penile fibrosis by measuring the elasticity of the corpora cavernosa. USE is an imaging technology that allows tissue stiffness to be measured. Studies have shown that elasticity scores of cavernous bodies are correlated between IIEF score, penile length, and Erection Hardness Scale score.[82,83]

Table 1. Ultrasonography (US) findings by penile pathology

Penile pathology	US findings
IPP Infection/Explantation	Circumscribed areas of fibrosis indicate where prior incisions or infections caused localized fibrosis within the corpora.
Ischemic Priapism	Diffuse corporal fibrosis from long-standing ischemic priapism may appear as hyperechogenic, ill-defined areas.
Non-ischemic priapism	Distal corporal fibrosis appears in select cases.
Blunt injury penile trauma	Circumscribed cavernosal fibrosis may result from healed extra- or intracavernosal hematomas or ruptured TA, which appears as an echogenic, inhomogeneous lesion along the penile septum.
Saddle-based sports penile trauma	Proximal cavernosal fibrosis occurs. The penile crura may have a coarse echotexture from sinusoidal spaces that are irregular and large with thick echogenic walls.
Repetitive ICI Usage	Fibrosis appears on US as circumscribed, heterogeneously echogenic nodules within the corpora.
Diabetes	US displays normal appearance of the corpora cavernosa or with slight increase in echogenicity and larger lacunar spaces with thickened walls.
Peyronie's disease	The fibrotic plaques manifest on US as areas of thickening within the TA.
Vascular disease	Echogenicity of the cavernosa is reduced in the areas around the cavernosal arteries.

ICI = intracavernosal injection; IPP = inflatable penile prosthesis; TA = tunica albuginea.

Building upon this principal, penile ultrasound vibro-elastography utilizes ultrasound and fluid mechanics to evaluate corporal visco-elasticity and correlate with severity of penile fibrosis. Investigators found that corporal elasticity and viscosity correlate with peak systolic velocity as measured by PDDU.[84] USE measurements are often overlapped onto axial grayscale US images as an additional parameter to visualize and measure the elasticity of areas of fibrosis.

We encourage providers to spend extra time to perform grayscale US, which can potentially identify and localize penile fibrosis and provide prognostic value. US should not be used to solely assess penile hemodynamics to assess ED but should also aim to capture tissue heterogeneity. In addition, grayscale US can provide an additional metric of tracking pre- and post-treatment fibrotic changes.

While grayscale US may become a valuable tool to assess corporal fibrosis, one limitation is the individual expertise required to perform and analyze US findings, a summary of which is provided in Table 1. Recognition of subtle sonographic changes is highly subjective, and normal features may be misinterpreted as fibrosis. The ultrasonographer must be knowledgeable of penile anatomy and the changes that occur due to pathological conditions. This limitation is exemplified by the number of cases of corporal fibrosis surprisingly found during penile implant surgery.[85] Data remains limited in the published literature about whether these intraoperative complications occur in the absence of positive US findings. However, this could be added as a limitation to the use of grayscale US for tracking pre-operative fibrosis, as the technique is considered operator dependent and requires both technical skill and detailed sonographic knowledge of penile anatomy.

CONCLUSION

Overall, grayscale US may be a useful and convenient imaging modality to assess penile corporal fibrosis secondary to explantation of an infected penile prosthesis, priapism, penile trauma, chronic intra-cavernous injection of vasoactive drugs, diabetes, PD, and vascular disease. While limited by the skill and knowledge of the US operator, the combined knowledge of pathophysiology and US may help clinicians identify and manage the underlying etiology of penile corporal fibrosis.

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