Chapter 5
Penile Ultrasound

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Introduction

Penile ultrasound is commonly used in the diagnostic workup of a patient with erectile dysfunction (ED), but also plays an important role by providing an anatomic and functional vascular assessment in a multitude of other conditions including Peyronie’s disease, high-flow priapism, penile fracture, penile urethral strictures, urethral stones, or diverticulae, or masses involving deep tissues of the penis. As a component of the evaluation for ED, penile Doppler ultrasound (PDU) is performed to assess the quality of arterial blood flow and sufficiency of veno-occlusive mechanisms, both necessary for an adequate erection. More recently, this imaging modality is playing a central role in the early detection and diagnosis of otherwise silent coronary artery disease (CAD) in men presented with ED as their initial symptom. PDU is also an essential component of the assessment of external genitalia in trauma situations where high-flow priapism or penile fracture is suspected. Penile ultrasound provides a readily available, minimally-invasive diagnostic modality that evaluates both the structural anatomy and functional hemodynamics at a reasonable cost.
Ultrasound Settings

Penile ultrasound is best performed with a high-frequency linear array transducer with an ultrasound frequency of 7.5–18 MHz which allows for high resolution images of the penis and internal vascular structures. Color and spectral Doppler are essential elements of penile ultrasonography in addition to B-mode ultrasound. 3-D ultrasound is a technique that has the potential for better defining anatomic and vascular changes occurring with disease processes of the penis. Innovative new technologies including sonoelastography have the potential for changing the way we diagnose diseases of the phallus and follow their resolution.

When available, split screen visualization allows for comparison of laterality very similar to scrotal ultrasound discussed earlier. This is very important in penile ultrasound, but more specifically in PDU whereby the differences among vascular diameter, velocity of blood flow, and measurement of resistive index can be elegantly displayed in a single view for comparison of the right and left sides.

Scanning Technique

Scanning technique, as with any ultrasound examination, is operator dependent and hence may vary greatly. Nevertheless, it is essential for each practitioner to establish a routine protocol to which they fastidiously adhere. This allows for data to be comparable across serial examinations of the same patient and between studies performed on different patients with similar pathologies. Also, a routine protocol allows practitioners to provide anticipatory guidance to patients prior to beginning the study. A technique for patient preparation, routine survey scanning, and indication-specific scanning protocols for penile ultrasound is presented.

Importance of the Angle of Insonation

The Doppler shift (FD) is a change in frequency between the transmitted sound wave $F_T$ and received sound wave $F_R$ resulting from the interaction between the frequency of the sound waves transmitted by the transducer ($F_T$), the velocity of blood ($V_{BF}$), the cosine of the angle of incidence ($\theta$) between the vector of the transmitted sound wave from the transducer and the vector of blood flow as well as the speed of sound in tissue (c) as given by the equation:

$$FD = F_R - F_T = (2*F_T * V_{BF} * \cos \theta)/c$$

This concept of a Doppler shift is used to measure blood flow velocity whereby the shift in sound-wave frequency is detected by the ultrasound transducer after encountering active blood flow.
However, several factors influence the resultant frequency shift and hence the measured velocity. These include the incident frequency of the ultrasound beam used, speed of sound in soft tissues, the velocity of the moving reflectors (i.e., blood in a vessel), and the angle between the incident beam and vector of blood flow (θ) called the angle of insonation.

The angle of insonation is inversely related to Doppler shift. Hence, as the angle of insonation increases, approaching 90°, the Doppler shift decreases, and therefore, the calculated blood flow velocity decreases to 0. The Doppler angle is therefore a significant technical consideration in performing duplex Doppler examinations, and an ideal angle of insonance between 0 and 60° is required (Fig. 1).

Clinical Pearl: Even if the angle of insonance is not corrected, the RI will be accurate. However, PSV and EDV will be inaccurate.

**Patient Preparation**

The patient should lie comfortably on the examination table in a supine position with legs together providing support for the external genitalia. An alternative position is dorsal lithotomy with the penis lying on the anterior abdominal wall. Regardless of the patient position preferred, the area of interest should remain undraped for the duration of the examination. Care should be taken to cover the remainder of the patient as completely as possible including the abdomen, torso, and lower extremities. Ample amounts of ultrasonographic acoustic gel should be used between the transducer probe and the surface of the penis to allow uninterrupted transmission of sound waves, thus producing a high quality image without acoustic interruption.

**Penile Ultrasound Protocol**

As with other ultrasound exams, penile ultrasound uses specific scanning techniques and images targeting the clinical indication prompting the study. Irrespective of the indication for penile ultrasound, routine scanning during penile ultrasound should
include both transverse and longitudinal views of the penis by placing the transducer probe on the dorsal or ventral aspect of the penis. The technique presented here, uses a dorsal approach, which is easier for the flaccid phallus. However, the ventral approach, often with placement of legs in the lithotomy position, is often better with a fully erect phallus as well as being able to visualize the proximal corpora cavernosa. The goal is to visualize the cross-sectional view of the two corpora cavernosa dorsally and the corpus spongiosum ventrally along the length of the penis from the base of the penile shaft to the glans penis (Fig. 2).

The corpora cavernosa appear dorsally, as two homogeneously hypoechoic circular structures, each surrounded by a thin (usually less than 2 mm) hyperechoic layer representing the tunica albuginea that envelops the corpora. The corpus spongiosum is a ventrally located circular structure with homogeneous echotexture, usually more echogenic than the corpora cavernosa [1]. It is best visualized by placing the ultrasound transducer probe on the ventral aspect of the penis, however, the urethra is easily compressible so minimal pressure should be maintained while scanning. For routine anatomic scanning of the flaccid penis with ultrasound, all three corpora can be sufficiently viewed from a single dorsal approach to the penile shaft. A survey scan is first performed prior to obtaining static images at the proximal (base), mid-portion, and distal (tip) of the corpora cavernosal bodies for documentation (Figs. 3–5). The value of the survey scan cannot be over stated. It often provides the prospective that is necessary to assure absence of coexisting pathology. A careful survey scan of the phallus will identify abnormalities of the cavernosal vessels, calcified plaques and abnormalities of the spongiosa tissue.

Still images recommended as representative views of this initial survey scan of the flaccid phallus include one transverse view at the base of the penile shaft, one at the mid-shaft, and a third at the distal shaft just proximal to the corona of the glans penis (Fig. 3a). Each image should show transverse sections of all three corporal bodies. As noted in the labeled images, orientation by convention is for the right corporal body to be on the left side of the display (as viewed by the sonographer).
while the left corporal body is located on the right side of the display on images obtained with the ultrasound probe on the dorsal aspect of the phallus. Although performed as an initial survey scan in the flaccid phallus, this can also be after pharmacostimulation for comparison (Fig. 3b). Figure 4 demonstrates a normal mid-shaft view with the transducer on the ventral aspect of the phallus depicting the right and left corpora cavernosa (CC) and corpus spongiosum (CS).
Focused Penile Ultrasound by Indication

There are several accepted indications for penile ultrasound, each with specialized focus beyond the routine survey scan as previously described. General guidelines for the use of penile ultrasound are delineated by the “Consensus Statement of Urologic Ultrasound Utilization” put forth by the American Urologic Association [2] and the American Institute for Ultrasound in Medicine (AIUM). These indications can be further classified as either vascular, structural, or urethral pathology in nature (Table 1).

Erectile Dysfunction

PDU has been a vital part of the assessment of patients with ED. Some practitioners immediately turn to intracavernosal injection therapy with vasoactive agents in patients who have failed a course of oral phosphodiesterase-5 inhibitors. However, PDU may be used as a diagnostic tool in conjunction with commencement of

Fig. 5  a Color Doppler and spectral ultrasound findings in a high-flow priapism demonstrating high peak systolic and high-end diastolic velocity in the cavernosal artery feeding the arteriovenous fistula (AVF). b Color Doppler and spectral ultrasound findings in a low-flow priapism demonstrating a negative end diastolic diastolic velocity (i.e., reversal of flow) and a resistive index of 1.19. Subjective tumescence was 100% with rigidity of 95%
Table 1 Indications for penile and urethral ultrasound

<table>
<thead>
<tr>
<th>Vascular Pathology</th>
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<td>Erectile Dysfunction (ED)</td>
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<tr>
<td>Cavernosal Artery Diameter</td>
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<td>Flow velocity</td>
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<td>Peak systolic velocity (PSV)</td>
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<td>End diastolic velocity (EDV)</td>
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<td>Resistive Index (RI)</td>
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<td>Priapism</td>
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<td>High-flow (arterial)</td>
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<td>Low-flow (ischemic)</td>
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<td>Penile Trauma/Fracture</td>
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<td>Dorsal Vein Thrombosis</td>
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<td>Structural Pathology</td>
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<td>Penile Fibrosis/Peyronie’s Disease</td>
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<td>Plaque assessment (number, location, echogenicity and size)</td>
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<td>Perfusion abnormalities</td>
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<td>Perfusion surrounding plaques</td>
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<td>Penile Mass</td>
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<td>Primary penile tumors</td>
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<td>Metastatic lesions to the penis</td>
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<td>Penile Foreign Body (size, location, echogenicity)</td>
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<tr>
<td>Penile Urethral Disease</td>
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<tr>
<td>Urethral stricture (location, size)</td>
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<tr>
<td>Perfusion surrounding plaques</td>
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<tr>
<td>Calculus/Foreign Body</td>
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<tr>
<td>Urethral diverticulum/cyst/abscess</td>
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injection therapy. PDU allows for a baseline evaluation of the functional anatomy as well as providing a real-time assessment of the dynamic changes experienced in response to the dosing of vasoactive medications. In cases where intracavernosal injection of vasoactive substances does not prompt a penile erection, documentation provided by PDU will be a foundation for other management options including use of vacuum constriction devices or insertion of a penile prosthesis.

Possibly one of the most compelling reasons for the performance PDU in men presenting with ED is the finding that impaired penile vascular dynamics, as documented on PDU, may be associated with a generalized vessel disease that often predates cardiovascular disease by 5–10 years [3–5]. Significantly, early treatment of metabolic factors (e.g., hypertension, dyslipidemia, hyperglycemia) can delay and possibly prevent the development of cardiovascular disease [6, 7]. Therefore, the physician evaluating ED has a unique opportunity to diagnosis vascular impairment at a time when lifestyle changes and possible medical intervention have the potential to change morbidity and mortality of cardiovascular disease. As suggested by Miner, there might be a “window of curability” in which the significant risk of future cardiovascular events might be averted through early diagnosis and treatment [8–10].

In cases of diagnostic study for ED, emphasis is directed toward the cavernosal arteries. However, the initial survey scan is essential to evaluate for plaques, intravernosal lesions and urethral pathology as well as evaluation of the dorsal penile
The cavernosal arteries are visualized within the corpora cavernosa, and the depth of these arteries can be easily defined within the corpora during transverse scanning to ensure a comprehensively represented assessment of diameter at different points along its course. Color Doppler examination of the penis should be performed in both transverse and longitudinal planes of view. Using the transverse views as a guide to cavernosal artery depth, turning the transducer probe 90° then provides longitudinal views of each corpus cavernosum separately, allowing for identification of the cavernosal arteries in longitudinal section (Fig. 5). The diameter of the cavernosal artery should be measured on each side. Color flow Doppler makes recognition of the location and direction of blood flow easy. Measurements of vessel diameter to assess the peak systolic flow velocity (PSV) as well as end-diastolic flow velocity (EDV), allow for the assessment of a vascular resistive index (RI) (Fig. 6). The diameter of the cavernosal artery ranges from 0.2 to 1.0 mm in a flaccid penis [11, 12]. PSV varies at different points along the length of the cavernosal artery, typically with higher velocities occur more proximally [13]. Hence, the assessment of the PSV and EDV should be recorded at the junction of the proximal
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one-third and the distal two-thirds of the penile shaft. In the flaccid state, cavernosal artery PSV normally measures 5–15 cm/s, at baseline. This should be assessed and compared to the pharmacostimulated state [14, 15].

The intracavernosal injection should then be given. An overview of the injection procedure that we teach our patients is shown in the appendix. At regimented serial time points following the injection of vasoactive medication, cavernosal artery dimensions and flow velocities should be recorded to assess the response to pharmacologic stimulation. After prepping the lateral aspect of the penile shaft with an alcohol or providone-iodine prep pad, a finely measured volume of a vasoactive agent should be injected into one corpus cavernosum (in the distal two-thirds of the penile shaft) using a 29, or 30 gauge 1/2 inch needle. Pressure should be held on the injection site for at least 2 min to prevent hematoma formation. The amount to inject is patient specific. For example, a patient presenting with no erections after a radical prostatectomy that had normal erections prior to his procedure would be given a very low dose (i.e., 0.05 mL) of our standard TriMix (Papaverine 30 mg/mL; Phentolamine 2 mg/mL; PGE-1 10 mcg/mL). A patient however, with significant cardiovascular disease with no erections would be given a much higher dose to begin with (i.e., 0.2 mL or greater).

Vasoactive agents used for pharmacologic stimulation of erection include prostaglandin E1, papaverine, or trimix (combination of prostaglandin E1, papaverine, and phentolamine) [16]. As with every medication administration, the expiration date of the medication should be reviewed, patient allergies should be evaluated, and the dosage administered should be documented. We obtain an informed consent after the patient is counseled about the known risk for developing a low-flow priapism and appropriate follow-up if this were to arise [17]. This protocol requires the patient to stay in the office until penile detumescence occurs. A treatment protocol for low-flow priapism is given in Table 2. Of note, for patients in which we have given a vasoactive agent and have had to treat for low-flow priapism, aspiration, irrigation, and injection of intracorporal phenylephrine are usually successful to reverse the priapism state. In our experience, corporal aspiration alone has been uniformly successful in the setting of pharmacologically induced priapism in the

Table 2 Treatment protocol for low-flow priapism caused by pharmacologic induction by vasoactive agents

<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
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<tbody>
<tr>
<td>1.</td>
<td>Observation: If no detumescence in 1 h, then</td>
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<tr>
<td>2.</td>
<td>Aspiration: With a 19 or 21 gauge butterfly needle aspirate 30–60 cc corporal blood. Repeat in 1/2 h if 100% rigidity returns. May be repeated up to three times. If 100% rigidity persists than consider pharmacologic detumescence</td>
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<tr>
<td>3.</td>
<td>Pharmacologic detumescence:</td>
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<td>a. Phenylephrine 100–500 mcg injected in a volume of 0.3–1 cc every 3–5 min for a maximum of 1 h</td>
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<td></td>
<td>b. Monitor for acute hypertension, headache, reflex bradycardia, tachycardia, palpitations, and cardiac arrhythmia</td>
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<tr>
<td></td>
<td>c. Serial noninvasive blood pressure and continuous electrocardiogram monitoring are recommended</td>
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</table>

Of note, for patients in which we have given a vasoactive agent and have had to treat for low-flow priapism, aspiration, irrigation, and injection of intracorporal phenylephrine are usually successful to reverse the priapism state. In our experience, corporal aspiration alone has been uniformly successful in the setting of pharmacologically induced priapism in the
absence of confounding factors (e.g., concomitant use of phosphodiesterase inhibitors, sickle cell disease, etc.) following diagnostic duplex penile ultrasonography.

Our algorithm for persistence of rigidity after an in office diagnostic injection:

![Algorithm Diagram]

Arteriogenic ED is a form of peripheral vascular disease, commonly associated with diabetes mellitus and/or coronary artery disease. PSV is the most accurate measure of arterial disease as the cause of ED. The average PSV after intracavernosal injection of vasoactive agents in healthy volunteers without ED ranges from 35–47 cm/s, with a PSV of 35 cm/s or greater signifying arterial sufficiency following pharmacostimulation [18–23]. Primary criteria for arteriogenic ED include a PSV less than 25 cm/s, Cavernosal artery dilation less than 75%, Acceleration time >110 ms. In cases of equivocal PSV measurements, particularly when PSV is between 25 and 35 cm/s include, we look for asymmetry of greater than 10 cm/s in PSV comparing the two cavernosal arteries, focal stenosis of the cavernosal artery, cavernosal artery and cavernosal-spongiosal flow reversal [24].

Veno-occlusive insufficiency, also referred to as venous leak, can only be diagnosed in cases of ED where the patient was confirmed to have appropriate arterial function as measured by PSV. PDU parameters to assess the presence of veno-occlusive insufficiency as the cause of ED are EDV and RI. Antegrade EDV greater than 5 cm/s in the cavernosal artery demonstrated throughout the study, especially at the most turgid level of erection achieved, is suggestive of a venous leak [25, 26]. This is only true if PSV is normal. Arteriogenic dysfunction by definition fails to produce a fully tumescent and rigid phallus. In the setting of venous leak, EDV is always greater than 0. The definitive test for venous leak is the DICC (dynamic infusion cavernosography and cavernosometry). However, when both arteriogenic and venogenic dysfunction exists, interpretation of DICC is difficult. On PDU, an RI of less than 0.75, measured 20 min following maximal pharmacostimulation has been found to be associated with a venous leak in 95% of the patients [27]. In the absence of a venous leak, a fully erect penis should have an EDV nearing zero and hence, the RI should approach or exceed (when reverse flow occurs) 1.0 (Fig. 7). In cases of diagnostic PDU with intracavernosal pharmacostimulation where a RI of 1.0 or greater is achieved, we recommend immediate treatment or prolonged
observation to achieve detumescence because of the high specificity of absent diastolic flow for priapism [28].

In cases where arterial function and venous leak may be coexistent processes, indeterminate results may be yielded on PDU and a mixed vascular cause of ED may be assumed. However, venous competence cannot be accurately assessed in a patient with arterial insufficiency (Fig. 8).

As previously discussed, arteriogenic ED has been found to correlate directly with other systemic cardiovascular diseases, both coronary artery disease (CAD) and peripheral vascular disease (PVD), in a number of population studies [29, 30]. Researchers have postulated the common risk factor of atherosclerotic vascular disease and impaired endothelium-dependent vasodilation by way of the nitric oxide pathway as the underlying pathophysiologic explanation for the remarkable overlap between these disease processes [31–33]. Also, hypogonadism has been noted as a common etiology for organic ED and disorders leading to metabolic syndrome [34, 35]. Vessel compliance is compromised in arteriogenic ED as it is in CAD. Patients with severe vascular etiology ED, have an increased cavernosal artery diameter of less than 75% (with overall luminal diameter rarely above 0.7 mm) following injection of vasoactive agents into the corpora cavernosa [22, 36].

Studies have demonstrated that vasculogenic ED may actually provide a lead-time on otherwise silent and undiagnosed cardiovascular disease [29, 37, 38]. ED
has also been found to predict metabolic syndrome in men with normal body weight, as defined by body mass index (BMI) less than 25 kg/m², suggesting that the early diagnosis and intervention of vasculogenic ED might avert significant morbidity and provide a public health benefit by reducing the significant risk of cardiovascular and metabolic syndrome risk in men with ED [3, 5, 10, 39–42]. This is why we recommend referral for cardiovascular evaluation in men with a maximal PSV of less than 16 cm/s after injection of a maximal dose of a pharmacologic agent.

**Priapism**

Priapism can be differentiated as low-flow (ischemic) or high-flow (arterial) using PDU. Ultrasound plays an adjunct role to an illustrative history which may commonly indicate the likely underlying mechanism of priapism. Laboratory tests including a cavernosal blood gas, PDU provides documentable findings that may guide further treatment. High-flow priapism is commonly a result of pelvic or perineal trauma which results in arterial fistulization between the cavernosal artery and the lacunae of the corpus cavernosum. Unlike low-flow priapism, which is a medical emergency associated with severely compromised venous drainage from the

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**Fig. 8** With maximal stimulation, a PSV less than 25 cm/s suggests significant arteriogenic dysfunction. In this patient, injection with a maximal dose of a mixture of papaverine, phentolamine and prostaglandin E1, the peak systolic (PS) velocity was 16.24 cm/s with an elevated end diastolic velocity of 4.49 with a calculated resistive index of 0.72. When a maximal PS velocity is less than 25 cm/s, referral for evaluation of cardiovascular disease is recommended.
high-flow priapism does not result in venous stasis and rapid risk of tissue necrosis. Ultrasound used as an aide in the definitive diagnosis and localization of the cause of high-flow priapism can expedite treatment with selective angioembolization [43]. In cases of high-flow priapism PDU reveals normal or increased blood flow within the cavernosal arteries and irregular, turbulent flow pattern between the artery into the cavernosal body at the site of an arterial-lacunar fistula (Fig. 9a). In contrast, a low-flow priapism on PDU would present with absent or very high-resistance flow within the cavernosal artery (Fig. 9b).

A transperineal approach should also be used in cases of suspected high-flow priapism to fully evaluate the proximal aspects of the corpora cavernosa. Ultrasonography of these deep structures may reveal ateriocavernosal fistula following perineal trauma, not evident by routine scanning of the penile shaft.

**Penile Fracture**

Similar to priapism, the diagnosis of penile fracture is largely clinical, based upon the history gathered combined with the physical examination findings. However, PDU may play an important diagnostic role in more elusive cases, expediting a
definitive diagnosis and early surgical management \cite{44, 45}. Penile fracture can be seen on ultrasonography as a break point in the normally thin, hyperechoic tunica albuginea with altered echotexture in the adjacent area in the corpus cavernosum (straight arrow). Fracture is shown (long arrow) with tissue bulging above the tunica albuginea. Transverse penile ultrasound demonstrating a defect in the tunica albuginea enveloping the right corpus cavernosum (RT) with adjacent hematoma found typically on physical exam as an “eggplant deformity”

In cases of both conservative management and post-surgical exploration and repair, PDU can be used as a minimally invasive follow-up study to ensure progressive healing, reabsorption of the hematoma, and intact blood flow on serial evaluations. Also, PDU allows for a dynamic anatomic assessment of erectile function following penile fracture in patients who have ED.
Dorsal Vein Thrombosis

Occasionally, dorsal vein thrombosis, often called Mondor’s phlebitis, occurs with the triad of clinical symptoms of inflammation, pain and fever resulting in patient consultation. There is often some induration and tenderness over the involved vein. The etiology has been variously ascribed to neoplasm, mechanical injury during intercourse, sickle cell disease, varicocele surgery and herpes simplex infection. Occlusion of the vein can be visualized on ultrasound (Fig. 11) and followed with serial imaging as required to document resolution which usually occurs spontaneously as patency is reacquired in 6–8 weeks [46–50].

Peyronie’s Disease

Penile ultrasonography is often used as an adjunct to a complete history and physical examination in the assessment of a patient with Peyronie’s disease. Fibrotic plaques can be visualized as hyperechoic or hypoechoic areas of thickening of the tunica albuginea [51, 52]. At times these plaques have elements of calcification, which cause a distinct hyperechoic focus with posterior shadowing on ultrasound (Fig. 12). Ultrasonography can aide to confirm the presence of plaques palpated on physical examination and allows for accurate measurement of these lesions. Whenever possible, measurement of the plaque length, width, and depth should be obtained and documented. PDU can be used to assess perfusion around the area of plaques. Hyperperfusion is suggestive of active inflammation.

Many men with Peyronie’s disease have coexistent ED. Men with Peyronie’s disease and ED most commonly have veno-occlusive insufficiency secondary to the fibrotic plaques present, but arterial insufficiency or mixed vascular abnormalities can also be implicated as the cause of ED [53]. Comprehensive assessment of
the underlying cause of ED using PDU provides guidance for the most appropriate patient-specific, treatment course. In men with normal erectile function, penile modeling, plaque injection, or surgical procedures such as plication or grafting procedures may be considered. In men with concomitant Peyronie’s disease and ED, reconstructive procedures may be undertaken with added care to define perforating collateral vasculature from the dorsal artery system. However, erectile function will not be improved in these men and often concomitant treatment for the erectile function is required. In more severe cases, penile implant may be indicated.

**Sonoelastography**

The ability to access pathology by palpation has long been a key part of the physician’s physical examination. Hard lesions are often a sign of pathology. Sonoelastography (tissue elasticity imaging) is an evolving ultrasound modality which adds the ability to evaluate the elasticity of biological tissues. Essentially, it gives a representation, using color, of the softness or hardness of the tissue of interest. The physics of this modality is given in an earlier chapter. Visually, the elasticity of a tissue is represented by color spectrum. Be aware that the color given to hard lesions is determined by the manufacturer of the equipment as well as being able to be set by the user. Therefore, just as in using color Doppler, the user needs to look at the color bar to know which color represents a ‘hard’ and ‘soft’ lesion. Penile curvature is sometimes present without a palpable plaque. In addition, B mode and Color Doppler are not sufficient to identify areas of the cavernosal bodies that are denser than the surrounding tissue. We have used sonoelastography of the phallus to locate these areas which might be amenable to treatment with injectable agents (Figs. 13 and 14) [54].
**Fig. 13** Sonoelastography (top image) and B mode image (lower image) of the mid-sagittal view of both the right and left cavernosal bodies of a 40-year old man with left penile curvature. No plaque could be identified on exam or by B mode ultrasound (lower images). Firmer issue (red) was clearly identified with sonoelastography.

**Fig. 14** Three sonoelastography transverse images of the base, mid and distal views of the same patient in Fig. 13 with penile curvature and a nonpalpable plaque. The base of the phallus clearly has less firm tissue than the distal phallus. Sonelastography again shows firmer tissue in the mid left cavernosal body.
Penile Masses

Most commonly masses discovered on physical examination are benign entities such as Peyronie’s plaques, subcutaneous hematomas, or cavernosal herniation through tunica albuginea defects.

Cancerous lesions of the penis are rare. Nevertheless, primary penile carcinomas with deep invasion and more rarely metastatic lesions may present as masses within the penile deep tissues (Fig. 15). Penile carcinoma is usually identified by inspection as most arise as a superficial skin lesion. Ultrasound usually identifies these lesions as hypoechoic ill-defined lesions with increased blood flow relative to surrounding tissues. Although not indicated for staging purposes, ultrasound can aid in assessment of anatomic relationships of the mass to deep structures, at times identifying depth of penetration in cases where the tumor clearly invades the tunica albuginea and corporal bodies [55, 56].

Metastatic deposits within the penis are exceedingly rare, but appear on ultrasound similar to primary penile carcinomas as hypoechoic lesions with hyperperfusion. However, metastatic lesions in the penis are rarely contiguous with the skin surface and more commonly well circumscribed compared to primary penile cancers [57].

Penile Urethral Pathologies

Penile ultrasound has been used as an adjunct to the physical examination to better diagnose and define specific urethral pathologies. Direct urethral visualization using a cystoscope is the preferred diagnostic test for many urologists. However, ultrasound can provide an economically-sound and noninvasive alternative for the assessment of urethral stricture, foreign bodies including urethral calculi, and urethral and periurethral diverticula, cysts, and abscesses.

Urethral strictures are the result of fibrous scarring of the urethral mucosa and surrounding spongiosal tissues which contract and narrow the luminal diameter of
the urethral channel. Common causes of penile urethral strictures are infections, trauma, and congenital narrowing. Urethral trauma resulting in stricture disease includes, but is not limited to: straddle injury, passage of stones or foreign bodies, and iatrogenic instrumentation including catheterization and cystoscopy. Although retrograde urethrography is the standard imaging modality for urethral stricture disease (both anterior and posterior segments), penile ultrasound provides a more accurate assessment of stricture length and diameter in the anterior segment [58–60]. Furthermore, penile ultrasound allows for assessment of stricture involvement within the periurethral spongy tissue whereas a classic urethrogram only assesses the luminal component of the pathology (Fig. 16) [61]. On B-mode ultrasonography, strictures appear as hyperechoic areas surrounding the urethra without evidence of Doppler flow, consistent with the findings of fibrosis. However, the fibrotic stricture segment may have surrounding Doppler flow demonstrating hyperemia from inflammation. With distension of the urethra with saline or lubricating jelly, areas of narrowing can be appreciated, corresponding to the location of a stricture.

Urethral foreign bodies or calculi suspected based upon patient history and physical examination can be easily confirmed with penile ultrasound. Shape, size, and location of these obstructing bodies can be assessed, and a therapeutic plan can be made based upon the data obtained [62].

Urethral and periurethral diverticuli, cysts, and abscesses can be delineated with penile ultrasound with ease. A contrast medium such as normal saline or lubricating jelly is needed to provide a differential in ultrasound impedance to identify urethral or periurethral diverticula with the best sensitivity [63]. Cysts and abscesses around the urethra can be visualized using penile ultrasound without the insertion
of contrast material. However, at times contrast material can be useful in identifying whether the structures noted are separate from the urethra once distended.

**Proper Documentation**

Complete and meticulous documentation of every ultrasound examination is an element of a comprehensive study. Documentation often entails a series of representative static images or cine series (when electronic storage space and technology allows) that are archived with an associated report documenting pertinent findings and indicated measurements and calculations. The combination of images and a written document of findings allows for optimal diagnosis aiding in patient care, archival reference in the patient medical record, and appropriate billing of services provided.

Each report must include patient identification (i.e., name, medical record number, date of birth, etc.), date of the examination, type of examination performed, indications for the examination, and pertinent findings and diagnoses. It is mandatory to include complete identification of the patient and study. Each report should also be undersigned by the ultrasonographer and physician interpreter of the study to document who performed the study and who read the results in cases where a technician performs the study-saving images for a physician’s interpretation. Copies of the printed images should be attached to the report or electronically stored images and/or videos should be referenced in the written report. The ultrasound images should be labeled with the date and time of the study, patient identification, and applicable anatomic labeling. Chapter 8 covers a suggested image and report documentation protocol with templates that can be used to assure comprehensive documentation of the study.

**Conclusion**

With a proper understanding of penile anatomy and functional physiology, penile ultrasound provides a real-time imaging modality assessing the static anatomic features and vascular dynamics. As a diagnostic modality, ultrasound provides urologists a vital tool in the office assessment of ED, Peyronie’s disease, penile urethral strictures, and masses of the penis as well as an acute care setting evaluation of a penile trauma patient. Newer technologies, such as sonoelastography, offer the potential to offer additional insight into the pathologic process.
Appendix

Patient Instructions for Penile Injection Therapy

I Preparation for Injection

Items You Will Need

- Alcohol sponges or swaps
- 1 mL insulin syringe with #28 or #30 gauge needle. These are disposable and not to be reused for a second injection. Disposal should be performed with the cap on the needle so as not to injure anyone disposing of trash.
- Papaverine/Phentolamine combination, Prostaglandin E1 or Papaverine/Phentolamine/Prostaglandin combination either pre-drawn by the physician a pharmacist in the syringe, or in a vial to be drawn into the syringe by the patient in the appropriate volume as prescribed by the physician. The medication must be refrigerated and away from light exposure.

Filling the syringe:

1. Check the expiration date of medication. Hold the medication bottle so that your fingers do not touch the rub or stopper.
2. Using a circular motion, wipe off the top of the bottle with alcohol swab.

3. Remove the needle cover. Do not allow the needle to touch anything before drawing the medication or before injecting the medication.
4. Draw an amount of the air is cool to the mountain medication to be injected into the syringe. Push the need of and to the center of the stopper. Push the air into the bottle.
5. Turn the bottle and syringe upside down. Solely draw the medication into the syringe. Tap the syringe gently to remove the bubbles.
6. Move the plunger in and out several times while gently tapping the syringe, just removing all air bubbles.

7. Gently removing the old from the bottle and replace the. The soon the protective and place the filled syringe within easy reach prior to injection.
II Self-injection Technique

Step 1  Grasp the head of the penis, not the skin, and hold upwards toward the trunk. Position the penis along your inner thigh. Choose the injection site on the side of the penis. Avoid injecting into any visible veins. The crossed hatched areas in the figure below represent the ideal locations to inject into.

Step 2  Wipe the skin with an alcohol swab.
Step 3 Pick up the syringe between the thumb and middle finger, like a pen, and push the needle gently but firmly through the skin until the entire needle is buried inside the penis.

Step 4 Holding the syringe, use your thumb to slowly (8–10 s) inject the entire amount of medication. Then remove the needle with from your penis.
Step 5 Immediately apply pressure on the injection site with another alcohol wipe for at least 2 min. Make sure there is no bleeding.

Step 6 Dispose of the syringe unit into the puncture-proof receptacle provided.

Step 7 Stand up to allow your erection to develop quickly. You are now ready to start sexual foreplay. You will have a full or action within a few minutes.

Normally, the erection will last anywhere from 30–120 min. If your erection lasts longer than 3 h, you should seek immediate medical attention.

References