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Variability in Penile Duplex Ultrasound International Practice Patterns, Technique and Interpretation: An anonymous survey of ISSM members

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Abstract

Penile duplex ultrasound (PDU), combined with pharmacologic stimulation of erection, is the gold standard for evaluation of multiple penile conditions. A 30-question electronic survey was distributed to members of the International Society for Sexual Medicine (ISSM). The survey assessed variability in current PDU practice patterns, technique and interpretation. Chi-square test was used to determine association between categorical variables. Approximately 9.5% of all 1,996 current ISSM members completed the survey. Almost 80% of members surveyed reported using PDU, with more North American practitioners utilizing PDU than their European counterparts (94% vs. 69%, $p < 0.01$). Approximately 62% of PDU studies were performed by a urologist and more than 76% were interpreted by a urologist. Although almost 90% of practitioners reported using their own protocol, extreme variation in technique existed among respondents. Over 10 different pharmacologic mixtures were used to generate erections, and 17% of respondents did not repeat dosing for insufficient erection. Urologists personally performing PDU were more likely to assess cavernosal artery flow using recommended techniques with the probe at the proximal penile

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Conflict of Interest:

The authors declare no conflict of interest.

Supplementary Information:

Penile Doppler Ultrasound Practice Patterns Survey Questionnaire – PDF File

(SUPPLEMENTARY_PenileDopplerUltrasoundPracticePatternsSurveyQuestionnaire.pdf)

shaft (73% vs 40%) and at a 60-degree angle or less (68% vs 36%) compared to non-urologists ($p < 0.01$). Large differences in PDU diagnostic thresholds were apparent. Only 38% of respondents defined arterial insufficiency with a peak systolic velocity < 25 cm/sec, while 53% of respondents defined venous occlusive disease with an end diastolic velocity > 5 cm/sec. This is the first study to assess variability in PDU protocol and practice patterns and to pinpoint areas of improvement. As in other surveys, recall bias, generalizability, and response rate (9.5%) are inherent limitations to this study. Although most respondents report utilizing a standardized PDU protocol, widespread variation exists among practitioners in terms of both technique and interpretation, limiting accurate diagnosis and appropriate treatment of penile conditions.

Introduction

Penile duplex ultrasound (PDU), combined with pharmacologic stimulation of erection, is the gold standard approach for evaluation of multiple penile conditions. These include erectile dysfunction (ED), Peyronie's disease (PD), penile fracture, and trauma¹. Unlike other imaging modalities (CT or MRI), ultrasound is frequently performed by urologists rather than radiologists. In addition to a vascular and anatomical evaluation, PDU also provides a dynamic, quantifiable, consistent, and reliable method for evaluation of several structural conditions. It can help detect fibrotic plaques and calcifications characteristic of PD, defects in the tunica albuginea and variable echogenicity in the corpus cavernosa in the setting of trauma or features of priapism that differentiate between high and low flow priapism, including arteriocavernosal fistulas and high-resistance cavernosal arterial flow. Anatomic variations in vasculature can also be detected.

Since Lue et al.'s early description of penile ultrasound in 1985, technological improvements in imaging have significantly improved its utility and precision (1). After an intracavernosal injection of a vasoactive agent, a 7.5- to 12-MHz linear array ultrasound probe is used to scan the penis typically on the ventral surface at a fixed angle (2). It is recommended that the angle between the incident beam and the vector of blood flow i.e. the angle of insonation be maintained at 60° or less (3, 4). The peak systolic velocity (PSV), end diastolic velocity (EDV), and a calculated resistive index ($RI = [PSV - EDV] / PSV$) are measured to assess penile hemodynamics. Change in diameter of the cavernosal artery and flow in the deep dorsal vein may also be measured. A PSV lower than 25 cm/second or an EDV greater > 5 cm/second in the setting of adequate arterial flow have been the major criteria used to define and distinguish ED due to arterial insufficiency or corporal veno-occlusive dysfunction, respectively (1, 2, 5–8).

A lack of standard approaches to performing and interpreting PDU limits its utility. In 2011, the American Institute of Ultrasound in Medicine (AIUM) and the American Urological Association (AUA) developed guidelines for penile ultrasound technique and training for physicians who evaluate and interpret urologic ultrasound examinations (9). Recognizing the variability and need for standardization, standard operating procedures to emphasize guidelines for PDU have been published in an attempt to emphasize correct technique (2, 10). To assess adoption of and adherence to the above-mentioned protocols and guidelines, we examined the variability in international practice patterns, technique and interpretation

among practitioners who perform PDU. Further standardization will help improve our ability to diagnose penile pathology and promote more effective comparison of results and clinical research in the field.

Materials and Methods

A 30-question electronic survey was developed to assess anonymous demographic information, current PDU practice patterns, technique and interpretation. We placed an emphasis on who performs the PDU, intracavernosal injection protocols, and which parameters are measured during the study. The entire content of the survey is available as Supplementary information. This survey was then distributed to all 1,996 members of the International Society for Sexual Medicine (ISSM) using Survey Monkey (SurveyMonkey Inc, San Mateo, CA, USA). All participants provided anonymous consent prior to starting the survey, and the study and survey were approved by the Baylor College of Medicine institutional review board. The survey was kept open for one month and only completed surveys were used for analyses. Descriptive analyses were performed, and chi-square test was used to determine association between categorical variables. All statistical analyses were done using SPSS v22 (IBM, NY).

Results

Approximately 9.5% (190) of all 1,996 current ISSM members completed the survey. The majority (65%) of respondents were fellowship-trained in Andrology, Sexual Medicine, or Male Infertility. 94% of respondents were males and 59% were in private practice. Almost 80% of respondents surveyed reported using PDU, with more North American practitioners utilizing PDU than their European counterparts (94% vs. 69%, $p < 0.01$). Over 1/3 of practitioners using PDU perform more than 10 studies per month, and 69% are done in a urology clinic. Approximately 62% of PDU studies were performed by a urologist and 77% were interpreted by a urologist. Demographic details are presented in Tables 1,2, and 3. Most of the respondents listed ED (90%) and PD (74%) as indications for PDU. All other indications reported are presented in Table 4.

Although almost 90% of practitioners reported using a standardized protocol, only 35% of practitioners were aware of the AIUM/AUA guidelines. Over 10 different intracavernosal pharmacologic mixtures were used to initiate erections prior to PDU (Table 5), with 10 mcg of Prostaglandin E1 being the most commonly used. 17% of respondents did not repeat dosing for insufficient erection and 34% reported never using pharmacologic intervention to facilitate detumescence following PDU. No form of audio-visual sexual stimulation was used by approximately 35% of respondents.

Overall, 60% of respondents assessed cavernosal artery flow at the proximal penile shaft and 56% of respondents assessed flow with the ultrasound probe angled at 60 degrees or less relative to the penis. Urologists personally performing PDU were almost twice as likely to assess cavernosal arterial flow with the probe at the proximal penile shaft (73% vs 40%, $p < 0.01$) and at a 60-degree angle or less (68% vs 36%, $p < 0.01$) compared to non-urologists. These differences in technique are presented in Table 6. The timing and frequency of

cavernosal artery flow measurements after response to ICI was highly variable amongst respondents (Table 5). Large differences in PDU diagnostic thresholds were reported (Table 5), with 38% of respondents defining arterial insufficiency with a PSV < 25 cm/sec, and 53% of respondents defining venous occlusive disease with an EDV > 5 cm/sec. Urologists interpreting PDU were more likely to define venous occlusive disease as EDV > 5 cm/sec (63% vs 34%, $p < 0.01$) than non-urologists (Table 6). No similar association was observed for arterial insufficiency, with the most common definition of PSV being < 25 cm/sec. No associations were found based on training or region.

Discussion

To our knowledge this is the first survey to evaluate variability in practice patterns, technique, and interpretations among practitioners using PDU for evaluation of erectile function. More North American practitioners use PDU than Europeans (94% vs 69%, $p < 0.01$), which may be due to geographic differences in management, reimbursement, or availability. According to AUA guidelines, intracavernosal injection with or without PDU is indicated prior to any invasive intervention for PD. EAU guidelines recommend PDU only in the context of questionable erectile function to ascertain vascular parameters, but not for measurement of plaque size in everyday clinical practice (11, 12). However, although PDU is explicitly mentioned as a specialized diagnostic test for vascular investigation for ED in EAU guidelines, AUA guidelines state that “additional testing such as testosterone level measurement, vascular and/or neurological assessment, and monitoring of nocturnal erections may be indicated in select patients” (12, 13). Reimbursement may favor North Americans due to varying healthcare models but no differences were observed in PDU use according to practice type (academic practice vs private practice) in our cohort.

A significant number of PDU examinations were performed and interpreted by non-urologists, including radiologists, ultrasound technicians, and advanced practice providers (Physician’s Assistant/Nurse Practitioners). Given the operator-dependent nature of PDU, Aversa and Sarteschi had previously suggested that practitioners perform a minimum of 200 investigations per year to be considered well trained (4). The guidelines developed by the AIUM in collaboration with AUA also detail the required number of yearly volume requirements and course credits depending on a physician’s background to be considered competent. This document favors a minimum of 100 diagnostic genitourinary ultrasound examinations to gain experience and proficiency with sonography as a diagnostic modality and 50 diagnostic genitourinary ultrasound examinations a year for a physician to maintain skill (14). According to our survey, 33% of respondents would fall below this benchmark set by the AUA/AIUM to maintain expertise using this modality.

Psychological and environmental factors influence erectile function and in turn PDU interpretation. The selection of vasoactive pharmacological substances used to achieve an erection is highly variable. A significant number of patients who are not sufficiently dosed or stimulated to achieve maximal rigidity may be undergoing suboptimal ultrasound procedures which do not result in an accurate diagnosis. Patients should be involved during this procedure to evaluate erection quality, especially since a large number of patients exhibit

needle phobia (15–17). In addition, re-dosing, and the use of audio-visual sexual stimulation might be required in the setting of inadequate response compared to erections at home.

The principal source of error in flow velocity determination is an incorrectly used Doppler angle(8). Distal locations and larger probe angles artificially lower PSV measurements and may lead to incorrect arterial insufficiency diagnoses(18–20). The standardization and knowledge of vascular parameters necessary for diagnosis is a vital area for improvement. Urologists should be aware of the standard pattern of Doppler waveform progression associated with hemodynamic changes in corporal pressure during progression to normal full erection. Measurements should be interpreted in conjunction with erectile response to avoid false positives associated with PDU measurements.(6, 21) For example, EDV may initially increase in the response phase prior to decreasing as rigidity and veno-occlusion are achieved and PSV decreases following full penile rigidity. The presence of significant sympathetic tone in young, anxious patients may falsely lower PSV and increase EDV, further complicating the process.(22–24) The diagnosis of mixed or veno-occlusive ED is difficult to make in patients with arterial insufficiency(25–28). Resistive Index offers another, more specific measure of veno-occlusive disease accounting for PSV but further investigation into its use is needed (29). The time to full erectile response is variable among patients, contributing to increased likelihood of test misinterpretation. Due to factors including environment, injection protocols, drug used, baseline function, and pathology, several authors have stressed using serial measurements to definitively establish a diagnosis (2, 21, 30–32). The wide variation seen in timing of initial measurement and lack of repeat measurements by a significant number of respondents are concerning for a high prevalence of inadequate PDU studies. This disparity seen in technique and interpretation strongly suggests the need for education and standardization of the approach to and interpretation of PDU.

This study has several limitations that should be discussed. As in any other survey study, recall bias is an inherent limitation. The survey was limited to members of the ISSM and our response rate was only 9.5%. Our results are thus applicable only to providers specifically interested in sexual medicine, and even more specifically, who are interested in membership in an academic society. Our study design neglects the remainder of providers who may be performing PDUs. However, the study provides valuable insight into PDU practice patterns, particularly in light of more recent efforts at standardization of the procedure and interpretation of results.

Conclusions

The minimally invasive nature of a PDU, its relatively low cost, and the ability to objectively and effectively diagnose a number of penile conditions make it an essential primary diagnostic modality. Although most respondents report utilizing a standardized PDU protocol, widespread variation exists among practitioners in terms of both technique and interpretation. This variation limits the utility of PDU and may impair accurate diagnosis and appropriate treatment of penile conditions. Our study demonstrates that gaps in knowledge remain, and there is room for improvement in the utilization of PDU. Further

standardization and implementation of established protocols could improve patient care and research in the future.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Table 1

Respondent Demographics

Question	Responses, n (%)
Gender	
Male	176 (93%)
Female	14 (7%)
Years in Practice	
< 10 years	64 (34%)
10 – 20 years	46 (24%)
> 20 years	80 (42%)
Level of Training	
Attending / Board-Certified	166 (87%)
Resident / Fellow	13 (7%)
Advanced Practice Provider	11 (6%)
Fellowship training	
Yes	123 (65%)
No	67 (35%)
Practice Type	
Private	112 (59%)
Academic	57 (30%)
Government	21 (11%)
Region	
North America	66 (35%)
Europe	54 (28%)
Other	70 (37%)

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Table 2

Associations between Demographics and PDU Use

	Use PDU, n (%)	Do Not Use PDU, n (%)	p Value
Respondents	151 (79%)	39 (21%)	
Fellowship			
Yes	102 (83%)	21 (17%)	0.11
No	49 (73%)	18 (27%)	
Practice Type			
Private	84 (75%)	28 (25%)	0.07
Other	67 (86%)	11 (14%)	
Region			
North America	62 (94%)	4 (6%)	< 0.01
Europe	37 (69%)	17 (31%)	
Other	52 (74%)	18 (26%)	

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Table 3

PDU Practice Patterns

Question	Responses, n (%)
How frequently?	
> 10 PDUs / month	59 (39%)
5 – 10 PDUs / month	42 (28%)
1 – 4 PDUs / month	50 (33%)
Where are PDUs performed?	
In Urology Clinic	104 (69%)
In Radiology Department	38 (25%)
Other	9 (6%)
Who performs PDUs?	
Urologist	93 (62%)
Radiologist	32 (21%)
Ultrasound Technician	20 (13%)
Advanced Practice Provider	6 (4%)
Who interprets PDUs?	
Urologist	116 (77%)
Radiologist	31 (20%)
Advanced Practice Provider	4 (3%)

Table 4

Indications for PDU

Question	Responses, n (%)
Indications for PDU?	
Erectile dysfunction	171 (90%)
Peyronie's disease / penile curvature	140 (74%)
Priapism	100 (53%)
Penile trauma	97 (51%)
Dorsal vein thrombosis	63 (33%)
Abnormality on physical exam	55 (29%)
Urethral stricture	19 (10%)

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Table 5

Technique and Interpretation of PDU

Question	Responses, n (%)
Standardized PDU protocol?	
Yes	134 (89%)
No	10 (7%)
Unsure	7 (4%)
Initial intracavernosal agent?	
Prostaglandin E1 10 mcg	46 (30%)
Prostaglandin E1 20 mcg	30 (20%)
Papaverine 3 mg / Phentolamine 0.1 mg (Bimix 0.1 ml)	5 (3%)
Papaverine 6 mg / Phentolamine 0.2 mg (Bimix 0.2 ml)	3 (2%)
Papaverine 3 mg / Phentolamine 0.1 mg / PGE1 1 mcg (Trimix 0.1 ml)	25 (17%)
Papaverine 6 mg / Phentolamine 0.2 mg / PGE1 2 mcg (Trimix 0.2 ml)	9 (6%)
Variable	11 (7%)
Other	17 (12%)
Unsure	5 (3%)
None	0 (0%)
Additional agent following insufficient erection?	
Yes	114 (76%)
No	26 (17%)
Unsure	11 (7%)
Frequency of pharmacologic intervention for detumescence?	
Never	51 (34%)
Around 25% of studies	72 (48%)
Around 50% of studies	10 (7%)
Around 75% of studies	7 (4%)
Always	4 (2%)
Unsure	7 (4%)
Where is cavernosal artery flow assessed?	
Perineum	6 (4%)
Proximal penile shaft	91 (60%)
Mid penile shaft	36 (24%)
Distal penile shaft	1 (1%)
Unsure	17 (12%)
At what angle is the probe held relative to penis to assess flow?	
30 degrees	19 (13%)
45 degrees	35 (23%)
60 degrees	30 (20%)

Question	Responses, n (%)
75 degrees	3 (2%)
90 degrees	30 (20%)
Unsure	34 (22%)
When is cavernosal artery first assessed after initial response to cavernosal injection?	
Immediately after erection is obtained	39 (25.83%)
5 minutes after erection is obtained	59 (39.07%)
10 minutes after erection is obtained	23 (15.23%)
15 minutes after erection is obtained	4 (2.65%)
I do not know	9 (5.96%)
Other	17 (11.26%)
In addition to a baseline assessment and an assessment following initial response to cavernosal injection, how many additional assessments of cavernosal artery flow are completed before the conclusion of the study?	
None	26 (17.22%)
1	36 (23.84%)
>1	78 (51.66%)
I do not know	11 (7.28%)
Peak systolic cavernosal artery flow defining arterial insufficiency?	
< 40 cm / sec	1 (1%)
< 35 cm / sec	30 (16%)
< 30 cm / sec	51 (27%)
< 25 cm / sec	73 (38%)
< 20 cm / sec	21 (11%)
Unsure	14 (7%)
End diastolic cavernosal artery flow defining venous occlusive disease?	
> 10 cm / sec	17 (9%)
> 7 cm / sec	13 (7%)
> 5 cm / sec	101 (53%)
> 3 cm / sec	21 (11%)
> 0 cm / sec	8 (4%)
Unsure	30 (16%)

Table 6

PDU Technique by Practitioner Type

	Performed by urologist, n (%)	Performed by non-urologist, n (%)	p Value
Probe location			
Proximal penile shaft	68 (73%)	23 (40%)	< 0.01
Other	25 (27%)	35 (60%)	
Probe angle			
60 degrees or fewer	63 (68%)	21 (36%)	< 0.01
Other	30 (32%)	37 (64%)	
Arterial insufficiency			
PSV < 25 cm / sec	42 (36%)	14 (40%)	0.68
Other	74 (64%)	21 (60%)	
Venous occlusive disease			
EDV > 5 cm / sec	73 (63%)	12 (34%)	< 0.01
Other	43 (37%)	23 (66%)	