

Penile Colour Duplex Ultrasonography as a Screening Tool for Venogenic Erectile Dysfunction

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Abstract

Introduction: Vasculogenic impotence is one of the major causes of erectile dysfunction. Cavernosometry and cavernosography is traditionally the gold standard for evaluation of venogenic impotence. However, it is invasive and there are potentially significant complications. Penile colour flow Doppler imaging (PCDI) is non-invasive and can be used to assess venous incompetence. **Materials and Methods:** One hundred and sixty-eight patients were referred for PCDI assessment from March 1998 to February 2001. Forty-three of these also had cavernosogram and cavernosometry done and were included in the study. **Results:** The sensitivity was 93.9%, the specificity was 90.0%, the accuracy was 93.0% with a negative predictive value of 81.8% and a positive predictive value of 96.9%. Kappa value of 0.81 was obtained, indicating excellent agreement between PCDI and cavernosogram and cavernometry. **Conclusions:** Penile colour flow Doppler imaging is accurate in the assessment of venogenic erectile dysfunction. It can replace cavernometry and cavernosogram as a screening tool. Cavernometry and cavernosogram should only be done in cases when PCDI suggests venogenic impotence, and when surgery is contemplated.

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Introduction

Penile colour flow Doppler imaging (PCDI) is a non-invasive, accurate and cost-effective technique. It has better patient acceptance as compared to cavernosometry and cavernosography, and it does not involve any ionising radiation. Real time appreciation of the penile vasculature can be obtained, and it also provides a functional assessment of both penile arterial and venous blood flow. Anatomical variants of vascular supply and abnormalities of the penile vasculature, such as stenosis, can be detected. Penile

musculature anatomy can also be assessed for any focal abnormalities such as fibrosis. Furthermore, PCDI is done with pharmacostimulation, which closely approximates the normal dynamic events that lead to erection.

Venogenic impotence has long been assessed with cavernosometry and cavernosography. However, these procedures are invasive and are not suitable for screening purposes. It is not without complications, always carrying with it the potential risk of contrast media reaction.

We present our experience with PCDI in the assessment

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of venogenic impotence and discuss if PCDI is suitable as a tool for screening of venogenic incompetence.

Materials and Methods

All PCDI reports from March 1998 to February 2000 were recalled from our department computer database. The medical records, ultrasound as well as cavernosometry and cavernosography images of these patients were traced from the medical records office and reviewed.

Only patients who had both PCDI and cavernosometry and cavernosography performed were included in the study.

Statistical analysis of agreement between two modalities was performed using Kappa statistic, which was used to measure agreement between the two modalities. A K value greater than 0.80 was considered as excellent agreement; between 0.60 and 0.80 as good agreement; between 0.41 and 0.60 as moderate agreement; between 0.21 and 0.40 as fair agreement; and equal to or less than 0.20 as poor agreement.¹ The sensitivity and specificity, accuracy as well as negative and positive predictive values were also determined

Technique

The ultrasound examination was performed in a peaceful environment with great care to ensure the patients' privacy. This helped to reduce patients' anxiety. An Advance Technology Laboratories HDI 3000 diagnostic ultrasound system (USA) with a 7-10MHz linear array transducer was used to scan all patients. Grey scale and colour flow imaging, as well as pulsed Doppler with real time spectral analysis were obtained in all patients. A single operator (THS) performed all the ultrasound studies. This reduces inter-operator variability. The patients were scanned in the supine position, and the penis was placed in an anatomical position on the suprapubic region in the midline. The cavernosal arteries were scanned with the transducer placed on the ventral surface of the penis. Sampling of the peak systolic velocity (PSV) was done near the base of penis. The penis was initially examined with grey-scale ultrasound, in both transverse and longitudinal planes. The penis was assessed in the flaccid state, as well as after pharmacostimulation with 10 µg of prostaglandin E1 (PGE1). This was administered intracorporally with a 29 G needle. The rigidity of erection was assessed by asking for the patient's subjective opinion, and with clinical palpation. The PSV was measured immediately after PGE1 injection and at regular intervals of 1 to 3 minutes thereafter. The end-diastolic velocity (EDV) was recorded at approximately 15 minutes or later. The examination was performed for at least up to 30 minutes post-injection until reversal of

diastolic flow was obtained, or when there was persistent high EDV with no progression towards a high resistance waveform. Patients were considered to have normal venous function when there was persistent reversal of diastolic flow and sustained erection. Otherwise, they were interpreted as having venous incompetence (Fig. 1). Arteriogenic impotence was diagnosed when there was a peak systolic velocity of <25 cm/s. In this case, the patient was excluded from the study because in the presence of a possible arterial insufficiency, venous leakage could not be accurately assessed.

Results

There was a total of 168 patients referred to our department for PCDI from March 1998 to February 2001. All cases were from the erectile dysfunction clinic in our hospital. Forty-three of these patients also had cavernosometry and cavernosography performed. These patients formed the study population. Their ages ranged from 26 to 72 years (mean 46 years). Of these, 11 had normal Doppler study with PSV of more than 25 cm/s and persistent reversal of diastolic flow. All achieved erection deemed adequate for penetration. Two of these were found to have venous leak on cavernosogram and cavernometry. Of the remaining 32, 22 had persistence diastolic flow, and 10 had diastolic flow reversal and erection which were intermittent and not sustained.

All those who had persistent diastolic were found to have venous leak on cavernosogram and cavernometry. And of those who had transient reversal of diastolic flow, all but 1 had venous leak on cavernosogram and cavernometry. These gave a sensitivity of 93.9%, specificity of 90.0%, accuracy of 93.0%, a negative predictive value of 81.8% and a positive predictive value of 96.9%. Kappa value of

TABLE I: CORRELATION OF RESULTS OF PENILE COLOUR DUPLEX ULTRASONOGRAPHY AND CAVERNOSOGAM AND CAVERNOMETRY

Penile colour duplex ultrasonography	Cavernosogram and cavernometry		
	Abnormal	Normal	Total
Abnormal	31	1	32
Normal	2	9	11
Total	33	10	43
Sensitivity	93.9%		
Specificity	90.0%		
Accuracy	93.0%		
Positive predictive value	96.9%		
Negative predictive value	81.8%		
Kappa	0.81		

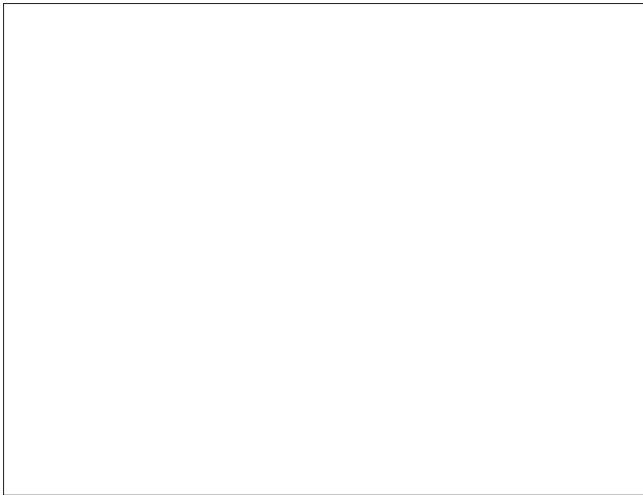


Fig. 1a. Patient with normal erectile function: Reversal of diastolic flow is demonstrated in a patient with normal penile venous competent. Patient also achieved sustained complete erection.

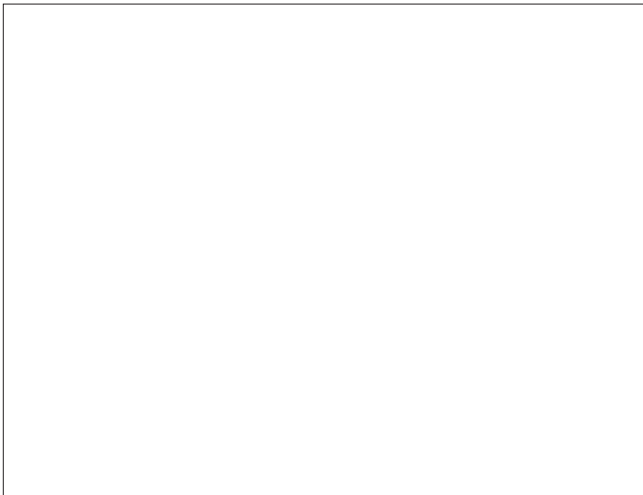


Fig. 1b. Venogenic erectile dysfunction: Persistent diastolic flow in a patient with venous leakage. This was confirmed with cavernosogram and cavernometry. Patient also achieved only partially turgid erection.

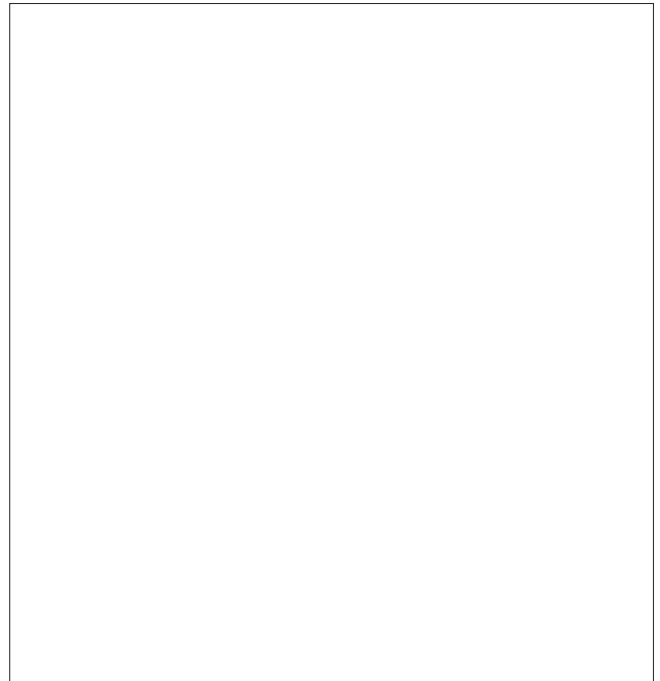


Fig. 1c. Venogenic erectile dysfunction: Cavernosogram showing bilateral venous leakage.

Fig. 1. Colour duplex Doppler ultrasound.

0.81 was obtained. This shows excellent agreement between PCDI and cavernosogram and cavernometry (Table I).

There was no complication arising from PCDI in these 168 patients.

Discussion

Erection is a complex physiological process. It is multifactorial in nature, and is determined by both vascular and non-vascular events. The exact mechanism of erectile failure is not yet fully understood. It has been suggested that the mechanisms in the initiation and maintenance of erection involve increased cavernosal arterial inflow and decreased venous outflow. These changes result in cavernosal engorgement leading to erection. Erectile dysfunction may be due to failure of smooth muscle

relaxation (i.e. psychogenic or neurogenic impotence), failure of arterial inflow or presence of continual venous leakage (vasculogenic impotence).² It was previously believed that psychological factors were the main cause of impotence. However, recent studies²⁻⁵ have suggested that vasculogenic impotence plays a major role in erectile dysfunction.

PCDI is able to detect the presence of vasculogenic dysfunction and it is also able to differentiate between arterial compromise and veno-occlusive incompetence. There is great contention as to which parameters are the most reliable, and what constitutes a normal study in the diagnosis of erectile dysfunction. Many parameters have been used. Criteria for a normal penile duplex ultrasound study, as originally described by Lue et al,⁶ included cavernous arterial dilatation, cavernous artery peak blood flow velocity and visualisation of arterial pulsation.

More recently, peak systolic velocity was found to be a more reliable parameter. The proposed cut-off value of PSV varies from 25 cm/s to 40 cm/s.⁷⁻¹¹ The large range of values may be due to many different reasons such as anatomical variants^{3,5,12,13} as well as the timing and location of sampling.^{5,14}

EDV reflects intracorporeal pressure. Different EDV measurements (range 5 to 9 cm/s) have been selected as the value above which the diagnosis of venous incompetence is made.^{3,9} However, it has been observed that in some

patients who have attained an EDV of 0 cm/s, only partial rigidity is achieved.¹⁵ On some occasions, reversal is only transient or observed unilaterally. The findings of incomplete erection in these patients indicate the presence of some degree of venous incompetence. Our results appear to concur with these observations. Furthermore, because excessive penile venous leakage is a potentially curable cause of erectile dysfunction, it is desirable that this is detected as much as possible (that is having a high sensitivity, but at the expense of specificity). Hence, a more stringent criterion for a normal venous response may be preferred.³

The temporal profile of the PSV as well as EDV in each individual is different. In most normal individuals, the EDV is usually high early (5 to 10 minutes after injection) in the examination. EDV approaches zero and ceases as erection progresses with reversal of EDV seen when full tumescence is attained. However, this may take 5 to 10 or even up to 25 minutes in some patients.^{3,9,16} On the other hand, PSV usually occur immediately at any time within the first 5 minutes after PGE1 injection. But in some, this occurs later at approximately 25 to 35 minutes post injection.^{15,16} Prolong sampling is therefore essential and sampling should be done continuously at regular intervals of 1 to 3 minutes for at least 30 minutes after injection.¹⁵⁻¹⁷ Venous leakage should only be diagnosed when there is persistently high EDV late in the examination (at 15 minutes or later after injection). An insufficient study time may lead to false-positive or false-negative results.

Another cause for wide variability in the velocity reading is the location of sampling. It is now generally preferred that patients are sampled near the base of the penis. Studies have shown that readings are more accurate at this location. It is also easier to keep the Doppler angle at $<60^\circ$ at this point.^{5,14}

However, there are great anatomical variations in the penile vasculatures.^{3,5,12,13} We have observed patients with multiple cavernosal arteries as well as those with a single dominant supply, which perfused the contralateral cavernosum via a communicating artery. In some, the dominant artery is seen arising in the proximal or mid third of the penile shaft rather than at the base. False-positive result may occur if non-dominant arteries with slow flow are sampled.⁵

The examination is performed in hospital outpatient setting. This by itself may cause distress in some patients even though care has been taken to reduce patients' anxiety. The sympathetic response in these nervous patients may inhibit pharmacologically-induced erection and gives a false-positive reading.^{5,18}

Other possible sources of error include pressing too hard on the penis with the transducer¹³ and improper injection of the vasodilator such as into the corpus spongiosum. Improper

Doppler angle adjustment is another potential source of error.

Our results are comparable with others¹⁹ and show excellent agreement ($K > 0.80$) between PCDI and cavernosogram and cavernometry. Our study indicates that PCDI is a reliable, safe and non-invasive screening test to detect the presence of venogenic impotence. PCDI also has the added advantage of being able to assess the arterial component of erectile response and identifies those patients with concomitant arterial dysfunction in whom venous ligation is likely to be of doubtful benefit.

Conclusion

The gold standard for diagnosis of venogenic impotence has been cavernosogram and cavernometry. It is a useful tool for quantifying and mapping of veno-occlusive dysfunction. However, it is a relatively invasive investigation and is not suitable as a screening test as there is poor patient acceptance. It should be reserved for selected patients in whom surgical repair for venous incompetence is considered.

Colour Doppler penile imaging study provides a relatively non-invasive, safe and cost-effective means of assessing the penile vasculature. It is also readily available in most modern radiology centres.

PCDI can be used to assess penile venous compromise as well as arterial function of the erectile mechanism. Evaluation with PCDI, prior to cavernography, also allows identification of those patients with arterial inflow dysfunction who may have a poor result from venous ligation.

Therefore, it is a useful screening tool in the assessment of erectile dysfunction.

We propose that PCDI be used as the first-line screening test for patients with erectile dysfunction.

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