A study on penile doppler

Introduction

Erectile dysfunction (ED) or impotence is defined as inability to achieve and/or maintain an erection for satisfactory sexual intercourse. Its prevalence increases with age and affects up to 52% men between age 40-69 years. Although erectile dysfunction (ED) does not affect life expectancy and it is not a life-threatening disorder but is associated with significant morbidity. Sex is important to men and it is important to preserve erection, orgasm and sexual desire. In a society in which sexuality is widely promoted, ED impacts on feeling of self worth and self confidence and may impair the quality of life of affected men and their partners. ED is strongly associated with unsatisfying personal experiences and relationships, highlights the association of ED with emotional and physical satisfaction with sexual partners and with feelings of general happiness. Improved erectile function is accomplished by improved quality of life and decrease in general psychiatric symptoms.

Keywords: dysfunction, decrease, symptoms, doppler sonography, vasculogenic

Aims and objectives

i. To assess the role of Penile Color Doppler Sonography in the evaluation of erectile dysfunction.

ii. To describe the ultrasound findings of arterial and venous causes of erectile dysfunction.

iii. To compare IIEF-5 score among ED patients.

iv. To differentiate vasculogenic causes from non vasculogenic causes of erectile dysfunction.

v. Association of risk factor in ED.

vi. Grading the ED.

vii. To evaluate the penile vascular function by color Doppler ultrasonography in patients with Peyronies disease.

Materials and methods

Study design: Cross sectional study.

Study period: 12 months; October 2015-september 2016.

Study group: All those patients which were referred for penile color Doppler study,in department of Radio diagnosis G.R Medical College Gwalior Madhya Pradesh.

Sample size: 52 patients.

Work place: Department of Radiodiagnosis G.R.Medical College and Jayarogya Hospital,Gwalior using ALOKA PROSOUND ALPHA (Aloka Trivilion Pvt.Ltd.Tokyo Japan) USG machine with high(7.5MHz) frequency linear probe.

Inclusion criteria:

i. Sexually active males of more than 18years of age

ii. Duration of complaint of ED ≥6months.

iii. Consenting to participate in the study.

Exclusion criteria

i. Patients with penile implant.

ii. Patients with Multiple myeloma, leukaemia, AV Block.

iii. Patients with previous history of priapism by intracavernosal papaverine injection.

iv. The severity of ED was evaluated using IIEF-5, and was classified into 4 levels based on the scores: severe (5–7), moderate (8–11), mild to moderate (12–16), and mild (17–21).

Technique: The penile colour duplex examination is typically performed for either;

i. Assessment of penile morphology for clinical indications such as penile trauma, lumps, infection or when there is suspicion of Peyronies disease and/or

ii. Erectile Dysfunction. This requires an intracavernosal injection of a pharmacostimulant which has been equivocal or abnormal response to oral pharmacological agents (PDE-5 inhibitors).

The examination

Pre Injection: 2.1.1. The examination should be performed in a quiet relaxed environment free of interruption. The examination should be explained in detail and verbal and written consent obtained. The low risk of priapism should be clearly stated. A high-frequency linear transducer is used to perform a B-mode/colour Doppler examination of the penis. There are variable techniques to scanning this region however using a gown or towel to fix the penis with the dorsal aspect accessible can be very useful. The corpus cavernosa, corpus spongiosum and glans are evaluated. The dividing penile septum is a valuable echogenic landmark. Prior to injection, the cavernosal arteries will be seen as fine echogenic parallel lines. Variations in vascular anatomy are common and rarely of clinical significance.

The injection:

i. Careful consideration should be given to the dose and recommended injection protocol of the pharmacostimulant. Follow the dosage
recommendations on the product guidelines. A lesser dose can be
given to a patient who is highly suspected of having psychogenic
impotence as this will decrease the risk of priapism. The higher
dose will be more suitable for those who are suspected of having
either arterial or venous sources of impotence. Too low a dose
however can create a confusing/ non-diagnostic result.

ii. A single injection into the base of one of the cavernosa is generally
sufficient as the agent will disperse into both sides of the penis. A
second injection may be considered if there has been an inadequate
response to the first injection. Patient anxiety though may reduce
the initial response. The risk of priapism should be kept in mind.

iii. Currently 60mg of papaverine is injected near the penile base.

**Post injection:**

i. The response of the agent will be almost immediate. Spectral
doppler waveforms should be performed at 5mins, 10mins,
15mins, 20mins, 25mins, 30min in the proximal 1/3 of each
cavernosal artery.

ii. The peak systolic velocity (PSV) and end-diastolic velocity (EDV)
should be recorded using a spectral angle ideally 60°. If 60° is not
possible, as near to 60° should be obtained.

iii. Late erectile responses at 30 to 40minutes have been reported.

iv. The examination can be curtailed if normal arterial and venous
responses are obtained prior to 30mins.

v. The engorged penis provides another opportunity for B-mode and
colour evaluation for plaques, fibrosis and anatomical/structural
change. This should be performed across the examination period.
The erectile response is graded visually from E0–E5 .grade E4 and
E5 are sufficient for penetration.\textsuperscript{1,5}

- E0: No response
- E1: Elongation of shaft only
- E2: Moderate tumescence, no rigidity
- E3: Full tumescence, no rigidity, easily bendable
- E4: Full erection, partial rigidity
- E5: Full rigidity for at least 20 minutes

These are further divided into four groups:

i. Group IV adequate response=E4andE5
ii. Group III moderate response=E3
iii. Group II Mild response=E2
iv. Group I no response=E0 AND E1

**Penile color doppler**

Penile Doppler is a non-invasive, radiation-free and relatively
cheap means of screening for penile arterial insufficiency in patients
with ED. Patients initially presenting with ED are typically offered
pharmacological therapy on the basis of a clinical assessment
involving history and physical examination, and basic laboratory
tests. Radiological vascular testing is of most use in the evaluation of
patients failing to respond to first-line therapy, and in the context of
research. Other specific clinical problems are well suited to evaluation
with penile Doppler. For example, ‘high flow’ priapism, due to
traumatic cavernosal artery tears, gives characteristic appearances
of turbulent flow in the arteriovenous fistula (often with a small pseudoaneurysm), high velocity proximal to the arteriovenous fistula
and low flow distally (and in the contralateral artery). Color Doppler
sonography can be useful in the evaluation of erectile dysfunction,
which can result from psychogenic, endocrinologic, neurologic,
pharmacologic, and vasogenic causes.\textsuperscript{3} It is used to determine the
integrity of the vascular mechanism. After an intracavernosal injection
of a vasodilatory agent, color Doppler sonography is performed to
evaluate cavernosal arteries and dorsal vessels. Flow color imaging
allows direct visualization of intrapenile anatomy, vascular variants,
and disease. It is also helpful in demonstrating transitions in cavernosal
and dorsal blood flow. Color Doppler sonography is combined with
spectral interrogation of the cavernosal arteries and dorsal veins to
help determine peak systolic and end-diastolic velocities. Cavernosal
artery size and systolic velocities help diagnose arterial insufficiency.
Recent work on cavernosal artery diastolic flow and dorsal vein flow
has indicated that color Doppler sonography, when correlated with
cavernosographic findings, may be helpful in diagnosing venous
incompetence. Temporal variations in transitions in cavernosal artery
dorsal vein flow during various stages of erection are important in
the accurate diagnosis of vasogenic impotence.

**Interpretation of penile color doppler**

We initially scan the flaccid penis to determine the presence of the
structural anomalies and plaques. Cavernosal artery diameters can be
obtained and are used by some authors in determining arterial integrity.
We currently inject 60mg of papaverine intracavernosal near the penile
base. Pharmacologic agent used at other institutions to induce erection
includes papaverine, phentolamine, prostaglandin E and various
combinations. We begin scanning dorsally but ventral transducer
placement may be necessary as erection progresses. We alternate
scanning of each corpus cavernosum and the dorsum immediately
after the injection and at 5minute interval for 20-30minutes.

**Temporal response to papaverine**

As previously mentioned, we routinely sample both cavernosal
arteries at 5minute interval from 1 to 25minutes after papaverine
injection or until waveform progression ceases.

**Arterial insufficiency**

Primary diagnostic criteria for arterial insufficiency include a peak
systolic velocity of less than 25cm/sec and waveform dampening.
Secondary diagnostic criteria include failure of cavernosal artery
dilatation and asymmetry of cavernosal flow velocities of greater than
10cm/sec.\textsuperscript{4,5}

**Venous insufficiency:** Venous incompetence or veno-occlusive failure
may represent the most common cause of vasogenic impotence.\textsuperscript{6}
The principal investigators used in arterial end-diastolic velocity of
greater than 5cm/sec to diagnose venous leakage. With increasing
intracavernosal pressures, there are specific transitions in spectral
waveforms, principally a progressive loss of diastolic flow and
ultimately diastolic flow reversal .Therefore, the presence of persistent
diastolic flow and elevated end-diastolic velocities are indirect
indicators of veno-occlusive failure. It should be emphasized that
the diagnosis of venous incompetence is made only if the patient has
normal peak systolic velocity (25cm/sec).When end-diastolic velocity
is used to diagnose venous incompetence, it should require accurate
angle correction. Although transient dorsal vein flow is a normal occurrence, persistent dorsal vein flow may reflect veno-occlusive failure.7–10

**Observations and results**

The age distribution of the patients studied was from 21 to 66 years, with the maximum number of patients (34.6%) being in the age group 21-30 years (Graphs 1-7).

**Graph 1** The vasculogenic cause of ED increases with age, percentage distribution in different age group patients was 21-30 (16.6%), 31-40 (33.3%), 41-50 (54.5%), 51-60 (63.6%) and >60 years (6.6%).

**Graph 2** With an increase in age, there is an increase in arteriogenic cause of ED and venogenic causes of ED are approximately same in different age groups.

**Graph 3** Multiple risk factors were found in majority of the patients with vasculogenic causes of ED.

**Graph 4** Significant difference was detected in IIEF-5 scores of men with non-vasculogenic ED compared to those with vasculogenic causes of ED.

**Graph 5** Medial IIEF-5 score was almost same in arteriogenic and venogenic causes of ED and the difference was not significant statistically.

**Graph 6** The correlation between the penile rigidity state and its hemodynamic parameters was analyzed. The mean PSV and RI in group I and II were below the normal cut off for vasculogenic ED.

**Graph 7** Mean R.I is found to be helpful in differentiating specific cause of vasculogenic ED. Patients with venogenic ED had significantly lower p-value (0.002) mean R.I (0.66) compared to mean R.I (0.96) in arteriogenic ED.
Discussion

The age distribution of the patients studied was from 21 to 66 years maximum number of patient 18(34.6%) were in age group (21-30) years Table 1 (Graph 1). Penile color Doppler examination of 21(40%) patients showed abnormal color Doppler findings were labeled vasculogenic ED patients and 31(60%) patients revealed normal penile vascular system in patients with ED by history were labeled non vasculogenic ED patients. The vasculogenic cause of ED increases with age, percentage distribution in different age group patient was 21-30(16.6%), 31-40(33.3%), 41-50(54.5%), 51-60(63.6%) and >60 years (66.6%) Table 2 (Graph 2). With increase in age there is increase in arteriogenic cause of ED and venogenic causes of ED are approximately same in different age groups Table 3 & (Graph 3). Forty four (84.6%) patients out of a total of 52 patients were married and 9(15.4%) were unmarried. In our study 13(25%) patients were smoker, among smokers 8(61%) patients had vasculogenic ED, compare to 5(38%) patients with non vasculogenic ED Table 4 & (Graph 4). Furthermore, our study highlights the potential interaction of buerger disease with ED. 11-15 Buerger disease was present in 5(9.6%) patients all of them were smokers and 4 out of 5(80%) were suffering from vasculogenic ED. Total 10(19.2%) patient in our study had history of alcohol intake, out of which 6(60%) were vasculogenic ED patients and 4(40%) were non vasculogenic ED patients. In our study 9(17.3%) patients had Hypertension and among these 6(66.6%) patients had vasculogenic ED thus Hypertension is important risk factor for vasculogenic ED. Out of total 8(15.3%) ED patients with diabetes, 5(62.5%) patients had vasculogenic ED and all of them were arteriogenic ED, thus supporting that diabetes is important risk factor of arterial involvement in patients with ED. Peyronies disease with Calcification/fibrosis of tunica albuginea on grey scale ultrasonography was found in 7(13.4%) of the patients with ED out of which 3(43%) were of vasculogenic ED patients, two third patients were of venogenic ED and one third were arteriogenic ED. In our study a significant difference p-value (0.0006) was detected in IIEF-5 scores of men with non vasculogenic ED then those with vasculogenic causes of ED 15.4 verses 11.3 Table 5 & (Graph 5). However medial IIEF-5 score was almost same in arteriogenic, venogenic causes p-value (0.38) of ED Table 6 & (Graph 6).

Table 1 Age distribution of patients studied

<table>
<thead>
<tr>
<th>Age in years</th>
<th>No of patients</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>21-30</td>
<td>18</td>
<td>34.60%</td>
</tr>
<tr>
<td>31-40</td>
<td>9</td>
<td>17.30%</td>
</tr>
<tr>
<td>41-50</td>
<td>11</td>
<td>21.10%</td>
</tr>
<tr>
<td>51-60</td>
<td>11</td>
<td>21.10%</td>
</tr>
<tr>
<td>&gt;60</td>
<td>3</td>
<td>5.70%</td>
</tr>
</tbody>
</table>

Table 2 Distribution of ED in different age groups

<table>
<thead>
<tr>
<th>Causes of ED</th>
<th>21-30</th>
<th>31-40</th>
<th>41-50</th>
<th>51-60</th>
<th>&gt;60</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vasculogenic</td>
<td>3(16.6)</td>
<td>3(33.3)</td>
<td>6(54.5)</td>
<td>7(63.6)</td>
<td>2(66.6)</td>
<td>21</td>
</tr>
<tr>
<td>Non vasculogenic</td>
<td>15(83.3)</td>
<td>6(66.6)</td>
<td>5(45.4)</td>
<td>4(36.3)</td>
<td>1(33.3)</td>
<td>31</td>
</tr>
<tr>
<td>Total</td>
<td>18</td>
<td>9</td>
<td>11</td>
<td>11</td>
<td>3</td>
<td>52</td>
</tr>
</tbody>
</table>

Table 3 Age and specific causes of vasculogenic ED

<table>
<thead>
<tr>
<th>Vascular Cause N (%)</th>
<th>21-30</th>
<th>31-40</th>
<th>41-50</th>
<th>51-60</th>
<th>&gt;60</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arteriogenic</td>
<td>2(13.3)</td>
<td>2(15.3)</td>
<td>5(29)</td>
<td>6(35)</td>
<td>2(13.3)</td>
<td>17</td>
</tr>
<tr>
<td>Venogenic</td>
<td>1(25)</td>
<td>1(25)</td>
<td>1(25)</td>
<td>1(25)</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>Total</td>
<td>3</td>
<td>3</td>
<td>6</td>
<td>7</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>

Table 4 Clinical parameter of ED patients

<table>
<thead>
<tr>
<th>Factors</th>
<th>With vasculogenic ED N (%)</th>
<th>With non vasculogenic ED N (%)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smoking</td>
<td>8(38)</td>
<td>5(16)</td>
<td>0.42</td>
</tr>
<tr>
<td>Alcohol</td>
<td>6(28)</td>
<td>4(13)</td>
<td>0.51</td>
</tr>
<tr>
<td>HTN</td>
<td>6(28)</td>
<td>3(9.6)</td>
<td>0.58</td>
</tr>
<tr>
<td>DM</td>
<td>5(23)</td>
<td>3(9.6)</td>
<td>0.61</td>
</tr>
<tr>
<td>Dyslipidinia (DL)</td>
<td>3(14)</td>
<td>1(3)</td>
<td>0.65</td>
</tr>
<tr>
<td>Peyronies (PYR)</td>
<td>4(19)</td>
<td>3(9.6)</td>
<td>0.59</td>
</tr>
<tr>
<td>Burgers disease(B)</td>
<td>4(19)</td>
<td>1(3)</td>
<td>0.63</td>
</tr>
<tr>
<td>Spinal trauma/infection</td>
<td>2(9)</td>
<td>3(9.6)</td>
<td>0.7</td>
</tr>
</tbody>
</table>
Table 5 Distribution of patients and median iief-5 scores with vasculogenic and non vasculogenic causes of ED

<table>
<thead>
<tr>
<th>Specific causes</th>
<th>Sever ED (1-7)</th>
<th>Moderate ED (8-11)</th>
<th>Mild-moderate ED (12-16)</th>
<th>Mild ED (17-21)</th>
<th>No ED (22-25)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vasculogenic ED</td>
<td>3</td>
<td>10</td>
<td>6</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Non vasculogenic ED</td>
<td>0</td>
<td>5</td>
<td>11</td>
<td>15</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>3</td>
<td>15</td>
<td>17</td>
<td>17</td>
<td>0</td>
</tr>
</tbody>
</table>

Chi sq 17.27, Df 3, P=0.0006

Table 6 IIEF-5 score in SPECIFIC causes of vasculogenic ED

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Arteriogenic</td>
<td>2</td>
<td>8</td>
<td>6</td>
<td>1</td>
<td>0</td>
<td>11.3</td>
</tr>
<tr>
<td>Venogenic</td>
<td>1</td>
<td>2</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>11.2</td>
</tr>
</tbody>
</table>

Chi sq 3.05, Df 3, P=0.38

Table 7 Penile rigidity state and its hemodynamic parameters

<table>
<thead>
<tr>
<th>Mean PSV(cm/sec)</th>
<th>Gr –IV (E4,E5)</th>
<th>Gr-III (E3)</th>
<th>Gr-II (E2)</th>
<th>GrI (E0,E1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Avg RI</td>
<td>0.99</td>
<td>0.92</td>
<td>0.88</td>
<td>0.83</td>
</tr>
<tr>
<td>Arteriogenic Ed</td>
<td>0</td>
<td>7</td>
<td>8</td>
<td>2</td>
</tr>
<tr>
<td>Venogenic ED</td>
<td>0</td>
<td>3</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

Chi sq 25.3 , Df 9, P=0.002

Table 8 R.I Value of cavernosal artery in different causes of vasculogenic ED

<table>
<thead>
<tr>
<th>Cases (n=21)</th>
<th>Mean resistive index R.I</th>
<th>Standard deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arteriogenic ED</td>
<td>0.96</td>
<td>0.09</td>
</tr>
<tr>
<td>Venogenic ED</td>
<td>0.66</td>
<td>0.1</td>
</tr>
</tbody>
</table>

Summary

The present study was carried out on 52 patients in Department of Radio diagnosis G.R. Medical college Gwalior To assess the role of Penile Color Doppler Sonography in the evaluation of erectile dysfunction. In our study 52 (sample size) patients of erectile dysfunction on the basis of IIEF-5 score were subjected to penile color Doppler and differentiated into vasculogenic and non vasculogenic causes of ED. The age distribution of the patients studied was from 21 to 66 years maximum number of patient 18 (34.6%) were in age group (21-30) years. On penile color Doppler examination of 21 (40%) patients showed abnormal color Doppler findings were vasculogenic ED patients and 31 (60%) patients revealed normal penile vascular system in patients with ED by history were non vasculogenic ED patients. The vasculogenic cause of ED increases with age. In our study, we used the PSV as the reference standard to diagnose arteriogenic impotence out of 21 patients of vasculogenic ED on penile color Doppler , 17 (81%) patients revealed normal PSV values (<25cm/s) in the cavernosal artery were considered to have arterial insufficiency and 4 (19%) patients with adequate arterial inflow that is, normal PSV, a short duration erection, with the persistent antegrade flow of >5cm/s throughout all phases suggestive of venous incompetence (Venogenic ED). Most common risk factors found were smoking, followed by hypertension, diabetes, alcohol, Peyronies disease and Burgers disease. In our study a significant difference p-value (0.0006) was detected in IIEF-5 scores of men with non vasculogenic ED then those with vasculogenic causes of ED. The IIEF-5 scores of men with nonvasculogenic causes of ED are higher than those with vasculogenic ED causes. However, medial IIEF-5 score was almost same p-value (0.38) in arteriogenic, venogenic causes of ED. In our study, the erectile response is graded visually from E0–E5 after injection of intracavernosal papaverine. We further divide the patients in 4 groups Gr –I to Gr-IV. Group I and II either had no or minimal response to papaverine which is not sufficient for penetration, group III showed moderate and Group IV showed adequate response to papaverine. We compared mean PSV and R.I in each group , none of the patient in group IV, 55% of the patients in group III and all the patients in group I and II were found to have vasculogenic cause of ED on Penile Color Doppler. Patients in group IV had penile erection which is theoretically taken sufficient to result in penetration had mean PSV and R.I were 68 and 0.99. Mean PSV and RI in group III was 35.9 and 0.92; PSV and R.I in groups I and II was 24.3 and 0.88 respectively. The mean PSV and R.I in group I and II were significantly p-value(0.002) below the normal cut off for vasculogenic ED. EDV>5 is associated with venogenic
ED but can be found in patients with arteriogenic ED since arterial flow is insufficient to cause enough engorgement of sinuses that can obstruct the venous outflow. Therefore, such threshold values for EDV can be misleading if arterial insufficiency is present. In our study Average R.I is found to be a significant indicator of differentiating vasculogenic ED avg. R.I (0.88) and non vasculogenic ED avg. R.I (0.98). avg. R.I is found to be helpful in differentiating specific cause of vasculogenic ED, with venogenic ED patients had significantly lower avg.R.I (0.66) compared to arteriogenic ED avg. R.I (0.96) p-value(0.002). Thus the present study provides information as to confirm that an endothelial dysfunction can manifest itself as ED, namely (Arteriogenic or Venogenic) based upon the data provided by PSV and RI levels measurements.20–21

**Conclusion**

Evaluation of patients based on the International Index of Erectile Function (IIEF-5) is a useful tool to screen a patient with erectile dysfunction for the etiology and level of dysfunction. However, it is also limited in its usefulness because of the inaccurate and reserved history provided by the patients. A positive response to the pharma coerection test in terms of rigidity and duration implies normal veno occlusive mechanisms. A duplex ultrasound of the penile arteries and veins for evaluation of impotence with different pathophysiology. Aversa A, Sarteschi LM. The role of penile color-duplex ultrasound for the evaluation of erectile dysfunction. *J Sex Med*. 2007;4(5):1437–1447.

**Limitation**

Limitations of penile Doppler include diagnostic misinterpretation as a consequence of the high prevalence of arterial anatomical variants in the penile circulation. For example, distal perforator branches may lead to the spuriously low flow recorded in the proximal cavernosal artery at the base of the penis.

**Acknowledgements**

None.

**Conflict of interest**

The author declares no conflict of interest.

**References**


©2017 Biswas et al.