Patterns of Cavernosal Arterial Flow in Patients with Erectile Dysfunction, as Evaluated by Color Doppler Flowmetry

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Abstract

Background: Erectile dysfunction (ED) is a growing common health problem that affects men of different age groups. Despite it is thought to be a para-aging disease, it affects young and middle aged men as well. Color duplex Doppler is a non-invasive tool of evaluation of the vascular mechanism of erection in patients suspected to have an organic cause of ED.

Objective: To demonstrate the color duplex Doppler measurements of cavernosal arterial hemodynamic parameters in non-diabetic patients with erectile dysfunction.

Patients and Methods: 100 consecutive non-diabetic men with erectile dysfunction were evaluated clinically and with color duplex Doppler ultrasonography after intracavernosal injection of papaverine to induce erection. Peak systolic and end diastolic velocities as well as the resistive index were measured in the right and left cavernosal arteries.

Results: Patients were classified into 4 groups according to the peak systolic and end diastolic velocities, that help to categorize patients as regard treatment options into patients recommended for medical treatment (having good veno-occlusive mechanism) and others recommended for surgical management (patients with veno-occlusive malfunction).

Conclusion: We conclude that peak systolic & end diastolic velocities of the cavernosal arteries as measured on duplex sonography gives an accurate evaluation of the vascular status in patients with vasculogenic erectile dysfunction, that help in choosing of management options.

Key Words: Erectile dysfunction – Cavernosal arteries – Color Doppler ultrasonography.

Introduction

ERECTILE dysfunction (ED) is defined as a persistent inability (lasting for at least 6 months) to attain and maintain an erection sufficient to permit satisfactory sexual performance. The 1993 National Institutes of Health Consensus Development Conference [1] recommended use of the term "erectile dysfunction" rather than "impotence," because it more accurately defines the problem. ED is a para-aging phenomenon associated with poor health, smoking, diabetes, heart disease, hypertension, hyperlipidemia, and substance abuse. The etiology of ED is wide ranging and penile vascular disorders are considered to be an important factor in organic malfunction [2].

Vascular disorders may result in impaired erection or complete impotence. Almost 30% of erectile dysfunction is due to the presence of systemic disease which affects the blood supply to the penis [3].

Penile erection is achieved by a complex balance between an increase in corporal arterial flow, relaxation of corporal smooth muscles and adequate veno-occlusive function. Normal cavernosal arteries have a maximum peak systolic velocity of greater than 35 cm/s and a minimum end-diastolic velocity of less than 0 cm/s [4,5].

The evaluation of vasculogenic impotence by ultrasonography and pulsed Doppler analysis was introduced by Lue et al. in [6]. In clinical practice, patients are screened for vasculogenic impotence by measuring their clinical response to an intra cavernosal injection (ICI) of a vasodilating pharmacological agent like papaverine, phentolamine or prostaglandin E1 [7,8].

Benson et al. [4] were the first to raise the consensus that a peak systolic velocity of at least 35 cm/sec indicates normal arterial supply. At peak systolic velocities less than 35 cm/sec, the likelihood and severity of arterial disease increase as the peak systolic velocity decreases, with a peak velocity less than 25 cm/sec indicating a high likelihood of severe arterial disease.

Penile color duplex Doppler ultrasonography combined with the pharmaco-erection test represents the first-line noninvasive approach to investigate arterial and veno-occlusive function. Peak
systolic velocity (PSV) indicates arterial inflow, while the end diastolic velocity (EDV) and resistive index (RI) point to the veno-occlusive function of the cavernosal sinusoids [3].

**Aim of the work:**

The aim of this study was to demonstrate the patterns of cavernosal arterial flow in non-diabetic patients with erectile dysfunction as detected with the hemodynamic parameters of penile color duplex Doppler, and its impact upon the choice of proper management options.

**Patients and Methods**

**Patients:**

Beforehand, a written informed consent was obtained from all the 100 participants of the study. These 100 non-diabetic patients were clinically presented with history of ED of at least 1 year. Each patient had undergone a full clinical evaluation by qualified urologist, including a detailed analysis of the history of illness, general examination and examination of the genitals and prostate.

The history taking included basically the 5 questions of the modified international index of erectile function (IIEF-5) (Table 1), that raises a minimum score of 5 and a maximum of 25. According to the IIEF-5 scores, ED is classified into five categories: severe (5-7), moderate (8-11), mild to moderate (12-16), mild (17-21), and no ED (22-25).

The last step in clinical evaluation was the pharmaco-test using intracavernosal injection (ICI) of papaverine at a dose from 15 to 60 mg. The erection response obtained after papaverine injection was clinically assessed according to the Bool-ell’s model as follows:

- G4: Fully rigid penis sufficient for penetration.
- G3: Penis not fully rigid but adequate for penetration.
- G2: Penis somewhat rigid but inadequate for penetration.
- G1: Penis increased in size but no hardness.

The patients were subsequently referred for color duplex Doppler Ultrasonography.

<table>
<thead>
<tr>
<th>Over the past six months</th>
<th>Score</th>
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<tbody>
<tr>
<td></td>
<td>1</td>
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<tr>
<td>How do you rate your confidence that you could get and keep an erection?</td>
<td>Very low</td>
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<tr>
<td>When you had erections with sexual stimulation, how often were your erections hard enough for penetration?</td>
<td>Almost never or never</td>
</tr>
<tr>
<td>During sexual intercourse, how often were you able to maintain your erection after you had penetrated (entered) your partner?</td>
<td>Almost never or never</td>
</tr>
<tr>
<td>During sexual intercourse how difficult was it to maintain your erection to the completion of intercourse?</td>
<td>Extremely difficult</td>
</tr>
<tr>
<td>When you attempted sexual intercourse, how often was it satisfactory for you?</td>
<td>Almost never or never</td>
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Doppler:

Initially, grayscale ultrasound scanning of the corpora cavernosal was performed to document any structural abnormality like corporal fibrous plaques, tunical or corporal calcification or calcification of the wall of the cavernosal arteries. The patient then received ICI of papaverine at a dose of 15-60 mg injected to the side of the penile shaft, according to the result of his preliminary clinical pharmaco-test. Before ICI of papaverine, a tourniquet was applied around the base of the penis for 2 minutes after which the patient was instructed to perform tactile genital self stimulation.

Patients were examined in a semi-dark room. Color duplex Doppler examinations were performed on the ventral surface of the penile base using a 7.5 MHz linear-array transducer with optimized gain settings including gate size and placement, steering angle, color and duplex gain scale and wall filter which were all adjusted for optimum evaluation.

Duplex Doppler was used to measure the PSV, EDV and RI within each cavernosal artery. The examination protocol included sequential assessments at 5 minutes interval for 25 minutes after the ICI of papaverine. At these points, spectral waveforms of flow in both cavernosal arteries were recorded and measured. The degree of erectile response during each point of the examination was recorded alongside with the Doppler evaluation. The examination was continued for 25 minutes even if a rigid erection was attained at any point of the examination period. Hemodynamic parameters were measured in the right and left cavernosal artery in every case and registered separately.

Results

Demographics:

The 100 patients in this study had a mean age of 56.9 years, ranging from 22 to 68 years. Patients complained of ED for 12 months to 16 years. The results of IIEF-5 scoring system given by the patients were as follows: mild (13 patients), mild to moderate (23 patients), moderate (26 patients), and severe (38 patients) (Graph 1).

The results of the office pharmaco-test in these patients (clinical erection grade) were as follows: G1 (16 patients), G2 (21 patients), G3 (29 patients), and G4 (34 patients), as shown in Graph (2).

There were 37 patients whose papaverine-induced erections adequate for penetration (G3 & G4 grades); 26 of them (70.2%) were below 50 years. All the 16 patients with G4 response were below 50 years. Among the patients with G1 response (34), there were 14 patients below 50 years (41.1%), and there were 15 patients among those with G2 response below the age of 50 years (Graph 3).
In 9 patients, the induced erection following intracavernosal injection of papaverine lasted for more than 1 hour yet detumescence occurred without need for evacuation, except in 1 patient who needed evacuation and intracavernosal injection of ephedrine.

**Doppler:**

A total of 200 corpora were evaluated. Patients were classified into 4 groups according to the measured PSV & EDV as follows:

- **Group 1:** Patients with normal PSV and normal EDV (19).
- **Group 2:** Patients with normal PSV and abnormal EDV (25).
- **Group 3:** Patients with subnormal PSV and normal EDV (24).
- **Group 4:** Patients with subnormal PSV and abnormal EDV (32).

PSV was considered normal when it outranges the standard 35 cm/sec. In persons, subjects of group 1, velocities beyond 70 cm/sec were encountered in some cases. Patients of group 1 were assigned as normal as regard the vascular mechanism of erection.

EDV was considered normal when diastolic blood flow reversal was noticed at anytime during the examination period, regardless the PSV reading. This was encountered in 43 subjects of the study population (Groups 1 & 3), 19 of whom had normal PSV and the other 24 patients had subnormal PSV. On the other hand, abnormal EDV was considered when persistent non-reversed (forward) diastolic flow was encountered regardless the velocity of this flow. This was found in 57 patients (Groups 2 & 4), 25 of whom had normal PSV and the other 32 patients had subnormal PSV (Graph 4).

Patients of Groups 1 & 3 had normal RI values (>1), in contrary to patients of Groups 2 & 4 who had subnormal RI values (<1). Discrepancy between the PSV of right and left cavernosal arteries was encountered in many patients from all groups, particularly in patients of Groups 3 & 4 in whom the PSV values were subnormal. A patient was assigned to have normal PSV when the PSV of both cavernosal arteries was above the limit of 35 cm/sec. If the PSV of one cavernosal artery was below 35 cm/sec, and the other artery shows normal PSV, the patient was categorized into Group 3 if the EDV of both arteries is normal and into Group 4 if the EDV was abnormal.

The analysis of hemodynamic parameters of flow shows that amongst the 100 examined patients, 57 had veno-occlusive malfunction denoted by abnormal EDV measurements (Groups 2 & 4). On the other hand, there were 56 patients with arterial insufficiency (Groups 3 & 4). Patients of Group 4 had arterial insufficiency combined with veno-occlusive malfunction.

**Discussion**

Erectile dysfunction should be evaluated by taking a careful medical history and physical examination, looking for evidence of underlying disorders such as hypogonadism and vascular disease. Color-Doppler sonography of the cavernosal arteries has received considerable attention since its description in 1985 by Lue et al. Color and spectral Doppler analysis, provides a useful noninvasive means of evaluating both morphologic and hemodynamic penile abnormalities. It is the best method in diagnostic evaluation of patients with erectile dysfunction. It assesses the integrity of the arterial supply to the penis and provides useful information on the veno-occlusive mechanism [11].

Clifford and Toppo [12], stated that color duplex Doppler sonography with papaverine induced erection is an excellent and highly accurate means of assessing patients with erectile dysfunction.

Erdogru et al. [13] stated that hemodynamic parameters might be variable at either side of the penis and depend on intrapenile arterial anatomic variations.

Benson et al. [14] stated that the difference in PSV between the right and left cavernosal arteries after papaverine injection (asymmetric arterial response) was significantly larger in patients with mild to moderate arterial insufficiency than in other patient groups. Their findings suggested that
Doppler measurement of maximal systolic velocity in the cavernosal arteries after papaverine injection is an accurate indicator of arterial function. They considered that asymmetric flow in the cavernosal arteries suggests some degree of arterial insufficiency.

We adopted the classification of patients based upon the PSV & EDV of cavernosal arterial flow as detected by duplex Doppler for management concerns. This classification scheme actually categorizes patients into 2 treatment groups; patients with normal EDV and subnormal or borderline PSV were found to get benefit from medical treatment with drugs like oral phosphodiesterase inhibitors, urethral prostaglandin pellets or ICI self-injection of vasoactive drugs. On the other hand, patients with abnormal EDV with or without normal PSV don't give good response to drug therapy and rather need surgical treatment in form of venoligation or penile implants.

There are probably some limitations to this study: (1) There is no control group; that is actually difficult to obtain with this kind of disease (2) The demographics of the patients for this study limit the ability to compare between groups, concerning the different age groups with different risk factors, among which only diabetes was excluded.
Case (5): A 33y patient with G4 response. Bilaterally subnormal PSV (34 & 20 cm/sec), yet with typically normal bilateral diastolic flow reversal (Group 3).

Case (7): A 33y patient with G3 response. Borderline PSV (35 cm/sec) in the left cavernosal artery, and markedly subnormal PSV in the right cavernosal artery (7 cm/sec). There's typically normal bilateral diastolic flow reversal. The patient was categorized in (Group 3) because of the significantly low PSV of the right cavernosal artery.

Case (6): A 42y patient with G3 response. Bilaterally subnormal PSV (33 & 13 cm/sec), yet with typically normal bilateral diastolic flow reversal (Group 3). There's big difference in the PSV between both cavernosal arteries that is concordant with arterial disease.

Case (8): A 62y patient with G1 response. Subnormal PSV (14 cm/sec), with baseline diastolic flow (Group 4).

Case (9): A 38y patient with G1 response. Subnormal PSV (17 cm/sec), and persistent forward diastolic flow (Group 4).
References


