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Colour Doppler Ultrasonography in the Evaluation of Erectile Dysfunction

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Abstract

Since June 1992, 280 impotent males have been submitted to colour duplex examination in the urology dept., Hamad general Hospital, Qatar, to evaluate the arterial and venous circulation of the penis and to rule out vascular causes for impotence. The examination was performed using a colour duplex Acouson 128xP/10 and 7.4MHz linear transducer. Arteriogenic impotence was diagnosed in 129 (46%) while veno-occlusive impotence was verified in 37 (13%) cases. It was our experience that colour duplex sonography in impotence is a reliable, relatively non-invasive test that should be applied whenever vasculogenic impotence is suspected. Our technique and results are demonstrated with a review of literature.

Introduction

ERECTION is a psychoneurovascular phenomenon that involved increased arterial flow and decreased venous flow [1]. These findings were supported by experimental studies in animals [2]. Male sexual dysfunction was traditionally considered to be psychogenic in origin and an accepted consequence of aging. Recent research, however, indicates that vascular disease, whether arterial insufficiency or venous leakage, may play a role in most cases of impotence.

In 1985 Lue et al. [3] introduced duplex sonography as a tool for evaluation of penile circulation by examining the diameter changes of the cavernous artery as well as the blood velocity after intracavernosal vasodilator injection. Doppler parameters for detection of venous leakage were added to the test to expand its diagnostic field to cover both arterial and venous causes of

vascular impotence [4]. Recently, colour doppler was used instead of the conventional one to improve the accuracy of the examination [5]. Since June 1992 we have applied the use of colour doppler sonography in our impotence clinic. Herein, we review our technique and findings in the first 280 impotence cases that were submitted to this test in our department. We do believe that colour doppler sonography in cases of impotence is an accurate non-invasive test that should be applied in all cases of suspected vascular impotence to improve the accuracy of diagnosis and to define the proper treatment option.

Material and Methods

Two hundreds and eighty patients presented to impotence clinic in Hamad General Hospital; Qatar, underwent a colour doppler ultrasonographic examination for evaluation of penile vascularity. The patients age ranged between 34 and 72 years (mean, 52,3 years). Diabetes mellitus was the commonest contributing factor to sexual dysfunction in our series followed by hypertension (table 1). All patients underwent routine laboratory investigations including complete blood picture, glucose tolerance curve and serum levels of creatinine, lipids, thyroid stimulating hormone, testosterone and prolactin.

Technique of colour duplex sonography:

All the examinations were done by one operator so subjective variations were minimized. A duplex scanner with coloured flow imaging facilities (Acouson 128XP/10) was used. B-mode colour images and doppler spectra were obtained with a 7.4 MHz linear array transducer. Patient lied in a supine position. Initially, scanning of the penis in transverse and longitudinal planes was done to detect any cavernosal fibrosis, calcification or atrophy then, whenever it was possible, the diameter of each cavernosal artery was measured in a transverse plane (Fig. 1). Either 10 μg. prostaglandin El (PGE1) in 1 cc saline (in 264 cases) or 60 mg papaverine (in 16 cases) were injected into the corpus cavernosum at the base of the penis via a 25 gouge 1/2 inch needle. Within the first five minutes, the diameter of each cavernosal artery was measured and then machine was switched to colour doppler to measure peak systolic velocity in cavemosal arteries at the base of the penis. The artery was precisely located and the doppler beam and sample volume were positioned on the vessel then the angle cursor was manually aligned parallel to it, keeping the angle between 50 to 60 degrees. Peak folw velocity at peak systole was measured in each cavernosal artery. We alternate scanning of each corpus at 5 minutes intervals for 2-30 minutes in cases of abnormal readings. If the findings were still abnormal the patient was advised to stimulate his penis manually, in privacy, then the test was repeated. In cases of normal arterial peak systolic flow and inadequate

response to intracavernous injection, diastolic cavernosal arterial flow together with deep dorsal vein flow were additionally measured. Penile rigidity was noticed all through the test and was scaled as tumescence, partial, adequate or excellent.

Patients were kept under observation for one hour after the test. Those who still had a persistent erection were managed by cavernosal aspiration with an 21 gouge canula till detumescence commenced.

Results

In the preliminary sonographic scanning of the penis, 12 patients had extensive intracavernosal fibrosis (Fig. 2), 5 had calcified plaques (Fig. 3), while atheroscelerotic cavernosal vessels (thickened walls and decreased pulsation) were detected in 137. The diameter of the cavernosal artery in the flaccid status prior to intracavernosal injection could be measured in 268 patients and ranged between 0.3 mm and 0.6 mm with an average of 0.41 mm.

The doppler parameters which we used to diagnose a normal penile arterial flow included systolic peak flow of more than 30 cm/sec. and increase in the cavernosal artery diameter by more than 70% after injection. Venous leakage was diagnosed when there was normal arterial systolic peak flow, persistent diastolic flow of more than 5 cc/sec. together with demonstration of blood flow in the deep dorsal vein of the penis. Accordingly, patients were grouped into 3

Table (1): Contributing Factors to 280 Cases of Impotence.

	No.	%
Diabetes mellitus	174	62
Hypertension	89	31.8
Transurethral surgery	39	13.9
Pelvic surgery	34	12.4
Heavy smoking	123	43.9
Pelvic or abdominal trauma	27	9.6
Coronary artery disease	22	7.9
Spinal cord surgery, disease.	19	6.8
Durgs	15	5.4
Pyeronie's disease	9	3.2
Alcoholism	2	0.3

Table (2): Colour Doppler Findings in 280 Impotent Patients.

Final Diagosis	Pt. Age (mean)	Abnormal CIS Test No.	%	Colour Doppler Findings: Calc. No.	Fibr-osis No.	Atherosc. C.A. No.	%	C.A. Diamete (mean)	C.A. Diameter (mean)	S.P.V. (mean)	E.D.F. > 5 cm/sec No.	D.D.V. Flow No.
1- Arteriogenic Impotence (129)	56.4y	122	94.6	1	3	109	84.5	0.41	34 %	16 cm/sec	-	-
2- Venogenic Impotence (37)	47.2y	37	100	3	9	3	8	0.42	112 %	53 cm/sec	37	34
3- Non-Vascular Impotence (114)	54.2y	17	14.9	1	-	10	13	0.41	98 %	44 cm/sec	-	-

CIS Test = Combined injestion and stimulation test
C.A. = Cavernosal artery
S.P.V. = Systolic peak velocity
E.D.F. = End diastolic flow
D.D.V. = Deep dorsal vein

groups: 1) arteriogenic impotence (129), 2) venogenic impotence (3) and 3) non vascular impotence (114). A comparative study between 3 groups is shown in table 2.

Arteriogenic impotence was diagnosed in 129 patients (46%), in 122; post-injection cavernosal artery dilatation was between 20% and 60% while the systolic peak flow was between 11 cm/sec and 28 cm/sec with a mean of 16 cm/sec (Fig. 4). In 7 patients delayed normal peak flow was recorded, yet arterial dilatation was less than 70% and we interpreted these cases as mild arteriogenic impotence.

Venous leakage was diagnosed in 37 patients (13%). Post-injection cavernous artery dilatation was between 72% and 128%, systolic peak flow ranged between 34 cm/sec (mean 53 cm/sec) and diastolic flow ranged between 7 cm/sec and 21 cm/sec (mean 11 cm/sec.). In 31 cases, blood flow was demonstrated in deep dorsal vein of the penis (Fig. 5).

In 114 patients colour doppler findings were considered normal and were diagnosed as non-vascular impotence. US scanning showed calcified plaque in one case. Arterial dilatation ranged between 78% and 110% while systolic peak flow was between 38 cm/sec. 63 (mean 44 cm/sec).

Discussion

Erection occurs when blood flows into the corpora at flow rates of approximately 100 ml/min., sufficient to raise intracorporal pressure above a critical level. When intracorporal pressure exceeds 80 mmHg, emissary veins are compressed against the inner aspect of the tunica albuginea and venous drainage is blocked to maintain erection [9]. Recent estimates suggest an erectile dysfunction prevalence of 5% at the age of 40 years, increasing to 15-25% by the age of 65 years and older [10]. Lue et al [11] in their duplex ultrasonographic study of 657 impotent patients, reported that 90% had vasculogenic

Table (3): Contributing Injection and Stimulation (CIS) Test.

1- Intracavernous injection of 10 μg and observation for 15 min.

2- If adequate erection after 5-7 min. which lasts > 30 min. ⟶ no vascular lesion.

3- Inadequate erection 15 min. ⟶ add manual genital stimulation ⟶ if good erection⟶ no vascular lesion.

4- Adequate erection which lasts less than 5 min. ⟶ ? venous leak.

5- Inadequate erection even after genital stimulation ⟶ ? vasculogenic impotence.

impotence compared to 59% in our series. Such discrepancy can be attributed to: the lower age average in our series, the increased accuracy of colour doppler in comparison to conventional one and our extension of test to 20-30 minutes with multiple data acquisition.

Since Lue et al [3] introduced pharmaco-penile duplex ultrasonography as a diagnostic tool, it has become the first-line to define vasculogenic erectile dysfunction. Recently, the use of duplex sonography as a means of evaluating the veno-occlusive function has been gaining acceptance [4]. The use of colour doppler has increased the accuracy of the test as it offers several advantages over duplex imaging, including rapid localization of the cavernosal artery and accurate angle correction; depiction of cavernosal artery and dorsal vein flow progression; and demonstration of venous flow, arterial variants and arteriosclerotic disease [5].

To accurately assess patients with erectile dysfunction, it is necessary to understand the progression of haemodynamic events leading to erection. Schwartz et al [12] have shown that, the normal progression of cavernosal artery flow during tumescence is as follows: In the flaccid state, monophasic flow is present with minimal diastolic flow. With the onset of erection or after intracavernosal injection there is increase in both systolic and diastolic flow. As intracavernosal pressure increases, a dicrotic notch appears at end systole and a decrease in diastolic flow occurs. With continuously increasing pressure, end diastolic flow declines to zero and then goes diastolic flow reversal. The systolic flow decreases, envelope is narrowed and diastolic flow disappears completely with firm erection (Fig. 6). The consensus in literature is that arterial response should be determined in the phase of erection with highest arterial flow (in the first few minutes after intracavernous pharmacological stimulation) and to abort the test once there is full erection [11,13].

Parameters for evaluation of arterial penile circulation are peak flow velocity, acceleration time and dilatation of cavernous artery (Fig. 7). To date peak flow velocity is the most commonly used ultrasonographic parameter for cavernous inflow tract. Although reference values in literature are controversial,yet, most of investigators agree that systolic peak velocity below than 30 cm/sec denotes cavernosal artery insufficiency [3,5,7,11,13]. In our study, 129 (46%) had a systolic peak flow less than 30 cm/sec. ranging between 11cm/sec. and 28cm/sec. with a mean of 16 cm/sec. Although arterial response has been shown to be independent of type and dosage of any currently used vasoactive agent [14,15], yet, externral factors such as anxiety and stress may modify the response leading to false results [16]. To abolish any possible effect of external factors and temporal variations, we; con-

trary to most of investigators; extend the test to 20-30 minutes with multiple readings taking. Extended data acquisition beyond five minutes after injection is necessary to avoid false-positive diagnosis of arterial insufficiency (Fig. 8).

Cavernosal artery dilatation is used as a parameter to assess local arterial integrity. Lue et al found that if the cavernous artery does not dilate by more than 70% after intracavernosal injection of 60 mg papaverine, there is a high likelihood of arterial disease [3,11]. Other authors, believe that arterial diameter is an unreliable parameter because accuracy of measurement of arterial diameter is operator dependent and specially difficult in the flaccid status beides the diameter of the artery is influenced by the changing intracavernous pressure [5,17] Colour doppler ultrasonography facilitates cavernous artery localization even in the flaccid status and out of the 280 cases we could localize the artery in 268 (95.7%). The effect of intracavernosal pressure can be eliminated by measuring the arterial diameter within the first five minutes of intracavernous injection. Actually, we believe that arterial dilatation is a reliable parameter for the local arterial integrity, thus in this series, patients with normal systolic peak flow but with arterial dilatation less than 70% were interpreted as mild arteriogenic impotence (7 cases). All the seven patients were included in self-injection program on relatively low doses of PGE1 (5-7 μgm.). In the follow up of those patients, one was not satisfied after 6 months and needed a higher dose of PGE1. Colour doppler sonography showed decreased systolic peak flow to less than 30 cm/sec. which may indicate that diminished arterial dilatation was an early sign of arterial insufficiency.

Mellinger et al have added the category of penile blood flow aceleration to the list of duplex data [18]. Meulman et al stated that acceleration time is more accurate than peak flow velocity and that it is always less than 120 msecs in normal volunteers [17]. We did not use this parameter as we think it is very variable and the reading will be greatly dependent on the phase of erection.

Literature on the colour doppler diagnosis in venous incompetence is scant. In our series, persistent diastolic flow more than 5cm/sec. specially if associated with deep dorsal vein flow were considered as a parameter suggestive of venous leakage provided that peak systolic velocity was normal [8,19]. Persistent dorsal vein flow has 80% sensitivity and 100% specificity for venous leakage [5]. When leakage is through the cavernosal and crural veins, only persistent end diastolic flow > 5cm/sec will be elicited [7]. Dorsal vein flow was detected in 31 out of our 37 cases diagnosed as venous leakage. Evaluation of veno-occlusive function is troublesome because it is influenced by

Fig. (1): Ultrasonographic scanning of the penis (T.V. plane). Right and left cavernosal arteries are demonstrated, their diameters are measured. Corpora spongiosa are seen (C.S.).

Fig. (2): Extensive fibrosis (arrrows) at the proximal part of the right corpus cavernosum in a longitudinal plane.

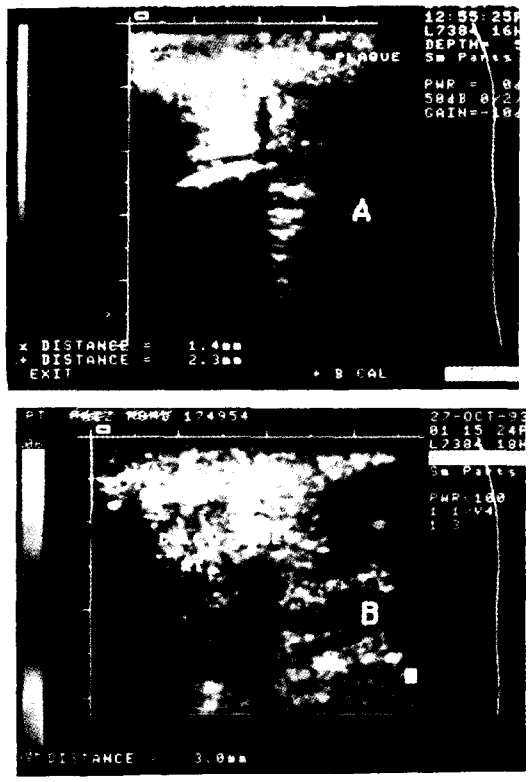


Fig. (3): Right tunical calcified plaque (Peyronies disease). A) Longitudinal plane. Notice the posterior shadowing (arrows) denoting calcification. B) Transverse plane.

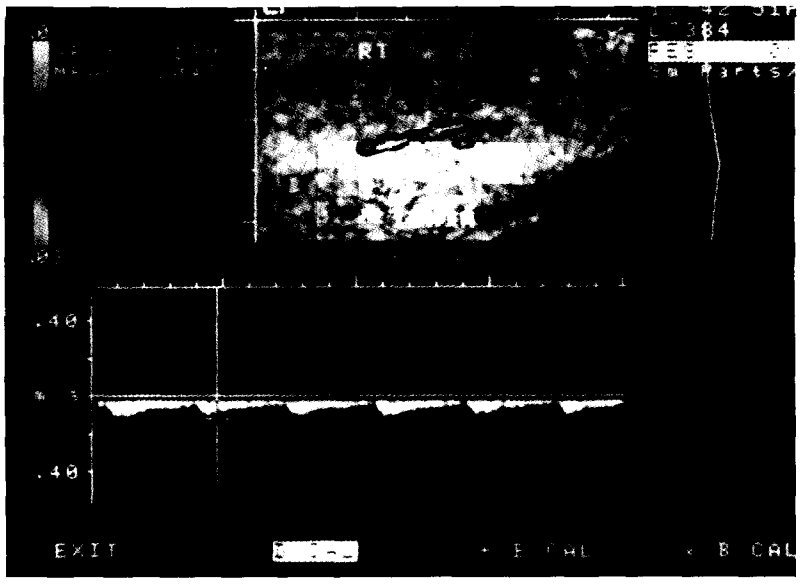


Fig. (4): Colour doppler imaging of the right cavernosal artery. Systolic peak flow is 12 cm/sec. 15 minutes after injection. A case of arteriogenic impotence.

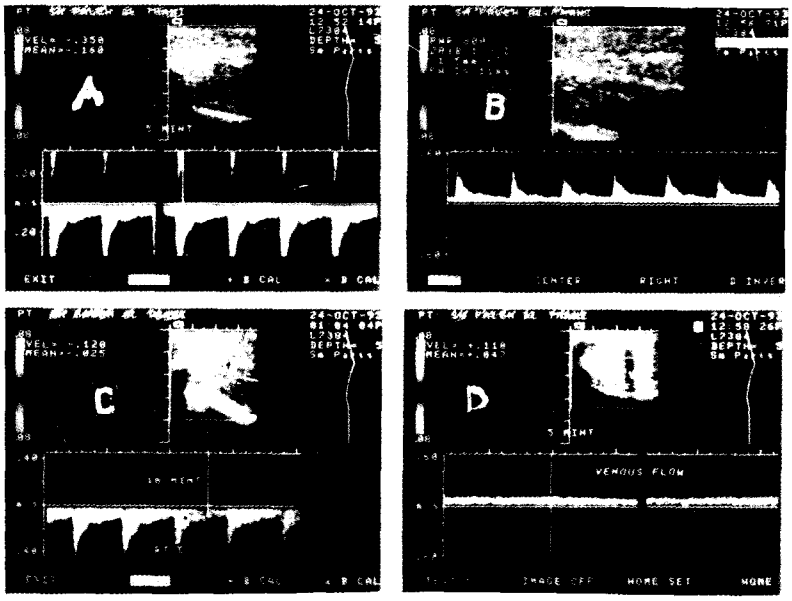


Fig. (5): Colour doppler findings in a case of venogenic impotence. A&B) Normal arterial in

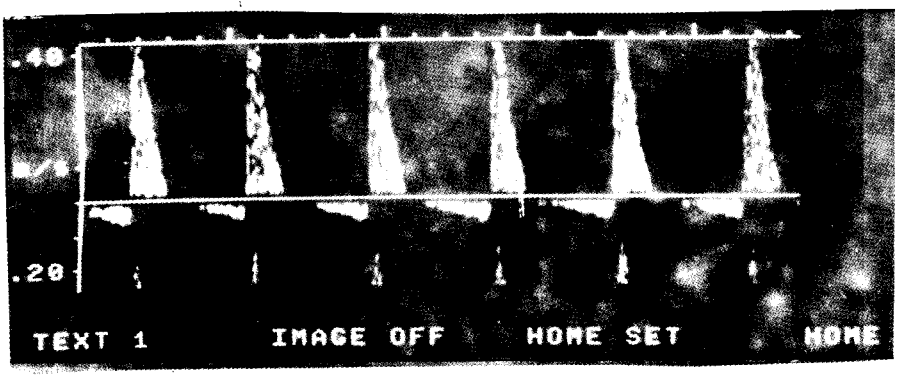
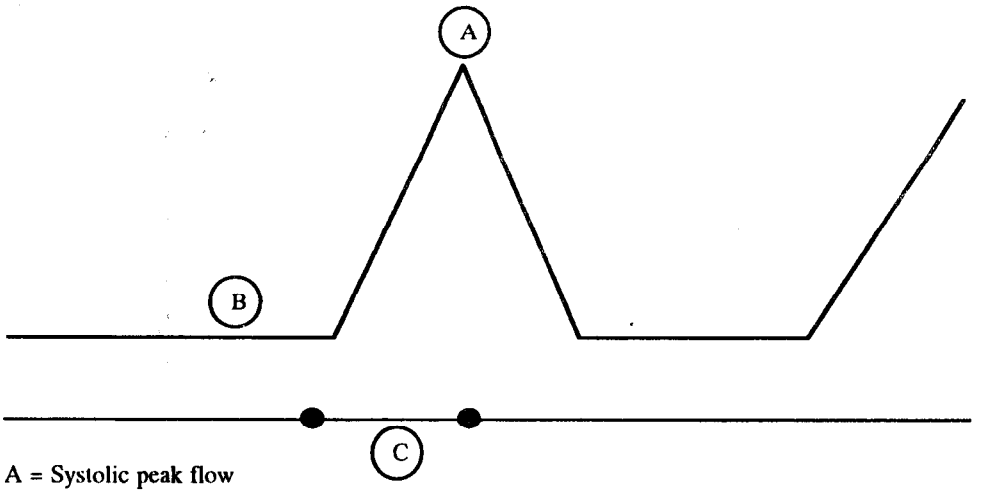


Fig. (6): Spectral waveforms in the cavernosal artery during normal progression of erection after vasoactive injection. A) As cavernosal pressure increases, a transition in diastolic flow occurs which is heralded by the development of a dicrotic notch (arrow). D) When intracavernosal pressure exceeds diastolic pressure within the artery, end diastolic flow undergoes diastolic flow reversal.



A = Systolic peak flow
B = Diastolic flow
C = Acceleration time

Fig. (7): Colour doppler spectrum.

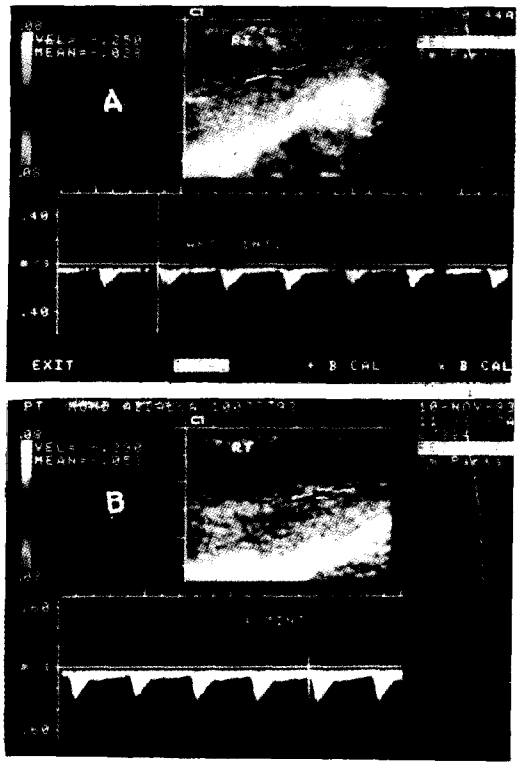


Fig. (8): Value of extending the doppler test to 20-30 min. A) Peak flow velocity in the right cavernosal artery 5 min. was 25 cm/sec. B) Peak systolic velocity 14 min. later was 39 cm/sec. denoting normal arterial in flow.

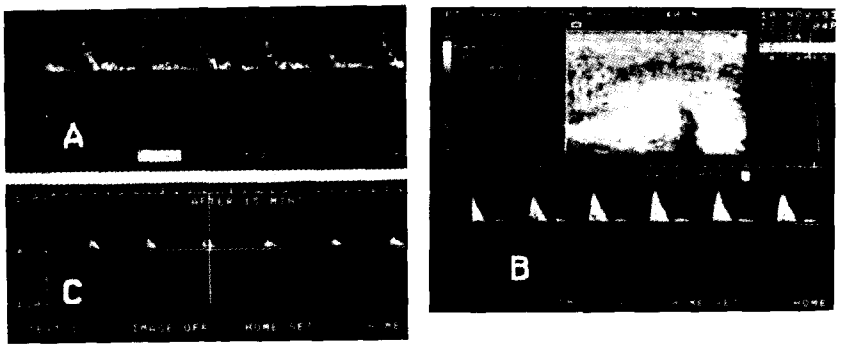


Fig. (9): value of extending the doppler test to 20-30 min. A) Normal systolic peak velocity and diastolic flow of 9 cm/sec. B) 15 min. later, diastolic flow became 2 cm/sec. C) Full erection with disappearance of diastolic flow.

the psycologic impact of the test on the patient which may lead to false-positive results [20]. We did not diagnose venous incompetence unless end diastolic flow was persistently high after multiple readings over 20-30 minutes and after manual genital stimulation (Fig. 9). Moreover, if we were still in doubt; patient self-reporting on erectile response after the test; was included before the final interpretation as we agree with others that this is the most versatile test for veno-occlusive function [15]. Clinical data and observations during the doppler test should have its impact on the interpretation and that is why we think that the test should be done by the andro-urologist for better assessment. With such strict rules, it is our experience that colour doppler sonography can be accurate in diagnosis of venogenic impotence in almost 95% of case (unpublished data).

Which patient should be submitted to colour doppler or duplex ultrasonography examination? is still controversial [21,22]. It is our opinion that colour doppler sonography is an accurate and a relatively non-invasive examination which makes it a perfect screening test for diagnosis of cause of erectile dysfunction in impotent patients. However, because of the high expenses of the test and the increasing number of the patients presenting to our clinic, we have recently started to use combined injection and stimulation test (CIS test, Table 3) as a parameter for selection of candidates for colour doppler examination [23]. Abnormal response to CIS test is our only absolute indication for colour doppler examination, however, some of the patients responding well to intracavernous injection may still want to know the cause of their erectile dysfunction and those can be also included.

In conclusion, colour doppler sonography is an acurate and reliable test for evaluation of penile vasculature in impotent patients. We do recommend extending the test to 20-30 minutes with repetition of readings every 5 minutes to avoid false-positive results. Colour doppler examination of penile vascularity should be the first-line tool in evaluating patients with suspected vasculogenic impotence. Pudendal angiography and cavernosornetry are to be preserved as second-line tests for patients in whom surgical repair is considered.

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