



Role of Colour Doppler Ultrasound Examination of Cavernosal Artery in Cases of Suspected Vasculogenic Cause of Erectile Dysfunction

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Authors' contributions

This work was carried out in collaboration between both authors. Author PS designed the study, wrote the protocol and wrote the first draft of the manuscript. Author RR managed the literature search. Both authors read and approved the final manuscript.

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Case Study

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ABSTRACT

Objective: The aim of our study was to evaluate role of Color Doppler ultrasound in suspected vasculogenic cause of male impotence in both erect and flaccid state of penis.

Materials and Methods: The study was conducted in Department of Radiodiagnosis, Deen Dayal Upadhyay Hospital, Delhi. Fifty male patients > 18 years of age with complaint of impotence for at least 6 months duration were included in the study.

Results: Peak systolic velocity (PSV) less than 25 cm/sec (post-intracavernosal injection of papaverine) had sensitivity of 82%, specificity of 96%, positive predictive value of 93.3%, and negative predictive value of 91.4% for arterial insufficiency. End diastolic velocity more than 5 cm/sec (post-intracavernosal injection of papaverine) had sensitivity of 80%, specificity of 92.5%, positive predictive value of 72.7% and negative predictive value of 94.8% for venous insufficiency

Conclusion: Color Doppler Ultrasound is first line modality in diagnosis of vasogenic cause of Erectile dysfunction both with or without use of pharmacostimulant. Our study suggests that PSV less than 25 cm/sec (post-intracavernosal injection of papaverine) helps in identifying patients with

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arterial insufficiency with sufficient amount of confidence with its specificity being more than its sensitivity.

Keywords: Penile doppler ultrasound; erectile dysfunction; arterial insufficiency; papaverine.

1. INTRODUCTION

The implications of Male erectile dysfunction (ED) surpass the simple concept of the "insufficient rigidity of the penis to penetrate" [1]. Male ED is a common problem, affecting an estimated one in ten men with prevalence much higher in certain subgroups. Recent work suggests that the majority of men suffering from erectile dysfunction have organic etiologies, with a vasogenic cause occurring most commonly [2,3]. Color Doppler ultrasound (USG) is one of the front line investigations in cases of ED as it has a proven utility in diagnosing vascular cause of ED [4-20]. Peak systolic velocity (PSV) of cavernosal artery in erect state is a good indicator of ED. Both arterial and venous cause of ED can be identified using duplex USG. However diagnosing ED in flaccid state still remains a topic of argument.

2. MATERIALS AND METHODS

The study was conducted in Department of Radiodiagnosis, Deen Dayal Upadhyay Hospital, Delhi. Fifty male patients ≥ 18 years of age who came to the infertility clinic with complaint of impotence for at least 6 months duration were included in the study. Patients <18 years of age, unwilling to undergo imaging techniques for evaluation of impotence and with known structural anomalies of the penis were excluded from the study. A detailed history of the presenting complaints in all patients was recorded with emphasis on any vascular disease, presence or absence of diabetes, and personal history. Physical examination of all patients was done with emphasis on local examination of the penis.

The following laboratory investigations were done in all patients :

- Complete hemogram with ESR.
- Blood sugar - fasting.
- Blood urea.
- Serum creatinine.
- Lipid profile.
- Urine – routine and microscopy.
- Hormonal assay, if any history of endocrine disorder was present.

All patients were examined in supine position with complete assurance of privacy in a quiet setting. Informed consent of patients was taken after explaining the procedure and its complications. Patients were subjected to gray scale and Color Doppler sonography of the penis using a multi-frequency (5 to 12 MHz) linear array transducer on a Philips Revision 1.0.6 USG machine. Real time gray scale sonography of penis was performed initially in the flaccid state. Any deviation from the normal appearance like plaques, fibrosis etc was noted. Color Doppler imaging of penis was then performed in flaccid state. PSV was recorded in each cavernosal artery at a position where the artery was at an optimal angle to the probe, using lowest filters and optimal color gain settings.

A rubber tourniquet was placed at the base of the penis and 60 mg of papaverine was injected intracavernosally with an insulin syringe under strict aseptic conditions. The tourniquet was removed 2 minutes after the injection was completed. Color Doppler imaging parameters were recorded beginning 2 minutes after injection for at least 20-30 minutes after the intracavernosal injection (ICI) of papaverine or until no significant waveform progression occurred for a 5 minute interval. Waveforms from left and right cavernosal arteries were recorded alternately. The presence of color flow within the dorsal veins was also noted during each of these 3 to 5 minutes intervals.

Duplex measurements were obtained near the base of the penis where the vessel curvature provided appropriate insulating angle of less than 60° to maximize accuracy. Spectral waveforms were used to obtain:

- PSV
- End diastolic velocity (EDV)
- Pulsatility index (PI)
- Resistive index (RI)
- Progression of spectral waveforms.

Normal Doppler spectral waveform pattern in the flaccid state before ICI of papaverine has a single systolic peak (Figs. 1, 2). During the process of erection after ICI of papaverine (Figs. 3, 4), the normal spectral waveform in most patients has four phases:

- In the first phase, the blood flow is unidirectional in both systole and diastole and has a prominent forward diastolic component. This phase reflects a relatively low resistance pattern (Figs. 5, 6).
 - In the second phase, the diastolic component ceases and blood flow is seen only in systole indicating intracavernosal pressure equals diastolic pressure.
 - In the third phase, reversal of direction of blood flow in diastole is seen indicating intracavernosal pressure is greater than the arterial pressure in diastole (Fig. 7).
 - In the fourth phase, rigidity occurs and the diastolic flow reverts back to zero. Any deviation from this normal pattern, if any was noted (Figs. 8, 9, 10).
- Patients were observed for persistent erection 1 hour after injection and were discharged from the Department only after the erection subsided. If the erection persisted for more than 4 hours, it was labeled as a case of priapism.

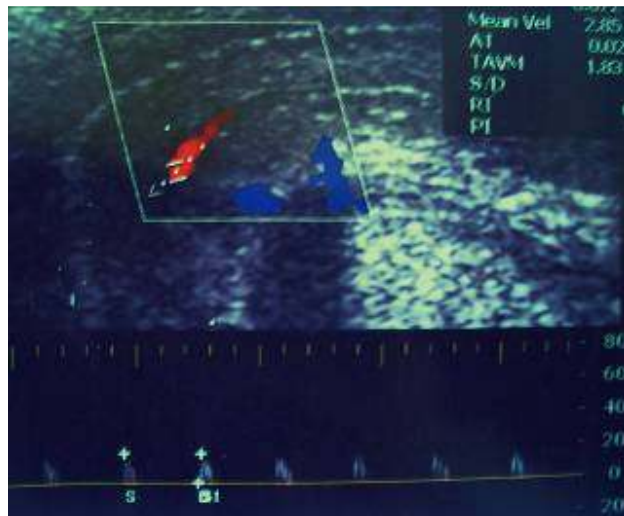


Fig. 1. Spectral analysis before injection of papaverine shows a monophasic flow pattern with PSV of 18 cms/sec (Normal)

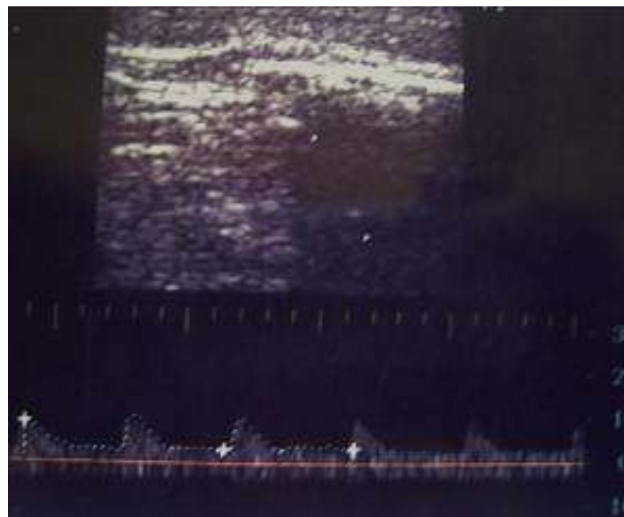


Fig. 2. Spectral analysis pre-papaverine injection showing a PSV of 15 cms/sec along with persistent diastolic flow which is due to tactile stimulus of probe leading to partial erection

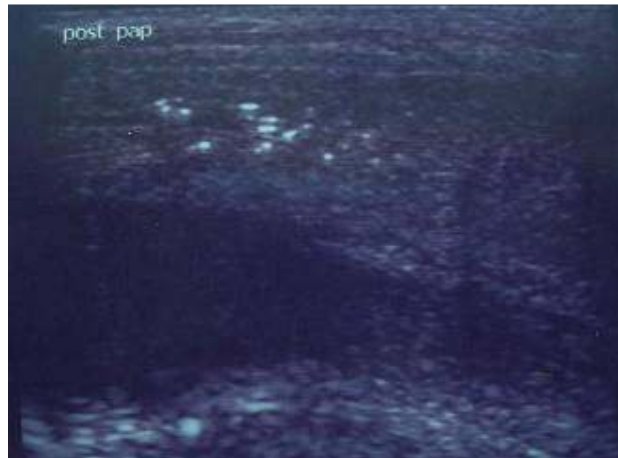


Fig. 3. Longitudinal scan of corpus cavernosum immediately after papaverine injection. The echogenic dots within cavernosum suggest papaverine is in correct location

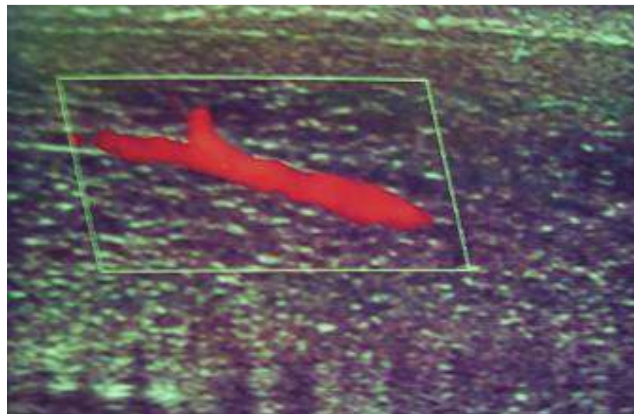


Fig. 4. Longitudinal scan 2 min post papaverine shows increased diameter of cavernosal artery with increased flow and normal branching pattern of artery

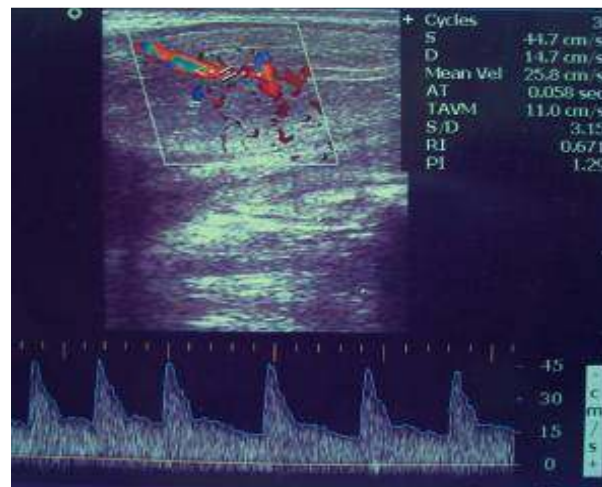


Fig. 5. Spectral analysis 4 min post papaverine shows increase in PSV and EDV suggestive of low resistance flow pattern

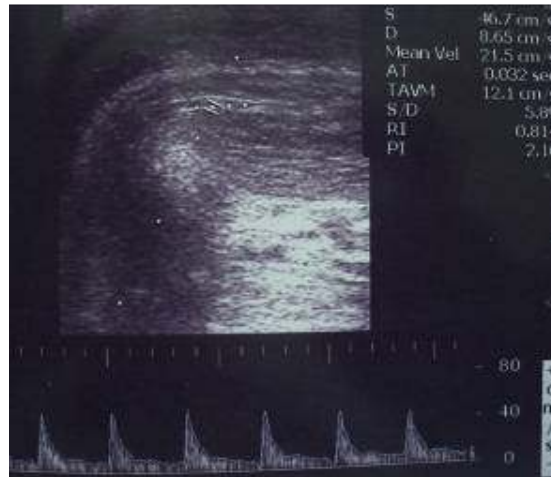


Fig. 6. Spectral analysis 8 min post papaverine shows increase in PSV and decrease in EDV suggestive of persistent increase in resistance to flow

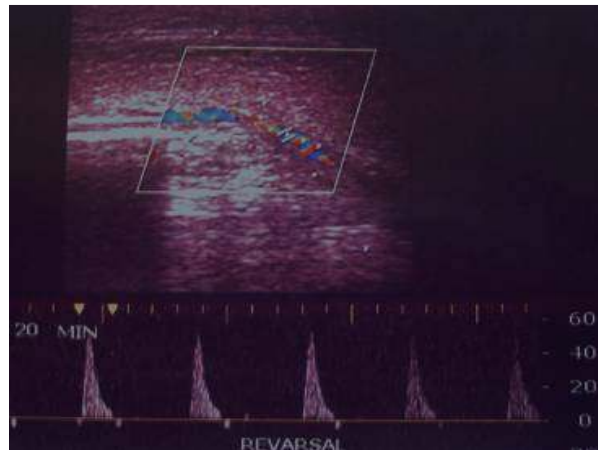


Fig. 7. Spectral analysis 20 min post papaverine shows increase in PSV but diastolic flow reversal suggestive of a very high resistance flow pattern

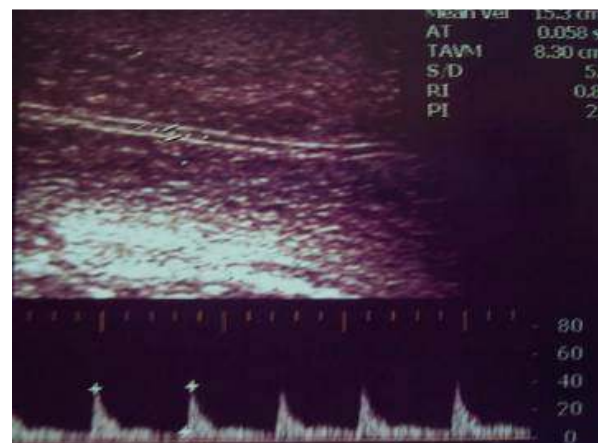


Fig. 8. Spectral analysis 20 min post papaverine shows persistently increased PSV but EDV failed to come down less than 5 cms/sec suggestive of venous incompetence

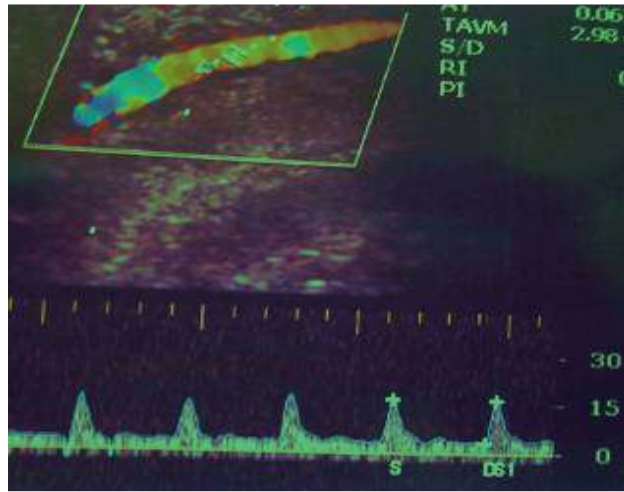


Fig. 9. Spectral analysis post papaverine shows PSV which failed to cross cut off of 25 cms/sec at 26 min suggestive of arterial incompetence

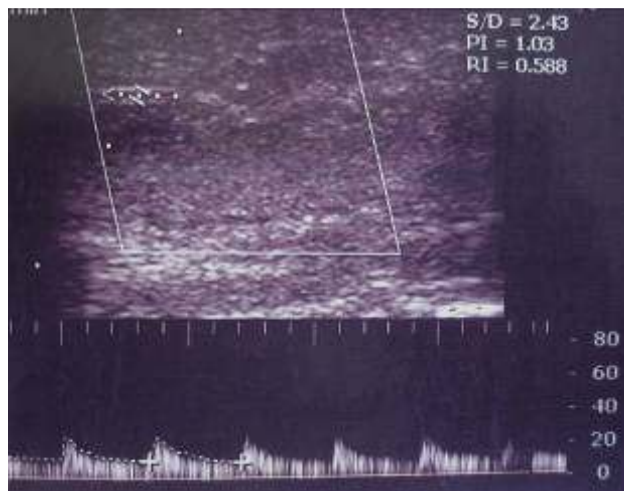


Fig. 10. Spectral analysis 22 min post papaverine shows PSV less than 25 cms/sec and EDV more than 5 cms/sec

3. OBSERVATION AND RESULT

Youngest patient in our study was 21 years old while the oldest was 60 year old. Maximum (21%) number of cases were in the age group of 21 to 30 years. Duration of history of ED was from 6 months to 5 years (Table 2). The younger patients reported with history of lesser duration (6 months to 2 years) as compared to older patients (>2 years). Eleven (22%) patients had history of smoking while 7 (14%) patients had diabetes mellitus and 6 (12%) patients had hypertension. Three (6%) patients had pelvic trauma which is a known cause of neurogenic impotence.

Laboratory investigations were analyzed and found to be normal except seven patients having raised blood sugar level. Four patients had pus and two patients had sugar in urine routine and microscopy.

On psychological evaluation, the patients having marriage problem and sexual inhibition were younger (mean age of 30 years and 29 years respectively) while the patients having stress and depression had mean age of 39 years. Patients with performance anxiety before sexual intercourse had mean age of 32 years.

Table 1. Predisposing factors for Erectile dysfunction in patients

Predisposing factors	No of patients	%
Trauma (pelvis)	3	6
Smoking	10	20
Diabetes	3	6
Hypertension	3	6
Diabetes mellitus & hypertension	3	6
Diabetes mellitus & smoking	1	2
No significant history	27	54

Table 2. Duration of Erectile dysfunction in patients

Duration of erectile dysfunction	No of patients	%
6 month - 1 yr	6	12
> 1 yr – 2 yr	21	42
>2 yr – 3 yr	10	20
> 3 yrs	13	26

Table 3. Psychological evaluation of Erectile dysfunction patients

Psychological evaluation	No of patients	Mean age of patients (years)
Performance anxiety	8	32
Stress	6	41
Depression	7	49
Marriage problems	2	31

In the flaccid state, single systolic peak was seen in most patients. Different phases of spectral waveforms were noted during the process of erection after ICI of papaverine. In flaccid state a mean pre-papaverine PSV of < 12 cms/sec had a significant correlation with a post-papaverine PSV of < 25 cms/sec. There was significant correlation between a pre-papaverine PSV of ≥ 12 cms/sec and normal clinical response of the patient. All patients including both normal arterial system and arterial insufficiency attained their maximum PSV post-ICI of papaverine after a time lapse of three to twenty five minutes, with the majority between six to fifteen minutes. However no correlation existed between time

lapse after ICI of papaverine, attainment of maximum PSV post-ICI and arterial integrity.

All patients with normal clinical response (responders: firm and sustained erection) to ICI of papaverine had mean PSV post-ICI of papaverine of ≥ 25 cm/sec except 3 patients who had normal clinical response and PSV < 25 cm/sec. All patients with abnormal clinical response to ICI of papaverine (non responders : no or suboptimal rigid erection) had mean PSV post-ICI of papaverine of < 25 cm/sec with average PSV post-ICI of papaverine of 18.89 cm/sec. Post ICI clinical response to papaverine was normal in 34 patients (68%) and abnormal in 16 patients (32%).

All ten patients with venous insufficiency had mean EDV (post-ICI of papaverine) of ≥ 5 cm/sec as well as persistent dorsal venous flow beyond the early transition phase of erection indicating presence of venous leakage except two patients who did not show dorsal venous flow. All patients who had mean EDV (post-ICI of papaverine) of <5 cm/sec did not demonstrate persistent dorsal venous flow beyond the early transition phase of erection except three patients who showed persistent dorsal venous flow. Post ICI spectral waveform in all 10 patients with venous incompetence did not demonstrate reversal of diastolic flow.

Three patients in our study developed priapism after ICI of papaverine. These patients were taken to Surgical emergency and treated with aspiration and/or irrigation of the corpora cavernosa with epinephrine. These patients were discharged from hospital only after complete recovery. No correlation was seen between mean PSV, mean EDV post-ICI of papaverine and priapism.

Using PSV (post-ICI of papaverine) of < 25 cm/sec as the diagnostic cut-off value for arterial insufficiency, we observed sensitivity of 82%, specificity of 96%, positive predictive value of 93.3%, negative predictive value of 91.4% and p value < 0.001 corresponding to computed Chi-square, using Chi-square test with 1 degree of freedom.

Table 4. Comparison of mean pre-papaverine PSV with clinical response to papaverine

Mean pre-papaverine PSV (cm/sec)	Clinical response to papaverine		Sensitivity	Specificity	PPV	NPV
	Responders	Non-responders				
≥ 12	29	5	75 %	85 %	70.5%	87.8%
< 12	4	12				

Table 5. Comparison of mean PSV post-papaverine with clinical response to papaverine

Mean PSV (post papaverine)	Clinical response to papaverine		Sensitivity	Specificity	PPV	NPV
	Responders	Non-responders				
< 25 cm/sec	1	14	82 %	96.9 %	93.3 %	91.4%
≥ 25 cm/sec	32	3				

Table 6. Comparison of mean pre-papaverine PSV with mean PSV post-papaverine

Mean Pre-papaverine PSV	Mean PSV post-papaverine		Sensitivity	Specificity	PPV	NPV
	≥ 25 cm/sec	< 25 cm/sec				
≥ 12 cm/sec	32	2	81.2%	94.1%	86.66%	91.42%
< 12 cm/sec	3	13				

Table 7. Comparison of threshold EDV post-papaverine with persistence of dorsal venous flow beyond the early transient phase of erection

Threshold EDV (post papaverine)	Number of patients		Sensitivity	Specificity	PPV	NPV
	Presence of persistent dorsal venous flow beyond the early transient phase of erection	Absence of persistent dorsal venous flow beyond the early transient phase of erection				
< 5 cm/sec	8	2	80 %	92.5 %	72.7 %	94.8%

Table 8. Etiology of erectile dysfunction

Etiology of erectile dysfunction	No of patients	Percentage
Arteriogenic	15	30
Venous	10	20
Psychogenic	23	46
Neurogenic	2	4

Using EDV (post-ICI of papaverine) of ≥ 5 cm/sec as the diagnostic cut-off value for venous leakage and comparing with persistent dorsal venous flow beyond the early transition phase of erection, we observed sensitivity of 80%, specificity of 92.5%, positive predictive value of 72.7%, negative predictive value of 94.8% and p value < 0.001 corresponding to computed Chi-square, using Chi-square test with 1 degree of freedom.

4. CONCLUSION

Men of all age beginning from second decade onwards can be affected with ED with organic cause being the most common etiology, comprising more than half of the cases. ED affects all age group with vasogenic cause seen more commonly in older age group. There is a wide range in time lapse post-ICI of papaverine

and attainment of maximum PSV post-ICI of papaverine due to wide variation in individual response to ICI of papaverine.

A maximum PSV of ≥12 cm/sec in flaccid state in our study group indicates normal flow in cavernosal artery and suggests a normal clinical response to papaverine. Mean PSV (post-ICI of papaverine) of < 25 cm/sec in our study group is suggestive of arterial insufficiency. Mean EDV (post-ICI of papaverine) of ≥ 5 cm/sec in patients with normal arterial system in our study group is suggestive of venous insufficiency. Presence of persistent dorsal venous flow beyond the early transition phase of erection in our study group is also suggestive of venous leakage.

Therefore Color Doppler USG is first line modality in diagnosis of vasogenic cause of ED both with or without use of pharmacostimulant. Our study suggests that PSV < 25 cm/sec (post-intracavernosal injection of papaverine) helps in identifying patients with arterial insufficiency with sufficient amount of confidence with its specificity being more than its sensitivity.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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