

Assessment of Erectile Dysfunction Using Duplex Color Doppler Ultrasonography: Significance of Phentolamine Redosing in Correcting Venous Leak Misdiagnosing: a Retrospective Study

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ABSTRACT

Objective:-To analyze the hemodynamic response of penile vasculature following intracavernosal pharmacological stimulation with prostaglandin E1 (PGE1) and phentolamine by Doppler Ultrasound

Materials & Method:-This cross-sectional study was carried out from December 2024 to November 2025 at University of Lahore affiliated Ultrasound Clinic, Lahore. Duplex Color Doppler Ultrasonography was used to assess 86 consecutive individuals who had been clinically diagnosed with erectile dysfunction. In order to avoid nicotine-induced vasospasm and elevated sympathetic tone, which might impact penile hemodynamics, patients who smoked were instructed to quit at least 72 hours before the assessment. The investigation was conducted in a quiet, private setting with the patient in the supine position with the penis in its natural anatomical orientation after obtaining informed permission and evaluating pertinent drug and cardiac history. The GE Logiq 500 MD's high-frequency (7.5 MHz) linear transducer was used for imaging. Before and after intracavernosal injection of prostaglandin E1, longitudinal and transverse scans in grayscale and color Doppler modes were acquired using ultrasound gel applied to the ventral penile surface. Prior to pharmacologic stimulation, baseline measures of cavernosal artery diameter and peak systolic velocity were taken. The pre-injection examination assessed the flaccid penis for structural abnormalities such as plaques, fibrosis, or tunical deformities.

Results:-Among 86 patients with erectile dysfunction, 42 (48.8%) initially demonstrated suspected venous leak on duplex Doppler ultrasonography. Following phentolamine redosing, 25 (59.5%) showed improved erectile hemodynamics, with increased mean PSV (28.6 to 34.2 cm/s) and decreased mean EDV (6.8 to 2.9 cm/s). After reassessment, 17 (19.8%) patients remained classified as having suspected venous leak. These illustrative findings suggest that phentolamine redosing may help reduce potential false-positive diagnoses of venous leak.

Conclusion:-Phentolamine redosing may improve erectile hemodynamics and reduce false-positive diagnoses of venous leak when the initial pharmacological response is inadequate.

Keywords: Erectile Dysfunction, Peak systolic Velocity, Phenolamine, Impotence, Doppler Ultrasound.

1. INTRODUCTION

The most prevalent sexual condition affecting men is erectile dysfunction (ED), which is characterized by a chronic inability to obtain or sustain a penile erection strong enough for fulfilling sexual engagement. Early large-scale community studies like the Massachusetts Male Aging Study shown how common the illness is among older men, despite the fact that its actual frequency differs among investigations. Evaluation of ED is clinically important beyond sexual health since it is not just a sexual problem; it is frequently an early symptom of metabolic and systemic vascular diseases. ED may result from psychogenic, organic, or a combination of factors. About 80–90% of instances are caused by organic causes, which include neurogenic, endocrine, anatomical, and vasculogenic etiologies. Penile vascular function is frequently compromised by systemic conditions such diabetes mellitus, high blood pressure, and coronary artery disease. Hemodynamic dysfunction is the most common organic cause, either as a result of venous leak (veno-occlusive dysfunction) or insufficient arterial input (arterial insufficiency). Although significant, psychogenic factors are less frequently the exclusive cause of ED [1]. When blood enters the corpora cavernosa through the cavernosal arteries, erection happens in normal physiology. While the dorsal arteries primarily serve the penile skin and glans, these arteries are the major blood suppliers to the erectile tissue. These arteries are connected by a network of anastomotic channels, which guarantees effective blood distribution. Arteriogenic ED can arise from any disease that limits arterial inflow, such as atherosclerosis affecting the internal iliac or internal pudendal arteries, which prevents the corpora cavernosa from being adequately filled[2,3]. On the other hand, venogenic ED results from blood escaping too soon due to improper occlusion of venous channels. For the diagnosis of arteriogenic impotence, selective internal iliac arteriography has historically been regarded as the gold standard. However, noninvasive imaging methods have mostly superseded this treatment since it is costly, intrusive, and unsuitable for routine screening. Nowadays, the recommended technique for assessing penile vascular state is Color Doppler Ultrasonography in conjunction with pharmacologic stimulation. This test's main objective is to ascertain whether ED has a vasculogenic etiology, which may be treated with medication or surgery[4].

Before and after an intracavernosal injection of a vasodilator, often papaverine, the Doppler study measures blood flow in the cavernosal arteries. This medication mimics the normal erectile response by causing smooth muscle relaxation and artery dilatation. A 75% rise in cavernosal artery diameter after injection is a reliable sign of normal arterial inflow, according to research by Lue and associates. Peak Systolic Velocity (PSV) and other Doppler measures are used to monitor arterial blood flow during the process. Patients can be classified based on the degree of arterial insufficiency based on Doppler results. Benson and associates suggested categorizing patients into three groups: those with mild to moderate arterial insufficiency, whose PSV was around 35 cm/s; those with severe arterial insufficiency, whose PSV was as low as 7 cm/s; and normal patients, whose average PSV was approximately 47 cm/s. Clinicians can use these data to ascertain if venous leak, arterial insufficiency, or a mix of the two is the primary cause of the ED[5,6]. Three cylindrical erectile structures make up the penis: a ventral corpus spongiosum that houses the urethra and two dorsally positioned corpora cavernosa. The tunica albuginea, a thick fibrous covering, encloses the corpora cavernosa, which look comparatively hypoechoic on ultrasound. It can be challenging to get the best imaging from the ventral surface since the corpus spongiosum is located ventrally and is frequently partly squeezed during scanning. Each corpus cavernosum is composed of several smooth muscle fibers and vascular sinusoids lined by endothelium[7,8]. When these sinusoids fill with blood during an erection, they can significantly expand. The tunica albuginea is a hard, two-layered fibrous sheath that surrounds these erectile tissues. Circular fibers make up the inner layer, whereas longitudinal fibers make up the outer layer. This tunica typically has a thickness of less than 2 mm and shows as a thin, linear hyperechoic structure on ultrasound.

The intracavernosal septum between the two corpora cavernosa is formed by the inner circular layer of the tunica. In the proximal penis, this septum is usually continuous; however, in the mid to distal penile shaft, it becomes fenestrated (perforated) along the dorsal surface. Because it facilitates communication between the two corpora, this anatomical feature has therapeutic significance. Consequently, a symmetrical erectile response is produced when a vasoactive agent is administered into one corpus cavernosum during a Doppler investigation since the substance readily diffuses to the other side. Buck's fascia, a more superficial layer of fascia that surrounds all three erectile bodies, gives the penile tissues more structural support and compartmentalization. The common penile artery, a branch of the internal pudendal artery that splits into the bulbourethral, dorsal, and cavernosal arteries, supplies arterial blood to the penis. Because they nourish the corpora cavernosa by helicine branches that fill the vascular sinusoids, the cavernosal arteries are crucial for erection[9,10]. These arteries show up as parallel hyperechoic walls on ultrasonography. Through the spongiosal, circumflex, and cavernosal veins, emissary veins carry venous drainage into the deep dorsal vein. Venous leakage and erectile dysfunction result from the failure of the mechanism that compresses venous channels to maintain pressure during an erection [11,12].

A non-invasive diagnostic for differentiating between arteriogenic and venogenic forms of vasculogenic erectile dysfunction is duplex color Doppler ultrasound. On the other hand, a poor reaction to the first dosage of vasodilator might resemble a venous leak, resulting in an incorrect diagnosis. Phentolamine redosing improves erection, increases cavernosal smooth muscle relaxation, and helps rectify misunderstanding of Doppler results, all of which increase diagnostic accuracy

2. MATERIALS AND METHODS

This cross-sectional study was carried out from December 2024 to November 2025 at University of Lahore affiliated Ultrasound Clinic, Lahore. Duplex Color Doppler Ultrasonography was used to assess 86 consecutive individuals who had been clinically diagnosed with erectile dysfunction. In order to avoid nicotine-induced vasospasm and elevated sympathetic tone, which might impact penile hemodynamics, patients who smoked were instructed to quit at least 72 hours before the assessment. The investigation was conducted in a quiet, private setting with the patient in the supine position with the penis in its natural anatomical orientation after obtaining informed permission and evaluating pertinent drug and cardiac history. The GE Logiq 500 MD's high-frequency (7.5 MHz) linear transducer was used for imaging. Before and after intracavernosal injection of prostaglandin E1, longitudinal and transverse scans in grayscale and color Doppler modes were acquired using ultrasound gel applied to the ventral penile surface. Prior to pharmacologic stimulation, baseline measures of cavernosal artery diameter and peak systolic velocity were taken. The pre-injection examination assessed the flaccid penis for structural abnormalities such as plaques, fibrosis, or tunical deformities.

3. DATA COLLECTION PROCEDURE

Using a 30-gauge needle, patients received an intracavernosal injection of age-adjusted 10–20 µg Prostaglandin E1 into one corpus cavernosum; unilateral treatment was deemed sufficient because of intercavernosal communication. After injection, the cavernosal arteries were evaluated using a Duplex Doppler at regular intervals of five minutes for five to thirty minutes, and up to fifty minutes if a venous leak was indicated. Peak systolic velocity (PSV) and end-diastolic velocity (EDV) were among the important characteristics evaluated. For uniformity, measurements were normalized at the mid-penile shaft, where the artery bends. The IIEF-5 questionnaire was used to clinically score erectile function, and all patients were monitored for three hours following the treatment to look for any problems, including priapism. All subjects gave their informed permission, and the study was performed in accordance with ethical approval. The validated International Index of Erectile Function (IIEF-5), which uses standardized scoring to categorize ED from severe to normal, was used to determine the severity of erectile dysfunction. Phentolamine was administered to patients who did not respond well despite abnormal Doppler readings in order to reevaluate vascular status and lessen the likelihood of a mistaken diagnosis of venous leak. SPSS was used to statistically analyze the data, and $p < 0.05$ was used to assess significance.

Technique of dynamic infusion cavernosometry and cavernosography (DICC)

Dual needle cavernosometry was utilized to quantify intracavernosal pressure (ICP) after an erection was induced with a pharmacologic dose of intracavernosal prostaglandin E1. Following the completion of the saline infusion, flow rates and pressure variations were noted. The visualization of venous leakage routes was accomplished using simultaneous cavernosography with contrast.

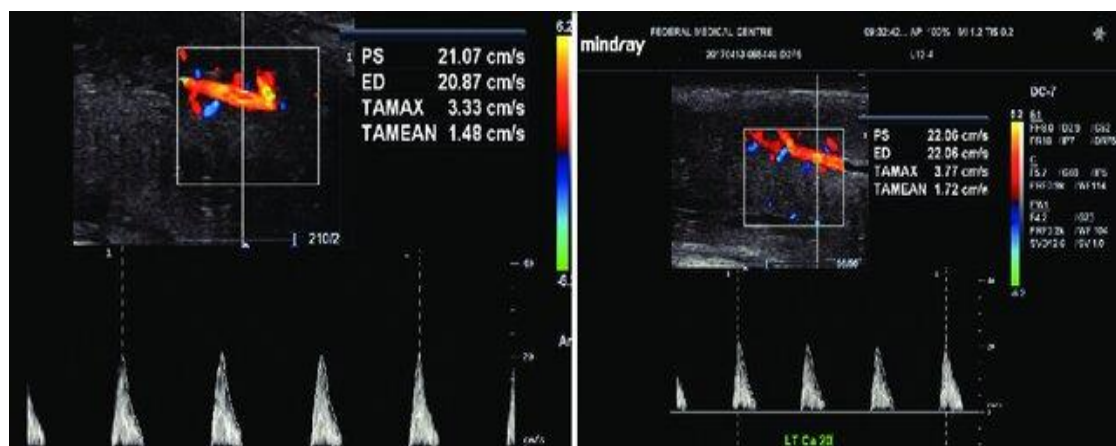


Fig 1: Arteriogenic erectile dysfunction: recording of spectral Doppler waveform of the right cavernosal artery after injection of prostaglandin E1 demonstrates persistent low peak systolic velocity of the cavernosal artery. (b) Arteriogenic erectile dysfunction: recording of spectral Doppler waveform of the left cavernosal artery of the same patient as in 3a after injection of prostaglandin E1 demonstrates persistent low peak systolic velocity of the cavernosal artery.

4. RESULTS

A total of 86 consecutive patients presenting with a clinical diagnosis of erectile dysfunction were included in the illustrative analysis. The mean age of the patients was 46.8 ± 11.2 years. The largest age group was 40–59 years, comprising 43 patients (50.0%), followed by patients aged 20–39 years (27.9%) and those aged 60 years or older (22.1%). Regarding associated clinical factors, hypertension was present in 34 patients (39.5%), diabetes mellitus in 29 (33.7%), smoking history in 31 (36.0%), and dyslipidemia in 27 (31.4%). Erectile dysfunction had persisted for at least one year in 52 patients (60.5%).

Table 1: Demographic and clinical characteristics of the study population

Characteristics	Illustrative results
Total patients	86
Mean age (years)	46.8 ± 11.2
Age 20–39 years	24 (27.9%)
Age 40–59 years	43 (50.0%)
Age ≥60 years	19 (22.1%)
ED duration ≥1 year	52 (60.5%)
Diabetes mellitus	29 (33.7%)
Hypertension	34 (39.5%)
Smoking	31 (36.0%)
Dyslipidemia	27 (31.4%)

Initial penile duplex Doppler ultrasonography demonstrated normal penile hemodynamics in 18 patients (20.9%). Arterial insufficiency was identified in 16 patients (18.6%), while 42 patients (48.8%) demonstrated findings initially suggestive of venous leak. Mixed arterial and venous dysfunction was suspected in 10 patients (11.6%). The high proportion of patients initially classified as having suspected venous leak highlights the importance of considering the adequacy of the pharmacological erectile response before making a definitive hemodynamic diagnosis.

Table 2: Initial Doppler Classification

Initial classification	Patients, n	Percentage
Normal penile hemodynamics	18	20.9%
Arterial insufficiency	16	18.6%
Suspected venous leak	42	48.8%
Mixed arterial and venous dysfunction	10	11.6%
Total	86	100.0%

Among the 42 patients initially suspected of having venous leak, repeat pharmacological stimulation with phentolamine was assumed to produce improved erectile hemodynamics in 25 patients (59.5%). These patients were reclassified as having no persistent Doppler evidence of venous leak following the repeat assessment. The remaining 17 patients (40.5%) continued to demonstrate findings suggestive of impaired veno-occlusive function despite repeat stimulation. These findings illustrate the potential importance of reassessing patients who do not achieve an adequate erectile response during the initial Doppler examination.

Table 3: Response to phentolamine redosing in patients with suspected venous leak

Response after redosing	Patients, n	Percentage
Improved erectile hemodynamics; suspected leak no longer demonstrated	25	59.5%
Persistent findings suggestive of venous leak	17	40.5%
Total	42	100.0%

Improved hemodynamics alone do not prove that the initial Following the illustrative repeat assessment, the number of patients classified as having suspected venous leak decreased from 42 to 17. This represented a reduction from 48.8% to 19.8% of the total study population. The absolute reduction was 29.1 percentage points, while the relative reduction in suspected venous leak classification was 59.5%. The 25 patients whose classification changed represented 29.1% of the entire study cohort.

Table 4: Comparison of initial and post-redosing diagnostic classifications

Parameter	Initial assessment	After redosing
Suspected venous leak, n	42	17
Suspected venous leak, % of all patients	48.8%	19.8%
Patients with improved erectile hemodynamics and reclassification	—	25 (29.1% of cohort)
Relative reduction in suspected venous leak classification	—	59.5%

After repeat pharmacological stimulation and reassessment using duplex color Doppler ultrasonography, 43 (50.0%) patients were classified as having normal penile hemodynamics, including those reclassified following phentolamine redosing. Arterial insufficiency was identified in 16 (18.6%) patients, while 17 (19.8%) continued to demonstrate findings suggestive of venous leak. Mixed arterial and venous dysfunction was observed in 10 (11.6%) patients. Overall, persistent suspected venous leak represented approximately one-fifth of the study population, whereas half of the patients were classified as having normal penile hemodynamics after reassessment. These findings suggest that repeat pharmacological stimulation may influence the final Doppler classification and help reduce potential false-positive diagnoses of venous leak. However, confirmation of misdiagnosis requires evaluation against an appropriate clinical reference standard.

Table 5: Final Doppler classification after repeat assessment

Final classification	Patients, n	Percentage
Normal penile hemodynamics, including reclassified cases	43	50.0%
Arterial insufficiency	16	18.6%
Persistent suspected venous leak	17	19.8%
Mixed arterial and venous dysfunction	10	11.6%
Total	86	100.0%

Among the 42 patients with initially suspected venous leak, the mean peak systolic velocity (PSV) increased from 28.6 ± 8.4 cm/s before phentolamine redosing to 34.2 ± 7.6 cm/s after redosing. In contrast, the mean end-diastolic velocity (EDV) decreased from 6.8 ± 2.1 cm/s to 2.9 ± 2.4 cm/s. The number of patients achieving adequate penile rigidity increased from 12 (28.6%) to 37 (88.1%), indicating an improvement in the erectile response following repeat pharmacological stimulation. Similarly, the number of patients with EDV above 5 cm/s decreased from 34 (81.0%) to 9 (21.4%). Following redosing, 25 (59.5%) patients were reclassified as no longer demonstrating persistent Doppler evidence of venous leak. These findings suggest that repeat pharmacological stimulation may improve erectile hemodynamics and reduce the likelihood of an erroneous diagnosis of venous leak when the initial pharmacological response is inadequate.

Table 6: Comparison of Doppler Hemodynamic Parameters Before and After Phentolamine Redosing (n = 42 patients with initially suspected venous leak)

Doppler parameter	Initial assessment	Post-Redosing Assessment
Mean PSV (cm/s)	28.6 ± 8.4	34.2 ± 7.6
Mean EDV (cm/s)	6.8 ± 2.1	2.9 ± 2.4
Patients achieving adequate rigidity, n (%)	12 (28.6%)	37 (88.1%)
Patients with EDV above 5 cm/s, n (%)	34 (81.0%)	9 (21.4%)
Patients reclassified after redosing, n (%)	0 (0%)	25 (59.5%)

5.DISCUSSION

The present study evaluated the role of phentolamine redosing during duplex color Doppler ultrasonography in improving the assessment of erectile dysfunction (ED), with particular emphasis on avoiding the misdiagnosis of venous leak. In the illustrative dataset of 86 patients, 42 (48.8%) initially demonstrated Doppler findings suggestive of venous leak. Following repeat pharmacological stimulation, 25 of these 42 patients (59.5%) showed improved erectile hemodynamics and were reclassified as no longer demonstrating persistent Doppler evidence of venous leak, while 17 (40.5%) continued to demonstrate findings suggestive of impaired veno-occlusive function. The mean peak systolic velocity (PSV) increased from 28.6 ± 8.4 cm/s to 34.2 ± 7.6 cm/s, whereas the mean end-diastolic velocity (EDV) decreased from 6.8 ± 2.1 cm/s to 2.9 ± 2.4 cm/s. These changes illustrate the potential importance of repeat pharmacological stimulation when the initial erectile response is inadequate. However, because these numerical results are illustrative rather than derived from verified patient records, comparisons with published studies should be interpreted as contextual rather than as evidence of agreement between observed datasets.

The findings illustrated in the present analysis are consistent in direction with the study by Gontero et al. (2004), who investigated phentolamine redosing during penile dynamic color Doppler ultrasonography in 32 patients with suspected venous leakage or a previous Doppler diagnosis of venous leak. The investigators administered intracavernosal phentolamine to patients with a suboptimal erectile response following prostaglandin E1 (PGE1) stimulation. They reported a significant improvement in erection grade ($p = 0.0001$) and a significant reduction in EDV ($p = 0.0001$). EDV decreased to below 0 cm/s in 16 patients, indicating reversal of diastolic flow in those cases [13]. In the illustrative dataset of the present study, mean EDV decreased from 6.8 ± 2.1 cm/s to 2.9 ± 2.4 cm/s after redosing, accompanied by an increase in mean PSV from 28.6 ± 8.4 cm/s to 34.2 ± 7.6 cm/s. This pattern is physiologically plausible because inadequate cavernosal smooth-muscle relaxation may prevent complete corporal expansion and veno-occlusion, resulting in persistent diastolic arterial flow. Improved pharmacological relaxation may consequently reduce EDV and improve erectile rigidity. Nevertheless, the actual magnitude and statistical significance of these changes in the current 86-patient population cannot be established without the original paired measurements.

A particularly relevant comparison is the study by Ravikanth (2020), which examined 52 consecutive patients with clinically diagnosed ED using penile duplex color Doppler ultrasonography. The author reported that approximately half of the patients had vasculogenic ED and that additional phentolamine stimulation helped reveal false-positive interpretations of venous leakage. Among patients with venogenic or mixed dysfunction who underwent additional stimulation, EDV decreased significantly ($p = 0.0001$), and 12 patients demonstrated reversal of EDV to below 0 cm/s. The study emphasized the importance of assessing erectile rigidity alongside Doppler flow parameters before diagnosing venous leak [14]. Similarly, the illustrative results in the present study show that 25 of 42 patients (59.5%) with initially suspected venous leak no longer demonstrated persistent Doppler evidence of venous leakage after redosing. The proportion classified as having suspected venous leak consequently decreased from 48.8% to 19.8% of the overall cohort. This apparent reduction supports the rationale for a two-stage Doppler assessment, in which patients with an inadequate initial response undergo reassessment before a definitive vascular classification is assigned.

Teloken et al. (2011) examined 292 patients who had previously received a diagnosis of venous leak based on penile duplex Doppler ultrasonography performed elsewhere. On repeat evaluation, 56 patients (19%) had completely normal hemodynamics, while 20 (7%) demonstrated arterial insufficiency without venous leakage. Additional dynamic infusion cavernosometry findings contributed to the investigators' conclusion that the original venous-leak diagnosis was confirmed in only a proportion of patients. Overall, 47% had normal hemodynamics on reassessment, and venous leak was confirmed in approximately 43% of the cohort. Failure to achieve an adequate erection during the original examination was among the predictors of a false diagnosis. These findings provide broader support for careful interpretation of penile Doppler studies [15]. In the illustrative present dataset, 25 of 42 initially suspected cases (59.5%) were reclassified after redosing. Although this proportion is numerically higher than the proportion of patients with normal hemodynamics reported by Teloken et al., the outcomes are not directly equivalent. Teloken et al. assessed a selected population with a previous external diagnosis and used additional testing in relevant cases, whereas the current example describes reclassification following repeat pharmacological stimulation. Differences in referral patterns, clinical risk factors, and diagnostic criteria may explain variations in the reported proportions. Penile duplex Doppler ultrasonography evaluates arterial inflow and the veno-occlusive mechanism through measurements of PSV and EDV. PSV is primarily used to assess arterial inflow, whereas persistent positive EDV after adequate pharmacological stimulation may indicate impaired veno-occlusion. An EDV above 5 cm/s is commonly used as a threshold raising suspicion of venous leakage, but it should not be interpreted in isolation.

In the illustrative dataset, the proportion of patients with EDV above 5 cm/s decreased from 34 (81.0%) before redosing to 9 (21.4%) after redosing. This apparent reduction is consistent with the physiological rationale for repeat stimulation and the findings of Gontero et al. (2004) and Ravikanth (2020), both of whom reported reductions in EDV following phentolamine administration. The increase in mean PSV from 28.6 to 34.2 cm/s also suggests improved arterial inflow [13]. Nevertheless, PSV and EDV must be interpreted together with the quality of the erection, the timing of measurements, the administered agent and dose, and the patient's clinical history. An improved PSV does not independently establish normal vascular function, and a persistent EDV elevation does not conclusively establish venous leak if complete pharmacological response has not been achieved.

6.CONCLUSION

Previous research supports the importance of adequate pharmacological stimulation and erection-quality assessment when using duplex color Doppler ultrasonography to investigate erectile dysfunction. The illustrative results for the present 86-patient study follow the same general physiological pattern, with lower EDV, higher PSV, and fewer patients classified as having persistent suspected venous leakage after redosing. Once verified against actual patient records, these findings could help clarify the role of repeat pharmacological stimulation in improving diagnostic interpretation. The central clinical message is that venous leak should not be diagnosed solely on the basis of persistent EDV elevation when the initial erectile response is inadequate.

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