

# Doppler Ultrasonographic Evaluation of Erectile Dysfunction in a Northern Nigerian Tertiary Hospital

## Abstract

**Background:** Colour duplex Doppler is a noninvasive tool for the evaluation of the vascular mechanism of erectile dysfunction (ED). It can be used to determine the integrity of the vascular mechanism and to differentiate between arterial and venous insufficiency. **Objectives:** To identify the vasculogenic causes of ED and subclassify them into arteriogenic, venogenic, or mixed to assist in predicting the clinical outcome. **Materials and Methods:** A retrospective study was conducted at the Department of Radiology, ABUTH Zaria, from records of patients who had presented to the Doppler suite with symptoms of ED available between July 2020 and August 2022. **Results:** A total of 23 patients were involved in this study. The age range was 25–66 years. The majority of the patients were seen in age groups 51–60 years and 41–50 years with 48% (11) and 22% (5), respectively. Only 3 (13%) of the patients were found to have normal penile Doppler study, 12 (52%) patients were found to have arteriogenic, and another 4 (17.4%) patients were found to have venogenic cause. In four (17.4%) patients, there was mixed/inconclusive picture. Among the nine (39%) patients with Peyronie's disease, only one showed normal Doppler study. The incidence of vasculogenic cause of ED was found to increase with age. **Conclusions:** The colour Doppler study is an important noninvasive nonionizing radiation tool for swift evaluation of penile erectile function and, thus, helps in classifying ED causes into structural, vascular, or possibly psychogenic, hence guiding the clinicians on the therapeutic options.

**Keywords:** Colour Doppler, erectile dysfunction, prostaglandin E1

## Introduction

Erectile dysfunction (ED) is a common cause of anxiety in the sexual life of a man and his partner.<sup>[1]</sup> This entity is defined as the inability to accomplish and sustain penile turgescence adequate for satisfactory coital activity.<sup>[2–8]</sup> ED is a serious cause for concern because of the stigma and ridicule that comes with it.<sup>[5,6]</sup> ED has been fingered as a source of depression, anger, a feeling of less masculinity, social isolation, denial, lack of self-confidence, and avoidance of spouse in the affected.<sup>[3,4]</sup> Therefore, in this clime, most affected men consume a whole lots of unorthodox substances to be “potent”, only a fraction present in the hospital, and hence, the real picture is underreported.

ED is age-related; the prevalence increases with advancement in age. Prevalent rates of 39% and 67% have been reported at the ages of 40 and 70 years, respectively.<sup>[2,7]</sup> The world prevalence of ED is projected to rise

to 322 million by 2025, whereas at least 30 million men suffer from ED in the USA.<sup>[2]</sup> In Nigeria, the “underestimated” documented ED prevalence varies between 26.4% and 46.9% due to regional multifactorial compounding factors.<sup>[2,3]</sup> Hence, the true picture of vascular abnormalities in ED patients here is hazy as in other less-developed climes.<sup>[9]</sup>

The value of routinely assessing the vascular supply of the phallus of ED patients, in which the other nonvascular causes have been ruled out, cannot be downplayed.<sup>[3,10–12]</sup> Erectile function is an important lawsuit discussed for cases of divorce, rape, and damages in some clime, especially the Indian subcontinent.<sup>[10,13]</sup> Lawyers and their clients often hide under the guise of ED in lawsuits concerning these cases; hence, Doppler evaluation at this point is of immense significance. Doppler ultrasound is a cheap, minimally invasive, highly sensitive, and specific means of assessing patients with ED.<sup>[10,12]</sup>

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The mechanism of penile erection is a complex interplay; a mental stimulus causing parasympathetic impulses discharge to the phallus must occur, thus relaxing the arterioles and the corpora cavernosa sinusoids.<sup>[3,13]</sup> As the sinusoidal spaces start filling, the corporal veno-occlusive mechanism is triggered, and the fibrous tunica albuginea compresses the emissary veins of the corpora, and a firm turgid phallus is attained. When any of the component this pathway is impeded ED may result.<sup>[3]</sup>

The causes of ED are broadly divided into two groups: psychogenic (10%) and organic causes.

The organic causes are vasogenic (arteriogenic impotence 30%, venogenic impotence 15%, and combined 10%), endocrine disorders, neurogenic disorders, morphological penile abnormalities, drugs, excessive alcohol, and smoking.<sup>[1,14]</sup>

Various parameters, such as the diameter of the cavernosal artery (CA), peak systolic flow velocity (PSV), degree of arterial dilatation, and acceleration time, have been suggested for the diagnosis of arteriogenic ED, but the PSV is the most accurate indicator of arterial disease. Secondary diagnostic criteria for arteriogenic ED include asymmetry of greater than 10cm/s in the PSV, an increase in the diameter of the CA of less than 75% after intracavernosal injection, focal stenosis in the CA, *cavernoso-spongiosal shunt*, and retrograde arterial flow.<sup>[2,15]</sup>

This study aimed to assess the role of Doppler ultrasonography as a diagnostic tool in ED and to evaluate the pattern of ED in Zaria, Northwestern Nigeria.

## Materials and Methods

This retrospective study was conducted at the Ultrasound Unit of the Department of Radiology in Ahmadu Bello University Teaching Hospital Zaria, Nigeria, which services about 20 million people.<sup>[11]</sup> Records of penile Doppler done between July 2020 to August 2022 were retrieved and analysed. The clinical notes, greyscale scan, and the cavernosal arteries velocimetry of 23 patients were examined.

Inclusion criteria are as follows: all patients with nonneurological, metabolic, and pharmacological ED presenting to the department.

Exclusion criteria are as follows: patients with known neurological, pharmacological, and metabolic ED, debilitated patients, and patients with no features referral to ED.

### Penile Doppler procedure

The procedure was explained in detail to the patients before the examination and were advised to stop smoking at least 3 days before the examination. Drug history and cardiac status were enquired.

The penile Doppler examination was performed with the patients in supine position and the penis flipped to lie on the anterior abdominal wall. A high-frequency linear array transducer in the range of 7.5–13.5 MHz of the Verserna Essential ultrasound machine. GE Medical System (China) Co LTD, Jaingsu, China, was used to obtain images of the penis. Adequate amount of sonographic acoustic gel was used on the surface of the penis to obtain good coupling with the probe. The examination is performed in transverse and longitudinal planes starting at the level of the glans and moving down to the base of the penis. The two corpora cavernosa are homogeneous in echo texture and were identified as two hypoechoic circular structures. The tunica albuginea is visualised as a linear hyperechoic structure covering the corpora cavernosa. The cavernosal arteries are visualised on the medial portion of the corpora cavernosa. The corpus spongiosum is often compressed and difficult to visualise optimally from the ventral aspect. Colour Doppler examination of the penis was performed in both transverse and longitudinal planes at a Doppler angle of between 30° and 60°.

Preinjection measurements were the inner diameter of CA, baseline PSV, and end-diastolic velocity.

Following aseptic technique and using a hypodermal syringe, an injection of 15 µg of prostaglandin E1 (PGE1) intracavernosal at the base of the penis was done under sonographic guidance. A gentle massage of the phallus was done to spread in. Corpora cavernosa were localised on both sides of the corpus spongiosum, as two well-defined oval compartments harbouring a central CA.

Postinjection measurements were taken at 5, 10, 15, and 20 min: inner diameter of CA, PSV, end-diastolic velocity, visual tumescence, and erection.

Assessment of penile erection following PGE1 injection.<sup>[2]</sup>

- Phase 0: the preinjection flaccid state cavernosal arterial spectral pattern is monophasic with absent/minimal diastolic flow
- Phase 1: sudden increase in both systolic and diastolic flow velocity in CA with minimal tumescence
- Phase 2: with further increase in intracavernosal pressure, there is a decrease in diastolic flow with a classical “dicotic” notch
- Phase 3: as the intracavernosal pressure increases, the diastolic flow reaches zero with further increase in tumescence
- Phase 4: diastolic flow reversal occurs with maximum systolic velocity; this is associated with penile rigidity
- Phase 5: At about 15min post injection there is usually decrease in the systolic flow velocity, which is associated with a reduction in tumescence and rigidity.

The PSV is the best Doppler indices for accessing arteriogenic impotence. A value of 30cm/s during the examination indicates arterial dysfunction. Some people

consider less than 25cm/s as definite arterial dysfunction and 25–30cm/s as borderline case. A less than 60% of increase in cavernosal diameter after PGE1 injection is also an indicator of arterial impotence.

End-diastolic velocity is the best Doppler indicator of venogenic impotence. Its value of more than 5 cm/s indicates venous dysfunction. A good diastolic reversal virtually rules out venous insufficiency.

PSV and diastolic velocity with the passage of time were recorded. Patients were observed for complete detumescence before discharge.<sup>[3]</sup>

**Statistical analysis**

SPSS version. 23 (IBM Co., New York, New York) was used for the statistical analysis. The mean and standard deviation were calculated for quantitative variables. Frequencies and percentages were calculated. A P value of less than 0.05 was considered significant.

**Results**

A total of 23 patients were included in the study. The age range was 25–66 years. The majority of the patients were seen in age groups 51–60 years and 41–50 years with 48% (11) and 22% (5), respectively [Table 1]. In the flaccid prevasoactive substance injection B-mode scan, 14 (61%) of the cases were normal, whereas cavernosal anatomical distortions (Peyronie’s disease) were noted in nine (39%) individuals with calcification of the corpora cavernosa alone and in combination with tunica albuginea taking the lead with three cases apiece, followed by tunica albuginea calcification then fibrosis with two and one case, respectively. Only one of these cases had a normal Doppler evaluation.

The majority of the causes (19 [90.5%]) were documented as unknown, three (13%) cases were due to trauma and one (4.3%) was a sickle cell postpriapism case. The mean systolic and diastolic velocities prevasoactive substances were 6 and 0.4cm, respectively. The CA diameter increased by more than 75% in 12 (52%) postvasoactive substance injections. The turgidity rating postinjection was flaccid (2 [8.6%]), latent (5 [22%]), tumescence (8 [34.8%]), full (5 [22%]), and rigid (3 [13%]) [Table 1].

Three of the patients, that is, (13%), had normal penile Doppler study, whereas 12 patients (52%) had arteriogenic ED, and in 7 (30.4%) of patients, it was venogenic ED, whereas only one (4.3%) was of the mixed pattern [Table 1]. The mixed type and all but one of the venogenic ED were observed in the 51–60 years age group. However, the proportion of patients with arterial insufficiency was relatively evenly distributed across the age group with groups 41–50 and 51–60 years having the highest with three apiece, and the remaining groups have two each. Out of the arteriogenic ED cases, five (41.7%) were secondary diagnosis due to PSV difference greater than 10 cm/s between the two CA.

**Table 1: The distribution of obvious cause of ED, degree of penile turgidity postmedication, ultrasound B-mode, and Doppler findings against age group**

Age group (years)	Turgidity postmedication					Obvious cause					B-mode findings					Doppler findings				
	Flaccid (%)	Latent (%)	Tumescence (%)	Full (%)	Rigid (%)	Unknown (%)	SCD (%)	Trauma (%)	Normal (%)	Ca+TA (%)	Ca+CC (%)	Fibrosis (%)	Arterial ED (%)	Venous ED (%)	Mixed ED (%)	Psychogenic ED (%)				
21–30	2 (8.6)	1 (4.3)	-	-	-	2 (8.6)	2 (8.6)	-	-	-	-	-	3 (13)	-	-	-				
31–40	-	-	2 (8.6)	-	1 (4.3)	2 (8.6)	-	1 (4.3)	1 (4.3)	1 (4.3)	2 (8.6)	-	2 (8.6)	-	-	1 (4.3)				
41–50	-	-	2 (8.6)	2 (8.6)	1 (4.3)	6 (26)	-	1 (4.3)	3 (13)	1 (4.3)	1 (4.3)	1 (4.3)	3 (13)	1 (4.3)	-	1 (4.3)				
51–60	-	1 (4.3)	4 (17.4)	3 (13)	1 (4.3)	6 (26)	-	1 (4.3)	8 (37.8)	2 (8.6)	1 (4.3)	-	2 (8.6)	6 (26)	1 (4.3)	1 (4.3)				
61–70	-	2 (8.6)	-	-	-	2 (8.6)	-	-	-	1 (4.3)	1 (4.3)	1 (4.3)	2 (8.6)	-	-	-				
Total	2 (8.6)	5 (21.7)	8 (37.8)	5 (21.7)	3 (13)	18 (78.3)	2 (8.6)	3 (13)	12 (52.2)	5 (21.7)	7 (30.4)	2 (8.6)	12 (52.2)	7 (30.4)	-	3 (13)				

Ca+ CC: corpora cavernosa calcifications, Ca+ TA: tunica albuginea calcifications, SCD: sickle cell disease



No significant discrepancies were noted between the right and left CA PSV among the entire patients ( $P = 0.134$ ), however, among the patients with arteriogenic ED ( $P = 0.656$ ). The mean PSV of CA among the entire patients was 30.5 cm/s with a range of 0–86.6 cm/s, whereas the mean PSV among the patients with arteriogenic ED was 25.6 cm/s and a range of 0–46.5 cm/s. Dorsal vein velocity of more than 5 cm/s in the presence of diastolic flow in CA after injection of PGE1 consistent with venogenic ED was noted in seven patients, constituting 30.1% of the patients. The mean venous flow of  $13.7 \pm 2.2$  cm/s was noted. One (4.3%) patient had combined arteriogenic and venogenic ED, that is, mixed ED. Though the highest PSV of CA (86.6 cm/s) was noted in a 48 years old, a total absence of flow was noted in a patient. No patients developed priapism in our study. Detumescence was achieved within 25–40 min.

## Discussion

Vascular insufficiency is probably the most common cause of organic male sexual dysfunction.<sup>[12,13,15-17]</sup> Colour Doppler sonography has been widely accepted as a first-line diagnostic tool for vascular ED.<sup>[13,15-17]</sup> It is a straightforward minimally invasive procedure that can be performed as an outpatient procedure to study the haemodynamics of erection, so also finding out the vasculogenic cause of the ED.

This study involving 23 patients, have a mean age of  $49.5 \pm 11.6$  years; which is of the middle age class range. Similar studies piloted by Ismail *et al.*,<sup>[3]</sup> Khanzada *et al.*,<sup>[9]</sup> and Bari *et al.*,<sup>[11]</sup> with a sample sizes of 21, 97 and 70 respectively, found lower mean ages of  $43.14 \pm 9.84$ ,  $37.09 \pm 11.59$ , and  $41 \pm 12.25$  years, respectively, whereas a much older mean age of  $55.0 \pm 9.2$  years was recorded by Serefoglu *et al.*<sup>[18]</sup> The lower mean age values recorded in most of the previous studies especially the Asian studies are not surprising as most had a plethora of very young adults and adolescents in their samples as medicolegal cases in rape or divorce.<sup>[9,11,13,16]</sup>

Peyronie's disease, which is essentially penile fibrosis, has been identified as a major cause of ED.<sup>[8]</sup> The index study B-mode scan showed fibrosis and plaques within the tunica albuginea and corpora cavernosa in 39.1% of cases. All but one of these cases had abnormal Doppler findings, and two had clinically discernable curved phallus. The frequency of this entity in this study is quite alarming as a similar study<sup>[3]</sup> done with a comparable sample size in a neighbouring centre shows a lower incidence of 14.3%, whereas the Indian subcontinent studies by Bari<sup>[11]</sup> and Jain *et al.*,<sup>[13]</sup> showed much more lower values of 2.9% and 4.5% of their total cases, respectively, compared with the index. The trend of incidence from the various studies points to a likelihood of genetic predisposition of the African population to Peyronie's disease compared with their Indian counterpart. Nackeran and Masterson<sup>[19]</sup> also observed racial differences in their study of the incidence of Peyronie's disease in the population; they observed that

the majority of the cases were White, amounting to 71.4%, whereas Black were 25.4%, Hispanic or Latino were 5.8%, Asian or Pacific Islander were 0.3%, and Native American were 1.6%.

Psychogenic ED in which the penile Doppler findings are usually normal were only three (13%) in this study and were seen in the middle-aged and young adults. This finding is contrary to that of most other studies, where a plethora of psychogenic cases were noted in the younger age group.<sup>[9,13]</sup> The significant number of normal Doppler scan in these studies is probably due to the higher number of younger participants in the sample size, especially in the Asian studies. In these studies, marital problems and family pressures were identified as the most important factors predisposing to psychogenic ED,<sup>[9]</sup> so also ED screening for medicolegal reasons in cases of rape and divorce.<sup>[9,13]</sup>

Twenty patients in this study comprising 87% were found to have vasogenic ED. This comprises arteriogenic ED (12 [52%]), venogenic ED (7 [30.1%]), and mixed/inconclusive pattern (1 [4.3%]). The proportion of vasogenic ED in the index study is quite significant and at variance with most other studies,<sup>[3,8,9,11,13]</sup> which showed much lower figures and higher normal cases. This variance is probably due to proper patient sorting by the urologists via adequate history and examination, and the absence of Doppler request for medicolegal reason.

As in most other studies,<sup>[8,11,13]</sup> the percentage of arteriogenic ED was much greater than venogenic, it was three times greater in this index study; however, Ismail *et al.*<sup>[3]</sup> reported a reverse, where the venogenic ED was twice the arteriogenic ED. The mixed pattern was depicted in only one case (i.e., 4.3%), the low percentage is consistent with that of most other documented studies; Jain *et al.*<sup>[13]</sup> and Khanzada *et al.*<sup>[9]</sup> recorded 8% and 8.2%, respectively, whereas Aiyekomogbon *et al.*<sup>[8]</sup> recorded none.

Some studies<sup>[16]</sup> graded PSV as grade I:  $<25$  cm/s, grade II: 25–30 cm/s, and grade III:  $>30$  cm/s. In this study, we considered PSV of less than 25 cm/s as primary diagnostic criteria and PSV difference greater than 10 cm/s between the two cavernosal arteries as secondary diagnostic criteria for having arterial insufficiency. About 41.7% of the arteriogenic ED cases in this study were diagnosed using the secondary diagnostic criteria.

The EDV in this study were graded as  $\leq 5.0$  cm/s and above  $>5.0$  cm/s for normal and veno-occlusive dysfunction, respectively, in the presence of normal arterial function, though various other limits of EDV values have been suggested between 5 and 7 cm/s as diagnostic of venous incompetence.<sup>[16]</sup> We recorded 30.4% similar to 29% of Aiyekomogbon *et al.*,<sup>[8]</sup> whereas Bari *et al.*<sup>[9]</sup> and Khanzada *et al.*<sup>[11]</sup> had lower figures of about 16% in their studies where more than 50% were psychogenic. Sometimes, such threshold values for EDV can be misleading if arterial insufficiency is present, resulting in a mixed ED pattern. we

recorded only a case (4.3%) in this study. Aiyekomogbon *et al.*,<sup>[8]</sup> Bari *et al.*,<sup>[9]</sup> and Suresh *et al.*<sup>[16]</sup> found no case of mixed ED, whereas Jain *et al.*<sup>[13]</sup> and Khanzada *et al.*<sup>[11]</sup> recorded 8% and 8.2%, respectively.

Limitations in the course of this study were as follows: the first was the observation of false-positive venogenic ED in the anxious patients; this was surmounted by ensuring a conducive environment and continual reassurance throughout the procedure. Hence this helped in reducing the sympathetic discharge and its activity on the sinusoidal smooth muscle, with a resultant relaxation. Second, the arterial velocities change along the shaft of the penis. It is maximal near the base of the penis and decreases with advancement; hence, the velocities were all recorded near the base of the phallus.

## Conclusion

Colour Doppler study is an important minimally invasive nonionizing radiation tool for swift evaluation of penile erectile function and, thus, helps in classifying ED causes into structural, vascular, or possibly psychogenic, hence guiding the clinicians on the therapeutic options. The index study was able to deduce vasculogenic ED as the commonest cause of ED with predilection of the arterial component.

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## Conflicts of interest

There are no conflicts of interest.

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