



## **Pattern of Lower Limb Doppler Ultrasonography Requests and Findings in a Tertiary Institution in Makurdi; North-Central Nigeria**

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### **Authors' contributions**

*This work was carried out in collaboration between all the authors. Author CDM was involved in the protocol, concept and design of the first and subsequent drafts of the study. Author AIT reviewed and edited the manuscript. Author HM managed the analysis and literature review. Author KPI performed collection and collation of data. Author AA managed statistical analysis. All authors read and approved the final manuscript.*

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### **ABSTRACT**

**Background:** Doppler ultrasound scan (DUS) is a valuable, cost effective, and relatively rapid diagnostic technique that provides a non-invasive assessment of the vascular circulation in the lower limb.

**Aims:** To determine the pattern of lower limbs Doppler requests in our environment and to evaluate the Doppler findings.

**Study Design:** Retrospective study

**Place and Duration of Study:** Radiology department of Benue state university Teaching Hospital over a one-year period from January 2018 to December 2018.

**Methods:** We included 200 patients that had lower limb Doppler ultrasound for various indications. Data on age, gender, indications and findings was retrieved from departmental cards and case

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notes, then collated and analyzed using SPSS software version 23, with the *P* value taken as =.005.

**Results:** Two hundred patients were scanned; 106 males and 94 females with age range of 10-109 years. Their mean age was  $34.2 \pm 13.5$  years. Most patients 48(24.0%), who presented for Doppler sonography of the lower limb had diabetic foot ulcer (DFU), followed by left leg swelling in 42(21.0%) patients. DVT alone was indicated in 33(16.5%) patients. Both DFU and DVT were more in the male patients with a M:F ratio of 26:22 and 21:12 respectively. The indications for lower limb doppler ultrasound scan are seen to generally increase with increasing age, with the least among those less than 40years 32(16.0%) and highest among the greater than 60years age groups 89(44.5%). At doppler ultrasound, there are more patients with Deep vein thrombosis (DVT) 104(52.0%). Normal study and peripheral vascular disease (PWD) have equal incidence respectively in 48(24%) of the patients. DVT and PWD were more in the male group with a M: F ratio of 55:49 and 27:21 respectively while normal studies were seen equally in both sexes (M: F=24:24).

**Conclusion:** Doppler ultrasound has been shown to be a cost-effective and valuable non-invasive tool for the diagnosis of lower limb vascular diseases.

**Keywords:** Deep vein thrombosis; diabetic foot; doppler ultrasound scan; lower limbs; leg swelling; north-central Nigeria; peripheral vascular disease.

## 1. INTRODUCTION

Doppler ultrasound, a universally available, relatively rapid, cost effective and non-invasive method of diagnostic imaging is a frequently used investigation of choice in the assessment of lower limb vascular diseases. This is largely as a result of the need to augment the information provided by the other imaging devices, like catheter digital subtraction angiography (DSA), magnetic resonance imaging (MRI), and computed tomography (CT). Doppler ultrasound, as opposed to these other imaging modalities is free of complications related to puncture site, radiation and exposure to high-density contrast media. Additionally, other laudable advantages of Doppler ultrasound imaging include low cost, worldwide availability, bedside scanning, especially in the intensive care unit (ICU) and the possibility for synchronous evaluation of lower limb vascular anatomy, physiology and pathology [1-5].

For imaging with Doppler ultrasound, which has become the best tool for detecting lower limb vascular abnormalities, given its high sensitivity (96.0%) and specificity (98.0%) [6], a good understanding of the ultrasonographic anatomy and the corresponding anatomical landmarks as well as vascular hemodynamics of the lower extremity vessels are absolutely necessary [7,8]. This is invaluable not only in the quest for detailed and accurate description of the size, severity, or type of the diseased portion of the vessel involved, but also in the planning for possible surgical or endoluminal intervention [9].

During Doppler ultrasound imaging of the lower limb vessels, simultaneous display of exceptional information about vascular anatomy, physiology and pathology is achieved using Gray-scale or B-mode ultrasound, complemented by Color flow vascular imaging and spectral Doppler ultrasonography in identifying blood vessels, locating vascular occlusion or ascertaining degree of severity of stenosis and establishing the direction of blood flow [9].

A wide range of indications for lower extremity Doppler Ultrasonography have been documented. These include peripheral arterial occlusive disease such as, limb ischemia and atherosclerosis [10,11] mass casualty limb accidents, [11,12] and embolism to venous lesions such as deep vein thrombosis (DVT), including the follow-up of known patients with Deep vein thrombosis (DVT), especially in the re-evaluation of presence or absence of residual thrombus near the expected end of anticoagulation therapy [1,11,13-15], superficial thrombophlebitis, reflux, primary and secondary varicose veins, venous ulceration, arteriovenous (AV) fistulas, and malformations. It is also indicated in the assessment of causes of burning sensation, pain, tenderness, and swelling [1,16].

A common worldwide and major preventable cause of death is Deep vein thrombosis (DVT), with many complications including the life threatening pulmonary venous thromboembolism (VTE). It affects approximately 0.1% persons per year and is predominantly a disease of the elderly with an incidence that rises markedly with

age [2,9,17]. Other Conditions that predispose to Venous thrombo-embolism (VTE) in adults are cancer and its treatment, prolonged immobility, stroke or paralysis, previous VTE, congestive heart failure, acute infection, pregnancy or puerperium, dehydration, hormonal treatment, varicose veins, long air travel, acute inflammatory bowel disease, rheumatological disease, and nephrotic syndrome. Acquired factors that have recently been associated with increased risk of VTE disorders include persistent elevation of D-dimer and atherosclerotic disease [9,17,18]

Regrettably, studies have shown that history and clinical examinations are of limited value in the accurate identification of patients with a low or even high probability of DVT [9,19,20]. To improve on the clinical prediction considerably, symptoms and clinical signs have to be weighed against the existence or non-existence of recognized risk factors for DVT [20]. Pain, warmth, redness and swelling of the lower extremity are typical symptoms of DVT, but symptoms may be absent altogether. The Homan's sign, (pain on forced dorsiflexion of the foot) with a specificity and sensitivity ranging from 39-84% and 13-48% respectively, may be present [14,20,21]. Deep vein thrombosis (DVT) presents with non-compressible venous segment, loss of phasic flow on Valsalva maneuver, absent color flow if completely occlusive, lack of flow augmentation with calf squeeze and increased flow in superficial veins. Acute thrombus, when seen is accompanied by increased venous diameter, soft/deformable intraluminal material, smooth surface and uncommonly a free-floating edge. Chronic post-thrombotic change is characterized by normal or decreased venous diameter, rigid intraluminal material, irregular surface, synechiae or bands, rarely calcifications, +/- acute thrombus [22,23]. Doppler ultrasonography is the mainstay of investigation of DVT and gives useful information about the anatomy, physiology and pathology of both the superficial and deep venous systems, thus providing both quick analysis of the extent and monitoring of the treatment. [10,13,24].

Lower extremity atherosclerotic artery occlusive disease, which is often referred to as Peripheral vascular disease (PWD) is associated with arterial wall atheromatous calcifications, seen as hyperechoic foci, which when large causes acoustic shadowing. Also seen is luminal stenosis with diameter and surface area reduction as well as reduced blood flow and

turbulent spectral pattern. Male gender, advanced age, diabetes, hypertension, hypercholesterolemia and smoking are associated with abnormal vascular findings in Peripheral vascular disease (PAD) [25-27]. These patients normally present with symptoms of intermittent claudication and rest pain, as well as signs of diminished peripheral pulses, ischemic ulceration and gangrene [26,27].

Vascular occlusion is characterized by diversion of blood away through collaterals, resulting in a gradual fall in blood velocity along the vessel. The waveform, however usually becomes monophasic close to the occlusion. At the point of blockage, the colour Doppler display shows absence of flow. The plaque causing the stenosis can be seen and the colour Doppler shows aliasing. The peak systolic blood velocity, increases from 0.26 proximally to 3.90 m/s through the stenosis, an increase by a factor of 15 indicating a very tight stenosis [9,28].

Doppler ultrasound is gaining more grounds in many developing countries, as a result of cost, limited availability and the invasive nature of the highly specific imaging modalities such as Computed tomography angiography (CTA), magnetic resonance angiography (MRA) and digital subtraction angiography (DSA) which are quite comparable in visualizing lower limb vessels just like conventional angiography [4,5,6]

There is a brilliant future for diagnostic medical ultrasonography, particularly as it relates to lower limb Doppler imaging, and it shall continue to be an essential tool in medicine. Drawbacks only relates to the need for highly trained manpower, operator's skill and the swollen edematous limbs, which limits anatomic, physiologic and pathological visualization of vascular structures [11,29,30]

To the best of the authors' knowledge, no documented study on the pattern of lower limb Doppler ultrasonography requests and findings has been carried out in our center. Reports, however exists of investigators who have contributed substantial knowledge to this subject matter in other parts of our country [2,5,6,9,11,14,17,26,31,32].

The aim of this study is to describe the pattern of requests for doppler studies in our institution, and to co-relate the clinical indications with the main findings.

## 2. MATERIALS AND METHODS

### 2.1 Study Area

The study area is Makurdi, the Benue state capital situated in North-central Nigeria. It lies between latitude 7.73 and 8.32 degrees with a population of 4,219,244 people according to the 2006 Nigerian population commission (NPC) figures [33]. The Benue State University Teaching Hospital (BSUTH), is a tertiary health institution that serves as a referral center for the state and other surrounding states of the federation.

### 2.2 Study Population and Design

The study was a retrospective analysis of the lower limbs' Doppler ultrasound scan of 200 patients at the department of Radiology, Benue State University Teaching Hospital (BSUTH) over a period of one year from January 2018 to December 2018.

### 2.3 Inclusion Criteria

- (i) Patients with history suggestive of deep vein thrombosis
- (ii) Patients with history of pain and lower limb swelling

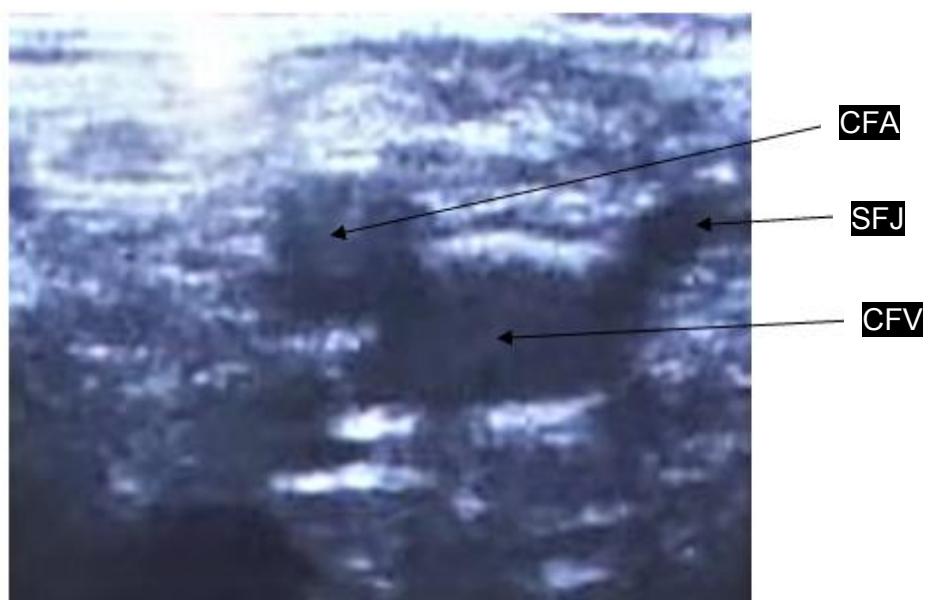
- (iii) Patients with history suggestive of peripheral vascular diseases
- (iv) Patients with diabetic foot disease/diabetic foot ulcer (DFU)

### 2.4 Exclusion Criteria

- (i) All Patients outside the inclusion criteria

### 2.5 Technique

The examination was performed using Siemens Sonoline G-50, a real-time ultrasound machine fitted with a 5-10MHZ linear transducer. The procedure was explained to all the patients and informed consent obtained. With the head slightly raised, leg bent at the knee and slightly rotated outwards, the patient was asked to lie supine. The probe was placed on the groin crease after coupling gel was applied on the thigh. The common femoral artery is seen lateral to the femoral vein, which is drained from the greater saphenous vein anteromedially at the inguinal area. Just below the inguinal crease, the common femoral artery, common femoral vein and great saphenous vein are seen showing a shape reminiscent of "Mickey Mouse's" face on the transverse scan as shown in Fig. 1.



**Fig. 1.** B-mode Doppler 'Mickey mouse' view, representing the normal anatomy of the common femoral vein and artery at the right groin in the transverse section; a) CFA, common femoral artery, b) CFV, common femoral vein, c) SFJ, sapheno-femoral junction

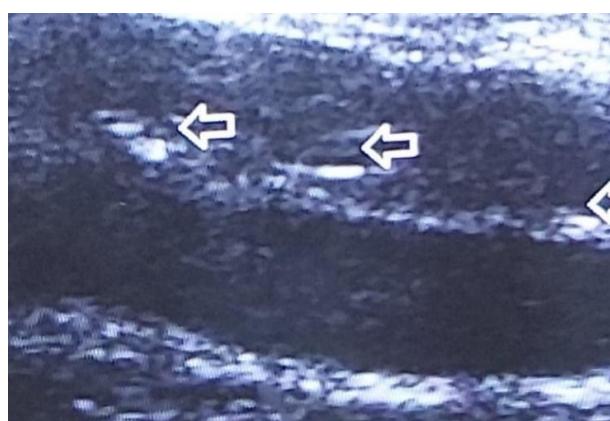
The indication for Doppler study largely determines the imaging protocols to be followed:

For the Arterial Studies of the Lower Limbs, grayscale, color flow, and duplex Doppler examination was employed. The vessels were sampled using  $60^{\circ}$  angle of insonation for Doppler tracings and peak systolic velocity (PSV) measurements. Peripheral arterial disease (PAD) was assessed using Doppler spectral analysis where normal waveform is triphasic with clear spectral window and abnormal waveforms range from mild disease with triphasic waveform plus minimal spectral broadening to moderate disease with biphasic waveform plus spectral broadening and severe disease with monophasic waveform

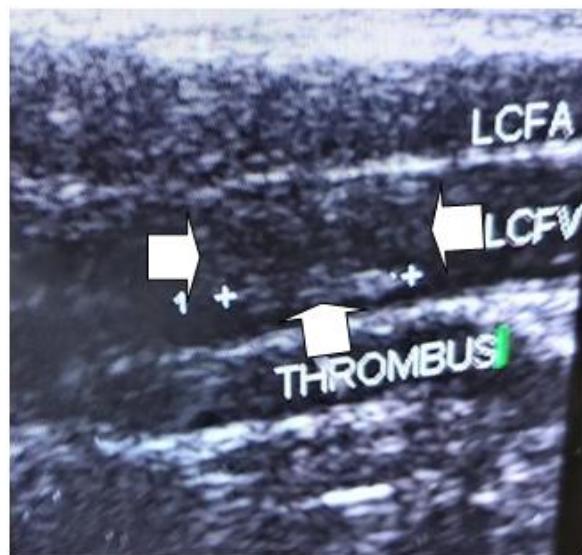
plus severe spectral broadening and arterial occlusion with absence of spectral information [11]. Using grayscale images, arteries were assessed for presence of plaques and characteristics of the plaques Fig. 2.

Arterial occlusions, AV fistulas, and aneurysms were similarly assessed with color flow images.

For the Venous Studies of the Lower Limbs, grayscale scan of the major veins was performed to assess for presence of thrombus (Fig. 3) within the lumen, and with application of color flow Doppler, residual blood flow in such vessels was assessed.



**Fig. 2. B mode Doppler showing multiple arterial wall calcifications**



**Fig. 3. Doppler scan of the left common femoral vein showing an extensive venous thrombus (thick white arrows) extending from the anterior wall of the vessel, and measuring more than 11.1mm in diameter, and 6.7mm in thickness**

Compressibility Fig. 4 of the vessels was also assessed as presence of thrombus in chronic DVT causes non-compressibility. Duplex Doppler examination of the major veins was done to assess for spontaneity of flow, phasic flow, augmentation Fig. 5 and effect of Valsalva maneuver. These changing Doppler signals are indicative of obstruction or extrinsic compression [11].

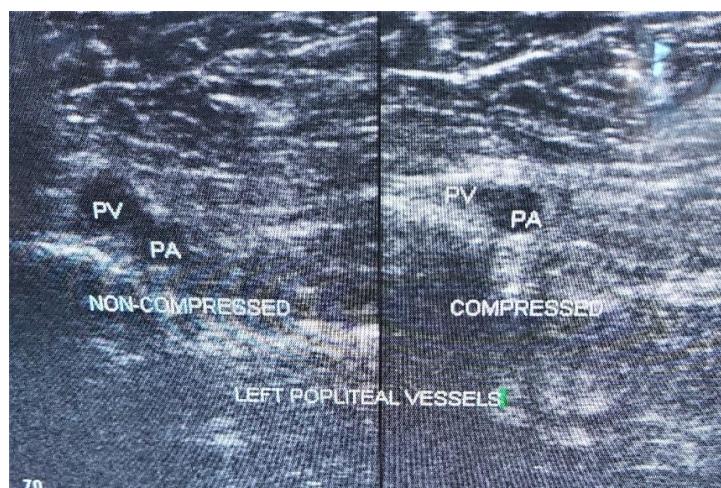
## 2.6 Data Analysis

Other information including age, gender, indications and findings at doppler scan was entered into statistical package for social science (SPSS) version 23 software for analysis. Results

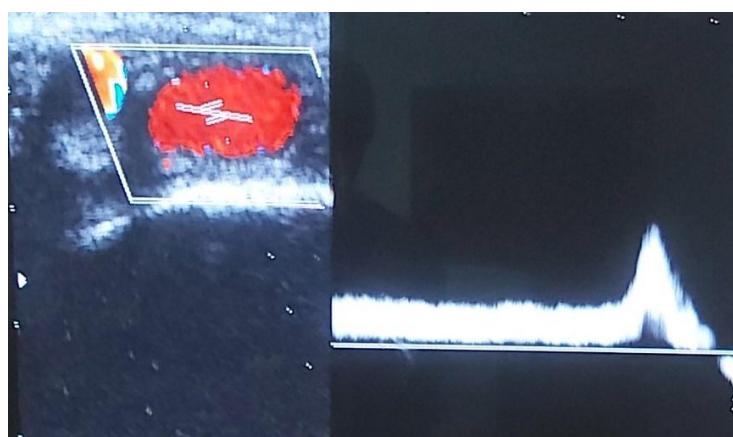
were presented as frequencies and proportions for categorical data and mean  $\pm$  SD for continuous variables, respectively. Chi squares were used to obtain the proportion of males to females in the study. Correlations were also used to test the relationship between variables.  $P$ -value =.005 was considered significant for the study.

## 3. RESULTS

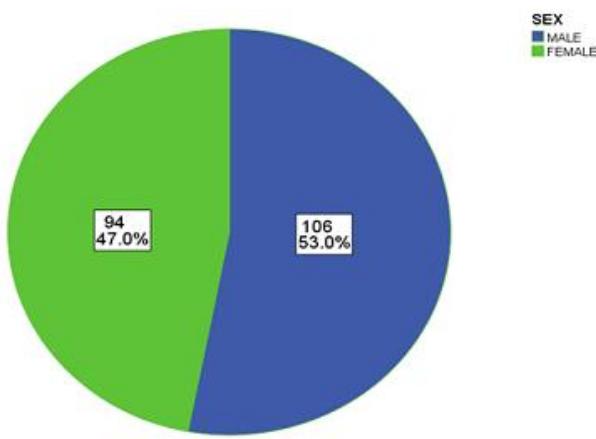
Two hundred (200) patients were scanned, of which 106(53.0%) were males while 94(47.0%) were females as shown in Fig. 6. The participants' age ranges from 10 to 109yrs with a mean age of 34.2years  $\pm$  13.51.



**Fig. 4. B-mode axial section of the popliteal vein showing normal compressibility of the vein, thus suggesting a patent vessel**



**Fig. 5. A spectral Doppler sonogram of the right thigh, showing normal respiratory variation and positive venous augmentation response**

**Fig. 6. Gender distribution**

Most patients 48(24.0%), who came for Doppler sonography of the lower limb had diabetic foot ulcer (DFU), with a greater male preponderance (M:F=26:22). This was followed by left leg swelling in 42(21.0%) patients. Right leg swelling was slightly more in males than females (18:15). Deep vein thrombosis alone (DVT) was indicated in 33(16.5%) of patients, with a male to female ratio of 21:12. Deep vein thrombosis (DVT) with co-morbidities of diabetes and hypertension was seen in 23(11.5%) and 16(8.0%) patients respectively. However peripheral vascular disease (PVD) was marginally more indicated in females than males (M:F=2:3). These are illustrated in Table 1.

The total indications for lower limb doppler ultrasound scan were seen generally to increase with age groups, with the least 32(16.0%) among those less than 40years and highest 89(44.5%) among the greater than 60years age groups Table 1.

At doppler ultrasound, majority of the findings were deep vein thrombosis (DVT) in 104(52.0%) patients, more common in males than females (55:49). Normal findings and peripheral vascular disease (PVD) have equal incidence respectively in 48(24%) patients Table 2.

Table 2 also shows that, the age group with the highest number of DVT in the whole population was that greater than 60years. A steady increase in the incidence of DVT was seen to have evolved steadily from the lower age groups with a peak at the greater than 60 years age group. Majority of the normal findings were noted at the

age group of 40-59years with a sharp decline at above this age group. PVD was noted to increase with age, with the highest incidence at the age group greater than 60years.

Of the patients scanned in our study, sixteen (16) with Hypertensive heart disease were suspected to have DVT and twelve {12(75.0%)} were actually confirmed to have DVT on Doppler scan. Also, 23 patients with Diabetes mellitus suspected of having DVT, had {14(61.0%)} of them actually confirmed with DVT on Doppler as depicted in Table 3

#### 4. DISCUSSION

Two hundred (200) patients were recruited, with a preponderance of males in our study (M:F=106:94). This was in sharp contrast to findings of a similar research by Salaam AJ et al [9] in which more females were scanned (M:F=59:67). The male predominance in our study is however in agreement with earlier studies by Olatunji AA [6] and Ikpeme A [31] which reported a male to female ratio of 29:13 and 51:25 respectively. This may just be coincidental, but most likely attributed to the increased incidence of vascular lesions in the males as reported by Michael H et al. [34]. Generally, males are involved in many high-risk activities including violence and road traffic accidents [11], thus more susceptible to increased incidence of vascular trauma.

The commonest single clinical indication for doppler ultrasound in our study was diabetic foot ulcer (DFU), a frequent complication of diabetes,

in 48(24.0%) patients. This was followed by leg swelling {left 42(21.0%) and right 33(16.5%)}  
DVT alone was indicated in 33(16.5%) patients.  
Then DVT with co-morbidities diabetes and hypertension as well as PVD. This was at variance with a study done in Jos university Teaching Hospital (JUTH) by Salaam AJ et al [9] which found DVT as the commonest indication in 101(80.2%) patients and PVD in the remaining 25(19.8%) patients. However, a study done by Olatunji AA et al [6] revealed that the most common indication for doppler study was diabetic foot syndrome (DFS) in 23(54.76%), followed by DVT in 8(19.04%) patients. Then leg swelling and peripheral arterial disease (PAD), which is comparable to our study, although with much lower numbers of patients in their case. The disparity in the case of the study by Salaam AJ et al [9] was because their study combined together the total number of patients seen purely for DVT alone with those who presented for not only DVT but with co-morbidities Hypertension and Diabetes. In the case of Olatunji AA et al [6], the lower DVT numbers was due to the smaller sample size of 42(100%) patients compared to our study with a sample size of 200(100%) patients.

The predominant limb involved in the request for Doppler ultrasound in our study, was the left lower limb, coincidentally, with the left lower limb swelling as an important single indication for study in 42(21.0%) patients. This was in agreement with previous studies [11,14,35], thus necessitating further studies to ascertain the reason for higher incidence of vascular lesions on this particular limb [11]. However, compression of the left common iliac vein with the right common iliac artery has been implicated as a plausible explanation for this observed left lower limb predominance [14,35].

Our index study revealed that DVT was the majority finding on Doppler scan in 104(52.0%) patients. This was followed by Normal scans and PVD with an equal incidence of 48(24.0%) patients respectively. There was no precise consistent percentage agreement with previous studies. However, DVT featured prominently as an important diagnostic Doppler finding in 13(31%), 9(12%) and 21(18.3%) patients scanned by Olatunji AA et al [6], Ikpeme A et al [31] and Salaam AJ et al [9] respectively. The lower values in their studies could be explained in part by the comparatively smaller sample size of 42,76 and 126 patients recruited respectively, compared to ours with 200 patients. Besides the

higher values of DVT findings in our case, incidentally coincided with the period of mayhem, trauma and violence, occasioned by massive herdsmen's attack on the local community with our study center (BSUTH) as the main referral hospital [36].

In the pattern of referral and eventual diagnosis for DVT on Doppler study, our research showed a consistent male predominance. This reinforces the general belief that the males are more prone to the risk factors for DVT [37], a major national health problem, which affects approximately 0.1% of persons per year, especially the elderly with an incidence that rises markedly with age [18,37]. In our study, age related findings show that the incidence of DVT was lowest at the <40years age group and highest at the >60years age group. Our finding was at variance with that of Salaam AJ et al [9] which show that DVT was higher in the 31-40 years age group. However, it was in agreement with that of Silverstein MD et al [37] which noted that deep vein thrombosis (DVT) was seen more in the elderly and increases with age. The reasons for an increased thrombosis risk with age are not clearly understood, but may be related to increasing presence of other acquired or genetic factors predisposing to thrombosis, thus increasing coagulation potential, or some combination of these [38].

Hypertension and diabetes mellitus were noted to have an association with DVT, in our study. This is in agreement with earlier studies which show that concomitance of hypertension with diabetes mellitus synergistically worsens the risk for lower extremity peripheral artery disease (LEAD) and is associated with much higher cardiovascular risk than either disease alone [32,39]. Of the patients scanned in our study, sixteen (16) with Hypertensive heart disease were suspected to have DVT and twelve (12) were actually confirmed to have DVT on doppler scan, with the highest incidence in the >60 years age group. Also, 23 patients with Diabetes mellitus suspected of having DVT, had 14 of them actually confirmed with DVT on doppler, with the highest incidence again in the >60 years age group. This collaborated well with a study by Umuemri EM et al [32] which observed that the prevalence of lower extremity peripheral artery disease (LEAD) was 57.6% in the hypertensive-diabetic subgroup compared to 37.5% in the hypertensive only sub-group. Salaam AJ et al [9] and Petrie JR et al [39] in their separate reports, had earlier shown that diabetes and hypertension

**Table 1. Relation between clinical indications, age group and gender**

<b>AGE</b>	<b>DFU</b>	<b>Left leg swelling</b>	<b>Right leg swelling</b>	<b>DVT</b>	<b>DVT with DM</b>	<b>DVT with HTN</b>	<b>PVD</b>	<b>Total (%)</b>
Male								
<40	1	4	4	5	1	0	0	15(14.2)
40-59	9	8	8	8	6	0	1	43(40.6)
>60	16	6	6	8	7	7	1	48(45.3)
Total	26	18	18	21	14	7	2	106(100.0)
Female <40	0	6	3	6	1	0	1	17(18.1)
40-59	12	12	8	3	4	0	0	39(41.5)
>60	10	6	4	3	4	9	2	38(40.4)
Total	22	24	15	12	9	9	3	94(100.0)
$\Sigma(M+F) <40$	1	10	7	11	2	0	1	32(16.0)
40-59	21	20	16	11	10	0	1	79(39.5)
>60	26	12	10	11	11	16	3	89(44.5)
Total (%)	48(24.0)	42(21.0)	33(16.5)	33(16.)	23(11.5)	16(8.0)	5(2.5)	200(100.0)

**Table 2. Relationship between findings, age group, and gender at doppler scan**

<b>Age</b>	<b>DVT</b>	<b>Normal</b>	<b>PVD</b>	<b>Total(%)</b>
Male				
<40	10	5	0	15(14.2)
40-59	21	15	7	43(40.6)
>60	24	4	20	48(45.3)
Total	55	24	27	106(100.0)
Female <40	10	5	2	17(18.1)
40-59	20	12	7	39(41.5)
>60	19	7	12	38(40.4)
Total	49	24	21	94(100.0)
$\Sigma(M+F) <40$	20	10	2	32(16.0)
40-59	41	27	14	82(41.0)
>60	43	11	32	86(43.0)
Total (%)	104(52.0)	48(24.0)	48(24.0)	200(100.0)

**Table 3. Relationship between clinical indications and doppler findings**

Indications		Doppler Findings			Total
		DVT	Normal	PVD	
	DFU	15	9	24	48
	LL swelling	23	14	5	42
	RL swelling	23	6	4	33
	DVT	15	14	4	33
	DVT with DM	14	2	7	23
	DVT with HTN	12	2	2	16
	PVD	2	1	2	5
Total		104	48	48	200

are closely interlinked because of similar cardiovascular risk factors. Common mechanisms, such as upregulation of the renin-angiotensin-aldosterone system, oxidative stress, inflammation, and activation of the immune system likely contribute to the close relationship between diabetes and hypertension in vascular complications [39].

## 5. CONCLUSION

The study has shown that, Doppler ultrasonography is a valuable, cost-effective and non-invasive method of investigating lower limb vascular diseases. It is the imaging modality of choice for the evaluation of venous insufficiency and peripheral arterial occlusive disease (PAD). DVT in our setting showed greater male preponderance and sizeable left-sided limb involvement as collaborated by other researchers. Despite considerable need for highly trained manpower and operator's expertise, the future holds bright for Doppler ultrasonography, as it has found extensive use in the initial and follow-up investigation as well as in the management of deep vein thrombosis (DVT), which formed the majority finding, in our environment.

## CONSENT

The procedure was explained to all the patients and informed consent obtained.

## ETHICAL APPROVAL

As per international standard or university standard written ethical approval has been collected and preserved by the author(s).

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## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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