Research Article

Comparison of Doppler and Greyscale Compression Sonography in the Diagnosis of Deep Vein Thrombosis

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Abstract |

Objective: To determine the agreement of Doppler and gray scale sonography in the diagnosis of Deep Vein Thrombosis.

Methods: This Cross-sectional analytical study was conducted at Afro-Asian Institute of Medical Sciences & Gilani Ultrasound Centre, Lahore Pakistan from 1st January 2015 to 30th June 2016. All the individuals conveniently enrolled voluntarily in this study by clinical prediction rules (Well's DVT criteria), including male, female. Grayscale compression sonography and Doppler examinations were performed with supine patient position. The lower limb under examination were entirely exposed to perform the examination without any hurdle. The American Institute of Ultrasound in Medicine (AIUM) vascular examination guideline were observed throughout the research study.

Results: A total of 200 subjects; 132 (66%) Females and 68 (34%) males were enrolled. Their mean age was 48.57± 17.92 years, ranges from 16 to 80 years. A strong agreement was found between the compression sonography and Doppler ultrasonography with Kappa value was 0.921, (Ref. Strong agreement 0.90 to 0.98). Doppler sonography was found slightly more sensitive and specific than the conventional Grayscale compression sonography. Additional provocative measures and operator expertise brought the overall reliability of Doppler Ultrasound to almost hundred percent.

Conclusion: A strong agreement was found between Grayscale compression sonography and Doppler in the evaluation of DVT. Doppler ultrasound with additional provocative measures and operator expertise is more reliable than conventional grayscale compression sonography.

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Keywords | Grayscale Compression Sonography; Deep Vein Thrombosis (DVT); Doppler Ultrasonography; Thrombophlebitis; Valsalva; Distal Augmentation

Introduction

Deep venous thrombosis (DVT) is a serious condition, and one of the most common cardio-vascular disorder causes death due to massive pulmonary embolism (PE)[(1)]. Annual deaths from DVT and PE are about 300000 in the United States[(2)]. When a blood clot is formed in one or more of the deep veins in the body, this condition is called DVT. Deep vein thrombosis can cause leg pain or swelling,

but also can occur with no symptoms[3]. A blood clot is a clump of blood that is in a gelatinous or solid state[4]. Deep vein blood clots typically form in the thigh or lower leg, but they can also develop in other areas of your body[5]. Pulmonary embolism is one of the most serious, life-threatening consequence of DVT, a massive PE can cause collapse and death[6,7]. Symptoms of DVT ranging from venous ulceration, pain, swelling, cord-like sensation, redness, the warmth of the a ected area, discoloration to no symptoms[8, 9]. There are various causes of DVT but the most famous Virchow's triad (stasis, endothelial injury, and hypercoagulability) address almost all of them[10,11]. DVT may either be symptomatic or asymptomatic. Usually, the DVTs of large proximal veins are symptomatic is found proximally but the DVTs of distal leg veins are non-symptomatic in nature[12]. Symptomatic DVTs of the proximal large veins are associated with unfavorable outcomes due to the likelihood of embolization to lungs[13].

DVT could be diagnosed with the help of various invasive and noninvasive imaging and serological tests, but Doppler ultrasound is considered as well accepted standard, these days[14]. D-dimer test and Doppler imaging are among the non-invasive investigations of DVT. Clinical algorithms, like Wells test, are helpful in the patient selection and investigating equipment[15]. But at least three-quarters of individuals with lower limb clinical symptoms of DVT, having no thrombus in the deep veins. It is therefore mandatory to have a confirmatory test, to make it sure that patient is under anticoagulant treatment having confirmed DVT on one hand but on the other hand important to prevent the complications and adverse reactions of inappropriate anticoagulation in those with other disorders. Apart from that ascending venography, Computed tomography (CT) venography and Magnetic Resonance (MR) angiography are included in the invasive imaging procedures. In the invasive procedures, the nephrotoxic contrast agent is administered to the vessels before the imaging[16]. According to a literature, the sensitivity, specificity, and accuracy of Doppler ultrasound in the diagnosis of DVT was estimated as 70%, 100%, and 76 % respectively[17]. But another study while comparing venography with sonography in the diagnosis of DVT estimated the overall sensitivity, specificity, and accuracy of venous sonography as 88.9%, 91.8%, and 90.9%. Btu the sensitivity was calculated as 100 % in the diagnosis of DVT above the calf, in the popliteal and femoral veins[18]. Early diagnosis and treatment of DVTs are utmost important because about 30-60% mortality rate is associated with unrecognized and untreated thromboembolism[19]. Compressions sonography was conventionally used in the diagnosis of DVT since long but the advent of color and power Doppler brought a dramatic enhancement in the diagnostic accuracy of DVT[20,21].

As we know Doppler ultrasound in non-invasive, real-time, dynamic and radiation-free investigation procedure. Although it has some limitation in very deep veins and obese patients, however, its overall reliability and clinical acceptability are high to such an extent, which reaches its acceptance to the level of gold standard. It's another most important limitation is the limited field of view, which make it operator dependent. However, the operator dependency could be overcome by improving knowledge of the operator with latest advances in the equipment and additional provocative measures applied for the diagnosis of DVT. We, therefore, intended this research to compare the agreement level of Doppler sonographic examination with conventionally used compression sonography. Moreover, we are using di erent provocative measures to enhance and improve the overall diagnostic accuracy of Doppler ultrasound in the evaluation of DVT.

Methodology

This cross-sectional observational study was conducted at Afro-Asian Institute of Medical Sciences & Gilani Ultrasound Centre, Lahore Pakistan from January 2015 to June 2016. Two hundred patients, who presented with clinical signs and symptoms of deep venous thrombosis of the lower limb, were selected with clinical prediction rules. Color Doppler ultrasound was performed in all patients, to compare the results Doppler with grayscale imaging criteria and predict the degree of agreement. All the participants were enrolled in this study voluntarily, while the procedure was explained to them and written informed consent was obtained. pre-approval was taken from the institutional review board (IRB) and ethical committee of the University of Lahore. Toshiba (Xario) and Mindray (Z5) with a multi-hertz linear frequency range from 7-14 MHz and convex

transducers with frequency range 3-6 MHz a were used. GE Logic E9 & Philips X-Matrix Ultrasound machines, having Color, Power & Power Doppler with Tissue harmonics facilities. Initially, Greyscale sonography was performed in each patient to rule out deep vein thrombosis using a 7.5-10 MHz linear transducer with graded compression technique in the transverse plane. Then followed by Color Doppler& Spectral Doppler analysis to confirm the diagnosis. When the deep veins were di cult to visualize then low frequency 3.5-5.0 MHz transducers were used. Compression test was performed with linear transducer preferably in short axis view. Normally the vessel appear anechoic and compressible on applying pressure, as shown in figure 3. However, some of the acute thromboses appear anechoic on grayscale sonography and compressible through transducer compression, because of gelatinous nature of the thrombus[22]. But chronic thromboses are echogenic in nature and the vessel appear tubular structure with echogenic contents and non-compressible with graded transducer compression, (figure 4)[23]. In some bedridden patients the blood flow become slow to such an extent that it couldn't be detected through even very high sensitive Doppler settings (low Pulse Repetition Frequency (PRF)), but on spectral doppler a surge in blood flow could be observed with distal augmentation (figure 5)[24]. Normally a steady flow will appear in vein on color and spectral Doppler and respiratory variations will be observed on spectral Doppler (Figure 6).

Data was collected during the allocated period. Statistical Package for the Social Sciences (SPSS) version 24 (SPSS 24, IBM, Armonk, NY, United States of America) software was used for the evaluation of data and graphs formation. The results were summarized in the form of graphs, tables, and charts. Descriptive data is explained in the form of frequency, mean and standard deviation. While kappa test was used to check for the degree of agreement between the diagnosis of grayscale and Doppler sonography.

Results

Two hundred individuals were voluntarily enrolled in this study. Mean age 48.57±17.92 years (16 to 80 Years). All the individuals were grouped into multiple classes with a width of 10 years. The highest frequency of the study sample was belonging to the age group 31-40 years 47 (23.5 %), followed by more than 70 years 36 (18%), then 21-30 years (16 %) & 41-50 years (13.5 %) Females were 132 (66.0%) compared to males 68 patients (34.0%), Male to female ratio was 1:1.9 (Table 1, Figure 1). Pain and swelling (edema) were the most common presenting symptom in patients with suspected DVT 181 (89.5%), while erythema was the least presenting complaint of the patients, representing only 1 (0.5%). Table 2, Figure 2; show the risk factors of DVT in the form of Frequency of risk factors in male and female and their ratio. Diabetes (DM) accounts for 21 (10.50%), Hypertension (HTN) 23 (11.50%), DM and HTN 19 (9.50%), Dyslipidemia (DLP) 4 (2.00%), Trauma 12 (6.00%), Prolonged Immobilization /Travelling 6 (3.00%), H/O Surgery 20 (10.00 %), Pregnancy / Post-partum 13 (6.50%), Pulmonary Embolism 5 (2.50%), Varicose Veins 19 (9.50%), Obesity 6 (3.00%), Old DVT 14 (7.00%), Others 10

Table 1: *Age Groups of Patients and their Relative Frequency in Male, Female Gender, and Total, Along with the Percentage*

Age in Years	Sex of patient		Total	Percentage
	Male	Female		
≤20	2	2	4	2.0%
21-30	15	17	32	16.0%
31-40	12	35	47	23.5%
41-50	3	24	27	13.5%
51-60	13	17	30	15.0%
61-70	9	15	24	12.0%
≥71	14	22	36	18.0%
Total	68	132	200	100.0%

Table 2 *Frequency of Risk factors of DVT in Male, Female and Total along with Percentage.*

Variables	Male	Female	Total	Percentage
Diabetes (DM)	12	9	21	10.50%
Hypertension (HTN)	7	16	23	11.50%
DM + HTN	7	12	19	9.50%
Dyslipidemia DLP	1	3	4	2.00%
Trauma	8	4	12	6.00%
Prolonged Immobilization /Travelling	3	3	6	3.00%
H/O Surgery	4	16	20	10.00%
Pregnancy / Post-partum	0	13	13	6.50%
Pulmonary Embolism	3	2	5	2.50%
Varicose Veins	4	15	19	9.50%
Obesity	2	4	6	3.00%
Old DVT	5	9	14	7.00%
Others	5	5	10	5.00%
No Risk factor	7	21	28	14.00%
Total	68	132	200	100.00%

Table 3: *Degree of Agreement of Grayscale Compression and Doppler Sonography*

		Value	Asymptotic Standard Error[a]	Approximate T[b]	Approximate Significance
Measure of Agreement	Kappa	0.921	0.029	13.028	.000
Number of Valid Cases		200			

a. Not assuming the null hypothesis.

b. Using the asymptotic standard error assuming the null hypothesis.

(5.00%), and without known risk factors 28 (14.00 %). Patients examined, 119 (59.5%) for bilateral, 46 (23.0%) left, and 35(17.5%) for the right leg, it was seen that left leg was more involved in DVT as compared to the right. Agreement between Color Doppler and the grayscale diagnosis was checked with Kappa test. The calculated Kappa value was 0.921, which means there was a strong agreement between the diagnosis of the two modalities, (Ref. Strong agreement 0.90 to 0.98) As shown in Table 3.

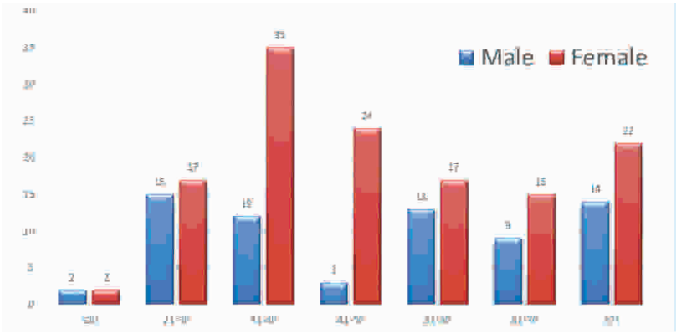


Figure 1: *Age Groups of Patients and their Relative Frequency in Male, Female Gender, and Total, Along with the Percentage*

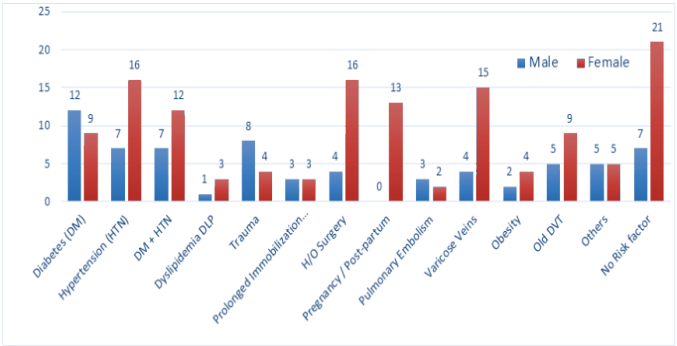


Figure 2: *Frequency of Risk Factors of DVT in Male, Female and Total.*

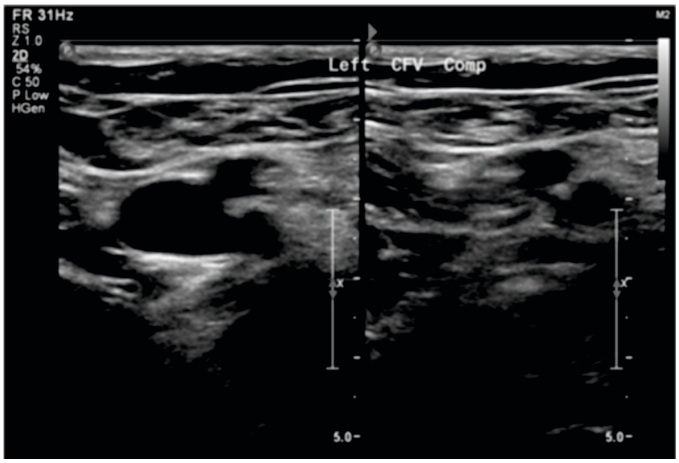


Figure 3: *Transverse views of Rt. CFV Showing Normal views of the Non-Compressed and Compressed Vein without Evidence of DVT.*

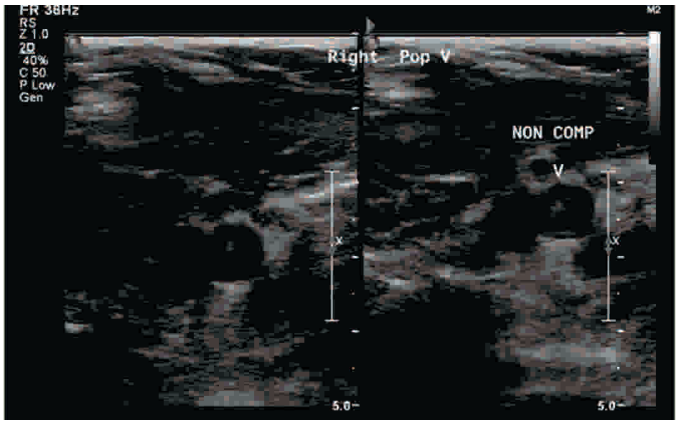
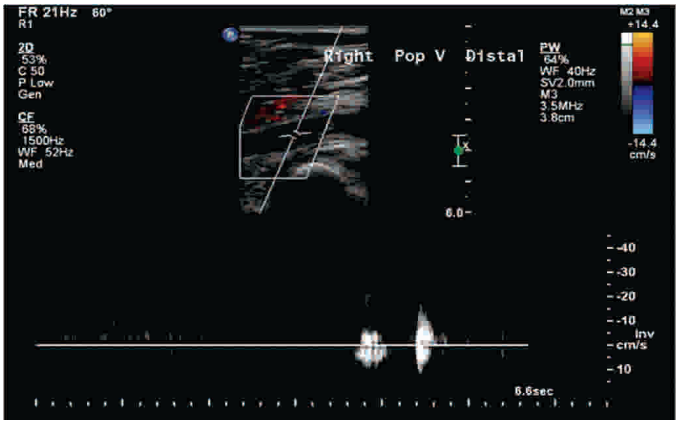
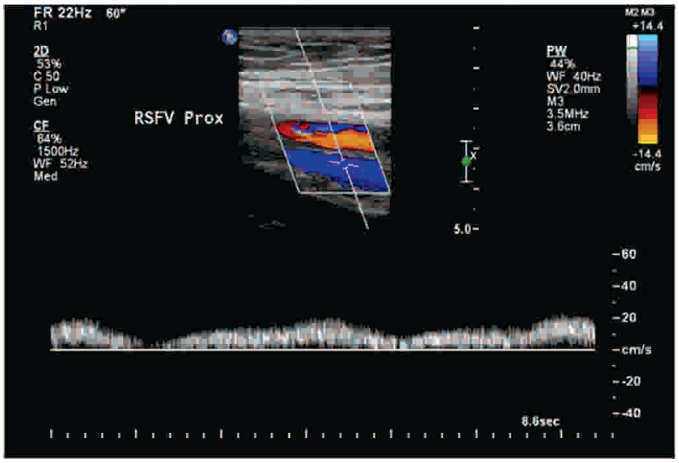


Figure-4: *Transverse Scan Showing Occluded Rt. Popliteal vein (DVT) with Significantly Enlarged size, Intraluminal Echogenicity and loss of*



Compressibility.

Figure-5: *Rt. Popliteal vein. Transverse Figure Shows Echogenic Lumen and is Non-Compressible which is also Accompanied by Complete Cessation of Flow in Color Doppler and Spectral Doppler in*



sagittal Figure suggestive of DVT.

Figure-6: *Normal Flow in the Rt. Proximal superficial Femoral Vein. Longitudinal Scan Showing Complete Colour Fill-in the Veins Lumen and Normal Spectral Doppler Wave Form.*

Discussion

It was an analytical study; the purpose of this research work was to assess the relationship between Gray-scale and Doppler Sonography. Myriad of signs and symptoms were associated with DVT which makes the diagnosis of DVT di cult and challenging. Furthermore, the thrombi may be asymptomatic making it exceedingly di cult to diagnose on clinical presentation. For proper management of the patients with DVT, it was necessary to know the nature, location, and the extent of the thrombus. The study included the assessment of spectrum of the finding of DVT by using B-mode and color Doppler USG. All the major deep veins and superficial veins of the lower limb were examined in all patients. Grayscale ultrasound was checked against the Doppler and the Kappa statistics is given in table 3. Seung-Kee Min, et al; proceeded a study with the objective, to frame rules and guidelines for the early evaluation and timely management by multidisciplinary consensus, of the lower limb deep vein thrombosis on the bases of evidence[12]. For this purpose, they investigated the treatment and diagnostic guidelines of other societies of di erent countries, i.e. in the United States in 2006 and 2012, the Society of Interventional Radiology, American College of Chest Physicians, Society of Vascular Surgeon, and American Venous Forum presented the recommended guidelines for the interventional procedures of acute DVT. In Europe in 2010 and 2012, the Scottish Intercollegiate Guidelines Network and National Clinical Guideline Center working group issued guidelines for management of venous thromboembolism (VTE). Numerous studies have been conducted for the establishment of guideline for the movement of DVT in Korea. Thus, experts from academies (The Korean Society of Interventional Radiology and The Korean Society for Vascular Surgery) related to interventional procedures in Korea came together and agreed to develop clinical guidelines. the sensitivity and specificity for D-dimer tests ranged from 75% to 100% and 26% to 83%, respectively[13]. Color Doppler ultrasonography findings include color flow within the veins, normal respiratory variability and augmentation are collectively clinically accepted methods for the diagnosis and surveillance of treatment.

A systematic review was published in the Cochran Medical library, in 2014, by Chappell FM, et al; with the aim to estimate the sensitivity and specificity of duplex ultrasound for the detection of distal and proximal DVT in symptomatic patients with prior testing by a clinical prediction rule[16]. It was stated that the reliability of Ultrasound in the diagnosis of DVT depends upon body habitus and history of the previous DVT. All the Cross-sectional studies and perspective, as well as retrospective cohort studies designs evaluating the diagnostic test accuracy of duplex ultrasound, were included for this review. According to Goodacre, et al; 2006; Duplex ultrasound is commonly used in the detection of DVT and is non-invasive, convenient and readily available. A systematic review found that ultrasound demonstrated good overall sensitivity (89.7%; 95% CI 88.8 to 90.5) and specificity (93.8%; 95% CI 93.1 to 94.4), but these varied according to ultrasound type and other factors[25].

To compare the results of computed tomographic venography and Doppler ultrasonography and predict the agreement of the two modalities in the diagnosis of DVT, a study was conducted by Lawrence R. Goodman, et al[3]. For this purpose, they included 711 symptomatic individuals and found that there was a strong agreement between the results of CT venography and ultrasonography. They found 95.5% concor-

dance between computed tomographic venography and compression sonography for the positive or negative results of deep venous thrombosis (DVT), The calculated Kappa value was 0.809. It was concluded that computed tomographic venography and compression sonography gave similarity in results during the diagnosing of DVT. The incidence of positive results in patients with no signs and symptoms of DVT was low. In patients with significant signs and symptoms of DVT of the lower limb, CT venography and sonography yield similar diagnostic results. It is, therefore, the choice of imaging modality depends upon the safety, expenses, time consumption, and availability. A comparison study of ultrasonography and magnetic resonance imaging was conducted by Michael R. Torkzad, et al, in 2010 with the objective to evaluate the concordance of magnetic resonance imaging and Ultrasonography in the diagnosis of pelvic veins thrombosis during pregnancy[26]. Twenty-Seven pregnant women were selected for this study with the mean gestational age of 29 weeks. Vascular sonologist performed ultrasound with compression technique. Without contrast agent, MRI was performed with di erent modes. The degree of agreement (Kappa statistics) was performed for the detection of DVT in individual veins was measured for the veins of the same side and inferior vena cava. Agreement between MRI and Ultrasound was in terms of Kappa statistics with K-value at 95% confidence interval was 0.33, reflecting merely a fair agreement. It was concluded that MRI has a complementary role in the diagnosis of DVT during pregnancy, but due to safety and easy availability ultrasound is the first line modality for the diagnosis of Pelvic DVT during Pregnancy. In symptomatic and clinically suspected cases, meticulousness in sonographic scanning develops which leads to increase the sensitivity and specificity of Ultrasound.

For the assessment of two diagnostic strategies in clinically symptomatic individuals, a prospective study was performed on two thousand four hundred and sixty-five individuals, in 2008, by Enrico Bernardi, et al[27]. The incidence of DVT was evident as 0.9%, with 95% connivance interval. The 2 diagnostic strategies are equivalent when used for the management of symptomatic outpatients with suspected DVT of the lower extremities. Awadalla Adam, et al; published in 2018, for the purpose to evaluate blood flow in the deep veins during lower extremity fracture to diagnose DVT before surgery with the help of Doppler ultrasound[11]. They prospectively evaluated 58 patients with various types of fracture for the lower extremity venous studies. They found DVT in 62.1% individuals having single closed fractures, but individuals having single opened fractures 15.5%, while individuals with multiple closed fractures 17.2%, and in 5.2% individuals with multiple opened fractures. Sensitivity and specificity for the detection of DVT with the help of grayscale compressibility were 81.25% and 87.50% and with the help of phasicity of blood flow in individuals with lower extremities fracture were 100% and 100% respectively. Additionally, the absence of compressibility and phasicity had a positive predictive value of 100% and 100% and negative predictive value of 93.75% and 95.65% respectively. It was concluded that grayscale ultrasonography with compression maneuvers and Doppler ultrasound with color and spectral Doppler instrumentation are the first-line imaging modality for suspected DVT in Individuals with fractured lower extremities. We observed similar results as previous studies, in our study we compared compression sonography with Doppler imaging. Compression test was performed with linear transducer, in normal conditions the lumen of the vessel appear anechoic and compressible on applying pressure, as shown in figure 3. However, some of the acute thromboses appear anechoic on grayscale sonography and compressible through transducer compression, because of gelatinous nature of the thrombus[22]. But chronic thromboses are echogenic in nature and the vessel appear tubular structure with echogenic contents and non-compressible with graded transducer compression, as shown in figure 4. In some bedridden patients the blood flow become slow to such an extent that it couldn't be detected through even very high sensitive machine settings (low Pulse Repetition Frequency (PRF)), but on spectral doppler a surge in blood flow could be observed with distal augmentation (figure 5). Normally a steady flow will appear in vein on color Doppler and respiratory variations will be observed on spectral Doppler (Figure 6).

Conclusion

Grayscale and Doppler Ultrasound with the application of some additional provocative measure having a very high agreement for the diagnosis of deep vein thrombosis.

Recommendations

As the small field of view and limited contrast resolution of the still ultrasound Figure lose its reproducibility, ultimately make the Doppler ultrasound operator dependent. A wide range of variability is experienced in the results of Doppler ultrasound. It is therefore recommended to give special attention to the operator training and refreshing basic medical knowledge especially regarding anatomy. Moreover, researchers should be conducted on the interobserver variability to enhance the operator learning curriculum and develop worldwide acceptable guidelines and accreditation system for Vascular Ultrasound.

Declaration of Interest

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of this article.

Addendum:

Author:	Contribution:
T. A. Abasi:	Data collection (Main Author)
S. A. Gilani:	Concept and design (Supervisor)
R. Bacha:	Analysis and interpretation of data
W. Fatima:	Reviving the intellectual content

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