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Role of Color Flow Ultrasound in Detection of Deep Venous Thrombosis

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Abstract
Background: Deep vein thrombosis (DVT) of lower limbs is one of the most causes for the majority of death caused by pulmonary embolism. Many medical and surgical disorders are complicated by DVT. Most venous thrombi are clinically silent. B-mode and color Doppler imaging is needed for early diagnosis of DVT to prevent complications and squeal of DVT.Aim and objectives: the objectives of our study were to evaluate the role of color flow Doppler in the diagnosis of deep vein thrombosis (DVT), and subsequently to investigate its diagnostic value in patients who have normal deep veins despite symptoms.Patients and methods: prospective cross sectional study of 50 patients, 32 patients male, 18female, diagnosed on Doppler with DVTResults: Color Doppler flow imaging in 50 cases had sensitivity of 90%, specificity of 96.7%, positive predictive value of 94.7%, negative predictive value of 93.5%, and accuracy rate of 94%, with majority belonging to fifth decade (26%). In our study, predominantly distribution of thrombus was found to be in above knee region with (65.63%), while only 34.38% of them had DVT below knee.Conclusion: Color Doppler is useful in diagnosing DVT in symptomatic and at risk patients and provides non- invasive method of investigation. It is also helpful in evaluating the site, extent and stage of thrombus.
Keywords: Color flow duplex venous examination, deep venous thrombosis, duplex scanning, pulmonary embolism, venous thromboembolism

Introduction

Venous thromboembolism is a significant, but relatively under diagnosed health problem. The threat of deep venous thrombosis (DVT) and pulmonary embolism (PE) is a daily concern in intensive care unit (ICU), hospitalized and bedridden patients. Early diagnosis of DVT is mandatory to prevent unnecessary deaths from PE. The incidence of DVT varies in different parts of the world for reasons that are not yet completely understood (1). Though, some of the recent studies published from other Asian countries have shown that DVT is not a rarity in Asian patients as was thought earlier (.2)

Risk of new postoperative DVT rises from 26% to 68% respectively. In patients on bed rest in a general medical ward, the rate of DVT is 10% but in an ICU it is 29 %(3). Venous thromboembolism is the third most common cardiovascular illness after acute coronary syndrome and stroke. Pulmonary embolism is the third most common cause of hospital related death and the most common preventable cause of hospital related death (4) .Most hospitalized patients have at least 1 or more risk factor for venous thromboembolism

Deep vein thrombosis (DVT) is a common disease with potentially serious consequences such as pulmonary embolism (5).The incidence of DVT in the general population is reported to be between 1.6 and 1.8 per 1000 people per year (6). Symptomatic DVTs are less frequent, comprising only 3.4% of the total (7).

The diagnosis of DVT with continuous –wave Doppler sonography was done of the first applications of sonography, in the late 1960s. In the early 1980s, B-mode sonography became the technical standard (8) The aims of sonographic examination are not only determination of the presence of a thrombus but also evaluation of the extent of the thrombus (particularly its upper limit), its age(of prognostic interest), and its attachment to the venous wall (partially or totally occlusive thrombus, attached or free floating thrombus).(9)

In the last few years, ultrasound has become increasingly accepted as an accurate, non-invasive mode of investigation for suspected DVT. Initially relying mainly on compression techniques,(10) duplex and color Doppler capability in present –day machine allow evaluation of flow characteristics as well. Assessment of calf veins is also made easier with color Doppler (11).

Venous duplex ultrasound combines two components to assess for DVT:B-mode or grey-scale imaging with transducer compression maneuver and Doppler evaluation consisting of color-flow Doppler imaging and spectral Doppler waveform analysis(12).

Duplex color Doppler imaging is highly sensitive to diagnose deep venous thrombosis in the femoropopliteal system**,** but has limitation, including operator dependence and low sensitivity to assess thrombus extent with iliac veins and inferior venal cava (13). Color Doppler flow permits pain-and risk-free direct imaging of the deep venous system of the lower extremities , to determine the value of color Doppler flow imaging in identification of deep venous thrombosis of the femoropopliteal system, results of each examination is recorded

as positive or negative for deep venous thrombosis.
Deep venous thrombosis of the lower extremities is subdivided in sub two categories:

- Distal (calf) vein thrombosis, in which thrombi remain confined to the deep calf veins or the muscular calf veins.
- Proximal vein thrombosis in which thrombosis involves the popliteal, femoral, or iliac veins [14].

The peripheral veins may be affected by a variety of disorders, which can be assessed by ultrasound. Deep vein thrombosis and thromboembolic disease are the most common indications for investigation of the peripheral but venous insufficiency and vein mapping are also reasons for examining the veins .Anderson et al found an average and incidence of 48 initial cases, 36 recurrent cases of DVT and 23 cases of pulmonary embolus per 100 000 population in the Worcester DVT study .The prevalence of varicose veins and chronic venous insufficiency is more difficult to quantify , but it has been estimated that 10-15% of males and 20-25% of females in unselected Western population over 15 years of age have visible tortuous varicose veins,2-5% of adult males and 3-7% of females have evidence of moderate or severe chronic venous insufficiency, with a point prevalence for active ulceration of 0.1-0.2% [15]

Anatomy –lower limb

The veins of the lower limb are divided into deep and superficial systems these are linked by a variable number of perforator veins which carry blood from the superficial to the deep system.

The anatomy of the lower limb veins is rather variable. Generally the veins accompany the arteries, but their number may vary and the communication with other veins along the way can show a variety of patterns. However, general arrangement is usually apparent. In the calf there are veins running with the main arteries, the posterior tibial, peroneal and anterior tibial veins, there are usually two, occasionally three veins with each artery. In addition there are venous channels, or sinuses which drain the major muscle groups in the posterior calf [16]. These are seen in the upper calf as they pass upwards to join the upper deep veins in the lower popliteal region; the gastrocnemius vein is the more superficial and may be mistaken for the small saphenous vein; clues to its role identity are that it is usually accompanied by the artery to the muscle and it can be followed distally down into the muscle rather than outward to lie subcutaneously on the fascia around the calf, which is the position of the small saphenous vein.

The calf veins join to form the popliteal vein; there may be two, or sometimes three channels, especially if there is dual superficial femoral vein. The popliteal vein becomes the superficial femoral vein at the upper border of the popliteal fossa, rarely popliteal vein run more deeply to join with the profunda femoris vein. The femoral vein passes through the femoral canal and runs up the medial aspect of the thigh, posterior to the femoral artery to join with profunda femoris vein (which can alternatively be called the deep femoral vein) in the femoral triangle below the groin; the profunda femoris vein drains the thigh muscles. The confluence of the femoral and profunda femoris veins to form the common femoral vein is normally a little more caudal than the bifurcation of the common femoral artery into the femoral and profunda femoris arteries. The femoral vein may have significant segments of duplication along its length in up to 25-30% of subjects [17], these dual segments may have a variable relation to the artery, so that they may be overlooked unless care is taken in the examination of the thigh veins with both transverse and longitudinal views being obtained [18].

Aim of the study:

- To determine the value of color Doppler flow imaging in the identification of deep venous thrombosis of the femoropopliteal system.

Objectives of this study are:

- To evaluate the accuracy of color flow Duplex (CFDS) in the diagnosis of deep vein thrombosis (DVT), and subsequently to investigate its diagnostic value in patients who have normal deep veins despite symptoms.

Patients and methods

A prospective cross sectional study was carried out in Rizgary teaching hospital, in Erbil –Iraq, from 15th of March 2015 till 10th of March 2016. A total of 50 patients included in the study, 32 of them were male, and 18 were female, every patient with symptoms or signs (pain, tenderness, or swelling) suggesting lower extremity DVT, referred to the diagnostic imaging department for the Doppler of the lower extremities. The inclusion criteria are DVT diagnosed on B-mode and color Doppler study in clinically suspected cases of DVT. Pediatric and neoplastic cases were excluded.

The procedure was explained to each patient, and verbal consent obtained, the examination began in the most proximal segment of the deep venous system that could be adequately visualized. This was usually the distal external iliac vein as it runs anteriorly from the deep pelvis. The common femoral vein, proximal deep femoral vein, superficial femoral vein, and popliteal vein were examined.

The ultrasound examination was done by PHILIPS HD 11XE, patient was initially placed in the supine position, and the common femoral and superficial femoral veins were evaluated as complementary and distally as possible in the both longitudinal and transverse orientation, the patient then assumed prone position and the popliteal was assessed with leg straightened, then the calf veins examined as they branch from the distal popliteal veins.

During ultrasound evaluation, the patients were instructed to breath normally, gain settings adjusted to minimize artefactual intraluminal echoes. At all points along the length of the vein, the venous lumen was examined for the presence of intraluminal clots. Additionally, compressibility of the veins lumen was assessed.

The amount of the pressure exerted on the transducer varied according to the soft tissue size of the leg ,the pressure applied with transducer to collapse a normal vein was sufficient to cause minimal dimpling of the skin ,a normal vein showed no intraluminal clots, and the lumen collapsed completely with compression .with Direct CDFI (color duplex flow imaging) of the iliac veins was performed with 4.5MHz transducer .Because of the depth of the iliac veins and their obscuration by overlying bowel gas, only 3-5cm of external iliac vein could be imaged in most patients. Iliac vein patency was further assessed by means of CFDI study of flow signals in the common femoral vein. Normal flow in the common femoral vein characteristically produce spontaneous centripetal Doppler signals, with respiration –induced modulation of flow velocity, cessation of flow during a vigorous Valsalva maneuver ,and augmentation of flow with compression of the calf.

Below the inguinal ligament, the 5.0- or 7.5-MHz transducer was used .Longitudinal image planes over anteromedial thigh were used to evaluate common femoral, superficial femoral, deep femoral and greater saphenous vein anatomy, patency, and blood flow characteristics. The transverse transducer orientation was used to confirm anatomic relationships and to assess vein compressibility.

The distal superficial femoral and popliteal veins were evaluated with transducer positioned posteriorly in the popliteal fossa. The posterior tibial and peroneal veins were examined with the transducer positioned poster medially along the calf. Longitudinal image planes were used in the popliteal region and calf to evaluate venous anatomy, patency, and augmentation of venous flow with foot or distal calf compression. Transverse transducer orientation in the popliteal area was used to confirm anatomic relationships and to assess vein compressibility .The anterior tibial veins were examined only if anterolateral calf symptoms were present. The anterior tibial veins were examined in the longitudinal sections, with the transducer positioned anterolateral to the tibia. In addition to examination of the deep venous system, regions of pain, tenderness, or local swelling were evaluated for evidence of superficial venous thrombosis.

The primary diagnosis of DVT was based on the non-compressibility of the vein lumen, we noted the presence of intraluminal echoes, but this finding was ancillary .The examination took approximately 12-15minutes.

Compression of the distal limb was routinely per- formed for all venous segments. Criteria for a positive scan included visualization of intraluminal thrombus, obvious encroachment on the color-flow image, absence of flow despite augmentation in veins in which no echogenic defect was identified, and venous incompressibility. Scans on which no thrombus was visible were reported as equivocal when spontaneous or augmented flow patterns appeared no confluent. Scans were interpreted as negative for DVT when no echogenic defect was present, if spontaneous flow or normally augmented flow was visualized, and when the color image filled the entire lumen. Complete collapses of the veins with compression was also used when necessary to confirm the absence of thrombi. When clots were hyperechoic, retracted against the venous wall, or the lumen was recanalized, the thrombus was classified as chronic.

When Doppler signals were abnormal or when there were other findings suggestive of obstruction at the level of groin, the iliac veins were examined.

The following criteria were followed in this study for DVT diagnosis

1-Visualization of Thrombus
2-Vein compressibility.
3-Vein size.
4-Respiratory changes.

The veins were evaluated for:

1-Absent or reduced compressibility of the vein.
2-Thrombus in the vein, static echoes in complete color fill in full expansion of vein.
3-Static valve leaflets.
4-Absent flow on spectral color Doppler.
5-Impaired or absent augmentation of flow.
6-Loss of spontaneous and respiratory variation.
7-Increased flow in controlled canal.

Data management and statistical analysis:

Data was recorded on a specially designed questionnaire, collected and entered in the computer and then analyzed using appropriate data system which is called Statistical Package for Social Sciences (SPSS) version 22 and the results will be compared between patients with different variables, with a statistical significance level of p value < 0.05. The results will be presented as rates, ratio, frequencies, percentages in tables and figures and analyzed using Chi square tests.

Results

1. Basic characteristics.

A total of 50 participants enrolled in the study; 64% of them were male and 36% were female. The male to female ratio was 1.7:1 (Figure 1).

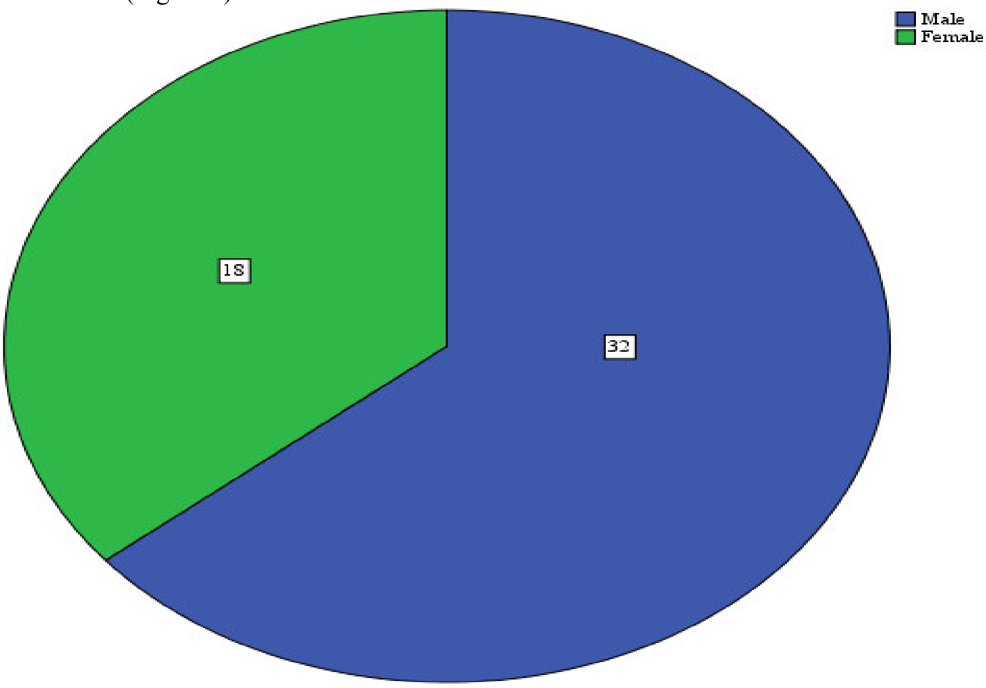

Figure 1: Gender distribution of participants.

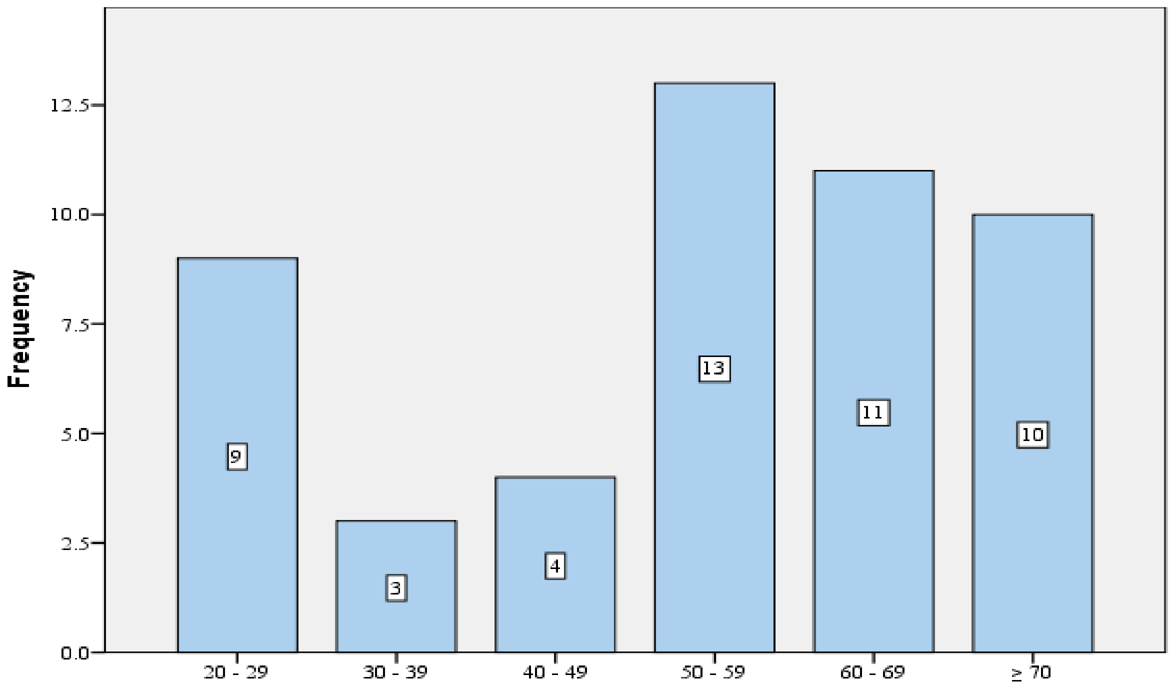

Figure 2: Age groups of DVT cases in years.

Figure (2) shows that highest frequency of the study sample was belonging to age group 50–59 years (26%) followed by 60–69 then 70 years and more (22% and 20% respectively).

Pain was the most common presenting symptom of DVT cases i.e. all of them had pain, followed by edema, pain and edema and limb tenderness (94% of them) while cyanosis was the least presenting complaint of patients representing only 28% of the cases (Figure 3).

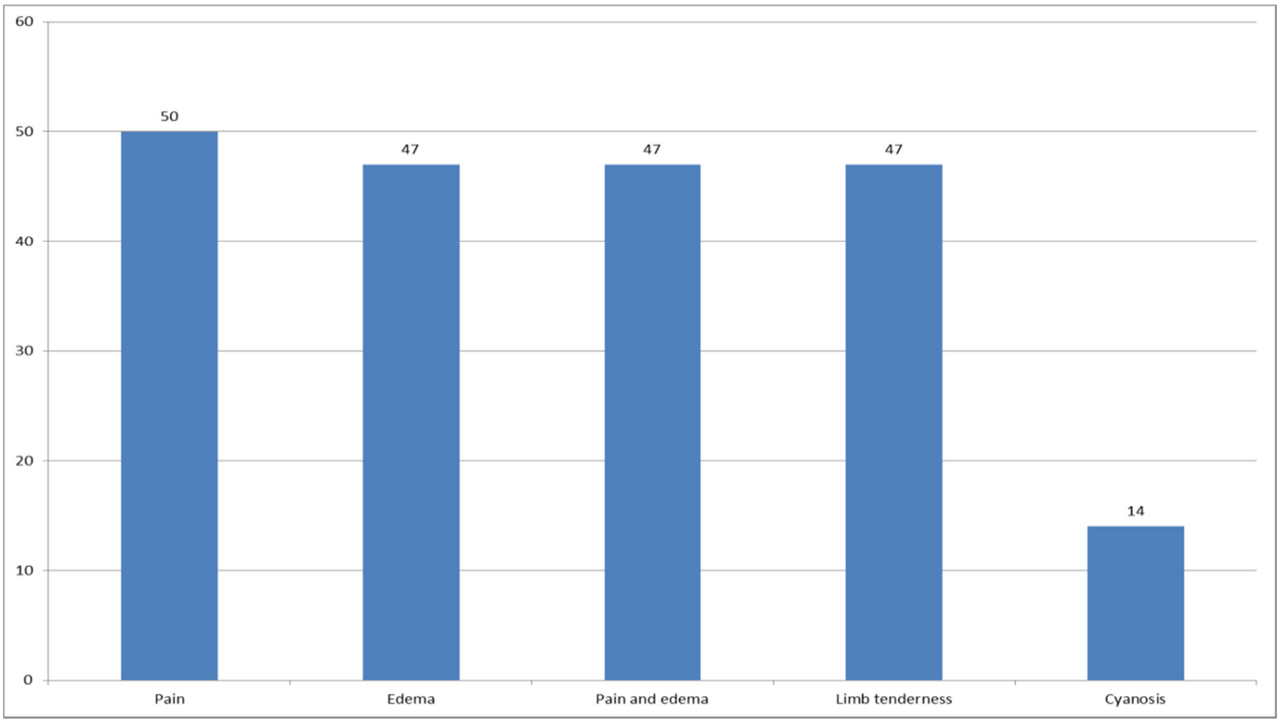

Figure 3: Prevalence of symptoms among DVT cases.

2. Association between DVT and predisposing conditions.

The findings of Table (1) reveal that there was a significant statistical relationship between study samples and all the predisposing conditions (HTN, DM, lipid profile, prolonged hospitalization and history of trauma).

- The vast majority (93.9%) of DVT cases had diabetes in comparison to less than half of non-DVT cases (47.1%), P-value was 0.001.
- Most DVT patients (84.8%) had hypertension while (58.8%) of control group had this condition, P-value was 0.04.
- Most of DVT cases (66.7%) had abnormal lipid profile in contrast to most of non-DVT participants (70.6%) who had normal lipid profile.
- History of trauma was prevalent among DVT patients (90.9%) while approximately half (52.9%) of control group suffered from trauma in the past.
- 69.7% of DVT cases experienced prolonged hospitalization in reverse to non-DVT cases was 76.5% of them did not report such a prolonged hospitalization.

Table 1: Relationship between DVT and predisposing conditions.

Variables	Categories	Doppler finding		Total	P
		Normal	Abnormal		
Diabetes	No	9	2	11	0.001
		52.9%	6.1%	22%	
	Yes	8	31	39	
		47.1%	93.9%	78%	
Hypertension	No	7	5	12	0.04
		41.2%	15.2%	24%	
	Yes	10	28	38	
		58.8%	84.8%	76%	
Lipid profile	Abnormal	5	22	27	0.01
		29.4%	66.7%	54%	
	Normal	12	11	23	
		70.6%	33.3%	46%	
History of trauma	No	8	3	11	0.002
		47.1%	9.1%	22%	
	Yes	9	30	39	
		52.9%	90.9%	78%	
Prolonged hospitalization	No	13	10	23	0.002
		76.5%	30.3%	46%	
	Yes	4	23	27	
		23.5%	69.7%	54%	
Grand total		17	33	50	
		100%	100%	100%	

3. Validity of Doppler ultra sound.

The results of Table (2) indicate that using color flow as a screening test in comparison to the gold standard procedure (venous compressibility) yielded a very good sensitivity (90%) an excellent specificity (96.7%), supreme positive and negative predictive values (94.7% and 93.5% repeatedly) and utmost accuracy rate of 94%.

Table 2: Sensitivity, specificity, PPV and NPV of Color Flow.

		Venous compressibility		Total
		Present	Absent	
Color flow *	Normal	18	1	19
	Abnormal	2	29	31
	Total	20	30	50

*** Sensitivity = 18/20= 90%, specificity = 29/30 = 96.7%, positive predictive value (PPV) = 18/19 = 94.7%, negative predictive value (NPV) = 29/31 = 93.5%, accuracy rate: 18+29/50 = 94%.**

Figure (4) reveals that the anatomical site of most DVT cases was above knee (65.63%) while only 34.38% of them had DVT below knee joint.

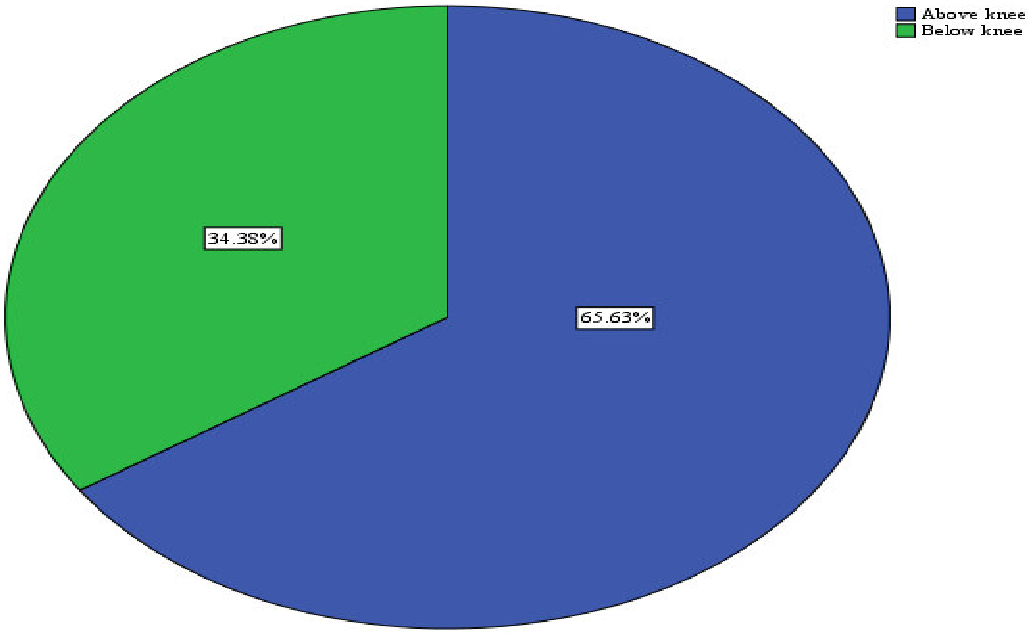

Figure (4): Anatomical distribution of DVT cases.

Discussion

The varied signs and symptoms that are associated with DVT make the diagnosis of DVT difficult and challenging. Furthermore, the thrombi may be asymptomatic making it exceedingly difficult to diagnose on clinical presentation. For proper management of the patients with DVT, the nature, location, and the extent of the thrombus is necessary to know.

The study included assessment of spectrum of findings 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. Color Doppler USG has a sensitivity and specificity of about 90% and 96.7%, respectively, positive predictive value (PPV) of 94.7%, negative predictive value (NPV) of 60% and accuracy rate of 94%

The accuracy, viability, and wide spread use of B-mode compression US has had a significant impact on the examination of patients with clinically suspected DVT. The advantages of this approach in reducing cost and patient risk are obvious. Several studies report low rates (1%-6%) of indeterminate examination results. Color Doppler flow imaging also can be used when results of compression US are indeterminate or the examination is compromised by technical factors such as large patient size, previous episodes of DVT, or pain with compression.

Few articles [19-22,25] ,report the use of color Doppler flow imaging in patients with suspected lower extremity DVT, and none of these studies relay on color Doppler flow imaging alone without compression. The purpose of our study was to determine whether color Doppler flow imaging alone, without the use of compression, was adequate for the evaluation of suspected acute DVT. If the two methods are of comparable accuracy, then it is appropriate to relay on the results of color Doppler flow imaging in those cases when the compression US examination is technically difficult or comprised in any way or the results are indeterminate.

Our results show that diagnostic color Doppler flow imaging of the femoropopliteal system, the sensitivity , specificity, accuracy , positive predictive value, and negative predictive value are comparable to those published for compression US[23,24]. The rate of indeterminate results in this group of patients was (6%). This is also comparable to that of compression US [4,6,28], although many reports of compression US studies did not include inadequate examinations or did not define what constitutes a non-diagnostic examination.

The age group of patients with DVT ranged from 21 to 79 years in our study. The majority of the patients belonged to the fifth decade (26%), followed by (22%) in the sixth decade. In our study conducted by Hill et al [26], they had found that the mean age of patients shown to have DVT was in the sixth decade. In our study (64%) of the patients were males and (36%) were females. Thus males dominated the study group. This correlate well with the study conducted by Hill et al [26] , which had higher incidence of DVT among males.

Pain was the most common presenting symptom of DVT cases (all of them), followed by edema, pain and edema, and limb tenderness (94% of them). This is well explained by the normal venous physiology that when major venous channel get occluded, there is resultant increase in venous pressure and volume which manifests into edema. This is also correlates with the study conducted by Langsfeld et al [27] who found pain, edema as the most common 2symptoms in patients diagnosed with DVT.

In this study there was significant statistical relationship between study samples and all the predisposing

conditions (HTN, DM, lipid profile, prolonged hospitalization and history of trauma). The vast majority (93.9%) of cases of DVT had diabetes, P value was 0.001, followed by hypertension (84.8%), P value was 0.04.
In our study thrombosis localized to the above knee joint which constitute (65.63%), as compared to below knee joint (34.38%). This correlate well with the study conducted by Markel et al[22], who concluded that proximal limb involvement was more common pattern of involvement as compared to the distal limb.

Conclusion
DVT of lower limbs is one of the most common causes for majority of deaths due to PE which can be detected reliably, non-invasively and rapidly by the use of Duplex Doppler USG. It has become the first line investigation of DVT. Gray scale findings together with color Doppler helps in qualitative evaluation of the venous system of lower limbs. Duplex Doppler USG can help in early detection of DVT in clinically suspected cases and help in prompt treatment is crucial in the course of DVT. It is also helpful in evaluating the site, extent and the stage of thrombus. Thus weighting the limitations and the advantages offered by the Duplex Doppler USG, it is good, reliable, inexpensive and rapid method of investigation at present for the investigation of DVT of lower limb.

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Conflicts of interest statement
Nothing to declare.

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