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Colour Doppler Role in Evaluation of Lower Extremity Deep Vein Thrombosis

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I. Introduction

DVT of lower extremities is one of the most common cause for pulmonary embolism which in turn is responsible for majority of deaths. It is a common clinical problem that complicates many medical and surgical disorders. It usually presents as pain and swelling of the affected limbs and may also cause structural damage to the valves of deep veins, which results in post phlebitic syndrome. Development of a thrombus within a vein may be considered functionally as an exaggeration of the normal process of haemostasis.

Group of patients with the high risk of developing DVT are the patients after a major surgery, trauma, prolonged immobilization such as in acute myocardial infarction, CCF, stroke and postoperative convalescence period. Other risk factors to mention a few are neoplasms, pregnancy, oral contraceptive pills and hypercoagulable states.

DVT occurs along a continuum with propagation, extension and progression. Most venous thrombi are clinically silent when they are first detectable by objective methods, probably because they do not totally obstruct the vein and also because of collateral circulation. Even among the fraction of patients with deep vein thrombosis who have symptoms in the lower extremities, fewer than the third present with the classic syndrome of calf discomfort, oedema, venous distension, and pain on forced dorsi-flexion of the foot (Homan's sign). When symptoms are initially attributed to deep vein thrombosis, reassessment by objective methods shows that this attribution is correct less than half the time.

Hence a need of an objective technique to supplement and confirm the clinical diagnosis of DVT is very important to prevent the complications and sequelae by early and appropriate treatment instillation.

The introduction of Doppler ultrasound technique has irrevocably altered the diagnosis and treatment of DVT. The rationale is quite simple: thrombotic obstruction of the underlying vein distorts the venous flow pattern and these perturbations are readily detected by the Doppler instrument. This technique is non invasive, repeatable, can be performed rapidly in the clinic, at patient's bedside or even at home and the results are available immediately. It can be used in pregnant women, permits multiple views in various positions of the leg and the study is safe, painless, inexpensive. Venous system is evaluated for flow, phasicity, pliability and augmentation. It is useful as a screening modality in high-risk patients to ensure prompt and early treatment. The duplex scan can diagnose many thrombi at a stage when no major changes have occurred in the venous haemodynamics and the patient is asymptomatic or minimally symptomatic.[11]

II. Methodology

Deep venous thrombosis (DVT) of lower extremities is one of the most common cause for pulmonary embolism, which inturn is responsible for majority of sudden deaths.

The present study is carried out on 40 patients with clinical suspicion of deep venous thrombosis referred to the Department of Radio Diagnosis in a period of 2 years from june 2016 to may 2018 in the hospital attached to RIMS MEDICAL COLLEGE SRIKAKULAM.

The patients were included in the study only if they met the following criteria.

Inclusion Criteria:

- Clinically suspected cases of Deep venous thrombosis
- Patients who are at increased risk of DVT.

Exclusion Criteria:
- Paediatric cases
- Neoplastic conditions

Specifications of the colour Doppler ultrasonography machine :
- Manufacturer : esoate
- Model : my lab 40 and my lab 7
- Image storage : Hard disc
- Type of transducer : Linear array
- Frequency of transducer : 3.5 MHz, 7.5 MHz

All patients included in the study were evaluated by the above mentioned colour Doppler ultrasound machine.

III. Methods

In all patients, the following protocol was followed :
- Detailed clinical history was elicited with reference to onset, duration and progress of the symptoms and special reference to risk factors and any evidence suggestive of pulmonary embolism.
- Patients with following symptoms were included in the study.

1. Pain in the lower limb particularly located to the calf (unilateral or bilateral).
2. Oedema of lower limb (unilateral or bilateral)
3. Pain and oedema combined.
4. Prior history of deep vein thrombosis
5. Shortness of breath (rule out pulmonary embolism)

- Thorough clinical examination of the patient was carried out.
- Review of all the previous radiological (chest radiographs, ultrasonography of abdomen and pelvis, Doppler ultrasonography of lower extremities in patients with history of DVT etc.) and pathological investigations was done.
- Lower extremities in patients with prior history of DVT etc. and pathological investigations were done.

Standard examination would evaluate common femoral vein and superficial femoral vein first, followed by popliteal and calf veins. External iliac veins and IVC were evaluated at last.

The patient was examined in supine position with legs abducted and extremely rotated with slight flexion of knee for evaluation of femoral venous segment. Patient was given prone position for evaluation of popliteal vein. Calf veins were evaluated in supine position and the knee slightly flexed, internally
rotated for the anterior tibial veins and externally rotated for the posterior tibial and peroneal veins.

7.5MHz linear array transducer was used for femoral and popliteal venous segments and calf veins while 3.5 MHz convex transducer was used for evaluation of iliac veins and inferior vena cava.

The Doppler report described presence or absence of deep vein thrombosis, location, extent, nature (acute or chronic) and complications, if any.

IV. Results

A study of 40 patients with symptoms of lower extremities were included in this study. Following observation were made.

TABLE – 1. AGE DISTRIBUTION

Age group (in years)	Cases with suspected DVT (n = 40)		Cases shown evidence of DVT (n = 31)		Rate of evidence of DVT against suspected (%)
	No.	Percentage	No.	Percentage	
21 - 30	6	15	5	16.13	83.33
31 - 40	11	27.5	10	32.26	90.90
41 - 50	6	15	4	12.90	66.66
51 - 60	12	30	9	29.03	75.0
61 - 70	3	7..5	2	6.45	66.66
71 - 80	2	5	1	3.23	50
Total	40	100	31	100	

Age of patients ranged from 21 to 79 yrs. 57.6% patients were older than 40 yrs of age. The mean age of cases suspected to have DVT being 48.7yrs and mean age of cases shown to have DVT being 46.25yrs.

TABLE – 2 SEX DISTRIBUTION

Sex	Cases with suspected DVT (n = 40)		Cases shown evidence of DVT (n = 31)	
	No.	Percentage	No.	Percentage
Male	28	70	23	74.19
Female	12	30	8	25.81
Total	40	100	31	100

Male predominance was found in our study. Of 40 patients 28 (70%) were males and 12 (30%) were females.

TABLE – 3DISTRIBUTION OF CASES BY SIGNS AND SYMPTOMS (MULTIPLE RESPONSE)

Symptoms	Cases with suspected DVT (n = 40)		Cases shown evidence of DVT (n = 31)	
	No.	Percentage	No.	Percentage
Pain	8	20	6	19.35
Edema	16	40	14	45.16
Pain and edema	10	25	8	25.81
Pulmonary embolism	3	7.5	2	6.45
Asymptomatic	3	7.5	1	3.23

Thus oedema (45.16%) was the most common presenting symptom in patients who were diagnosed as DVT on colour Doppler, followed by pain (19.35%) as second most common presenting symptom in our study.

TABLE – 4 Clinical Conditions In Study Population For Doppler Ultrasound Examination For Suspected DVT

Clinical conditions	Cases with suspected DVT (n = 40)		Cases shown evidence of DVT (n = 31)	
	No.	Percentage	No.	Percentage
Prolonged hospitalization	12	30	9	29.03
Post-operative	3	7.5	3	9.68
Trauma	3	7.5	3	9.68
OC pill users	2	5	2	6.45
Dialysis	2	5	2	6.45
Others (Snake bite)	1	2.5	1	3.23
No known predisposing condition	17	42.5	11	35.48

In our study it was found that prolonged hospitalization (29.03%) was the most common predisposing factor, followed by post-operative (9.68%) and trauma (9.68%). However in 35.48% of patients with deep venous thrombosis no predisposing factor was found.

TABLE – 5 Type Of Involvement In Study Population With Evidence Of DVT On Doppler Ultrasonography

	No. of cases	% of cases
Unilateral	30	96.77
Bilateral	1	3.23
Total	31	100

TABLE – 6 Distribution Of Thrombi In Right And Left Limb In Study Population With Evidence Of DVT On Doppler Ultrasonography

	No. of extremities involved	Percentage (%) of extremities involved
Right lower extremity	8	25.80
Left lower extremity	24	77.41

1 case showing bilateral involvement, total number of extremities shown evidence of thrombosis are 32. Left lower extremity predominance was noted in our study.

TABLE-7anatomicdistribution Of Thrombi In StudyPopulation With Evidence Of DVT On Doppler Ultrasonography

	CFV	SFV	PV	PT	AT	PER	CIV	EIV	SVS
No. of cases showing involvement	18	26	23	20	14	12	3	8	4
Percentage of cases showing	58.06	83.8	74.19	64.52	45.16	38.71	9.68	25.81	12.90

Predominant distribution of thrombi was seen in SFV, (83.87%) followed by popliteal vein (74.19%) and calf veins (posterior tibial vein- 74.19%). Thus thrombus involvement is more common in proximal segments (femoro-popliteal) than in distal segments (calf veins).

TABLE–8stage Of Involvement In Study Population With Evidence Of DVT On Doppler Ultrasonography

	No. of cases	Percentage of cases
Acute	18	58.06
Chronic	13	41.94
Total	31	100

In our study acute thrombosis (58.06%) predominance was noted.

TABLE – 9 Type Of Occlusion In Study Population With Evidence Of DVT On Doppler Ultrasonography

	No. of cases	Percentage of cases (%)
Complete	21	67.74
Incomplete	10	32.26
Total	31	100

Most of the occlusion seen in our study was complete type of occlusion (67.74%).

TABLE – 10 Pattern Of Involvement Of Veins In Thrombosis In Study Population With Evidence Of DVT On Doppler Ultrasonography

Thrombosis location	No. of cases	Percentage of cases (%)
Isolated	2	6.45
Multiple contiguous	29	93.55
Multiple non concontiguous	0	0
Total	31	100

Multiple contiguous involvements was seen in 93.55%, followed by isolated seen in 6.45%. Thus multiple contiguous involvements predominated our study.

V. Discussion

The diagnosis of deep vein thrombosis has always been difficult and problematic. The myriad of signs and symptoms that can be associated with DVT and the fact that many thrombi are asymptomatic, make it exceedingly difficult to rely on the clinical presentation. The management of patients with clinical diagnosis of DVT in the lower extremity needs to identify the presence of thrombus, its nature, location and extent.

The present study was performed with the objective of assessing the role of colour Doppler USG in the diagnosis of DVT of lower extremity. It included detection and assessment of spectrum of findings of DVT by using colour Doppler ultrasonography. We studied the colour flow findings in patients who presented with pain, oedema or both of the lower extremities, pulmonary embolism and prior history of DVT. Our technique involves a complete survey of all major deep veins and
superficial veins of the lower limb. Amongst the total 40 cases studied for suspected DVT of lower limbs, 31 cases showed the presence of thrombus. In 9 patients, although there was clinical suspicion of DVT of lower limbs, the colour Doppler study was negative for DVT.

The data published by Sheiman RG et al in 1995 and Strothman G et al in 1995 indicates a low incidence of thrombus in contralateral extremity. This supports the unnecessity of bilateral examination in patients with unilateral extremity symptoms. However the examination of both the lower extremities is advisable in patients with signs or symptoms of pulmonary embolism, even though one extremity is symptomatic.

Age:

The range of age of patients with suspected DVT in our study was 21-80 years, with mean age of cases suspected to have DVT being 48.7 years and mean age of cases shown to have DVT being 46.25 years.

In their study series, Hill SL et al (1997) had found mean age of males shown to have DVT 60.3 years and females shown to have DVT 65.5 years.

Sex :

Males contribute a major group (70%) in our study of cases with suspected DVT and they also have a higher incidence (74.19%) of positive Doppler study. In the present study of the cases with suspected DVT, 12 (30%) are females, with 8 (25.81%) showing evidence of DVT.

This correlates with the study conducted by the Hill SL et al in 1995 which concluded that higher incidence of DVT was seen in males. In their study, 22.1 % of males and 15.2 % of females had positive studies.

The symptoms that prompted for Doppler examination were pain in 8 patients (20%), oedema in 16 (40%), pain and oedema in 10 (25%), symptoms of pulmonary embolism in 3 (7.5%), and 3 (7.5%) patients were asymptomatic.

In cases showing evidence of DVT; 6 (19.35%) had pain as presenting symptom, 14 (45.16%) had oedema, 8 (25.81%) had pain and oedema, 2 (6.45%) had symptoms of pulmonary embolism, while 1 (3.23%) were asymptomatic. Amongst the patients showing evidence of DVT, the common symptom suggestive of DVT was oedema. This correlates with the study by Glover J et al[81] and Eze et al who found 25 patients with unilateral leg swelling to have DVT in their study. In their study, 40% were found to have DVT by duplex scanning whereas DVT was evident in only 5 % of patients in the absence of leg swelling. This is explained by the venous physiology that when major venous channels are occluded, the resultant increase in venous pressure and volume manifests itself in oedema.

This is in correlation with the study by Langsfeld M et al in 1987 who found leg swelling as the most common sign in patients diagnosed to have DVT. In contiguous segment involvement, the oedema is the common presentation due to occlusion of major venous channels. Isolated thrombosis does not cause oedema due to extensive collateral circulation.

The study by Hill SL et al displayed statistically significant effects of the presence of pain, oedema, history of DVT, miscellaneous symptoms and post operative state, regardless of and beyond the effect of age and gender. According to them, bilateral oedema and the post operative states are not substantive indicators of DVT when they occur alone. When either of these symptoms, occur in combination with another significant symptom, their predictive ability is much greater.

In present study only one case with bilateral pain and oedema showed evidence of thrombosis. However in the study conducted by Colucciello SA DVT never occurred in patients with bilateral symptoms.

Colour Doppler USG was advised to rule out DVT of lower limbs as the source of pulmonary embolism in 3 cases. This is based on the concept that majority of pulmonary embolism originate in lower extremity veins.

Amongst the 3 patients with suspected pulmonary embolism, colour Doppler USG revealed DVT in only 2 cases who had left side calf tenderness on clinical examination.

Clinical conditions that prompted for colour doppler :

In the present study, 12 cases (30%) with suspected DVT were bedridden (prolonged hospitalization), 3 (7.5%) were post operative, 3 (7.5%) had history of recent trauma, 2 (5%) were OC pills users, 2 (5%) were dialysis patients and 1 (2.5%) was patient with snake bite. In cases showing evidence of thrombosis on colour Doppler USG; 9 (29.03%) were bedridden (prolonged hospitalization), 3 (9.67%) were post operative, 3 (9.67%) had history of trauma, 2 (6.45%) were OC pill users, 2 (6.45%) was dialysis patient and 1 (3.23%) was patient with snake bite. Type of involvement :

In the present study, 30 cases showed unilateral involvement. 29 cases with unilateral symptoms showed involvement of the same symptomatic limb while 1 case with unilateral involvement had bilateral symptoms. 1 case (3.23%) with bilateral involvement was symptomatic. This correlates with the data published by Sheiman RG et al in 1995 who indicated a low incidence of thrombus in contralateral extremity.

In 77.41% of cases with evidence of DVT on colour Doppler USG the thrombus was localised to left limb, while in 25.80% of cases, thrombosis was localised to right limb. This correlated with the venographic study of Stamatakis JD et al(1978) who found major thrombi occurring more frequently in left limb.

Localisation and extent of thrombosis :

Colour Doppler USG helps in exact localisation of the thrombus. Salzman EW et al in 1976, Hume M et al in 1976, Yao ST et al in 1974 and Cranley J et al in 1976 had stated that clots propagating into or beyond the popliteal vein assume greater clinical significance as they increase the possibility of fatal pulmonary emboli.

In the present study, thrombosis was localized to thigh or popliteal region in26 (83.87%) out of 31 cases with evidence of thrombosis. This roughly correlated with the study by Hill SL et al (1997) who found 49% thrombi in the thigh or popliteal space without calf involvement.

The distribution of thrombi in present study is 9.68% in common iliac vein, 25.81 % in external iliac vein, 58.06 % in the CFV, 83.88% in SFV, 74.19 % in the popliteal vein, 64.52% in posterior tibial vein, 45.16% in anterior tibial vein, 38.71% in peroneal vein and 12.9% in the superficial veins. All the 8 cases in our study with external iliac vein thrombosis out of which 3 were showing both proximal and distal extension i.e. into common iliac vein and common femoral vein. This finding correlated with the study by Appleman PT et al (1987).

The study by Hill SL et al (1997) reported involvement of ilio femoral segment in 16% , CFV in 13% , SFV in 19% ,PV in 18 % , calf veins in 24% and superficial veins in 11%.

Identifying the thrombus in proximal veins of lower extremity is important for they pose greater risk in terms of both embolism and local residual changes. Calf vein thrombi often resolve spontaneously and do not result in emboli. So they are considered clinically insignificant. The presence of DVT above knee greatly increases the risk for pulmonary embolism and eventual post-phlebitic syndrome.

In a prospective study of 755 patients conducted by GenaFrederick et al, (1996) DVT was limited to the SFV in 4.6%, to the CFV in 6.1%, and to the popliteal vein in 10.7%. They concluded that DVT limited to a single vein occurs with Ssufficient frequency that the limited USG screening survey is not sufficiently accurate.

In our study, DVT isolated to SFV was seen in one patient (3.23%) and DVT isolated to popliteal vein was seen in another patient (3.23%). This is similar to the study conducted by Gena Frederick. Hence we conclude that complete colour Doppler examination should be done in all symptomatic patients, in order to reduce examination time and also to avoid missing the thrombus isolated to single vein.

Acute vs chronic :

Acute thrombosis was found in 18 (58.06%) and chronic in 13 (41.94 %). This finding roughly correlated with the study by Grosser S et al in 1990. They found 7 cases of older thrombi by colour Doppler of which finding was confirmed phlebographically in 4 cases.

In the study, the positivity rate for acute DVT is 45% (18 cases amongst 40suspected cases of DVT). This is higher than that in the study-by Hill SL et al (1997) who determined the positivity rate of 17.4% for acute DVT in symptomatic patients.

Complete vs incomplete:

21(67.74%) cases showed evidence of complete thrombosis while 10 cases (32.26%) demonstrated incomplete thrombosis. All the incomplete thrombi were chronic in nature. Of the cases showing evidence of incomplete thrombosis, 5 had pain as presenting complaint, 4 had oedema and 1 had pain and oedema.

Pattern of involvement:

The three different types of thrombosis according to anatomical segments and patterns are :

1. Isolated thrombi confined to one venous segment.
2. Thrombi extending across two contiguous anatomical segments.
3. Thrombi in multiple different non contiguous locations in one extremity.

In the present study, 6.45% were isolated thrombi confined to one segment, 93.55% were multiple contiguous thrombi. There is not a single case showing multiple non- contiguous involvement. The pattern of involvement which constituted the major group in our study is one with multiple contiguous involvement of venous segments in single extremity. This finding correlated with the study by Hill SL et al in 1997.

The study of Hill SL et al (1997) found 34% isolated thrombi confined to one venous segment, 52% thrombi extending across two contiguous anatomical segments which constitute the major group, 8% thrombi extending across multiple non contiguous segments in one extremity and 8 % bilateral thrombi.

Isolated iliac vein thrombosis did not occur in this series of patients. Rose SC et al (1990) in their study however identified three cases of iliac vein DVT which had non contiguous DVT of the femoro-popliteal segment.

It is found that the age of patients with contiguous thrombosis or bilateral thrombosis was greater than the age of patients with isolated thrombosis.

Venous distension:

The criterion included in the diagnosis of acute thrombosis was increased venous diameter which was found in all 18 cases of acute thrombosis. This correlated with the study by van Gemmeren D et al in 1991 who had found a significant correlation between age of thrombosis and the venous diameter ($P<0.001$). In 13 cases with chronic thrombosis 11 had normal dimension while 2 had diameter less than adjacent artery.

Loss of compressibility:

Compressibility of veins was lost in all 31 cases (acute and chronic) with DVT. In 10 cases with incomplete thrombosis, involved veins were not completely compressible. In one case with suspected DVT and prior history of DVT, the femoral venous segment in the region of adductor canal was not compressible. The diagnosis of DVT in this segment was excluded on demonstrating normal colour flow signal. This is in correlation with the study by Wright DJ et al in 1990 who had stated that, it is difficult to demonstrate the compressibility of the vein due to thick muscular structure as in adductor canal.

Free floating thrombus:

In present study, only one case with acute DVT showed free floating proximal end of thrombus. Norris CS et al in 1985 found 5 cases out of 78 (6%) with free-floating thrombi on venography.

Presence of signal void even on augmentation was considered as a criteria for DVT which was found in all 21 cases with complete thrombosis. Eccentric flow was demonstrated in 10 patients with partial thrombosis. The colour Doppler flow imaging diagnosis based primarily on the presence of a focal void within the colour encoded blood flow or the absence of visible flow within a segment of a vessel, correlated with the study by Rose SC et al in 1990.

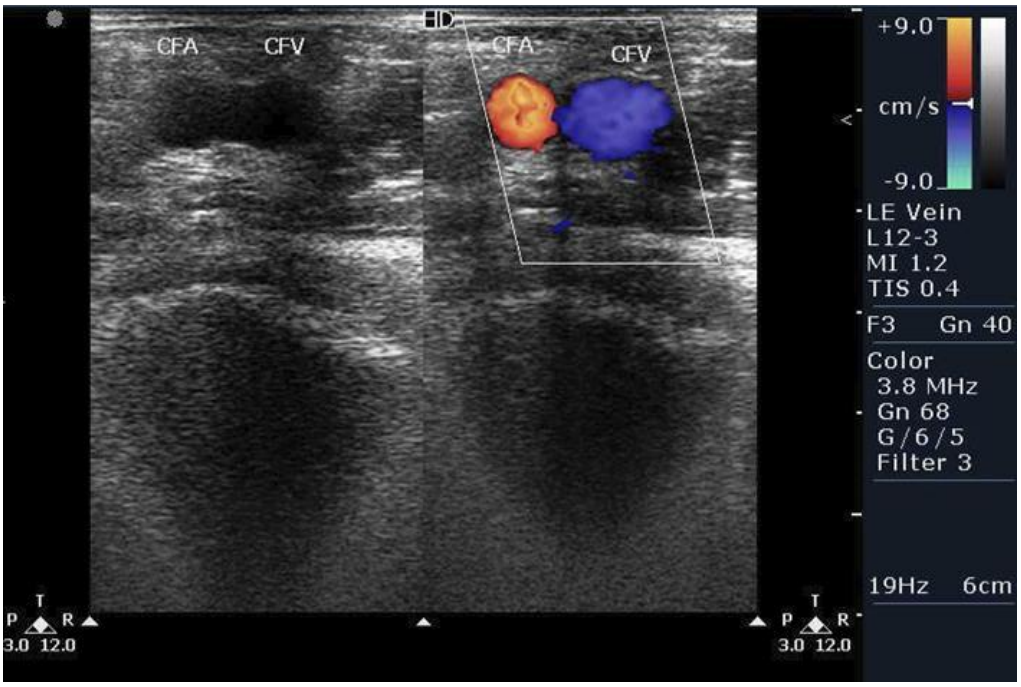
In 3 patients with acute DVT collaterals were demonstrated while in 5 patients with chronic DVT collaterals and increased flow through saphenous veins was demonstrated. This correlated with the study by Persson AV et al in 1989, who found an increase in the size and flow in collateral veins, in the majority of patients with acute deep venous thrombosis.

All the 3 cases with CIV involvement and 8 cases with EIV involvement showed contiguous involvement of femoral venous system.

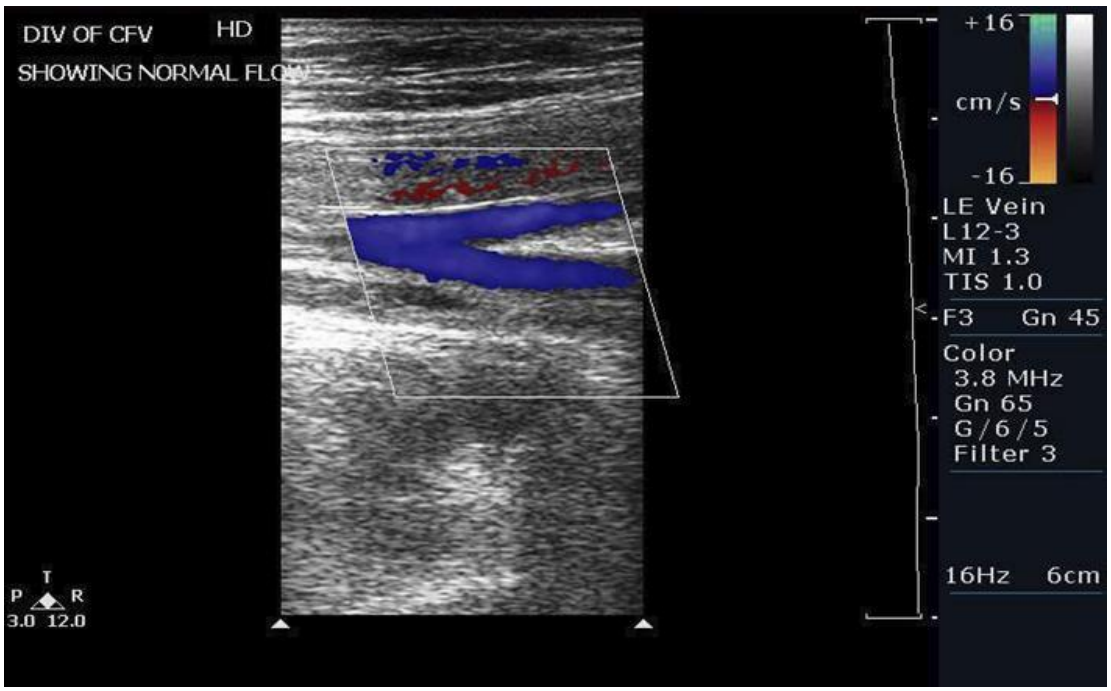
Conditions mimicking DVT:

9 cases (22.5%) in the study population demonstrated clinical conditions mimicking DVT, 1 showed presence of Baker's cyst, 1 had ruptured Baker's cyst at clinical presentation with pain and marked swelling of the calf, clinically indistinguishable from DVT. 2 cases showed evidence of cellulitis with subcutaneous swelling. Inflamed bursa was found in 2 cases as the cause of pain in patients with suspected DVT of which one was associated with fascitis.

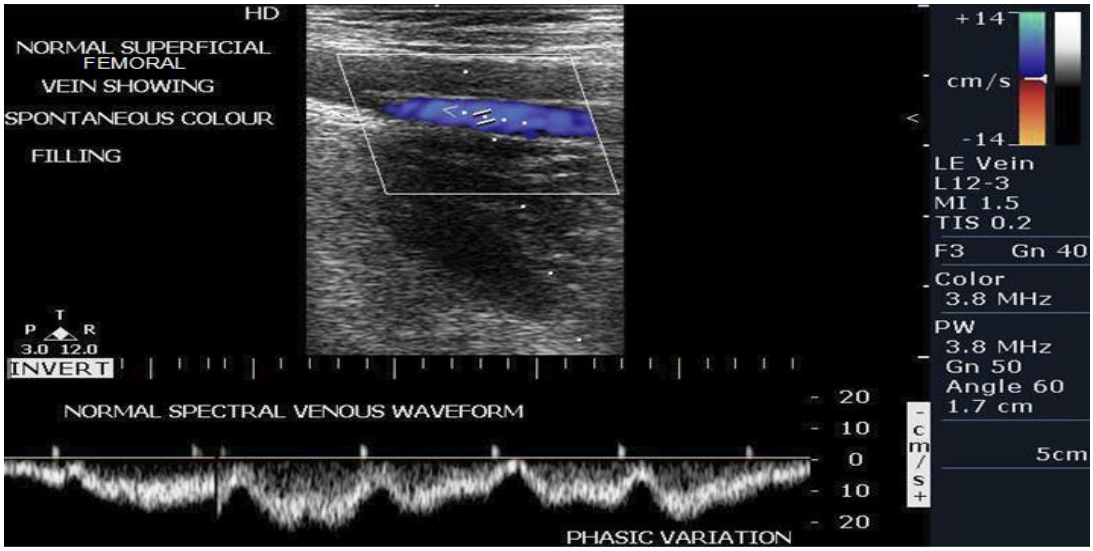
Additional finding of intramuscular haematoma was found in the left rectus femoris muscle in 2 patients who also had Doppler evidence of partially recanalized thrombus in distal SFV. Probably it might have also contributed to the presenting symptom of pain in the case.



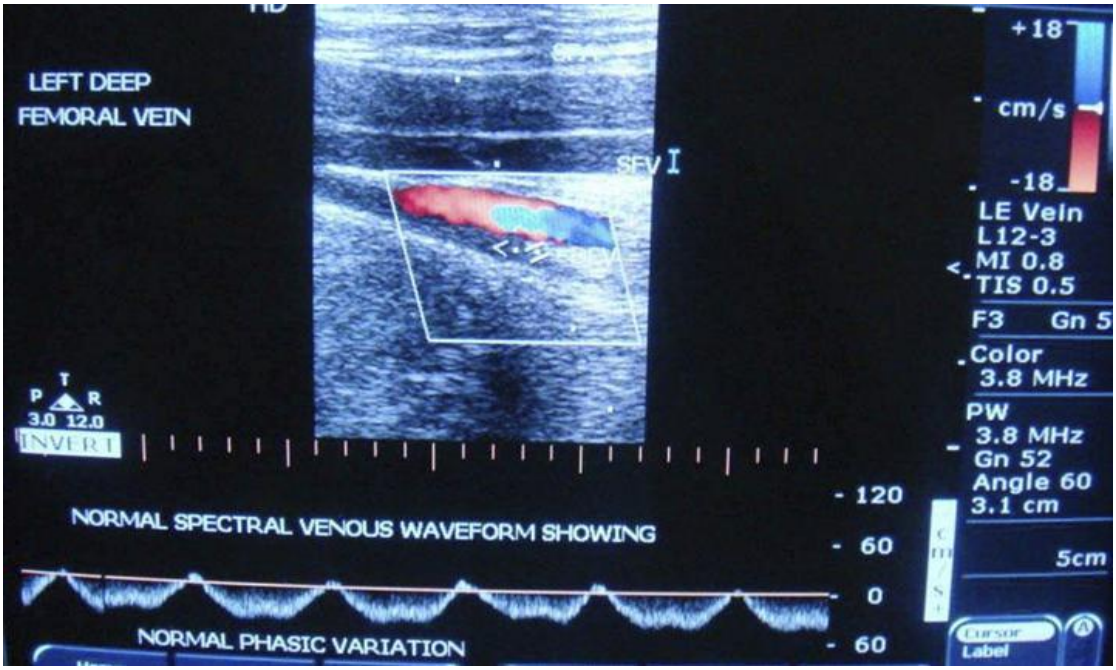
Transverse image of the common femoral vein in the groin : showing normal caliber and spontaneous colour filling on colour flow image (Right) suggestive of normal CFV



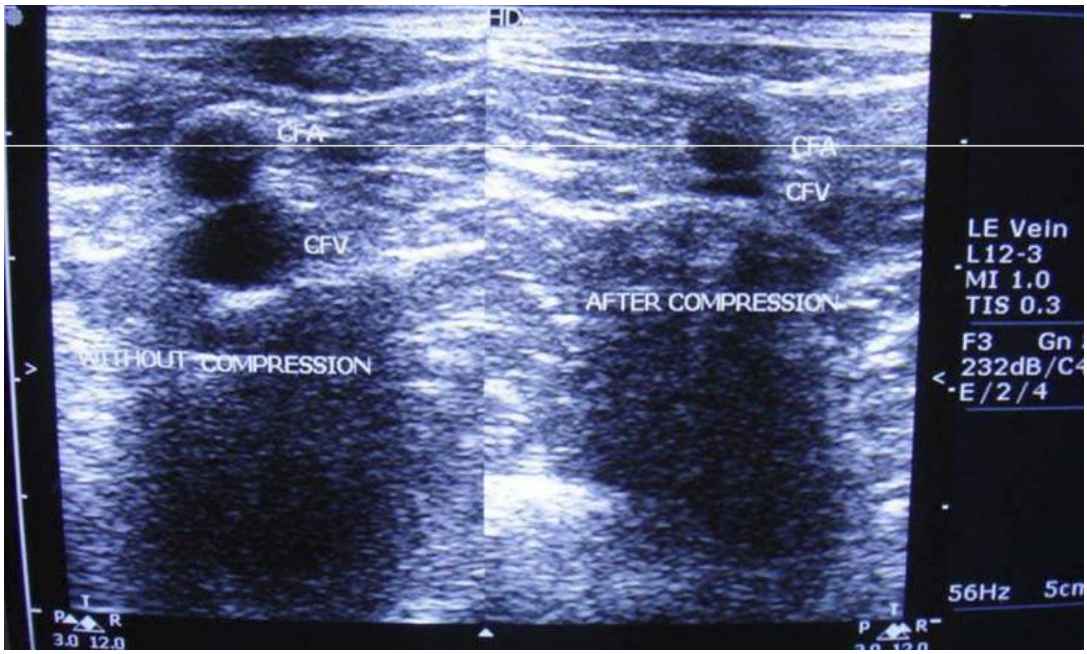
Longitudinal image showing normal anatomical confluence of superficial and deep femoral vein uniting to form common femoral vein with normal colour flow noted in all the veins



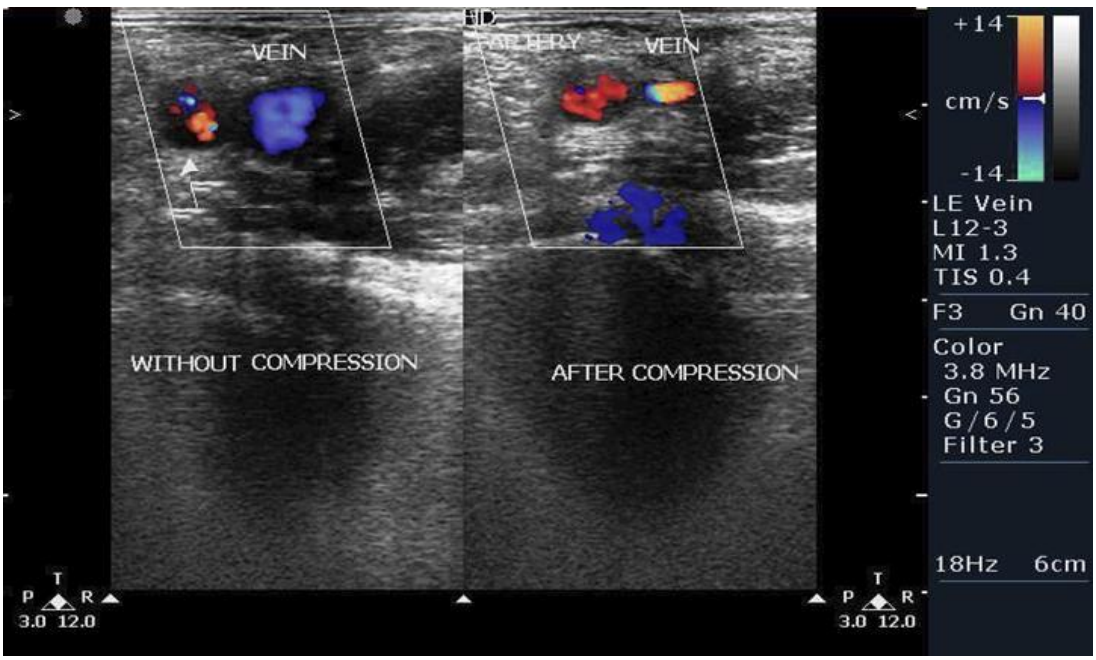
Longitudinal image of the normal superficial femoral vein : showing normal respiro-phasic variation.



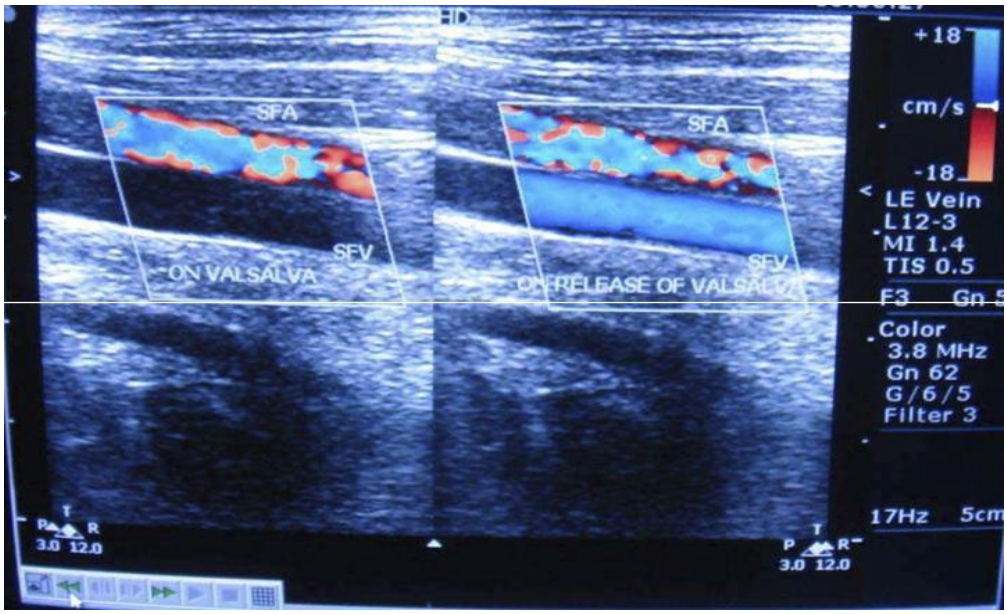
Longitudinal image of the normal deep femoral vein showing : normal spectral venous wave form along with demonstrating normal respiro-phasic variation.



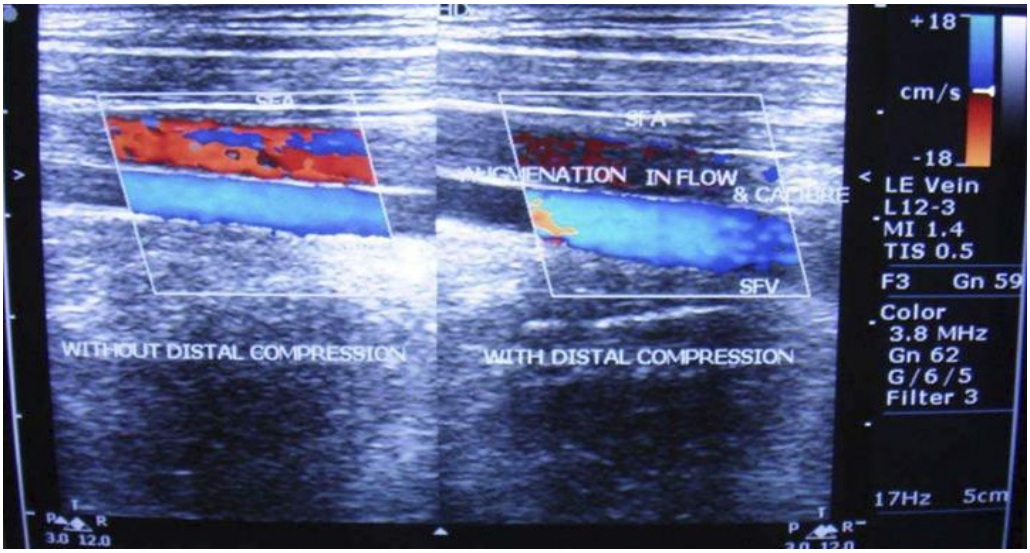
Transverse B-mode view of normal compressibility of CFV : on left prior to compression, vein is seen as round anechoic structure just beneath the artery on compression (Right image) the vein is completely compressed suggestive of normal compressibility



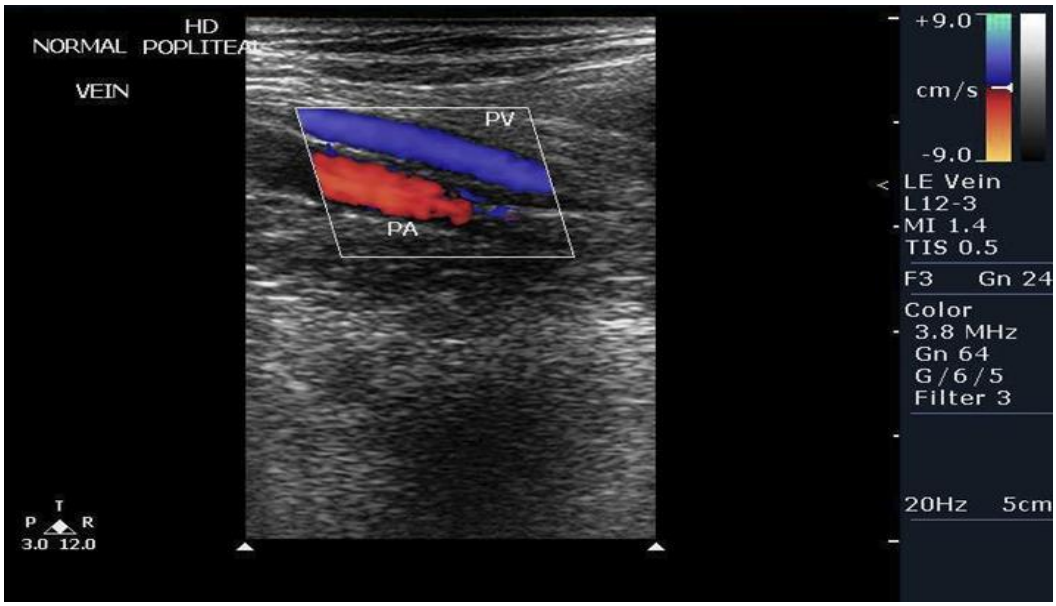
Transverse colour flow image of normal vein showing compressibility



Longitudinal image of normal lower extremity vein showing changes on valsalva maneuver : to the left, deep inspiration followed by bearing down results in the abrupt cessation of blood flow. Reversed flow does not occur, indicating that the extremity valves are competent. Flow resumes promptly with exhalation (right).

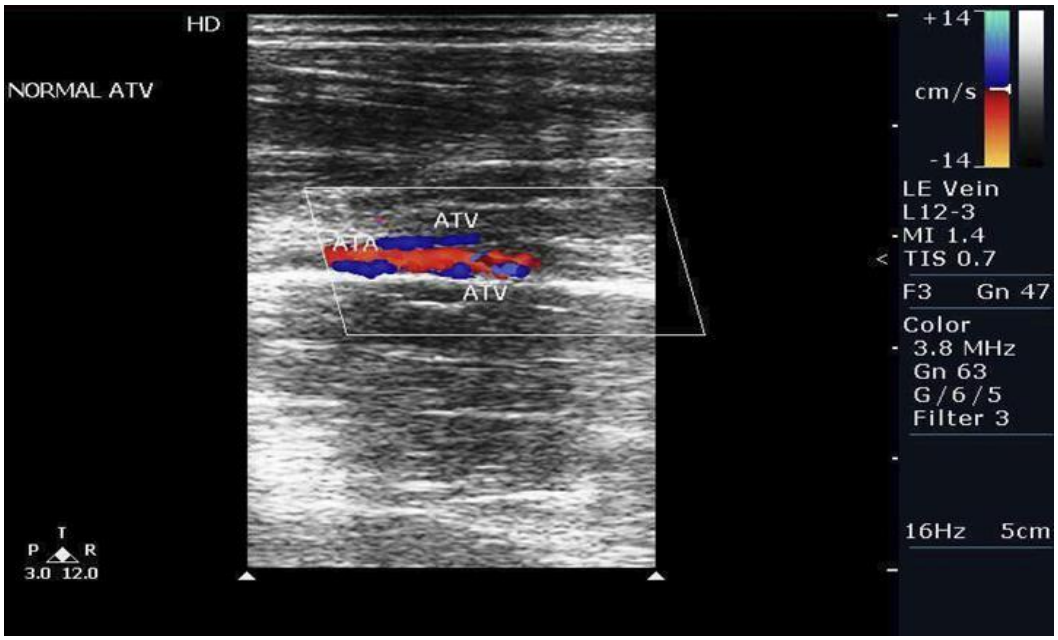


Longitudinal image of normal lower extremity vein showing changes on augmentation: to the right, gentle calf compression results in dramatic increase in flow velocity in the common femoral vein with increase in the caliber of the vein. This finding confirms substantial patency of the veins between the calf and the common femoral vein.

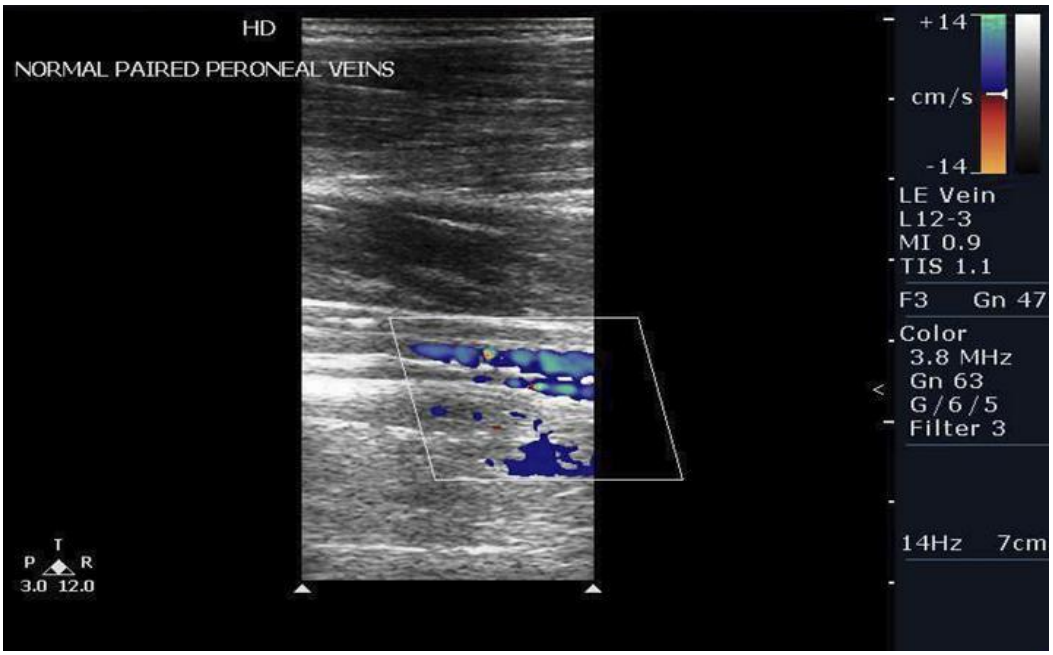


Longitudinal image of the popliteal vein : showing normal spontaneous colour filling of popliteal vein

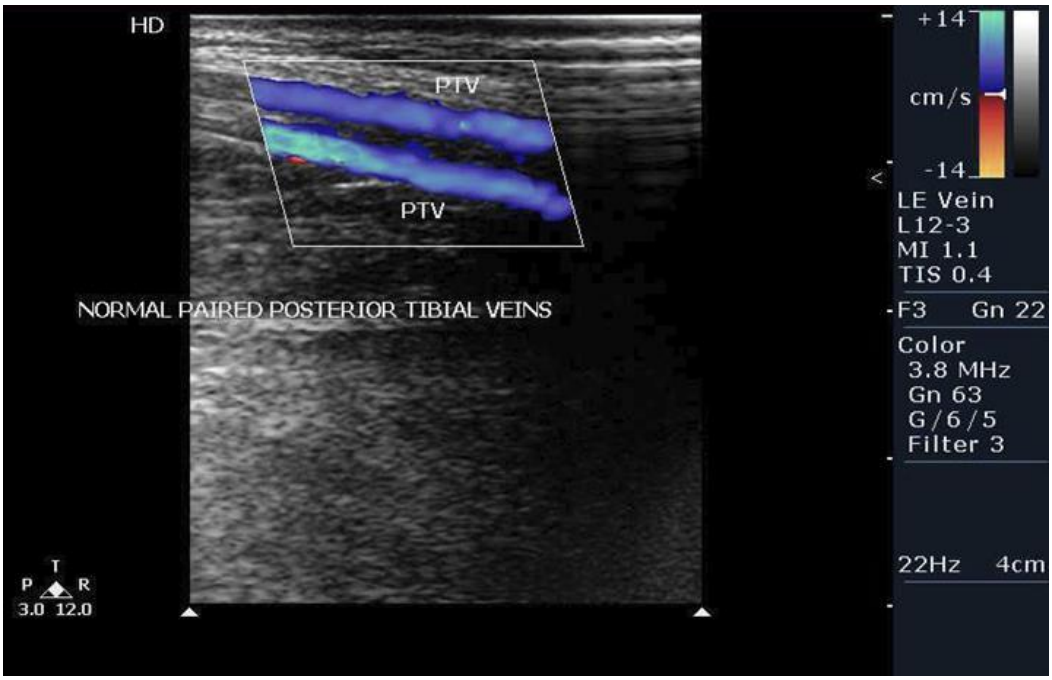
Longitudinal image of the popliteal vein : showing normal spectral venous wave form of popliteal vein



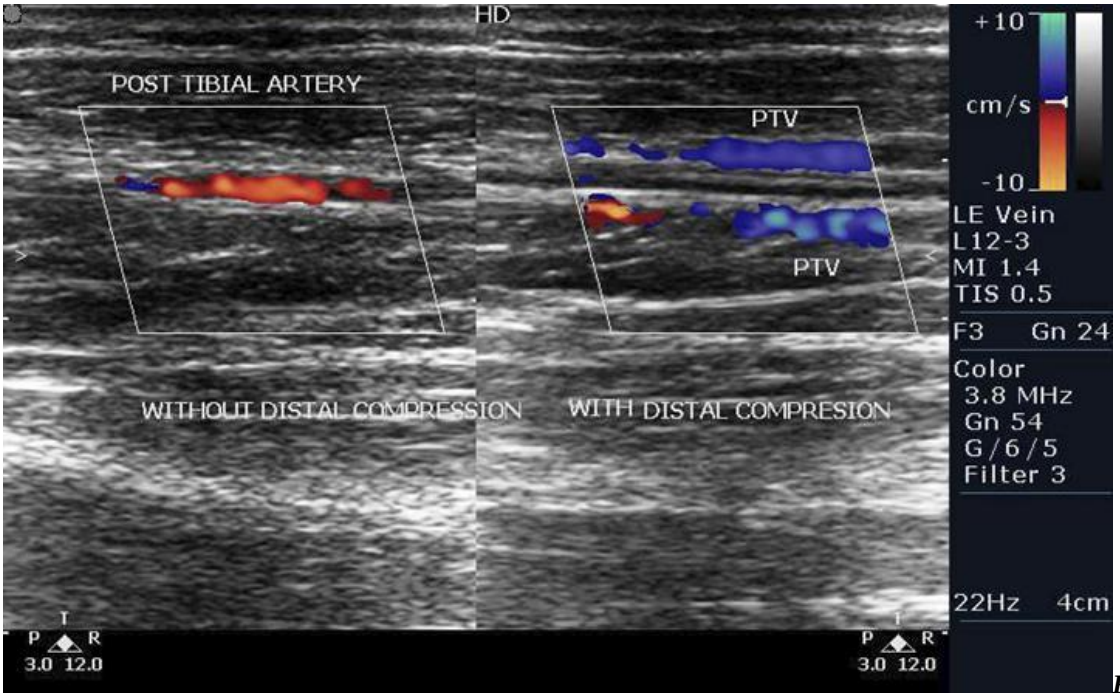
Longitudinal image of the normal paired anterior tibial veins : showing normal paired anterior tibial veins with spontaneous colour flow



Longitudinal image of normal paired peroneal veins: showing normal paired peroneal veins with spontaneous colour flow



Longitudinal image of normal paired posterior tibial veins : showing normal paired posterior tibial veins with spontaneous colour flow



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Longitudinal image of flow augmenatation in posterior tibial vein showing normal paired posterior tibial veins demonstrating augmentation in flow on distal compression

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