International Journal Dental and Medical Sciences Research
Volume 4, Issue 4, July-Aug 2022 pp 781-801 www.ijdmsrjournal.com ISSN: 2582-6018

# Role of Colour Doppler Ultrasound in the Evaluation of Deep Vein Thrombosis of the Lower Limbs.

Dr.VanajaBulkapuram, Dr.VeenaMadireddy, Dr.Aswini Jyothi Jayam Subramanyam

*Assistant Professor of Radiology, Osmania Medical College, Hyderabad, Telangana, India*
*Professor of Radiology, Government Medical College, Sangareddy, Telangana, India.*
*Professor of Radiology, Osmania Medical College, Hyderabad, Telangana, India*

Submitted: 15-08-2022 Accepted: 30-08-2022

**ABSTRACT**
The diagnosis of deep vein thrombosis has always been difficult. 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.

**KEY WORDS-** Colour doppler, Deep venous thrombosis, Compressibility, Valsalva maneuver, Doppler effect.

## I. INTRODUCTION

Deep Vein Thrombosis of lower extremities is one 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 is also a most timely subject as it continues to be an elusive diagnosis. Failure to detect deep venous thrombosis, can lead to catastrophic results. 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 phlebitis syndrome. (1) Development of a thrombus within a vein may be considered functionally as an exaggeration of the normal process of hemostasis. Group of patient with the high risk of developing DVT are the patients after a major surgery, trauma, prolonged immobilization and postoperative convalescence. Other risk factors to mention are neoplasms, pregnancy, oral contraceptive pills and hyper coaguablestates. Formation of clotted blood within the non-interrupted vascular system is called thrombus. A DVT occurs along a continuum with propagation, extension and progression. (2) 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.Evenamongthefractionofpatientswithdeepveinthrombosiswhohavesymptomsinthe lower extremities, fewer than the third present with classic syndrome of calf discomfort, edema, venous distension, and pain on forced dorsiflexion of the foot (Homans sign). When symptoms are initially attributed to deep vein thrombosis, reassessment by objective methods shows that this attribution is correctless than half the time.

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

The introduction of Doppler ultra sound 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 noninvasive, repeatable, can be performed rapidly in the clinic, at patient & #39;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, painless inexpensive. The present study aims to evaluate the role of colour Doppler clinically suspected patients of deep venous thrombosis of lower limbs.

### AIMS AND OBJECTIVES

**AIM:**
Toassesstheroleofcolourdopplerusgin evaluationofdeepveinthrombosis ofthelowerlimbs.

International Journal Dental and Medical Sciences Research
Volume 4, Issue 4, July-Aug 2022 pp 781-801 www.ijdmsrjournal.com ISSN: 2582-6018

**OBJECTIVES:**

1. TostudythespectrumoffindingsoncolourDopplerultrasoundinpatientswhopresentedwithclinicalsymptomsandsignsof deepvenousthrombosis.
2. Toevaluatethedistributionofthrombiinproximalanddistaldeepveinsof Lowerlimbs.
3. Toknowthesensitivity,specificityandreliabilityofultrasoundindetectionofdeepveinthrombosis.

**INSTRUMENTATION**

**Doppler Effect:**

The Doppler effect is the phenomenon by which the frequency of a wave received after reflection by a moving target is shifted from that of the source. The phenomenon can be explained by considering the compression of transmitted waves into a contracting space and viceversa.

An ultrasound acoustic wave is a longitudinal compressional wave consisting of a series of compressions and rarefactions. The characteristics of acoustic wave important for understandingtheDoppler effectare propagation velocity, frequency, reflection and scattering.

In medical USG the Doppler signal, of interest are predominantly the result of scattering fromRBC"s[21].

Dopplershiftoccurswhenreflectorsmoverelativetothetransducer.Movementofthereflector (i.e. movement due to flowing blood cells) results in change in wavelength. The frequency of echosignalsfrommovingreflectorsishigherorlowerthanthefrequencytransmitted by the transducer, depending on whether themotion is towards or away from thetransducer. The Doppler shift frequency is the difference between the received and transmittedfrequencies[13].

**Doppler Equation:**

Whenthespeedofultrasoundinthemediumisc,thetransmittedfrequencyisf,thevelocityof reflector towards the transducer is Vr, the wavelength of the waves (λs) traveling from thesource tothereflectorisgivenby

$\lambda s = C/f$ _____(1)

As the reflector is moving either towards or away from the source, it encounters more or lesscyclesrespectivelyofultrasoundthanitwouldhavedonehadit beenstationary.

Theactualnumber of extracyclespersecond=$Vr/\lambda s$.

This frequency is added to the frequency transmitted by the source to obtain the frequency,whichisreradiatedtowardsthereceiverbythereflector.

TheDopplerfrequency (fD)is thus

$fD = 2Vr/\lambda s = 2fVr/c$ (2)

(Substituting$\lambda s$fromequation (1)).

Thefactortwoappearsintheequationasthereflectedwavesarefurthercompressedinspacedueto reflectoritselfmovingtowardsthetransducer.

Inpractice,itisseldomthecasethatthereflectormovesexactlyalongtheeffectivedirectionof the ultrasound beam. The direction of movement of the reflector and the ultrasonic beamareatsomeanglecalledangleofattack(θ).

TheDoppler frequencyshiftarises becausethereflector has aneffectivecomponentofvelocity (Veff) along the direction of the ultrasonic beam, the magnitude of which is calculatedbytrigonometricrelationship.

$Veff = VrCOS\theta$.

The Doppler shift frequency is thus given by$F_D = 2fV_r\cos\theta/c$

The angle of attack (θ) strongly influences the detected doppler frequency for a given velocityreflector

When θ=O

Then cosθ= 1 and Vr= Veff

For the sound beam incident at an angle other than $0^0$, the detected Doppler frequency isreduced according to the cos θ term. The transducer beam is usually oriented to make a 30to60degreeanglewiththevessellumen.

International Journal Dental and Medical Sciences Research
Volume 4, Issue 4, July-Aug 2022 pp 781-801 www.ijdmsrjournal.com ISSN: 2582-6018

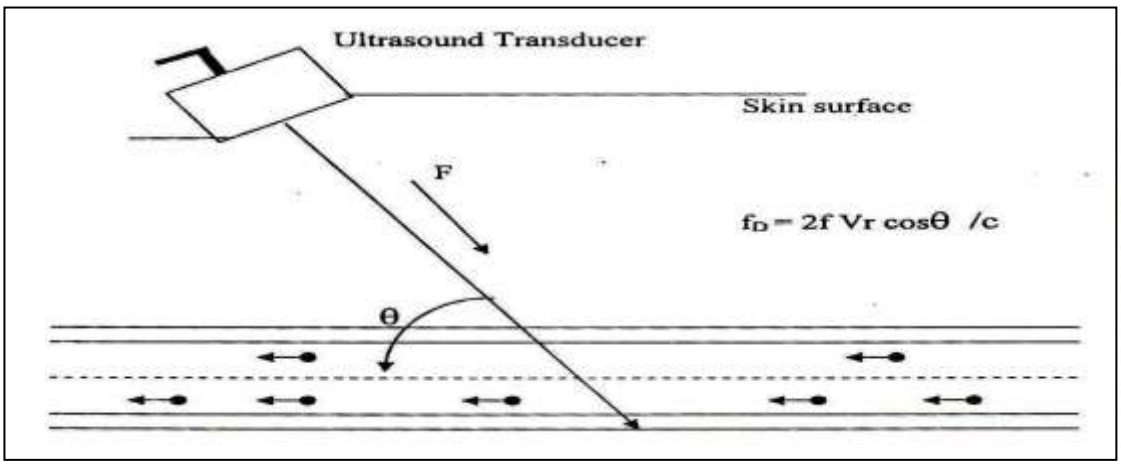



**Fig. 1: Principles of Doppler Effect Arrangement for detectingDoppler signals from blood. The angle θ is the Doppler angle,which is the angle between the direction of motion and thebeam axis,lookingtowardsthetransducer.**

**INSTRUMENTATION:**
The ideal instrument for venous studies comprise a high resolution gray-scale imager withpulsedandcolourDopplercapabilitiessensitiveto low-flow states.

**ContinuousWaveDoppler:**
Continuous Wave Doppler operation is used in a variety of instruments, ranging from simple,inexpensive hand held Doppler units to duplex scanners in which CW Doppler may be one oftheseveraloperatingmodes.Thetransmitterisoncon tinuously.
With CW Doppler instruments, reflectors and scatterers anywhere within the beam of thetransducer contribute to the instantaneous Doppler signal. The frequency difference signalmay be presented audibly as well as graphically[10]. Only the magnitude of the Dopplerfrequencyisdetected.
A continuous wave pencil probe is available on some commercially available duplex equipmentandcanbeveryuseful for peri-orbitalDopplerstudiesandfor tumorevaluation.

**Advantage:**Thissystemmeasureawiderangeofveloci ties without limit[10].

**Disadvantages:**
1. Lackofaxial resolutionastheDopplersamplevolume includesallstructureswithin the entire overlapping regions of the transmitted and received beams, allowing vascularstructuresatdifferentdepthtobesampled simultaneously.
2. It doesnot indicate thedirectionflow, whetherit is towards orawayfromthe transducer.

**PulsedwaveDoppler**[9]
Pulsedwavedoppler overcomesthe positioninsensitivity ofCWD to alargeextent. Themajordifferencebetweenpulsedandcontinuousw avesistheamountoftimethatthebeamisturnedon.Asin gletransducerassemblytransmitsthesoundpulseandd etectsthe
returning echo. The time delay between the pulse and the returning echo depends on thevelocity ofsoundanddirectlyrelatestothedepthofthereflector.
**Advantage:** Itispossibletomeasureselectivelythevel ocityatspecificlocationsinthebeam.

**Disadvantages:**
1) Parameters including pulselength and duty cycle place an upper limit on themaximumvelocitythatcanbe measured.
2) Theprecisesourceisdifficulttodetermineast hepictureofsubsurfaceanatomyisnotshown.

**PulseDuplexDoppler:**
Duplex ultrasound instruments are real time B-mode scanners with built in Doppler capabilities. Duplex imaging is possible with a single machine that produces both image and velocityinformation. As the optimal requirements for imaging and velocity information are slightlydifferent,many
systemsusetwotransducerslocatedinone probefordupleximaging[8].
This device allows the operator to interrogate the flow characteristics of any isolated area

International Journal Dental and Medical Sciences Research
Volume 4, Issue 4, July-Aug 2022 pp 781-801 www.ijdmsrjournal.com ISSN: 2582-6018

onthecorrespondingBimageandtodisplaytheflowdataasacontinuoustimevelocitywaveform called Doppler spectral waveform. It detects all the velocities within the region ofinterest together with their variation in time over the cardiac and respiratory cycles. Thetechnique thus provides a temporal display of hemodynamics. It is clinically useful in evaluatingcarotidvessels, foetal,uterineandabdominalvessels.

**Spectralwaveform:**

The Doppler spectrum is an image of the Doppler frequencies produced by the moving blood.Itisquantitativegraphicdisplayofvelocitiesand directionsofmovingRBCspresentinDopplersamplevolume.

TheDoppler spectrum displaysvelocities onY- axis andtime on X-axis. Frequency shiftisfirst calculated and then the angle between the Doppler beam and long axis of blood ismeasured. Taking both these into consideration and in addition to the knowledge of originalfrequencybeam,thevelocityofsoundiscalculated.

ComplexmathematicalprocessescalledtheFast Fouriertransformationdo this.

The frequency spectrum shows blood flow from a specific location called "Doppler samplevolume". Flow towards the transducer is displayed above the spectral base line while flow inopposite directionisshownbelowthebaseline.

VariousDopplerindiceshavebeenevaluatedforquantitativeassessmentofDopplerwaveform.

TheyarebasedonPSV,EDVandmeanvelocity(M).

**The commonlyused indicesare:**

1) Pulsatilityindex=$\frac{PSV-EDV}{M}$

2) Resistanceindex =$\frac{PSV-EDV}{PSV}$

3) Systolictodiastolicratio=$\frac{PSV}{EDV}$

**ColourDopplersonography:**

This has been one of the most remarkable developments in US instrumentation .This methodextractsvelocityinformationfromthereturningechoesandaddstheinformationtotheconventionaltwodimensionalimageascolourinformation.[6,7]

Itis thereal-time encodingofthe Dopplerflowsignalisasacolourmap.[6,7]

Returning echoes are analyzed for amplitude, phase and frequency shift. Amplitude dataprovide a gray scale or tissue image. Moving targets produce phase and frequency shifts.Colour assignment (either blue or red) depends on flow direction with respect to the transducerandisselectedbytheoperator.Coloursaturationorhuereflecttheextentoffrequencyshift, which is dependent on flow velocity and the angle of the sound beam in relation to thelongitudinalaxisoftheflowlumen.

High frequency shifts result in greater colour saturation towards the whiter shades of red andblue. The amplitude of doppler signal is dependent on power output, reflectivity of the movingRBCs and receiver gain. A display threshold setting controls the amplitude of the colour flowsignalonthevideo-displayterminal.[22]

Framerates iscolourflowimaging are lowerthanframerates instandard B modeimaging.

In colour flow Doppler imaging, the velocity of flow and direction of flow is determined. Thevelocity information for the entire image is made available.[21] This imaging is done byestimatinganddisplayingthemeanvelocityofscatterersandreflectorsinascannedregion

.The Doppler shift is determined by the above mentioned equation. The direction of flow isdecided by whether the returning echo has a frequency higher or lower than the frequencytransmittedbythetransducer.

A higher frequency i.e. a positive Doppler shift indicates that flow is towards the transducer.Lower frequencyor negativeDoppler shiftindicatesthatflowis awayfromthetransducer.

Byconvention flowtowardsthetransduceris designatedinredcolour and flow

International Journal Dental and Medical Sciences Research
Volume 4, Issue 4, July-Aug 2022 pp 781-801 www.ijdmsrjournal.com ISSN: 2582-6018

awayfromitisseeninbluecolour.Howeverthiscanbeinterchanged.
The blood moves slowly in the veins, so different settings are used. Most scanners come withamenuofrecommendedsettingsfordifferentapplicationsincludingperipheralvenousstudies[23].

**Advantagesofcolourflowimaging:**

1. It permits physiologic and anatomic interrogation of the venous system in realtime[24].
2. Haspotentialtoproducetotallowerextremityvenous imagingstudynon-invasively[22].
3. Technicalefficiency: Presenceofbloodflowcanbeeasilyassessed.
4. Requiresless timeforexamination.
5. Assists insortingout anatomy.
6. Helpsindifferentiatingvascularandnonvascularstructures.
7. Abilitytovisualizespontaneousvenousflowincolour.Withtheadventofslowflowsensitivity software upgrade, spontaneous colour flow signal outlining the full cross sectionalarea oftheveinduringmaximumflowcanbeappreciatedin normalpatients.
8. The location, velocity and direction of flowing blood are displayed in a real time colourDopplerflowimage.
9. Combinestheadvantage ofa compressionsonographictechnique.
10. Demonstrates recanalized venous segments that cannot be shown by compression BmodeUSG.
11. Flowcanbe assessedin entirelumen.
12. Colour flow imaging can detect low velocity flow in residual lumen and helpsindifferentiatingpartial occlusionandtotalocclusion.
13. Improves evaluation of blood flow in the pelvic veins which are amenable toUS compression.

**Disadvantagesofcolourflowimaging:**

1. Flowinformationisqualitative andnot quantitative.
2. LowPRFandlow framerates.

As a lot of information needs to be processed there is a resultant delay. PRF (number ofpulses sent out by the transducer) and frame rate (number of times/second monitor screen isrenewed)bothare reduced.

- Degradationof B modeimage.
- Aliasing.
- Visualizationofrapidlymovingstructuresishampered e.g.cardiacvalves.

3. Flowdetectionisangle dependent.If transduceris keptatangleof900noflowis detected.
4. Flowdirectionisarbitrary.Colourassignedtothetransducerisarbitraryandmaybechanged.
5. Skillandexperiencerequiredtoobtain suitableandsatisfactoryimagesoftheveins. Grey scale mages identify thrombus, duplex assessment provides a measurement ofblood velocity through a vessel and colour Doppler imaging enables the rapid localisation ofocclusion[23].

**EXAMINATION TECHNIQUE IN LOWER LIMB DOPPLER**

**Patient's position:**

Clear visualization of the lower extremity veins requires adequate distention of the venoussystem. Thelower extremity musttherefore be dependent. This canbe accomplished bytilting down the feet at about 15 or 20 degreeor by examining the patient in the sittingposition.[12] All venous segments are examined for the characteristics ofvenous flow and theeffects ofcompression. Spectral analysis is notperformedroutinely asall relevant Doppler information is encoded in a colour flow signal throughout the full length ofthe venous segment being imaged at any one time. [11]

**COLOUR DOPPLER FINDINGS IN VENOUS THROMBOSIS:**

The distinction between acute and chronic thrombus is important because acute DVT has agreaterpotentialtoembolization.Acuteclotisnotwell attachedtoveinwallsandismorelikely to progress proximally. Characterization of clot as acute or chronic also carries importanttherapeuticimplications.

**ACUTETHROMBOSIS:**

It refers to thrombus days to perhaps2 weeks old. Recently formed thrombus is not very echogenic and may be difficult to identifysonographically.Thistypeofthrombuscanbeidentifiedbythefollowingsonographicfeatures:

**1) Lowechogenicityintraluminalmaterialproducingaflowvoid:**Recentlyformedthrombus has low echogenicity, is seen as large anechoic area on the grey-scale image andthough difficult to visualize, is identified by a flow void on colour Doppler images.[16] Patientswith a largeanechoic clotusually have ahistory ofDVT ofless than

International Journal Dental and Medical Sciences Research
Volume 4, Issue 4, July-Aug 2022 pp 781-801 www.ijdmsrjournal.com ISSN: 2582-6018

oneweek duration.Olderclotsaremoreechogenic.
The absence of spontaneous flow is characteristics of complete venous thrombosis.[14] Smalland non-occlusive thrombi, which are also difficult to visualize, are indicated by a flow void oncolourDopplerimages.

**2) Venousdistension:**

Increase venous diameter is a sign of acute clot.[15] The acutely thrombosed vein enlarges totwicethesizeofthecorrespondingarteryinmanypatients.
Exception ispartialocclusion.
Venous distension is a significant finding because it helps to distinguish between acute andolder thrombus. In late cases, the thrombosed vein may be normal in size or smaller thanadjacent artery.[10] A significant correlation exists between the age of thrombosis and thevenous diameter ($p < 0.001$).
Lossofcompressibility:
Excellent results for diagnosing venous thrombosis of any age have been reported on thebasis ofthiscriteriaalone.Completecompressionoftheveno uslumen is the most reliable criteria of normality when one evaluates the possibility of DVT.[14] The degree of force necessary to completely collapse the vein lumen may be greater whenexamining the calf veins than when examining the femoro-popliteal system.[12] If the collapseof the vein is incomplete following compression, it indicates the presence of partially occludingthrombus.
But it is difficult to demonstrate the compressibility, if the vein is surrounded by thick muscularstructure as in adductor canal.[16]
Compression US usually have sensitivity of88%andspecificityof96%foridentificationofcalfvein thrombosis.[16]

**a. Free floating thrombus:**Proximal end ofacute thrombus may not adhere to the veinwall. In such cases the thrombus is freely floating in the venous lumen and has potential forpulmonary embolization. Unnecessary manipulation of such a vein is dangerous thoughrarely,dislodgementofathrombus during USGexaminationhasbeenreported.[17]

**b. Doppler signal abnormalities: -** When the Doppler probe is directly over an obstructedvein,nospontaneoussignalwillbedetected.

- If the probe is over a patent vein but distal to an obstruction, the signal may be absent orreducedand isoftencontinuous, showinglittlerespiratory variation.
- Although augmentation may be observed withpartial venous occlusion, astrong responseisusuallynotseenwithcompletevenousocclusion.Aweakresponsesuggestspartialthrombosisorcompleteocclusionwithvenousreturnviacollaterals.[13]
- Little or no increase in flow will be detected with limb compression when the probe ispositioned cephalad to an obstruction, although the spontaneous flow pattern may closelyresemblethatfoundin normallimbs.
- Non-occlusivemuralthrombus has asingleeccentricflowlumen.[12]
- When the normal phasic pattern is absent in a vein it is called continuous flow.Thisflowpatternindicates substantialobstructionproximalordistal tothe siteof thrombus.

Doppler examination. The phasic pattern may persist when thrombus does not substantiallyobstruct the vein lumen and therefore identification of a phasic flow pattern does not excludethrombosis.[9]

**c. ValsalvaManeuver:**

This technique is used to verify indirectly the patency of deep venous system in the abdomenand pelvis.

In normal iliofemoral venous system, the diameter of the CFV increases in response to thismaneuverorduringcoughingifthemaneuverisinsufficient.
This criteria does not apply to DVT distal to the CFV. The sensitivity and specificity of thiscriteriontobe93%and100%respectively.[17]

**d. Collateralisation**:

Peri-arterial and intramuscular collateral venous channels enlarge rapidly during the acutephaseofvenousthrombosisandthesechannelsare oftenvisibleduringDopplerUSGexamination.Thefeaturessuggestiveofcollateralsare:

1. A vein located 1 cm or so away from the artery is almost surely a collateral. Normally amajordeepveinisimmediatelyadjacenttothearteryofthesame name.
2. Tracingtheveineitherproximallyordistally.Majordeepveinsarestraightandadheretowelldefinedanatomicpathways,whilecollateralsareusuallycircuitousanddifficulttofollow.
3. Collaterals being quite superficial are obliterated by minimal compression oftheskin bytheoverlyingprobewhilemajordeepveinislittleaffected.

International Journal Dental and Medical Sciences Research
Volume 4, Issue 4, July-Aug 2022 pp 781-801 www.ijdmsrjournal.com ISSN: 2582-6018

**CHRONIC THROMBOSIS :**

1) **Increasedechogenicity:**Thethrombusgradually becomesmoreechogenic.

Heterogeneityis observedduringclotandrecanalizationmaybecausedbyclotfragmentationorpenetrationbycapillaries.VisualizationofanechogenicbandintheCFV, PVorbothisconsideredtobeahighlysensitivecriterionforproximalveinthrombosisandhassensitivityof99%andspecificityof52%.[19]

2) **Incompletecompression:**Thisisduetointimalthickeninginarecanalizedveinorlesscommonlypersistentvenousocclusionbyorganisedthrombus.Intheformercircumstance,theveinisseentocompresssothattherecanalizedlumenisobliterated.Howevertheouterveinwallsdonotcoapt asaresultoftheinterposedthickenedintima.
3) **Decreasedthrombussize:**Detraction and lysis mayreducethesizeofthethrombus,asseenonserialexaminations.Clotismorerigidonexaminationa ndmaydemonstrateirregularborders.[20]
4) **Reducedveinsize:**Withretractionandlysisofthethrombus,theveinbecomeslessdistendedandreturnstonormalcaliberormaybecontracted.[19]
5) **Adherenceofthrombus:**Freefloatingacutethrombusbecomesattached toveinwall.
6) **Resumptionofflow:**Withretractionandsubsequentdissolutionofthethrombus,obstruction to the flow may diminish, as revealed by colour Doppler examination. Veins withrecanalizedthrombushas tortuouseccentricflowchannelsfilledwithcolour flowsignal.[18]
7) **Collateral vessels :**They tend to be larger than during the acute phase. However not allthrombosedvesselsrecanalize.Someremainspermanentlyoccluded.[16]

**PITFALLS IN THEDIAGNOSISOF DVT:**

The following pitfalls can occur while performing the lower limb dopplerand caution must beexercised while interpreting the results. Careful and meticulous scanning is required to avoidthemandobtainagoodqualityimage.

1) **Due tosuboptimalimagequality:**Thisresultsin diagnostic error.Thoughvenouspatencycanbeconfirmedgrossly,smallandnonocclusivethrombicannotbeexcluded.

Thefactors beyondoperator's control are:

- Obesity
- Softtissue edema.

Thefactorswhichcanbecontrolledare:

- Transducerwithproperfrequencyandfocalcharacteristics.
- Gainsettings.
- ColourDoppleradjustments.

2) **Compression difficulties:** They are encountered for iliac veins due to restriction fromoverlying abdominal contents. The adductor segment of the CFV and in many patients theproximal calf veins are difficult to compress because of resistance from overlying muscle.Voluntaryandinvoluntarymusclecontractionmayalsolimitthecompression.Thismayleadtothe falsepositivediagnosis ofDVT.Colour Doppler imagingis useful toassess suchareas.
3) **Mistaken identity:**This may lead to serious diagnostic errors. Usually occurs in thepresence ofvenousocclusion,whenalargecollateral ismistakenforanoccludedvein.
4) **Assessment of thrombus age :**Fresh thrombus is anechoic to hypoechoic while chronicthrombus is strongly echogenic. Between these extremes, the age of the thrombus cannot bedeterminedwithcertainty.
5) **Improper use of colour Doppler image :**colour blooming occurs if the sensitivity or gainlevels of the Doppler image are set too high, causing the flow information to bleed into the B-mode image. This may also obscure small to medium sized thrombi. False positive diagnosisof thrombus may occur if spurious flow voids are generated by an improper gain setting, aninadequateDopplerangleoruse ofwrongvelocityrange.

## II. MATERIALS AND METHODS

**Sourceofdata:**

Thepresent studyis carriedouton patientswithclinical suspicionofdeepVenousthrombosisreferredtotheDepartmentofRadioDiagnosis,Osmania Medical College.

Period of study: From January2021 to January 2022.

Studydesign: randomisedcross sectionalstudy.

Samplesize:80

**InclusionCriteria:**

- Clinicallysuspected cases ofDeepvenousthrombosis
- Patientswhoareatrisk ofDVT.

**ExclusionCriteria:**

- Paediatriccases

International Journal Dental and Medical Sciences Research
Volume 4, Issue 4, July-Aug 2022 pp 781-801 www.ijdmsrjournal.com ISSN: 2582-6018

- Neoplasticconditions.

**Methods:**

In allpatients,thefollowingprotocol wasfollowed:

- Detailedclinical history was elicited with referencetoonset,durationandprogress of the symptoms and special reference to risk factors and any evidence suggestiveofpulmonaryembolism.
- Patientswithfollowingsymptomswereincludedi n thestudy.

Pain in the lower limb particularly located to the calf (unilateral or bilateral).
Edema oflowerlimb(unilateralorbilateral)
Pain andedemacombined.
Priorhistoryofdeepveinthrombosis.
Shortnessofbreath (rule outpulmonaryembolism)

Standard examination would evaluate common femoral vein and superficial femoral vein first,followed bypoplitealandcalfveins.Externaliliac veinsandIVC were evaluated at last.Thepatient was examined in supine position with legs abducted and extremely rotated with slightflexionofkneeforevaluationoffemoral venoussegment.Patientwasgivenpronepositionforev aluationofpoplitealvein. Calfveinswere evaluated insupinepositionand the kneeslightly flexed, internally rotated for the anterior tibial veins and externally rotated for theposterior tibial and peroneal veins.7.5MHz linear array transducer was used for femoral andpoplitealvenoussegmentsandcalfveinswhile3.5 MHzconvextransducer wasusedforevaluationofiliacveinsandinferiorvenaca va.

The Doppler report described presence or absence of deep vein thrombosis, location, extent,nature(acuteorchronic)andcomplications,ifan y.

**Machinedetails:**

GE.LOGIQF8ANDLOGIQP5.

- Imagestorage:Harddisc
- Typeoftransducer :Lineararray
- Frequencyoftransducer :3.5MHz,7.5MHz

All patients included in the study were evaluated by the above mentioned colour Dopplerultrasoundmachine.

## III. OBSERVATION AND RESULTS

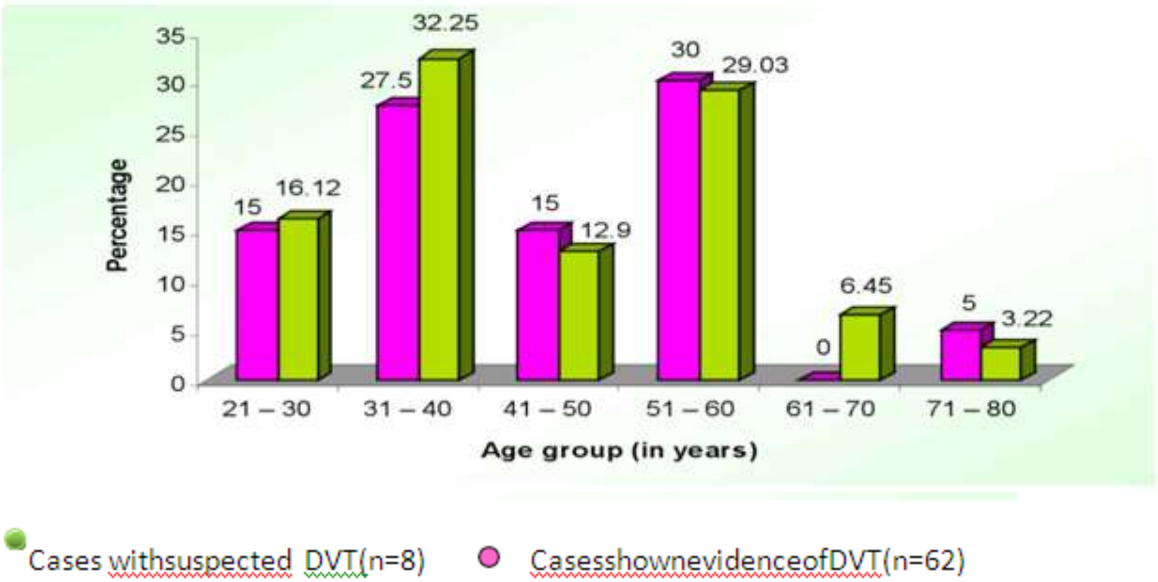
**TABLE–1:AGE DISTRIBUTION**

Astudyof80patientswithsymptomsoflowerextremitieswereincludedinthisstudy.Followingobservationweremade.

| **Agegroup (inyears)** | **Caseswith suspectedDVT(n=80)** | | **Caseswithev-idence of DVT(n=62)** | | **Rate of evi-dence of DVTagainstsus-pected(%)** |
|---|---|---|---|---|---|
| | **No.** | **Percentage** | **No.** | **Percentage** | |
| 21–30 | 12 | 15 | 10 | 16.12 | 83.33 |
| 31–40 | 22 | 27.5 | 20 | 32.25 | 90.90 |
| 41–50 | 12 | 15 | 8 | 12.90 | 66.66 |
| 51–60 | 24 | 30 | 18 | 29.03 | 75.0 |
| 61-70 | 6 | 7..5 | 4 | 6.45 | 66.66 |
| 71–80 | 4 | 5 | 2 | 3.22 | 50 |
| Total | 80 | 100 | 62 | 100 | 77.5 |

Ageofpatientsrangedfrom21to79yrs.57.5%patients wereolderthan40yrsofage.The meanageofcasessuspected tohaveDVTbeing48.7yrs and meanageofcasesshowntohaveDVTbeing46.25yrs.

International Journal Dental and Medical Sciences Research
Volume 4, Issue 4, July-Aug 2022 pp 781-801 www.ijdmsrjournal.com ISSN: 2582-6018

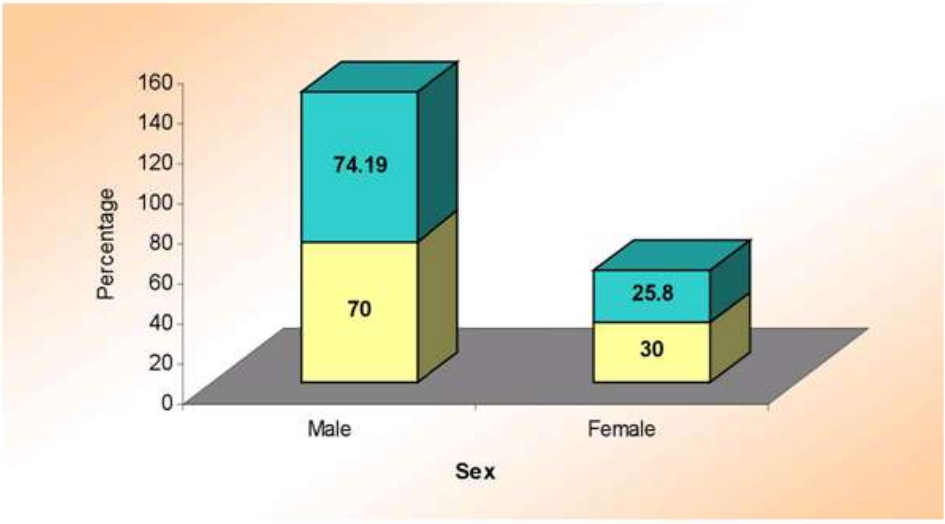



**TABLE–2:SEXDISTRIBUTION**

| Sex | CaseswithsuspectedDVT (n=80) | | Casesshownevidenceof DVT(n =62) | |
|---|---|---|---|---|
| | **No.** | **Percentage** | **No.** | **Percentage** |
| Male | 56 | 70 | 46 | 74.19 |
| Female | 24 | 30 | 16 | 25.80 |
| Total | 80 | 100 | 62 | 100 |

Malepredominancewasfoundinourstudy.Of80patients56(70%)weremales and24(30%)werefemales.

International Journal Dental and Medical Sciences Research
Volume 4, Issue 4, July-Aug 2022 pp 781-801 www.ijdmsrjournal.com ISSN: 2582-6018




Cases with suspectedDVT(n=80) Casesshown evidence ofDVT(n=62)

**TABLE–3:DISTRIBUTIONOFCASESBYSIGNSANDSYMPTOMS (MULTIPLE RESPONSE)**

| **Symptoms** | **Caseswithsuspected DVT(n =80)** | | **Cases shown evi-dence ofDVT (n=62)** | |
|---|---|---|---|---|
| | **No.** | **Percentage** | **No.** | **Percentage** |
| Pain | 16 | 20 | 12 | 19.35 |
| Edema | 32 | 40 | 28 | 45.16 |
| Painand edema | 20 | 25 | 16 | 25.80 |
| Pulmonaryembolism | 6 | 7.5 | 4 | 6.45 |
| Asymptomatic | 6 | 7.5 | 2 | 3.2 |

Thusedema(40%) was themostcommonpresentingsymptominpatients who werediagnosedas DVTon colour Doppler, followed by pain(20%)assecondmostcommonpresentingsymptomin ourstudy.

International Journal Dental and Medical Sciences Research
Volume 4, Issue 4, July-Aug 2022 pp 781-801 www.ijdmsrjournal.com ISSN: 2582-6018

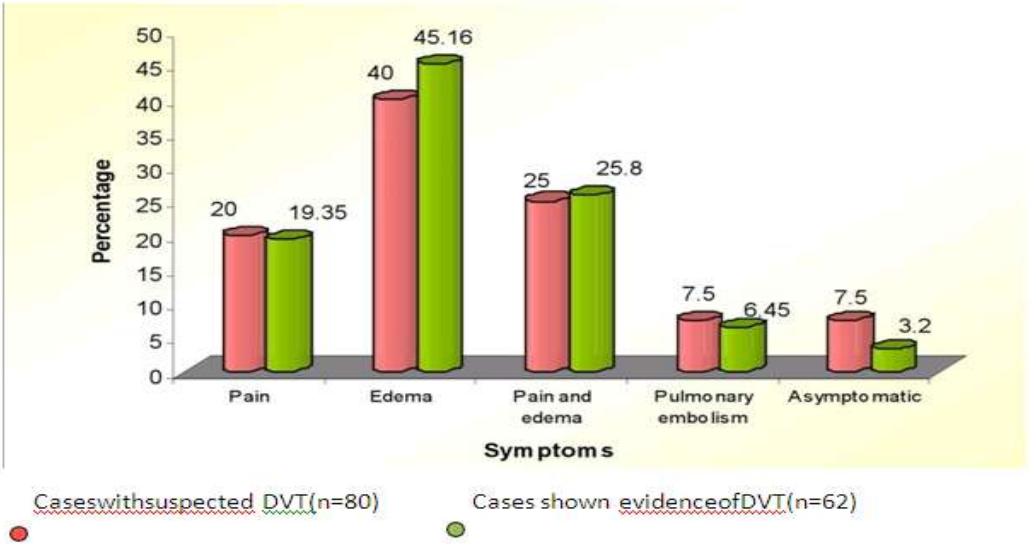



**TABLE – 4: CLINICAL CONDITIONS IN STUDY POPULATION FORDOPPLERULTRASOUNDEXAMINATIONFORSUSPECTEDDVT**

| Clinical conditions | Cases with suspectedDVT(n= | | Cases shown evidenceofDVT(n= | |
|---|---|---|---|---|
| | No. | Percentage | No. | Percentage |
| Prolongedhospitalization | 24 | 30 | 18 | 29.03 |
| Post-operative | 6 | 7.5 | 6 | 9.67 |
| Trauma | 6 | 7.5 | 6 | 9.67 |
| OC pillusers | 4 | 5 | 4 | 6.45 |
| Dialysis | 4 | 5 | 4 | 6.45 |
| Others(Snake bite) | 2 | 2.5 | 2 | 3.22 |
| No knownpredisposingcondition | 34 | 42.5 | 24 | 38.70 |

In our study it was found that prolonged hospitalization (30%) was themostcommonpredisposing factor, followedby post-operative(7.5%) andtrauma (7.5%). Howeverin 42.5% ofpatients with deepvenous thrombosisnopredisposingfactor wasfound.

International Journal Dental and Medical Sciences Research
Volume 4, Issue 4, July-Aug 2022 pp 781-801 www.ijdmsrjournal.com ISSN: 2582-6018

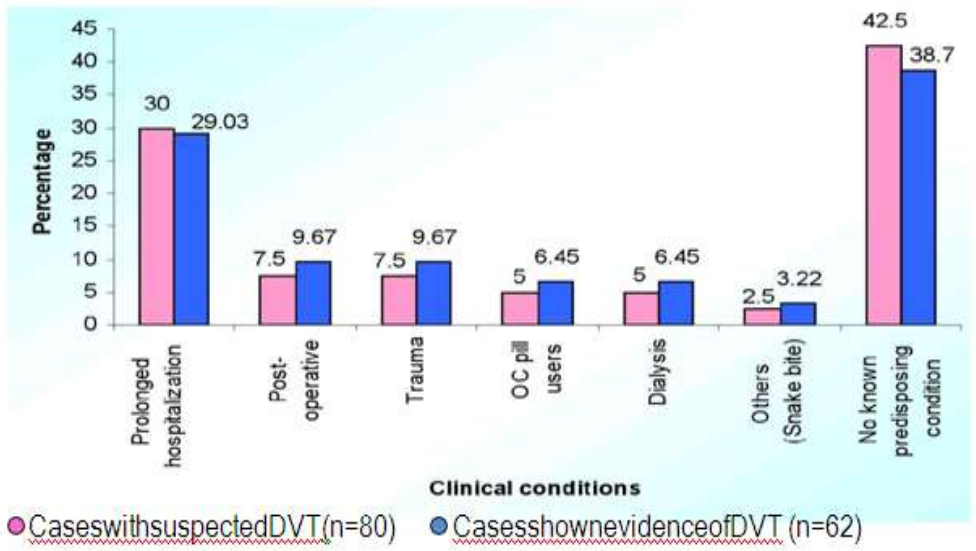



**TABLE – 5 : TYPE OF INVOLVEMENT IN STUDY POP-ULATION EVIDENCE OF DVT ON DOPPLER ULTRA-SONOGRAPHY**

| | **No.ofcases** | **%ofcases** |
|---|---|---|
| Unilateral | 60 | 96.77 |
| Bilateral | 2 | 3.23 |
| Total | 62 | 100 |

International Journal Dental and Medical Sciences Research
Volume 4, Issue 4, July-Aug 2022 pp 781-801 www.ijdmsrjournal.com ISSN: 2582-6018

Ourstudyshowed unilaterallimbpredominance(96.77%).

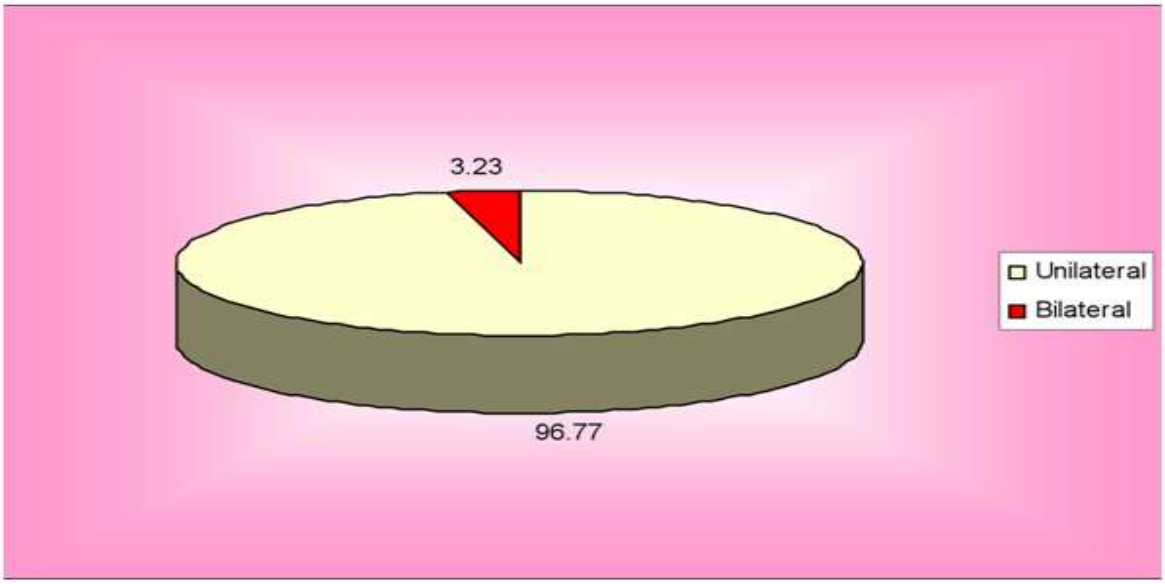



**TABLE – 6 : DISTRIBUTION OF THROMBI IN RIGHT AND LEFTLIMB IN STUDY POPULATION WITH EVIDENCE OF DVT ONDOPPERULTRASONOGRAPHY**

| | **No.ofextremities Involved** | **Percentage(%)of extremitiesinvolved** |
|---|---|---|
| Rightlowerextremity | 16 | 25.80 |
| Leftlowerextremity | 48 | 77.41 |

Twocasesbeingshowingbilateralinvolvement,totalnumberofextremitiesshownevidenceofthrombosisare64. Leftlowerextremitypredominancewas notedinourstudy.

International Journal Dental and Medical Sciences Research
Volume 4, Issue 4, July-Aug 2022 pp 781-801 www.ijdmsrjournal.com ISSN: 2582-6018

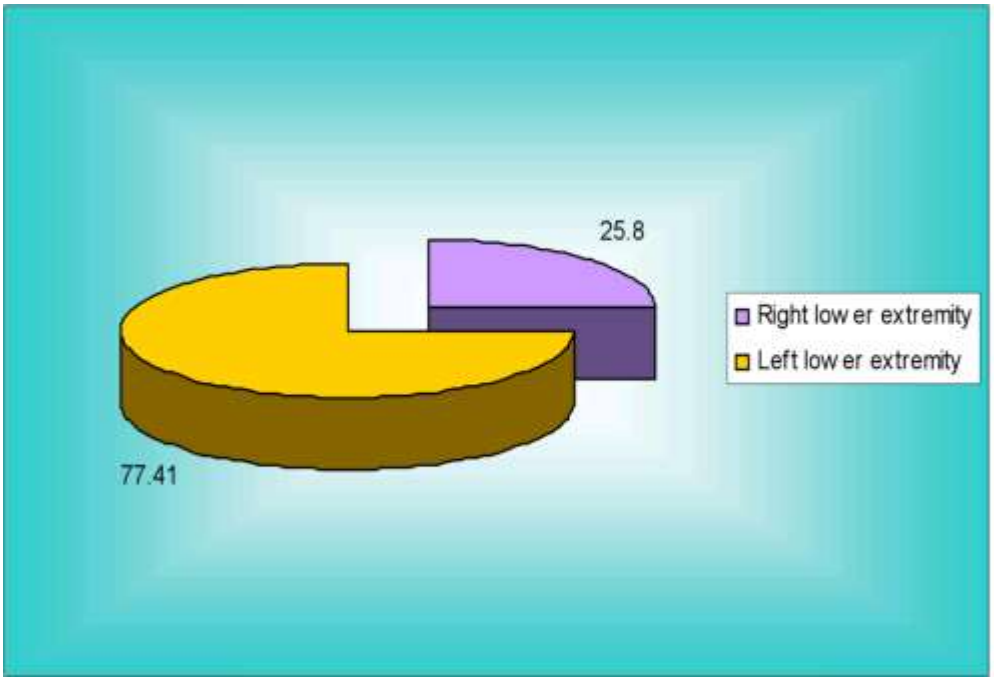



**TABLE – 7 : ANATOMIC DISTRIBUTION OF THROMBI INSTUDY POPULATION WITH EVIDENCE OF DVT ONDOPPLERUSG**

| | CFV | SFV | PV | PT | AT | PER | CIV | EIV | SVS |
|---|---|---|---|---|---|---|---|---|---|
| No.ofcas-es showinginvolve- | 18 | 26 | 23 | 20 | 14 | 12 | 3 | 8 | 4 |
| Percentage ofcasesshowingin- | 58.06 | 83.87 | 74.19 | 64.51 | 45.16 | 38.70 | 9.67 | 25.80 | 12.90 |

PredominantdistributionofthrombiwasseeninSFV,(83.87%)followed by poplitealvein(74.19%)andcalfveins(posteriortibialvein— 74.19%).Thusthrombusinvolvementismorecommoninproximalsegments(femoropopliteal)thanindistalsegments(calfveins).

International Journal Dental and Medical Sciences Research
Volume 4, Issue 4, July-Aug 2022 pp 781-801 www.ijdmsrjournal.com ISSN: 2582-6018

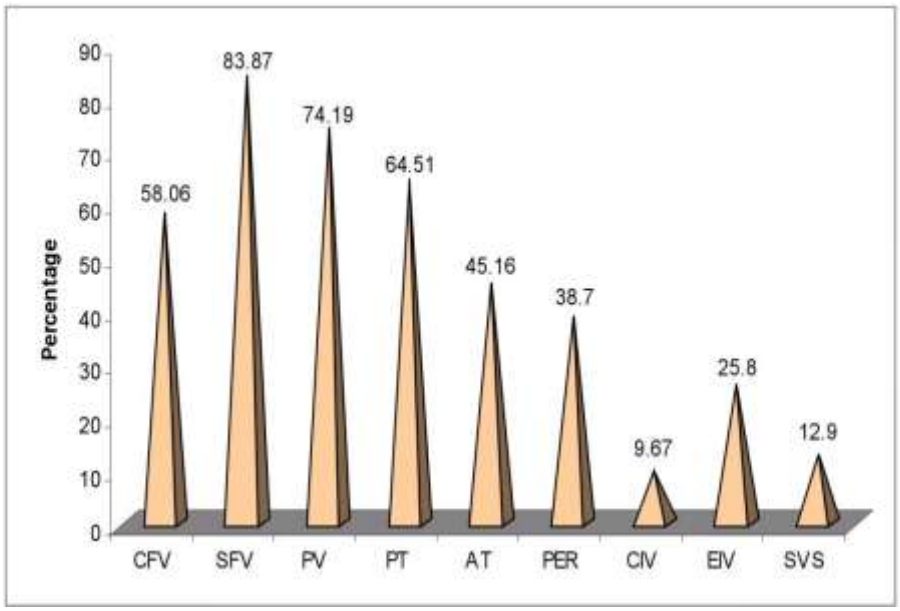
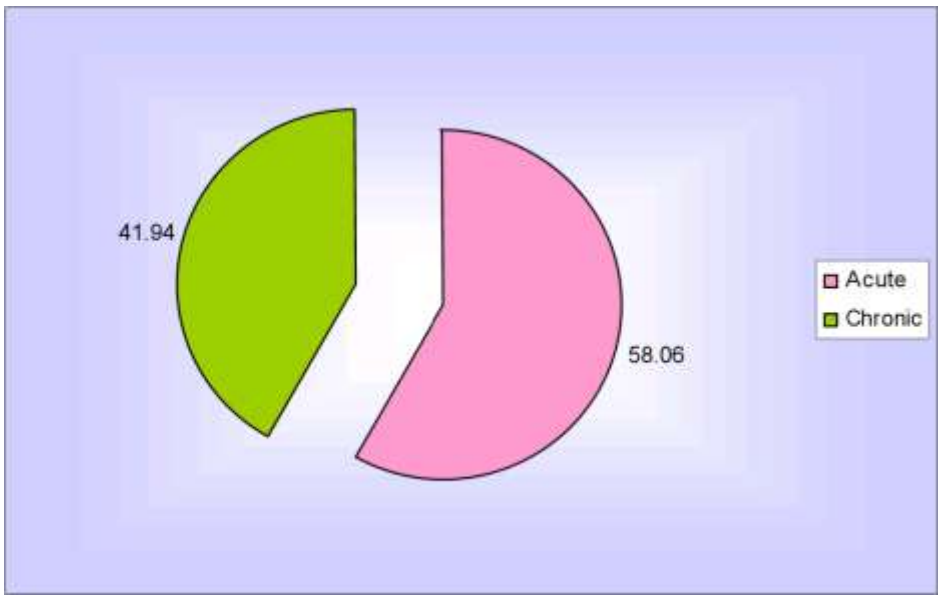



**TABLE – 8 : STAGE OF INVOLVEMENT IN STUDYPOPULATION WITH EVIDENCE OF DVT ON DOPPLERULTRASONOGRAPHY**

| | No.ofcases | Percentageofcases |
|---|---|---|
| Acute | 36 | 58.06 |
| Chronic | 26 | 41.94 |
| Total | 62 | 100 |

In our studyacute thrombosis(58.06%)predominancewas noted.




**REPRESENTATIVE CASEIMAGES**

International Journal Dental and Medical Sciences Research
Volume 4, Issue 4, July-Aug 2022 pp 781-801 www.ijdmsrjournal.com ISSN: 2582-6018

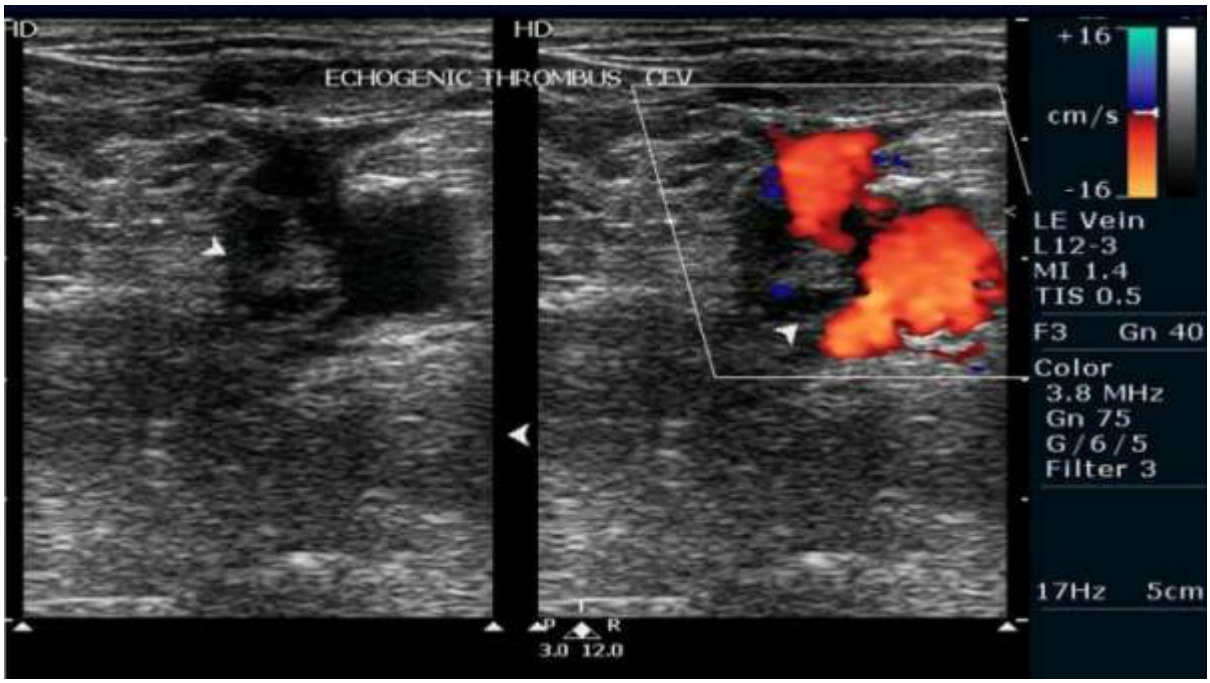



**Fig.2: Transverse image of the common femoral vein thrombosis: showingechogenic thrombus(chronic) in the common femoralvein**

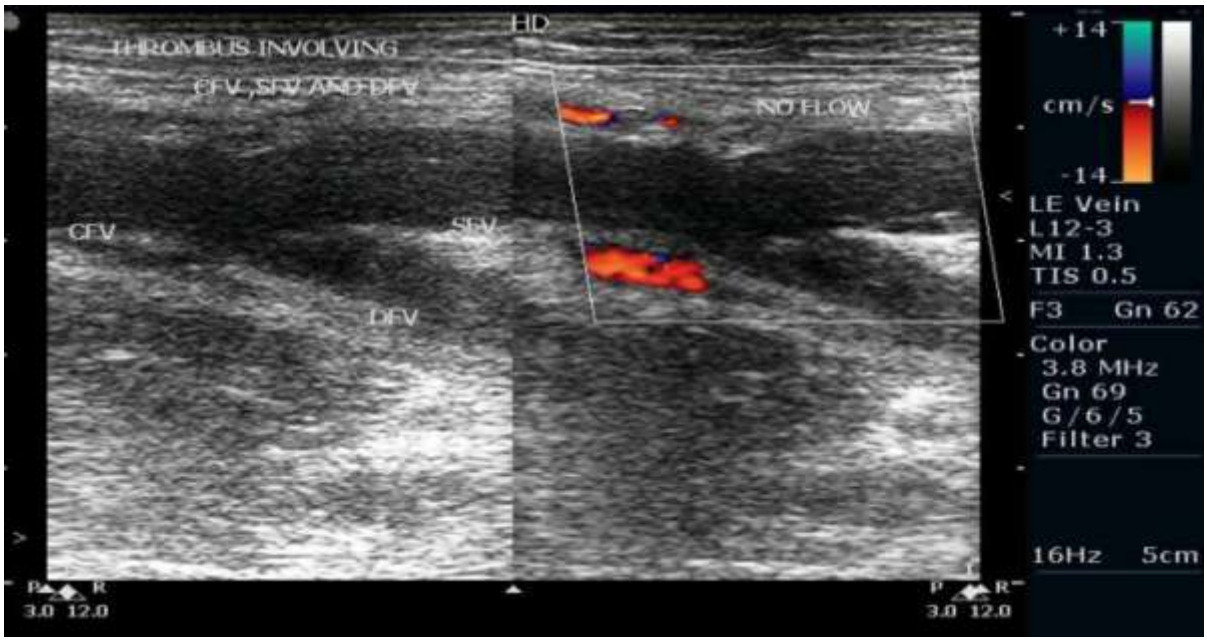



**Fig.3: Longitudinal image of the CFV, SFV and DFV thrombosis: showingabsence of colour flow in the common femoral vein, superficial femoral anddeepfemoralveinsuggestiveofthrombosis**

International Journal Dental and Medical Sciences Research
Volume 4, Issue 4, July-Aug 2022 pp 781-801 www.ijdmsrjournal.com ISSN: 2582-6018

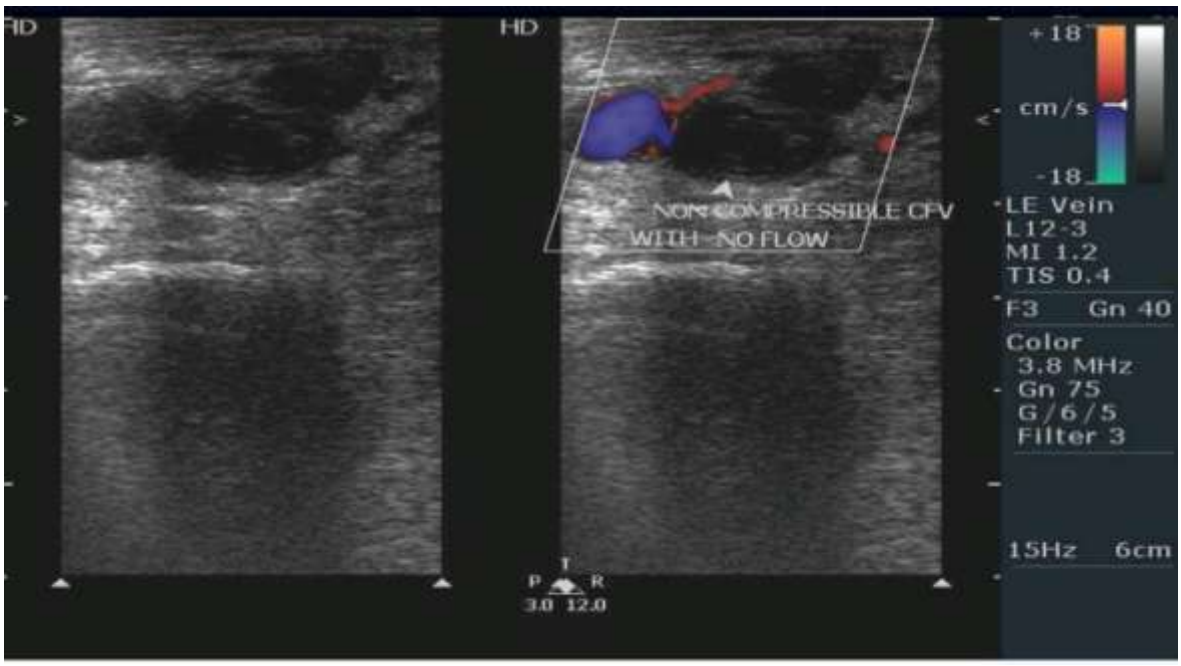



**Fig.4: Transverse image of the common femoral vein thrombosis: showinglack of compressibility of common femoral vein with increased venous diameterandabsenceofspontaneouscolourflowsuggestiveofthrombosis**

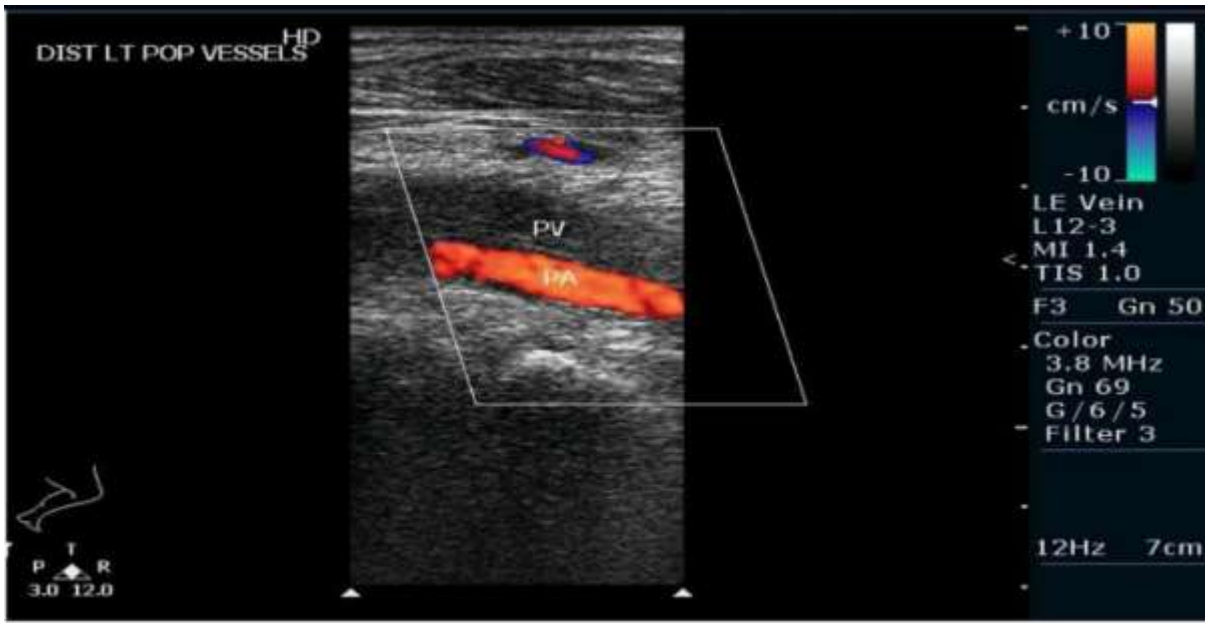



**Fig.5: Longitudinal image of popliteal fossa showing popliteal veinthrombosisevidenceofabsenceofcolourflownotedinthepoplitealvein**

International Journal Dental and Medical Sciences Research
Volume 4, Issue 4, July-Aug 2022 pp 781-801 www.ijdmsrjournal.com ISSN: 2582-6018

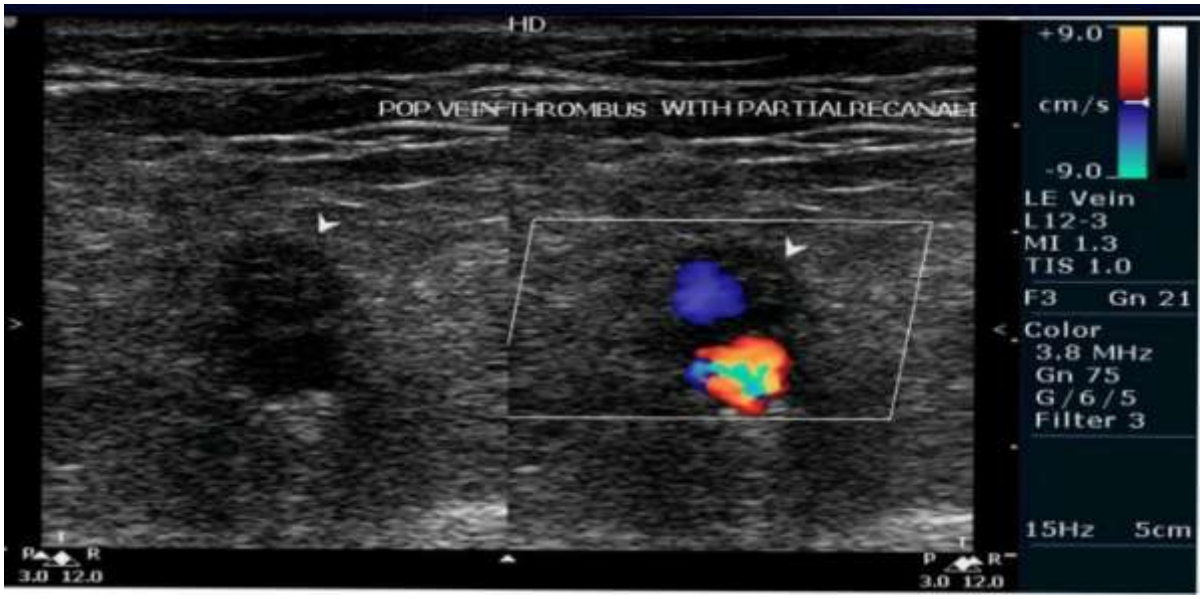



**Fig.6: Transverse image of chronic popliteal vein thrombosis: showingdilated popliteal vein with partial filling of colour suggestive of thrombosiswithpartialrecanalization**

## IV. DISCUSSION

The diagnosis of deep vein thrombosis has always been difficult. The myriadof signs andsymptoms that can be associated with DVTand the fact that manythrombi are asymptomatic, make it exceedingly difficult to rely on the clinicalpresentation. The management ofpatients with clinical diagnosis ofDVT in the lower extremity needs to identify the presenceofthrombus,itsnature, locationandextent.Thepresentstudywasperformedwiththeobjective of assessing the role of colour Doppler USG in the diagnosis of DVT of lowerextremity. Itincluded detection and assessment of spectrum of findings of DVT by usingcolour Doppler ultrasonography. We studied the colour flow findings in patients who presented with pain, edema or both of the lower extremities, pulmonary embolism and prior history ofDVT.Ourtechniqueinvolvesacompletesurveyofall majordeepveinsandsuperficialveinsofthelowerlimb.

Amongst the total 80 cases studied for suspected DVT of lower limbs, 62 cases showed thepresence of thrombus. In 18 patients, although there was clinical suspicion of DVT of lowerlimbs,thecolourDopplerstudywasnegativefor DVT.

**Age:**

TherangeofageofpatientswithsuspectedDVTinourstudywas21-80years,withmeanage of cases suspected to have DVT being 48.7 years and mean age of cases shown to haveDVTbeing 46.25years.

**Sex:**Males contribute a major group (70%) in our study of cases with suspected DVT andthey also have a higher incidence (74.19%) of positive Doppler study. In the present study ofthe cases with suspected DVT, 24 (30%) are females, with 16 (25.80%) showing evidence ofDVT.

ThesymptomsthatpromptedforDopplerexamination werepainin16patients(20%),edemain32(40%),painandedemain20(25%),symptomsofpulmonaryembolismin6 (7.5%),priorhistoryofDVTin 10 (12.5%) and 6(7.5%)patientswereasymptomatic.

IncasesshowingevidenceofDVT;12(19.35%)hadpainaspresentingsymptom,28(45.16%) had edema, 16 (25.80%) had pain and edema, 4(6.45%) had symptoms of pulmonary embolism, 10 (16.12%) had prior history of DVT while 2 (3.2%) were asymptomatic.Amongstthe patients showing evidence ofDVT, the common symptomsuggestiveofDVTwas edema.

In present study only one case with bilateral pain and edema showed evidence of thrombosis.

Colour Doppler USG was advised to rule out DVT of lower limbs as the source of pulmonaryembolism in 6 cases. This is based on the concept that majority of pulmonary embolismoriginateinlowerextremityveins.

Amongst the 6 patients with suspected pulmonary embolism, colour Doppler USG revealedDVTinonly4caseswhohadleftsidecalftenderness onclinicalexamination.

**Clinicalconditionsthatpromptedforcolourdopple**

International Journal Dental and Medical Sciences Research
Volume 4, Issue 4, July-Aug 2022 pp 781-801 www.ijdmsrjournal.com ISSN: 2582-6018

**r:**
Inthepresentstudy,24cases(30%)withsuspectedDVT werebedridden(prolongedhospitalization), 6 (7.5%) were post-operative, 6 (7.5%) had history of recent trauma, 4(5%)were OC pills users, 4(5%) were dialysis patients and 2 (2.5%) was patient with snake bite. Incases showing evidence of thrombosis on colour Doppler USG; 18 (29.03%) were bed ridden(prolongedhospitalization),6(9.67%)werepos t-operative,6(9.67%)hadhistory oftrauma, 4 (6.45%) were OC pill users, 4 (6.45%) was dialysis patient and 2 (3.23%) was patient withsnakebite.

**Typeofinvolvement:**
Inthepresentstudy,60casesshowedunilateralinvolve ment.58caseswithunilateralsymptoms showed involvement of the same symptomatic limb while 2 cases with unilateralinvolvementhadbilateralsymptoms.2case( 3.23%)withbilateralinvolvementwassymptomatic.
In 77.41% of cases with evidence of DVT on colour Doppler USG the thrombus was localisedto left limb, while in 25.80% of cases, thrombosis was localised to right limb.

**Localisationandextentofthrombosis:**
ColourDopplerUSGhelpsinexactlocalisationofthethr ombus.
The distribution of thrombi in present study is 9.67% in common iliac vein, 25.80 % in externaliliac vein, 58.06 % in the CFV, 83.87% in SFV, 74.19 % in the popliteal vein, 64.51% inposterior tibial vein, 45.16% in anterior tibial vein, 38.70% in peroneal vein and 12.9% in thesuperficialveins.Allthe16casesinourstudywithext ernaliliacveinthrombosisoutofwhich6 were showing both proximal and distal extension i.e. into common iliac vein and commonfemoralvein.
Identifyingthethrombusinproximalveinsoflowerextr emityisimportantfortheyposegreater risk in terms of both embolism and local residual changes. Calf vein thrombi oftenresolvespontaneouslyanddonotresultinemboli. Sotheyareconsideredclinicallyinsignificant. The presence ofabovekneeDVT greatly increasestheriskfor pulmonary embolismandeventualpost-phlebiticsyndrome.[20]
CFVdemonstratedthrombiin18cases(58.06%),SFVi n26(83.87%),CIVin6(19.35%) andEIVin 9(29.03%) cases.
In our study, DVT isolated to SFV was seen in two patients (3.23%) and DVT isolated topopliteal vein was seen in another two patients (3.23%). Hence we conclude that complete colour Doppler examination should bedone in all symptomatic patients, in order to reduce examination time and also to avoidmissingthethrombus isolatedtosinglevein.

**Acutevschronic:**
Acute thrombosis was found in 36 (58.06%) and chronic in 22 (41.94 %). This finding roughlycorrelatedwiththestudybyGrosserSetal[20] in19 90.They found7casesofolderthrombiby colour Doppler of which finding was confirmed phlebographically in 4 cases. In the study, thepositivity rate for acute DVT is 45% (36 cases amongst 80 suspected cases of DVT). This ishigher thanthat inthestudy-byHillSLet al[18] (1997) whodeterminedthepositivity rate of 17.4%foracuteDVTinsymptomaticpatients.

**Pattern of involvement:**The four different types of thrombosis according to anatomicalsegmentsandpatternsare:

1. Isolated thrombiconfinedtoonevenoussegment.
2. Thrombiextendingacrosstwocontiguousan atomicalsegments.
3. Thrombiinmultipledifferentnoncontiguous locationsinoneextremity.

In the present study, 6.45% were isolated thrombi confined to one segment,93.55% weremultiple contiguous thrombi. There is not a single case showing multiple non- contiguousinvolvement. The pattern of involvement which constituted the major group in our study is onewith multiple contiguous involvement of venoussegments in single extremity.
It is found that the age of patients with contiguous thrombosis or bilateral thrombosis wasgreaterthantheageofpatientswithisolatedthrombo sis.[8]

**Venousdistension:**
The criterion included in the diagnosis of acute thrombosis was increased venous diameterwhich was found in all 36 cases of acute thrombosis. This correlated with the study by vanGemmeren D et al65 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 normaldimensionwhile2had diameterlessthanadjacentartery.

**Lossofcompressibility:**
Compressibility of veins was lost in all 62 cases (acute and chronic) with DVT. In 20 caseswith incomplete thrombosis, involved veins were not completely compressible. In one casewith

suspected DVT and prior history of DVT, the femoral venous segment in the region ofadductor canal was not compressible. The diagnosis of DVT in this segment was excluded ondemonstratingnormal colour flowsignal.
Thisisincorrelationwiththestudy byWright DJet alin1990whohadstatedthat, it is difficult to demonstrate the compressibility of the vein due to thick muscular structure as inadductorcanal.

**Free floating thrombus:**In present study, two cases with acute DVT showed free floatingproximalendofthrombus.
NorrisCSetalin1985found5casesout of 78(6%)withfree floating thrombi on venography. Presence of signal void even on augmentation was consideredasacriteriaforDVTwhichwasfoundinall42caseswithcompletethrombosis.Eccentric flow was demonstrated in 20 patients with partial thrombosis.The color Doppler flowimaging diagnosis based primarily on the presence of a focal void within the colour encodedblood flow or the absence ofvisible flow within a segment of a vessel, correlated with thestudybyRoseSCetalin1990.In6patientswithacute DVTcollateralsweredemonstrated while in10 patients with chronic DVTcollaterals and increased flow through saphenousveinswasdemonstrated.Thiscorrelatedwiththestudyby PerssonAVetalin1989, whofound an increase in the size and flow in collateral veins, in the majority of patients with acutedeepvenousthrombosis.
All the 6 cases with CIV involvement and 16 cases with EIV involvement showed contiguousinvolvementoffemoralvenoussystem.

**Conditions mimicking DVT:**18 cases (22.5%) in the study population demonstrated clinicalconditions mimicking DVT, 2 showed presence of Baker's cyst of, 2 had ruptured Baker's cystat clinical presentation with pain and marked swelling of the calf, clinicallyindistinguishablefromDVT.
4casesshowedevidenceofcellulitiswithsubcutaneous swelling.Inflamedbursa was found in 4 cases as the cause of pain in patients with suspected DVT of which onewasassociatedwithfascitis.
Additionalfindingofintramuscularhaematomawasfoundintheleftrectusfemorismusclein4 patients who also had Doppler evidence of partially recanalized thrombus in distal SFV.Probablyitmighthavealsocontributed tothepresenting symptomofpaininthecase.

## V. CONCLUSION

The clinical diagnosis of DVT is erroneous in approximately half of the casesinwhich the disease is suspected. If diagnostic accuracy is to be improved and theappropriatetherapyinstituted,anobjectivetechniquemustbeusedtosupplementthediagnosis.
It has been conclusively established that colour Doppler USG is a non-invasive, accurate,easily repeatable, widely available and relatively sensitive in the diagnosis of lower extremitydeep vein thrombosis and also helps in providing valuable information of therapeutic significanceandriskofpulmonaryembolism.

## REFERENCES

[1]. Fraser JD, Anderson DR. Deep venous thrombosis: recent advances and optimalinvestigationwithUS.Radiol1999;211:9-24.
[2]. Hill SL, Holtzman GI. Selective use of the duplex scan in diagnosis of deep venousthrombosis. 1995;170:201-205.
[3]. Harold R, Hansen KJ. Expanded criteria for the diagnosis of deep venous thrombosis. ArchSurg 1984;119:1167-1170.
[4]. Effency DJ, Friedman MB, Gooding GAW. Iliofemoral venous thrombosis. Real timeultrasounddiagnosis,normalcriteriaandclinicalapplication.Radiol1984;150:787-792.
[5]. Hull R, Hirsh J. Cost effectiveness of clinical diagnosis, venography and noninvasivetesting in patients with symptomatic deep vein thrombosis. N Engl J Med 1981;304:1561-1567.
[6]. Ramchandani P, Soulen RL. Deep vein thrombosis: significant limitations of noninvasivetests.Radiology1985;156:47-49.
[7]. Holden RW, Klatte EC. Efficacy of noninvasive modalities for the diagnosis of thrombo-phlebitis.Radiology1981;141:63-66.
[8]. Dosick SM, Blakemore WS et al. The role of Doppler ultrasound in acute deep veinthrombosis. 1978;126:265-268.
[9]. SumnerDS,LambethA.ReliabilityofDopplerultrasoundinthediagnosisofacutevenous thrombosis both above and below the knee. Am JSurg1979;138:205-209.
[10]. LangsfeldM,HersheyFB.DuplexB-modeimagingforthe diagnosis ofdeepvenousthrombosis.ArchSurg1987;122:587-5.
[11]. Comerota AJ, Katz ML. Venous duplex imaging : should it replace hemodynamic tests fordeepvenousthrombosis.JVascSurg 1990;11:53-61.

[12]. DavidCosgrove. Clinicalultrasound,2nd Ed.ChurchillLivingstone,2001:3.
[13]. LusbyRJ,FerrelLD,EhrenfeldWKet al.Carotidplaquehemorrhage.ArchSurg;1981;117: 1479-1487.3P
[14]. EugeneDStrandness (Ed), Duplexscanninginvasculardisorders. 1990,RavenPress(NY).
[15]. Ackerman RH.A perspective on non-invasive diagnosis of carotiddisease.Neurol(Minneap),1979;29:615-622.
[16]. ZwiebelWJ, Knighton.VascularColorDuplex.SeminUS 1990;CT,MRVol.II,No. 2:97-135.
[17]. Miselli-A; Larini; Mandrioli-R; Ugolotti-U; Marcato; Quintavalla. Ultrasonography in thediagnosis of deep venous thrombosis of the legs. Radiol-Med-Torino. 1990 Oct; 80(4): 469-73.
[18]. Keogan-MT; Paulson-EK; Paine-SS; Hertzberg-BS; Carroll-BA. Bilateral lower extremityevaluationofdeepvenousthrombosis withcolorflowandcompressionsonography.J-Ultrasound-Med.1994Feb;13(2):115-8.87
[19]. Lewis-BD; James-EM; Welch-TJ; Joyce-JW; Hallett-JW; Weaver-AL. Diagnosis of acutedeep venous thrombosis of the lower extremities: prospective evaluation of color Doppler flowimagingversusvenography.Radiology.1994Sep;192(3):651-5.
[20]. Anand.S.S etal.Does thispatienthavedeepveinthrombosis.JAMA1998;279;1094-1099
[21]. Blaivas-M; Lambert-MJ; Harwood-RA; Wood-JP; Konicki-J. Lowerextremity Doppler fordeep venous thrombosis--can emergency physicians be accurate and fast?,Acad-Emerg-Med.2000Feb;7(2):120-6.
[22]. IntersocietalAccreditationCommission(IAC) vascular testing standards:venousdis-ease.http://www.intersocietal.org/vascular/standards/IACVascularTestingStandards2013.pdf.AccessedMarch31,2013.
[23]. Quinlan DJ, Alikhan R, Gishen P, Sidhu PS Variations in lower limb venous anatomy:implicationsforUSdiagnosisofdeep veinthrombosis.Radiology.2003;228:443–44.