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COMPARISON OF BALANCED STEADY STATE FREE PRECESSION MAGNETIC RESONANCE VENOGRAPHY IMAGING AND DOPPLER ULTRASONOGRAPHY IN THE DIAGNOSIS OF PELVIC AND LOWER EXTREMITY DEEP VEIN THROMBOSIS.

Radiology

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ABSTRACT

Aim: Comparison of balanced steady state free precession Magnetic Resonance venography imaging and Doppler ultrasonography in the diagnosis of pelvic and lower extremity deep vein thrombosis.

Methods: A diagnostic study of 50 patients were carried in the Department of Radio-diagnosis, of a tertiary care centre. Patients with suspected deep venous thrombosis who were being evaluated by ultrasonography and Doppler were taken up for MRI.

Results: Out of these 50 cases studied, 16 cases had Acute DVT, 21 cases had chronic DVT and 4 cases had acute on chronic DVT while 9 cases were normal and did not have any DVT. There was 100% agreement between ultrasonography and MRV. In addition to this, there were 05 cases where DVT was identified by MRV in the contralateral limb which otherwise was not examined by the USG.

Conclusion : Balanced-SSFP MR venography holds an important place for DVT evaluation and has the potential as a highly accurate substitute for the diagnosis of DVT.

KEYWORDS

Introduction:

Deep venous thrombosis (DVT**)** is a commonly encountered condition in clinical practice. DVT may be asymptomatic and often goes undiagnosed with development of serious complications. Signs and symptoms of this entity are often occult wherein lies the role of imaging in the management of these cases. Ultrasound coupled with Doppler evaluation is the 'gold standard' in the diagnosis of DVT. The sensitivity and specificity of US for detecting DVT in the deep veins of the thigh and popliteal vein are in the range of 95% to 99%, the results of which are as good and close to that of conventional venography[1,2]. Ultrasound however has its limitations and since the procedure involves direct contact of the probe with the skin surface and compression, it may be difficult to perform a scan in patients who are in casts, who are obese and those with marked swelling of the lower extremity. Moreover it is a highly operator dependent. In order to consider Magnetic Resonance Imaging (MRI) as a substitute for the evaluation and diagnosis of DVT in circumstances where ultrasonography is not feasible, MRI should offer most of the diagnostic advantages of ultrasonography. Balanced Steady State Free Precision (SSFP) sequences have now become widely and commonly available, and the short imaging time permits fast motion-resistant image acquisition. There is inherently high signal intensity in blood irrespective of flow characteristics thereby reducing the artefacts and problems associated with slow-flowing blood[3,4]. The essential and positive properties of balanced SSFP sequences have led to the hypothesis that the balanced SSFP MRV as a procedure for diagnosis of DVT is a rapidly performed and preferred alternative imaging method and modality for the diagnosis of DVT. We performed balanced steady state free precession Magnetic Resonance venography imaging in suspected cases of deep venous thrombosis and determined the sensitivity and specificity of this technique in the diagnosis of pelvic and lower extremity deep venous thrombosis.

Materials and Methods:

A diagnostic study was undertaken at a tertiary care centre over a period of two years. After calculating a sample size of 37 patients a total of 50 patients with suspected deep venous thrombosis who were being evaluated by ultrasonography and Doppler were taken up for MRI . The inclusion criteria were adult patients with suspected deep venous thrombosis referred for ultrasound and Doppler evaluation of the pelvis and lower limbs. Patients in whom MRI was contraindicated were excluded from the study. Approval for the study was taken from our institutional ethics committee. Written informed consent was obtained from all patients. There was no delay or interference by MRI examination with patients' therapy if DVT was diagnosed on USG. MRI examination was performed as early as feasible, within an interval of no more than 24 hours.

IMAGING PROTOCOL: Ultrasonography and Doppler was performed using LOGIQ P5(GE Medical Systems, Milwaukee, Wisconsin, USA) with a 2–5 MHz convex array transducer (low frequency probe) and a 7-12 MHz linear transducer (high frequency probe). Standard techniques of ultrasound and Doppler evaluation were utilised which included grey scale evaluation and compression, color Doppler analysis, and pulsed Doppler waveform acquisition with respiration, Valsalva's manoeuvre and augmentation. The examination took about 15-25 minutes. The decision to start treatment for DVT was based on ultrasound and Doppler findings.

Following this the patients underwent MR Venography study using Balanced Steady state free precession(SSFP) imaging of the lower extremities and the pelvis. Imaging was done to include infrarenal Inferior Vena Cava (IVC) till the ankle with acquisition of images in the axial and the coronal planes. For comparison purposes, venous system was divided into 3 segments i.e. Pelvic veins, Proximal segment(Common femoral vein (CFV) , the Superficial Femoral vein (SFV) and the Popliteal vein) and the distal segment i.e. (Anterior tibial vein (ATV), Posterior tibial vein (PTV) and Deep Peroneal vein). For each examination by ultrasound as well as MRI the involved venous segments, proximal extent , thrombus age (acute or chronic), and ancillary findings was recorded.

OBSERVATIONS & RESULTS:

Statistical methods used: The sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV) and accuracy were calculated for MRI venography against USG Doppler as a Gold standard. The precision of accuracy measure was given using 95% confidence intervals. The extent of statistical agreement between two techniques was studied using Cohen Kappa test.

P-values less than 0.05 were considered statistically significant. All the hypotheses were formulated using two tailed alternatives against each null hypothesis (hypothesis of no difference). The entire data was statistically analyzed using Statistical Package for Social Sciences (SPSS ver 16.0, Inc. Chicago) for MS Windows.

Status of DVT:There were 50 cases / limbs evaluated by USG for suspicion of DVT in this study and out of these 50 cases studied, 16 cases (32.0%) had Acute DVT, 21 cases (42.0%) had chronic DVT and 4 cases (8.0%) had Acute on chronic DVT while 9 (18%) cases were normal and did not have any DVT.

In addition to this, there were 05 cases where DVT was identified by MRV in the contralateral limb which otherwise was not examined by the USG.

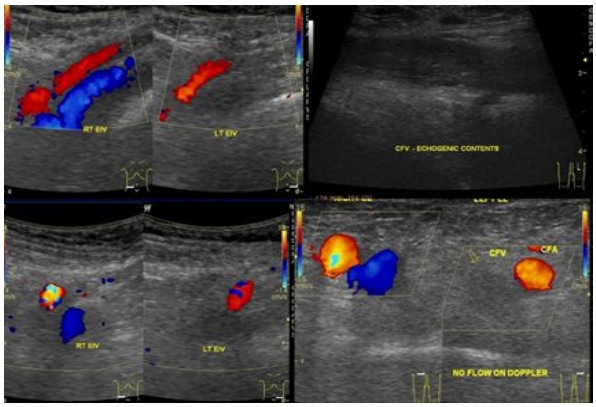

Fig. 1: Sagittal and axial grey scale and color Doppler images showing presence of thrombus as echogenic contents and absent flow in the left Common femoral vein(CFV) which was seen extending upto the External Iliac Vein(EIV).

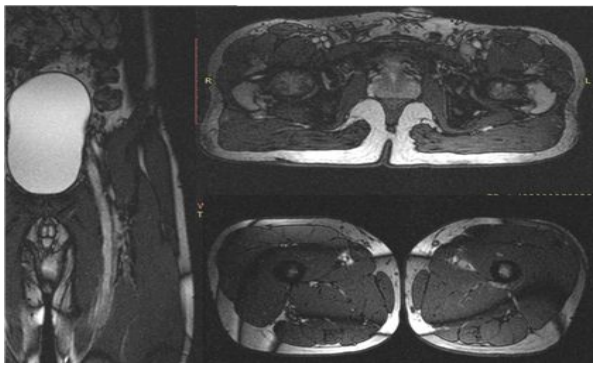

Fig 2: Coronal and axial Balanced SSFP images showing the enlarged veins on the left with loss of the normal intraluminal hyperintensity suggestive of thrombosis.

Table 1: The indices of diagnostic efficacy of MRI Venography against the USG

(Gold standard) for each type of vein (n= 50). All values are in %. PPV: Positive predictive value, NPV: Negative predictive value, CFV: Common femoral vein, FV: Femoral vein, PV: Popliteal vein, IVC: Inferior vena cava, EIV: External Iliac vein, CIV: Common iliac vein.

Indices of diagnostic efficacy (%)							
Segment	**Veins**	**Sensitivity**	**Specificity**	**PPV**	**NPV**	**Accuracy [95% CI]**	**Youden's Index**
Proximal	CFV	100.0	95.8	96.3	100.0	98.0 [94.1 – 99.9]	95.8
	FV	100.0	90.0	93.8	100.0	96.0 [90.6 – 99.9]	90.0
	PV	94.1	93.8	96.9	88.2	94.0 [87.4 – 99.8]	87.9
Distal	Calf veins	58.3	100.0	100.0	88.4	90.0 [81.7 – 98.3]	58.3
Pelvic Veins	IVC	100.0	97.9	66.7	100.0	98.0 [94.1 – 99.9]	97.9
	CIV	88.9	97.6	88.9	97.6	96.0 [90.6 – 99.9]	86.5
	EIV	93.8	94.1	88.2	96.9	94.0 [87.4 – 99.9]	87.8

Discussion:

Deep venous thrombosis is one of the commonly encountered which often poses a diagnostic challenge and may be associated with high morbidity and mortality.

In majority of DVT cases, thrombus is commonly seen to arise from the calf veins. This calf vein thrombosis can be clinically asymptomatic or may quite often resolve spontaneously. However, it may become clinically significant when it extends proximally and propagates into the popliteal, femoral, or the pelvic veins. It can then lead to the dangerous sequel of pulmonary embolism[5].There have been other studies that have shown that DVT can also initially arise from the larger proximal veins of the lower limbs and the pelvis[6,7]. Isolated pelvic vein DVT has an incidence of approximately 2% to 4% and is relatively less common in the absence of predisposing factors like pelvic malignancy, pelvic trauma or hematoma.

Current 'gold standard' in the evaluation of deep venous thrombosis is ultrasonography with color Doppler evaluation. A ideal MR venographic technique which can be considered for evaluating DVT of lower extremities should be highly accurate, fast and should avoid the use of contrast administration. Various MR venographic protocols have shown high diagnostic accuracy for DVT. However, no particular protocol has been extensively used in clinical practice. While unenhanced techniques like spin echo, gradient-recalled echo and time-of-flight are not yet commonly in use due to their long image acquisition times, the contrast enhanced scans are comparatively rapid sequences , however, they would require intravenous administration of gadolinium.

Balanced steady-state free precession(SSFP)Fast Imaging with steady-state precession (FISP) sequence has been acknowledged as an excellent technique to assess blood vessels[8,9]. Characteristics of this sequence consists of a fast data acquisition that has reduced sensitivity to motion, relatively high image signal-to-noise ratio, and intrinsically high signal intensity of intraluminal blood without requiring IV contrast material. These features are useful for revealing luminal morphology and possibly for showing intraluminal filling defects of the blood vessels. In addition, this sequence has the potential to reduce the total examination time and the cost of the study by eliminating contrast medium requirement.

Our study showed that balanced-SSFP MRI is highly accurate for diagnosing DVT and the findings agreed with the ultrasound findings in all cases. None of our MRI examinations were non-diagnostic. Balanced-SSFP MRI had an overall sensitivity of 100 %, specificity of 92%, positive predictive value of 97%, and negative predictive value of 100 % and accuracy of 98 % for the diagnosis of proximal DVT. Balanced-SSFP MRI was highly accurate in the common femoral vein, femoral vein and popliteal vein. This is of great significance as diagnosis of DVT with balanced SSFP MRV technique approaches the diagnostic accuracy of the USG and can be effectively used for diagnosis of DVT.

In case of distal veins of the calf, our study showed that balanced-SSFP MRI had a sensitivity of 58.3 %, specificity of 100%. The lower sensitivity of MRI to detect calf veins DVT has been reported in previous studies as well. This we feel would not have a clinical bearing as most of the isolated calf DVT can resolves spontaneously and also these rarely cause pulmonary thromboembolism. These cases can at best be put on ultrasound or MR follow up to see resolution.

In our study of 50 cases of suspected DVT, a total of 41 patients were diagnosed with DVT. Of these 41 DVT cases in 15 cases proximal extention of the thrombus into the pelvic veins was picked up by ultrasound whereas MRI picked up proximal extension in 18 cases. The importance of identifying this proximal extension into the pelvic veins lies in the fact there is a higher possibility of pulmonary embolism with increase in the proximal extension of the thrombus[10].

MRI by virtue of its multiplanar capability, soft tissue contrast resolution and less operator dependence is a superior imaging modality for detecting ancillary finding which one may encounter while imaging a 'painful swollen limb'. This is of clinical as well as diagnostic significance as presence of these findings may help in distinguishing acute and chronic DVT. Our study showed that acute DVT was more often associated with presence of edema and was seen in 14 patients (93%) of acute DVT as compared to 05 patients (16%) of chronic DVT.

Collaterals were identified more commonly in patients with chronic DVT as compared to 24% patients with acute DVT. Lymphadenopathy was seen in 46% of acute cases of DVT as compared to 9% of chronic DVT cases.

These association can prove to be beneficial in interpreting the thrombus age. They may also help in diagnosing acute on chronic DVT as was evident in two of our cases which showed features of chronic DVT in the form of small veins with thickened irregular wall. However, presence of edema and a small thrombus indicated the diagnosis of acute on chronic DVT.

MRI provided alternate diagnosis in two cases of suspected DVT. One was a case of Tennis leg and the other of a calf hematoma which were referred to us with a clinical suspicion of DVT. Other incidental findings that were picked up on MR were pelvic kidney, ascites, hydrocele and pelvic mass etc.

Balanced SSFP MRI had some clear advantages over ultrasound. The average examination time for MRI examination was about 8–10 minutes whereas the approximate time to perform an ultrasound examination was about 15 to 30 minutes depending upon whether single or bilateral limbs was examined. Another advantage of balanced SSFP MRI was the study of both the limbs simultaneously. This helped in detecting presence of asymptomatic DVT, which was otherwise not under evaluation.

Balanced SSFP MRI acquisition is rapid, painless and not restricted by edema, surgical scars or wounds. The multiplanar capabilities of MRI and the big field of view(FoV) helped us to pick up ancillary findings .
Our study emphasized that balanced-SSFP MR venography holds an important place for DVT evaluation and has the potential as a highly accurate substitute for the diagnosis of DVT. It should be useful in circumstances in which ultrasound is difficult or cannot be effectively performed and in those situations where the findings are inconclusive and non-diagnostic.

Our study had some limitations like small sample size, limitation of ultrasonography as a reference standard in the evaluation of distal DVT.

SUMMARY AND CONCLUSION:

The findings of this study indicate that balanced SSFP MRI is a viable alternative to ultrasonography and Doppler evaluation in evaluation of DVT. It can be utilised as an adjunct or alternative to sonography in situations where it is not possible to get a satisfactory sonographic evaluation given that the equipment and expertise are available.

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