EVALUATION OF COLOR DOPPLER IMAGING IN THE DIAGNOSIS OF DEEP VEIN THROMBOSIS

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ABSTRACT

Objective: To evaluate the accuracy of Color Doppler Imaging in diagnosing deep vein thrombosis (DVT) of the lower extremities taking Venography as gold standard.

Study Design: Cross validation study.

Place and Duration of Study: The study was conducted in the radiology department Combined Military Hospital Peshawar from January 2007 to August 2008.

Patients and Methods: Seventy four patients suspected of having deep venous thrombosis of the lower extremities were examined by Color Doppler Imaging (CDI). But sixty nine patients underwent successful venography of the affected lower limbs and 5 patients were excluded from the study.

Results: Using venography as the reference standard for diagnosing DVT, the sensitivity and specificity of CDI was 96% and 94.4%, respectively. Positive predictive value was found to be 98% and negative predictive value was 89.5%. Overall accuracy of the CDI was 95.6%.

Conclusion: With meticulous technique, Color Doppler Imaging is highly accurate in diagnosing deep vein thrombosis of symptomatic lower limbs, avoiding contrast venography in most of the cases.

Keywords: Deep vein thrombosis; Color Doppler Imaging; Venography; Lower extremities.

INTRODUCTION

Deep vein thrombosis (DVT) is one of the most common diseases of the lower extremities. It is associated with a high mortality rate due to pulmonary embolism [1]. Its pathogenesis involves one or more of the mechanisms known as the Virchow triad: stasis, vessel wall injury and hypercoagulability. Risk factors for the development of DVT are surgery, trauma, immobilization, paresis or paralysis, malignancy, anesthesia, advanced age, obesity, long journeys, central venous catheters, superficial vein thrombosis, varicose veins, pregnancy, pueperium, oral contraceptives and other hormone replacements [2].

Previous studies suggest that more than half of the patients with DVT, diagnosed by other methods, would have been missed by clinical examination alone. Clinical diagnosis is also inaccurate for distinguishing DVT from the post-thrombotic syndrome or other causes of leg pain and swelling. Therefore, adjunctive diagnostic techniques were recommended to begin early treatment. Physical examination is rarely helpful. This was demonstrated in the study of Geerts et al [3] in which the clinical signs of DVT (e.g. edema, pain and flushing) occurred in less than 1.5% of patients.

Ascending contrast phlebography was initially considered the most sensitive and complete of the tests and has been used to visualize the entire venous system of the lower extremity, iliac veins and vena cava [4]. Later on, Color Doppler Imaging (CDI) was considered replacement of contrast venography as the standard test for diagnosing clinically suspected DVT [5] because it was easily accessed, non invasive, short lasting and had high sensitivity and specificity [6].

Numerous studies have compared Ultrasound (US) to contrast venography in patients with clinically suspected DVT. These were summarized by Kearon in 1998 who concluded that US had a sensitivity of 97% for proximal DVT, 72% for distal DVT and a specificity of 94% [7]. In another systematic

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review, pooled sensitivity of US for detecting any DVT was 89.7%. Pooled sensitivity for detecting proximal DVT was 94.2% and for distal DVT was 63.5%. Pooled specificity calculated using data from all the studies was 93.8% [8].

Local studies have suggested that clinical diagnosis of DVT was correct in only half of the patients and CDI was better for diagnosing proximal DVT than distal DVT [9].

Though few studies conducted abroad and locally, have shown comparable results for CDI and Venography for the diagnosis of DVT in lower limbs, it is necessary to validate the reliability of CDI in our peculiar set up and to recommend its use as a routine diagnostic technique. Therefore, the present validation study was planned to determine the sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV) and accuracy of CDI in diagnosing lower limb deep vein thrombosis taking Venography as gold standard.

PATIENTS AND METHODS

Seventy four patients suspected of having deep venous thrombosis of the lower extremities by clinical criteria of calf tenderness, warmth, edema, Homan's sign and fever were selected for this validation study conducted at the department of Clinical Radiology, Combined Military Hospital Peshawar from 1st January 2007 to 14 August 2008. A proforma was completed for each patient recording age, sex, presenting symptoms and signs. These patients were selected according to non probability convenient sampling. Most of the patients were Pakistan Armed Forces personnel and their families. However some civilian patients from NWFP and Afghanistan were also included. The study sample included 53 inpatients and 21 outpatients. Out of these, 69 patients underwent venography. Two patients refused to undergo this invasive procedure and in 3 patients, venography could not be performed due to failure of venous cannulation in the presence of extensive thrombosis or swelling of the feet.

Technique of Color Doppler Imaging

All the patients underwent Doppler analysis on commercially available high resolution Ultrasound equipment (ALOKA Prosound SSD-5500, Japan) having 5 and 7.5 MHz curved linear array transducers and color flow mapping/ pulsed Doppler technique. Verbal consent was obtained from all patients. Prints of the study were captured on Video graphic Printer MP-895 MD (Sony, Japan).

The examination was performed by one of the three consultant radiologists. Patients were examined while relaxed and supine. The end of the probe was covered with Aqua sonic Ultrasound Gel. The skin overlying the vessel to be examined was smeared with gel and the probe placed on the skin. The probe was passed across the vessel while observing its image on the monitor beginning at the distal external iliac vein as it runs anteriorly from the deep pelvis. The common femoral vein, proximal deep femoral, superficial femoral, popliteal vein and moving distally to the trifurcation in the calf including the posterior tibial, anterior tibial and peroneal veins, were examined in the longitudinal and cephalad or caudad angled transverse planes. Color sensitivity and gain settings were optimized in each patient to enhance detection of slow blood flow. The caliber of the veins was compared with the other side while observing first for phasic flow with respiration. An immediate increase in flow velocity with compression at a point distal to the vein was expected in normal veins-Augmentation maneuver [10].

The average scanning time was 15 minutes for complete assessment of a unilateral lower limb venous system. Criteria considered showing the presence of deep venous thrombosis included visualization of filling defect or thrombus in the color column of the vessel lumen (Fig 1), absence of spontaneous flow by Doppler Ultrasonography, absence of phasicity of flow with respiration, and incompressibility of the vein with probe pressure [11]. Results of the color Doppler flow imaging examination

were considered negative if color filled the vein lumen from wall to wall.

Technique of Venography

Sixty nine out of 74 patients after the CDI examination had their veins of the affected lower limbs examined by venography so as to confirm the accuracy attributed to the CDI. Before this procedure proper written informed consent was obtained.

The contrast enhanced venograms were carried out with an Image Intensifier Fluoroscopic X-Ray Machine (KXO- 80G-KDU 800-1000 mA, Toshiba, Japan) using the technique described by Kakkar [12].

The venography was performed by the co-investigating radiologists, who were unaware about the findings of Color Doppler Ultrasonography. The tourniquets were applied above the ankle and knee to force the contrast into the deep veins of the calf and upper leg and improve their visualization. The patients were placed in a 45O semi upright position. The contrast agent (Urografin 76%, Schering AG, Berlin, Germany) was injected under visual control via a 20-21 gauge butterfly needle inserted in the superficial venous plexus of the foot. The filled sections were documented on standard radiographs with two views and deep veins were studied and interpreted for filling defects. Results of venography were considered positive for acute DVT if a constant filling defect or thrombus was identified, if there was persistent non filling of a venous segment (Fig 2), or if there was abrupt termination of the opaque column of contrast material in a venous segment.

Data were analyzed by SPSS 11.0 for the Windows software program. Specificity, sensitivity, PPV, NPV and accuracy were calculated.

RESULTS

CDI was carried out on 74 patients suspected of having deep venous thrombosis of the lower extremities. There was no patient having bilateral limb problems. The gender distribution of the subjects was 45 (61%) men, 29 (39%) women with the mean age 45 years [range: 21- 82 years]. Seventy four patients were subjected to affected lower limb venography so as to confirm the accuracy attributed to the color Doppler. Two patients refused to undergo the invasive procedure. In three patients, vein cannulation at the dorsum of the foot failed due to extensive thrombosis or swelling. In 69 patients successful venograms were performed therefore total number of patients included in the study was 69.

The Doppler diagnosis of DVT was confirmed in 49 of these cases. One patient had a diagnosis of thrombophlebitis made by Doppler but the venogram was normal (Table). This error arose in the calf region. In two patients, where Doppler was normal, venogram confirmed DVT. Seventeen cases were found negative for DVT on CDI as well as Venography.

When diagnosed, most patients with thrombophlebitis had involvement of the veins above the knee (82%). As shown in Figure 3, eighteen cases had involvement of all major deep veins including the iliofemoral segment (37 %). Most of patients involving popliteal segments had the end of thrombus around the adductor hiatus. Only 4 patients (8%) had isolated calf thrombosis.

Using venography as the reference standard for diagnosing DVT, the sensitivity and specificity of CDI was 96 % and 94.4 %, respectively, Positive predictive value was found to be 98% and negative predictive value was 89.5 %. Overall accuracy of the CDI was 95.6 %.

DISCUSSION

The present validation study was carried out to evaluate accuracy of CDI for the diagnosis of DVT which occurs as a complication of wide variety of medical and surgical illnesses. The most serious manifestation of DVT is pulmonary embolism, which occurs in up to 1% of hospitalized patients. Stein and Henry estimated that 90% of cases of pulmonary embolism originate in the deep venous

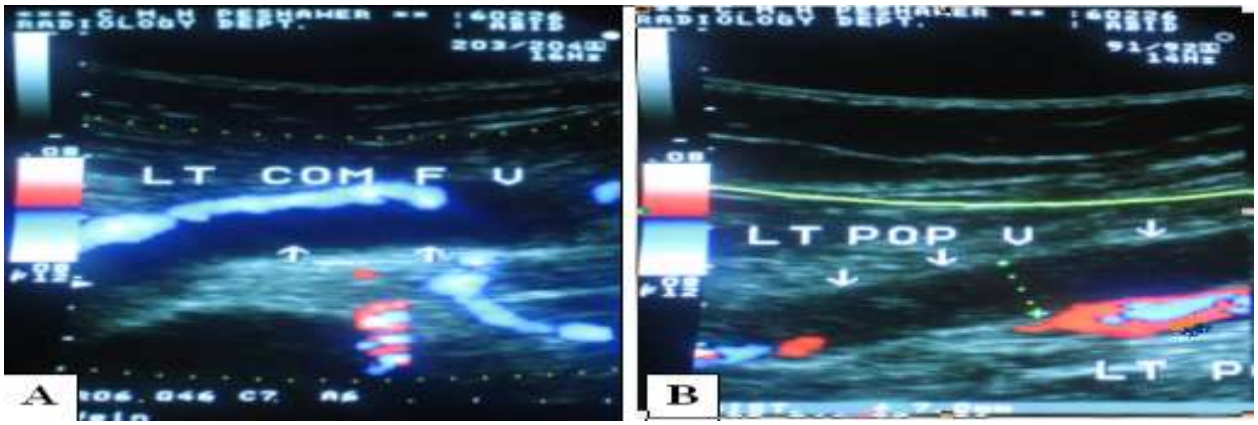

Figure-1: Longitudinal Color Doppler Images demonstrate hypoechoic thrombus (arrows) completely filling left common femoral and popliteal veins

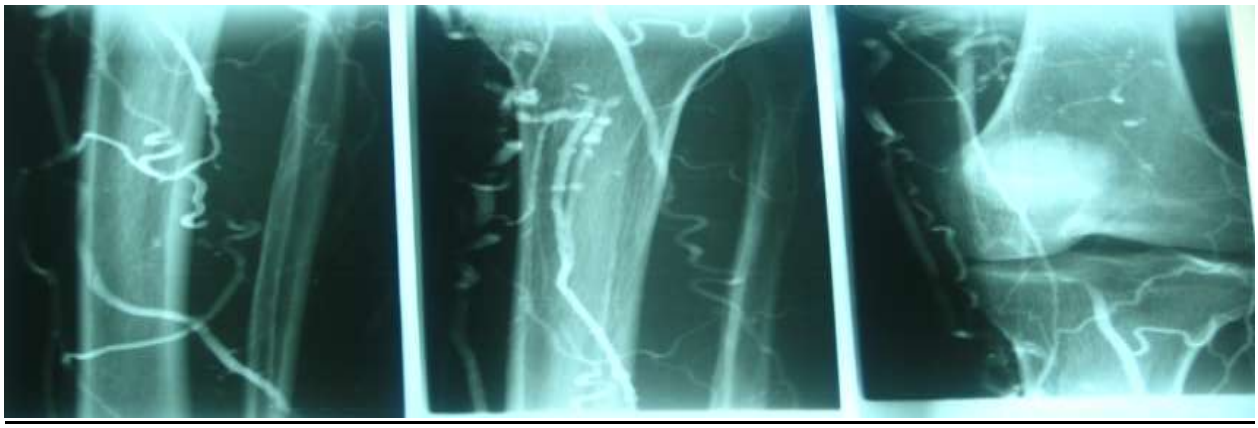

Figure-2: Venogram. Persistent non-filling of the lower limb veins in a case of complete deep venous thrombosis.

Table. Comparison of Color Doppler and Venography in 69 patients suspected of having deep venous thrombosis

	Cases	Percent
Positive CDI- Positive venogram	49	71%
Positive Doppler- Negative venogram	1	1.4%
Negative Doppler- Positive venogram	2	2.9%
Negative CDI- Negative venogram	17	24.6%

system of the lower limbs [13]. Zahid et al conducted a study on 50 patients and concluded that patients with all four classical features of DVT have two and a half times greater chance of having DVT as compared to those with only two clinical features. This means that the classical features of DVT are sufficiently specific [14].

As the clinical diagnosis is unreliable, several techniques have been developed for confirming the presence or absence of deep vein thrombosis. The accuracy of clinical diagnosis by the traditional signs (swelling, erythema, pain and Homan's sign) was only

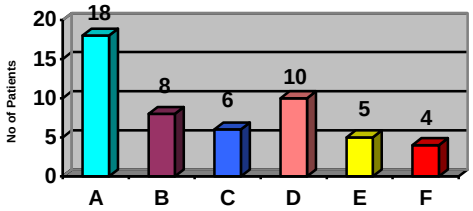

Figure 3: Anatomical sites of Thrombus in proven patients with DVT (n= 51)

Key:

A: Iliofemoral to calf veins **B:** Iliofemoral to popliteal segment
C: Superficial femoral only **D:** Superficial femoral to Calf
E: Popliteal and calf veins **F:** Calf veins only

45% percent. The most frequently encountered signs and symptoms in those patients clinically diagnosed as having thrombophlebitis were swelling, erythema and calf muscle tenderness.

In the present study, venography was used as the gold standard for the evaluation of CDI because venography has been shown to be the most reliable method of diagnosis and it is the touchstone to judge the accuracy of other methods. It accurately pinpoints the site and extent of involvement but has several disadvantages such as its cost and some degree of discomfort. It is invasive and almost always results in a transient and mild phlebitis. It can not be performed on all patients easily and can not be repeated, a limitation which diminishes its usefulness in evaluating prophylactic measures. Its other drawbacks are side effects associated with ionic contrast media [15].

Another technique for the diagnosis is conventional ultrasonography which is also non-invasive method and is widely available for the diagnosis of proximal DVT. However, ultrasonography cannot reliably detect the small proportion of patients with isolated calf clots [16]. CDI is now claimed to be the first line investigation for diagnosing DVT. It is easy, non invasive, safe, rapid, cost effective and portable. It can quickly pinpoint a major obstruction and is very useful in helping distinguish thrombophlebitis from cellulitis or lymphangitis in an acutely swollen limb. Baxter showed that Color Doppler allows the classification of thrombi into occlusive and non-occlusive types, which may be of prognostic significance [17].

In only two patients, where CDI was normal, venogram revealed DVT. In one patient, error of diagnosing thrombophlebitis made by Doppler where venogram was normal arose in the calf region. This was attributed to the slow flow in the calf veins due to swelling because of some other reasons.

Our findings were in agreement with many previous reports. Theodorou et al studied 136 patients with suspected DVT using sonography and contrast-enhanced venography. Using venography as the reference standard for diagnosing DVT, the sensitivity and specificity of sonography was 92.8% and 98%, respectively, yielding an accuracy of 96.8%. Overall accuracy to detect an acute calf DVT was 96%. The frequency of indeterminate examinations for calf DVT was 32.4% [18]. In a prospective study by Miller et al, sensitivity and specificity of duplex scanning at above-knee level were 98.7% and 100% respectively while corresponding values were 85.2% and 99.2% at below-knee level [19]. In another study by Baxter et al, the sensitivity and specificity of CDI for detection of lower limb venous thrombosis, including calf vein assessment, were 93% and 100% respectively [20]. Mitchell et al regarded femoropopliteal duplex scanning as sufficiently accurate to initiate the treatment on the basis of the scan [21]. Ozbudak et al observed the sensitivity and specificity of Doppler Ultrasonography in the diagnosis of DVT as 76% and 100%, respectively, and NPV and PPV were 81% and 100%, respectively [22]. In a study by Philbrick et al, the sensitivity of Doppler USG below the knee was only 40%, however, calf vein thrombi rarely produce major pulmonary embolism [23].

Becker et al compared 566 phlebographies with 526 color Doppler sonographic examinations and observed that thrombosis diagnosed with CDI showed a sensitivity of 98.0% (400 of 408). In 91.6% (482 of 526) of all examinations the extent of the thrombosis diagnosed with phlebography could also be seen with color Doppler imaging [24]. Power Doppler used complementary with CDI is capable of significantly improving identification of paired calf veins without loss of diagnostic accuracy [25].

As our study has clearly shown the accuracy of CDI in diagnosis of DVT comparable to that of venography, we can confidently recommend its routine use as it will facilitate early, cost effective and non invasive diagnosis of DVT.

CONCLUSION

In our set up, the accuracy of Color Doppler Imaging is comparable to venography for the diagnosis of lower limb deep venous thrombosis including the calf veins. It can be used as the routine diagnostic test for deep vein thrombosis.

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