East African Medical Journal Vol. 84 No. 7 July 2007
COMPARISON OF SONOGRAPHY WITH VENOGRAPHY IN THE DIAGNOSIS OF DEEP VENOUS THROMBOSIS
A.A. Aywak, MBChB (Nbi), MMed (Nbi), Lecturer, Department of Diagnostic Radiology, College of Health Sciences, University of Nairobi, P.O. Box 19676-00202, Nairobi, Kenya and J.V. Masesa, MD (Dar), MMed (Nbi), Radiologist, Diagnostic Centre Kenya Limited, P.O. Box 41595, Nairobi, Kenya

Request for reprints to: Dr. A.A. Aywak, Department of Diagnostic Radiology, College of Health Sciences, University of Nairobi, P.O. Box 19676-00202, Nairobi, Kenya

COMPARISON OF SONOGRAPHY WITH VENOGRAPHY IN THE DIAGNOSIS OF DEEP VENOUS THROMBOSIS

A.A. AYWAK and J.V. MASESA

ABSTRACT

Objective: **To compare the findings of venous sonography with contrast venography in the detection of deep venous thrombosis (DVT) of the lower limbs.**

Design: **Prospective study.**

Setting: **The Kenyatta National Hospital, a teaching and referral hospital in Nairobi.**

Subjects: **Fifty five limbs in 44 patients with clinical suspicion of DVT were evaluated during the seven months study period (October 2002-April 2003). The ethics committee in the institution granted approval for the study and participants gave written informed consent.**

Intervention: **Venous sonography in which a three step protocol involving B-mode gray scale compression sonography, colour and colour Doppler sonography was obtained after contrast venography in patients with clinical suspicion of DVT. The ultrasound examination was done within 24 hours of the contrast venogram.**

Results: **The overall sensitivity of venous sonography was 88.9%, specificity 91.8% and accuracy 90.9%. Considering only DVT above the calf, the sensitivity improved to 100%. An alternative diagnosis was found by ultrasound in 48.6% of the negative for DVT cases.**

Conclusion: **The accuracy of venous sonography as done locally is high and comparable to that in developed countries. We recommend that for patients with clinical suspicion of DVT, venous sonography be done as the initial imaging investigation and venography be reserved for those patients with equivocal or inadequate sonography results.**

INTRODUCTION

Deep venous thrombosis (DVT) is a serious health concern worldwide and affects one to two per 1000 people in the general population, the incidence increasing from one in 10,000 people in the less than 40 years age group to 1 in 100 for those older than 60 years of age (1). The sequelae of venous thrombosis include pulmonary or systemic embolism, post-thrombotic syndrome, and recurrent venous thromboembolism. Reducing the burden of disease due to venous thromboembolism requires effective primary prevention, prompt diagnosis, appropriate treatment of acute thrombosis and effective long-term secondary prevention (2).

Risk factors predisposing to formation of clots in the veins have been identified and subdivided into acute and chronic (3). The acute factors include hospitalisation, surgery, trauma, lower limb or pelvic fractures, long haul travel, recent commencement on steroid therapy within two weeks, and intravascular device. Chronic predisposing factors are further subdivided into inherited and acquired. Natural anticoagulant deficiency, Factor V Leidin and

Prothrombin G20210A mutation fall under the inherited factors. Acquired factors include age, obesity, cancer (chemotherapy), leg paralysis, oestrogen therapy, pregnancy or puerperium, major medical illness and previous venous thromboembolism. Other risk factors like high plasma homocysteine and high plasma coagulation factor VIII, IX, XI can be acquired or inherited (3).

The importance of accurately diagnosing deep venous thrombosis relates to its association with acute pulmonary embolism (PE). Though the presence of DVT does not equate with that of PE, its detection and adequate treatment can prevent development of pulmonary embolism (4). It has been recorded that pulmonary embolism is likely to occur in up to *50%* of untreated DVT (4). More importantly, in up to 30% of pulmonary embolism episodes the outcome is death (3). This mortality rate can be greatly reduced if DVT is diagnosed early and effectively treated. Since an estimated 90% of pulmonary embolism arise in the lower extremity, it is obvious that the lower extremity veins must be accurately assessed when DVT is suspected (5).

The clinical diagnosis of DVT is unreliable among those with symptoms and signs of DVT, only *25%* have thrombosis confirmed on a diagnostic test (5). Every clinical sign attributed to DVT has been statistically analysed and found to be of no value in reliably determining the presence or absence of DVT (5). Regarding pain or swelling, the location of signs and symptoms is generally known to be unrelated to the extent or location of the clot. Symptoms localised to the calf may be produced by an abnormality in the femoral vein and vice versa.

This together with the fact that treatment of DVT does have some side effect (6), points out the vital role of investigative techniques as the means of accurately making the diagnosis. The specificity of clinical diagnosis is low; symptoms associated with DVT can have among other causes a musculoskeletal or lymphatic basis. In addition, asymptomatic DVT can occur and the sequelae can be severe enough to cause death by pulmonary embolism (5,6).

Differential diagnosis: The differential diagnosis for the symptoms of leg swelling with pain or oedema includes deep venous thrombosis, Baker (popliteal) cyst, cellulitis, lymphoedema, chronic venous insufficiency, superficial thrombophlebitis, popliteal venous aneurysm, popliteal artery aneurysm, enlarged lymph nodes extrinsically compressing the veins, heterotopic ossification, haematomas and muscular tears. Through the appropriate use of imaging studies in particular through the appropriate use of ultrasound (US) imaging we can distinguish which of these clinical entities is present (6).

Imaging tests: There are various methods of evaluating the lower extremities for DVT. These include contrast venography, venous ultrasound including colour Doppler flow imaging and Doppler spectral analysis, impedance plethysmography; radionuclide approaches; magnetic resonance venography; computed tomography; non imaging continuous wave Doppler analysis and thermography (6-18). The Cardiovascular Appropriateness Panel of the American College of Radiology (ACR) has studied these methods and rated each for appropriateness (4). Colour duplex Doppler compression ultrasound was given the highest possible rating by the panel and recommended as the study of choice for the evaluation of symptomatic patients (6-12).

Contrast venography is the "gold standard" by which other examinations have been rated (6-13). However it may not give reliable results in 5%–10%, requires use of intravenous contrast medium with its associated risks of renal failure, extravasation, chemically induced thrombophlebitis and idiopathic contrast reactions besides use of ionising radiation (13). It was thus given only an intermediate appropriate rating (4), since it is also unsuitable for follow up of patients. Non-invasive tests such as venous sonography are now widely being employed as first line for the diagnosis and follow up of DVT (6-12). The major shortcoming in ultrasound examination is its operator dependency. Thus experience and skill of sonographer / sonologist is of paramount importance for appropriate yield in any given ultrasound examination. Compression, colour and spectral sonography of a whole limb can be quite demanding requiring patience and strict adherence to set technical approach. A complete examination may require 10–15 minutes for each limb (6,8-10). Failure to abide with set standards will lead to a large number of false positive or negative results and cause loss of faith in the test by referring physicians. Knowledge of the accuracy and the non-invasive nature of venous sonography by the clinicians are expected to boost their confidence in

the test and make them more liberal in utilising the examination and ensuring early case detection for proper clinical management. Studies done in the developed world have demonstrated an accuracy of venous sonography close to that of venography in the diagnosis of DVT (7,8). By period of the study colour venous sonography had been in use locally for about five years, however, to our knowledge no study has been done to assess its performance compared to venography in the local setting .The investigators embarked on making an assessment of the performance of this relatively new technology in diagnosing DVT and set quality assurance standards locally.

MATERIALS AND METHODS

All patients referred to KNH for lower limb venography on clinical suspicion of deep venous thrombosis (during the study period of seven months) were offered venous sonography in which gray scale compression, colour and spectral doppler examination was done at no extra cost provided that the ultrasound examination could be performed within 24 hours of the venography.

The contrast venographic technique was a modification of that of Rabinov and Paulin (19). Following application of tourniquet on the ankle with the patient lying on a tilting fluoroscopy table 100 ml of non-ionic contrast was injected into a dorsal foot vein slowly. Venous opacification was monitored fluoroscopically and two views of the calf and thigh were taken with the patient tilted at least 30° in reverse Trendelenberg (head up) position. A single view of the upper thigh and pelvis was obtained with the patient supine.

The study was considered completed when the entire venous system was demonstrated from the ankle to the common iliac vein (Figure 1).

Results of venography were considered positive for DVT if a constant filling defect or thrombus was identified, if there was persistent non-filling of a venous segment despite adequate technique or if there was abrupt termination of the opaque column of contrast media in a venous segment (Figure 2).

Colour doppler sonography was performed using a 5–7.5 MHz linear array probe. With the patient in a supine position and the leg in slight external rotation, the common and superficial femoral veins were examined down to the level of the adductor canal in both the transverse and the longitudinal axis.

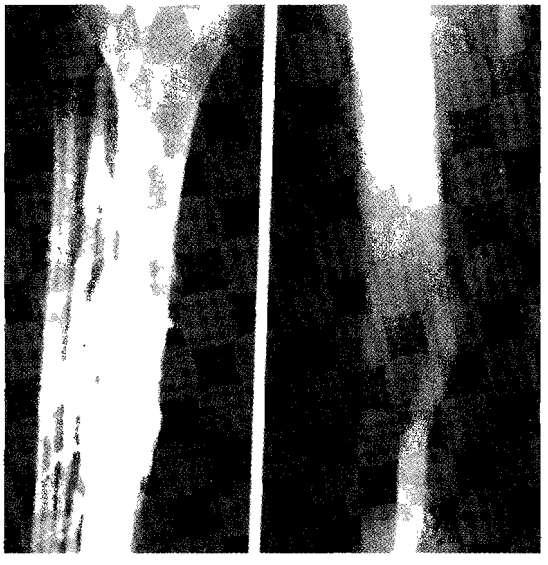
The patient was then turned prone or in lateral decubitus position with the knee slightly flexed (30°) and assessment of the popliteal and proximal calf vessels was then performed. All venous segments were assessed for compressibility, colour flow and venous flow pattern both spontaneous and after distal calf compression.

Both examinations (venography and ultrasound) were performed by different consultant radiologists. In order to capture the real situation, almost every radiologist taking part in the daily evaluation of patients, in the services of venography and doppler sonography was involved in a blinded manner (Figure 3).

The results of colour doppler ultrasound were considered positive if there was absence of the normal venous compressibility, a focal flow void within the colour-encoded blood flow image or the absence of visible flow within a segment of a vessel on spectral doppler (Figure 4).

Figure 1

Contrast venogram



Normal veins

Figure 2

Contrast venogram: Persistent filling defects on two views of tibial and femoral veins consistent with DVT

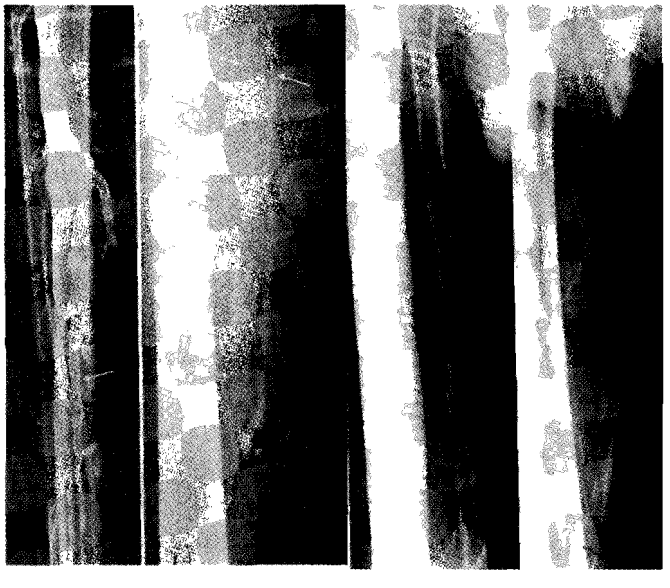
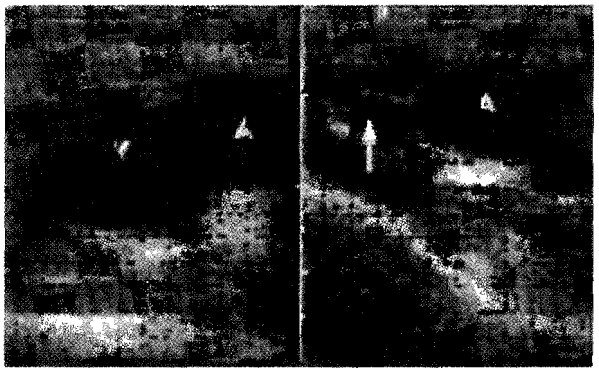


Figure 3

Increased flow with distal augmentation



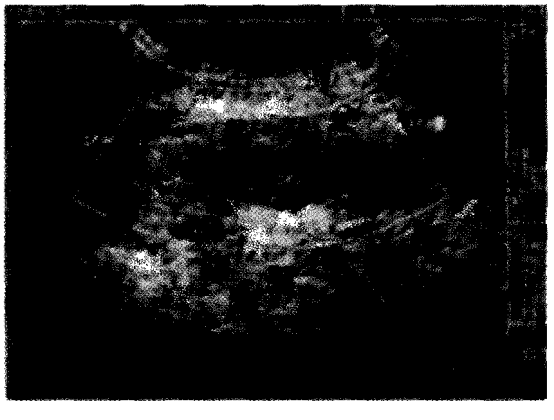
3 (a) Complete compression of vein

3 (b) Complete filling of normal vein with colour flow

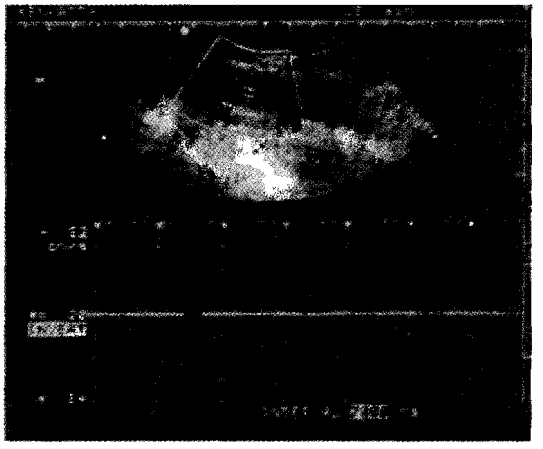
3 (c) Increased flow with distal augmentation

Figure 4

4 (a) Transverse colour doppler image showing lack of venous compressibility and absence of colour filling in the lumen of the common femoral vein



4 (b) Longitudinal colour doppler showing low level echoes within the lumen of the common femoral vein in the same patient. Absence of colour filling is also seen



4 (c) Spectral doppler image demonstrating absence of flow in the Rt. common femoral vein. This patient had a clot extending to the external iliac vein

RESULTS

Fifty five limbs were studied in 44 patients, 30 males and 14 females. All patients underwent both venous sonography and contrast venography, for suspected deep venous thrombosis of the lower extremity. Venography results were positive for acute DVT in 18 (32.7%) examinations and 19 (34.5%) limbs were shown to have DVT on sonography (Table 1). Three positive ultrasound examinations demonstrated no clots on contrast venography (false positives). There were two false negative examinations both of which had DVT confined to the calf veins. These results present an overall sensitivity of 88.9%, specificity of 91.8%, and 84% and negative predictive value of 94.3%. The accuracy is 90.9%. When only DVT above the knee was considered, there were 15 true positives, 34 true negatives, and one false positive (Table 2). No false negative examinations were seen. This improved the sensitivity to 100% and specificity to 97%.

During the study period in three examinations, venopuncture was not successful due to marked oedema, ultrasound came in handy and a diagnosis of severe extensive DVT was made. On follow up these patients did well after effective treatment. Two other examinations were non-diagnostic due to inadequate opacification of the femoral and iliac vessels, again ultrasound was helpful. These five cases were not included in the study.

In 18 of the 37 (48%) limbs negative for DVT on sonography examination, an alternative diagnosis was found. Ten cases had valvular insufficiency,

four had lymphadenopathy with cellulitis, and two had extensive collaterals suggesting post phlebitic syndrome. Diffuse thickening of subcutaneous tissues with prominent lymphatic channels was seen in two patients and diagnosed as cellulitis lymphoedema (Table 3).

Table 1

Comparison between colour doppler sonography and contrast venography (whole limb)

	Venography		
Ultrasound	Thrombus present	Thrombus absent	Total
Thrombus present	16	3	19
Thrombus absent	2	34	36
Total	18	37	55

There were three false positives and two false negatives.

Table 2

Comparison between colour doppler sonography and contrast venography (DVT above the knee)

	Venography		
Ultrasound	Thrombus present	Thrombus absent	Total
Thrombus present	15	1	16
Thrombus absent	0	34	34
Total	15	35	50

There was one false positive and no false negative on ultrasound. Sensitivity 100%, specificity 97%, positive predictive value 93% and negative predictive value 100%

Table 3

Ancillary findings in patients without deep venous thrombosis of the lower limbs

Finding	No.	(%)
Prolonged flow reversal	10	27
Extensive collaterals	2	5.4
Lymphadenopathy	4	10.8
Cellulitis/lymphoedema	2	5.4
Total	18	48.6

In 48.6% of the cases without DVT an alternative diagnosis was established

DISCUSSION

Deep venous thrombosis continues to offer challenging diagnostic problems in clinical medicine. The clinical diagnosis of DVT is generally known to be inaccurate with sensitivity ranging between 14% and 78%. The specificity ranges between 4% and 21% depending on the clinical sign being considered (14-18). In this study only 32.7% of the clinically suspected cases had DVT on imaging highlighting the inadequacy of clinical diagnosis colour doppler ultrasound had a sensitivity of 88.9%, specificity 91.8% and accuracy 90.9% with the sensitivity rising to 100% when only DVT above the knee was considered.

Similar findings have been demonstrated by other researchers (14,16-18). An alternative diagnosis was provided by ultrasound in 48.6% of the limbs found negative for DVT on ultrasound, a finding sited by others on colour doppler imaging of clinically suspected DVT (5-13).

Contrast venography was considered as the definitive modality for the diagnosis of DVT, unfortunately it is associated with significant patient discomfort and a low level risk for contrast induced nephropathy, phlebitis and other contrast media reactions.

Our results show that for diagnostic ultrasound in evaluating DVT of the lower limbs the sensitivity, specificity, positive and negative predictive values are comparable to studies done elsewhere (14).

In this study calf veins were routinely examined. Three patients (16.6%) had isolated calf thrombi and two of them were missed by sonography. On the other hand, of the three false positive cases seen by colour doppler sonography two were isolated below calf DVT.

These observations suggest that sonography can be limited in as far as isolated DVT below the calf is concerned. A repeat examination in a week or two is suggested in patients initially negative for DVT, whose symptoms persist. This measure would identify cases that have developed proximal thrombus propagation to the popliteal or femoral veins.

The improvement of sensitivity to 100% and specificity to 97% when only DVT above the knee was considered implies that colour doppler ultrasound is highly reliable in detecting the life threatening femoropopliteal DVT. These findings have been recorded by other researchers (11-17).

Finding an alternative diagnosis is very vital as it allows the attending clinician to shift his attention and concentrate on the problem at hand thus improving patient management.

The majority of alternative findings amongst those without DVT were cases of post phlebitic syndrome. The limitations of ultrasound include operator dependency, difficult in definition of the iliac or calf veins, and occasional inability to distinguish between chronic and acute recurrent DVT by compression. Presence of duplicated vessels can be an important challenge to achieving an accurate study. Absolute dedication by the attending sonologist/sonographer is thus a necessity other than a requirement.

In conclusion, on the basis of the results presented here it is recommended that venous sonography be utilised as the primary imaging modality in patients with lower extremity symptoms suggestive of DVT. This will improve the pick up rate of DVT and lessen patient risk and discomfort. Moreover it may establish an alternative diagnosis.

Contrast venography with its attendant discomforts and risks should be reserved for special cases, such as those with equivocal results on sonography and those who for one reason or other would not have an adequate conclusive ultrasound examination.

REFERENCES

1. Incidence of venous thromboembolism: a community-based study in Western France. *Thrombo Haemost.* 2000; **83:** 657-660.
2. Lee C.H., Hankey G.H., Ho W.K. and Eikellboom J.W. Venous thromboembolism: Diagnosis and management of pulmonary embolism. *Med. J. Aust.* 2005; **182:** 476-481.
3. Heit J.A., O'Fallon W.M., Petterson T.M., *et al.* Relative impact of risk factors for deep venous thrombosis and pulmonary embolism: A population based study. *Arch. Int. Med.* 2002; **162:** 1245-1248.
4. Needleinan L. and Polak J. Suspected lower extremity deep vein thrombosis. American College of Radiology Appropriateness Criteria for Imaging and Treatment Decisions. Reston, Va: *Amer. J. Radiol.*1995; 8.1-8.6.
5. Wells P.S., Hirsh J., Anderson D.R., *et al.* Accuracy of clinical assessment of deep vein thrombosis. *Lancet.* 1995; **345:** 1326-1330.
6. Borgstede J.P. and Clagett G.E. Type's frequency and significance of alternative diagnoses found during

duplex Doppler venous examinations of the lower extremities. *J. Ultrasound Med.* 1992; **11:** 85-86.

7. Kearon C., Julian J.A., Newman T.E. and Ginsberg J.S. Non-invasive diagnosis of deep venous thrombosis. Macmaster diagnostic imaging practice guidelines initiative. *Ann. Int. Med.* 1998; **128:** 663-677.
8. Burn P.R., Blunt D.M., Sansom H.E. and Phelan M.S. The radiological investigation of suspected lower limb deep vein. *Thrombos. Clin. Radiol.* 1997; **52:** 625-628.
9. Rose S.C., Zweibel W.J., Nelson B.D., *et al:* Symptomatic lower extremity deep venous thrombosis: Accuracy, limitations and role of colour duplex flow imaging in diagnosis. *Radiol.* 1990; **175:** 639-644.
10. Carpenter J.P., Hofland G.A., Baum R.A., *et al.* Magnetic resonance venography for the detection of deep venous thrombosis: Comparison with contrast venography and duplex doppler ultrasonography. *J. Vascular Surg.* 1993; **18:** 734-741.
11. Bald M.M., Zontisch T., Stumpfien A., *et al.* Deep vein thrombosis of the lower limb extremity: Efficacy of CT venography compared with contrast venography in diagnosis. *Radiol.* 1996; **200:** 423-428.
12. Line B.R., Peters T.L. and Keenan J. Diagnostic test comparisons in patients with deep venous thrombosis. *J. Nucl. Med.* 1997; **38:** 89-92.
13. Moody A.R., Pollock J.G., O'Connor A.R. and Bagnell M. Lower limb deep vein thrombosis: Direct MRI imaging of the thrombus. *Radiol.* 1998; **209:** 349-355.
14. Baarslag H.J., van Beek E.J.R., Koopman M.M.W. and Reekers J.A. Prospective study of color duplex ultrasonography compared with contrast venography in patients suspected of having deep venous thrombosis of the upper extremities. *Ann. Int. Med.* 2002; **136:** 865-872.
15. Bear M.H., Porter R.S., Jones T.V. and Berwits M (Eds). Deep venous thrombosis. 18th Edition, Chapter 8. The Merck Manual of Diagnosis Therapy. Merck Research Laboratories, Whitehouse Station, NJ. 2006.
16. Fraser D.G.W., Moody A.R., Morgan P.S., Martel A.L. and Davidson I. Diagnosis of lower-limb deep venous thrombosis: A prospective blinded study of magnetic resonance direct thrombus imaging. *Ann. Int. Med.* 2002; **136:** 89-98.
17. Baxter G.M., Mackechnie S., Duffy P., *et al.* Colour doppler ultrasound in deep venous thrombosis: A comparison with venography. *Clin. Radiol.* 1990; **42:** 32-36.
18. Lewis B.D., James E.M., Welch T., *et al.* Diagnosis of acute deep venous thrombosis of the lower extremities: Prospective evaluation of duplex flow imaging versus venography. *Radiol.* 1994; **192:** 651-655.
19. Cronan J.J., Dorfman G.S. and Scholar F.H. Deep venous thrombosis US assessment using vein compression. 1987; **162:** 191-194.