The Ulster Medical Journal, Volume 68, No. 2, pp. 59-63, November 1999.

Early experience using duplex ultrasonography in the diagnosis of deep venous thrombosis; a prospective evaluation

P T Kennedy, W Loan, M Buckley, P Rice, P Hanley

Accepted 12 March 1999

SUMMARY

Duplex ultrasound is used in many radiology departments as the first line of investigation for symptomatic deep venous thrombosis. Before changing the practice of our department from venography to duplex ultrasonography, we wanted to assess our ability to identify deep venous thrombosis on ultrasound. Thirty-eight patients were investigated for suspected deep venous thrombosis by venography and duplex ultrasound. The results were compared using venography as the 'gold standard'. Duplex ultrasound correctly identified 13 out of 16 limbs with deep venous thrombosis. Four of the 38 duplex ultrasound examinations (11%) were described as inadequate at the time of examination, and when these are excluded from the analysis a sensitivity of 93%, and specificity of 80% are achieved. We conclude that there is a significant learning curve when performing duplex ultrasound of the lower limb, and that change-over from venography to ultrasound should include a period during which both examinations are routinely performed.

INTRODUCTION

Deep venous thrombosis (DVT) is a common condition with potentially serious sequelae which is difficult to diagnose clinically with accuracy. Contrast venography has been the 'gold standard' investigation for a long time. However it involves irradiation, is often a painful procedure and has associated risks such as hypersensitivity reaction to the contrast, chemical phlebitis, contrast extravasation and renal failure. Consequently, many different modalities for diagnosing DVT have been developed over the years. Duplex ultrasonography (a combination of real-time grey scale image, and pulsed doppler to provide flow information) has improved in image quality over the past decade, and is now used as the primary imaging technique in many centres. Our department envisages using ultrasound as its first-line investigation in the future. Therefore this study was instigated to assess the accuracy of duplex ultrasonography in a clinical setting, when performed by sonographers with little experience of the technique. The study did not set out to validate the investigation, but to explore its reliability early in its use within a department.

PATIENTS AND METHODS

Between August 1997 and January 1998 patients referred to our department with symptoms suggestive of DVT were investigated by contrast venography. For 38 patients a duplex ultrasound examination was performed within one hour of the venography. For each patient the presence of thrombus and its distribution were recorded, and a comparison made between the two modalities, using venography as the 'gold standard'.

Department of Clinical Imaging, The Ulster Hospital, Belfast.

P T Kennedy, FRCSI, FRCR, Specialist Registrar in Radiology.

W Loan, FRCS, Specialist Registrar in Radiology.

M Buckley, MB, Specialist Registrar in Radiology.

P F Rice, FRCSI, Specialist Registrar in Radiology.

P Hanley, FRCR, Consultant Radiologist.

Correspondence to Dr Loan, Department of Radiology, Royal Victoria Hospital, Belfast BT12 6BA.

The mean age of the patients was 68 years, (range 31-85). Twenty-two of the patients were female. All patients were referred either from casualty (63%) or from the wards (37%). A previous history of DVT was obtained in five patients. The time taken for each examinaåion was recorded.

All the duplex examinations were performed by two specialist registrars trained in the principles of the technique, but with experience of less than ten previous examinations. They were blinded to the results of the contrast venography examination. ATL 3000 HDI scanners (Advanced Technology Laboratories, Bothwell, WA, USA) with a 7-10MHz probe were used for each examination. Each patient was examined supine, prone or left lateral decubitus, and sitting, depending on which segment of the deep venous system was being assessed. The examination began at the calf and worked proximally, so that the sonographer was not biased, when examining the calf, by the presence of more proximal thrombus. The anterior tibial group of calf veins were not assessed. For each patient the sonographer recorded whether sufficient visualisation of the calf veins had been obtained to render the examination diagnostic. When the calf was inadequately visualized the examination was considered negative for thrombus. In two patients sonographic examination of the calf was impossible due to patient immobility.

The diagnosis of DVT on duplex scanning is based on a number of criteria, the most important of which is direct visualization of thrombus within the vein. Non-compressibility of the vein, lack of flow, and abnormal flow patterns during respiration are also important. The presence of non-occlusive thrombus however, can cause false negative results if too much emphasis is placed upon flow analysis. All criteria must therefore be assessed in diagnosing DVT.

RESULTS

Contrast venography revealed DVT in 16 of the 38 limbs, whilst ultrasound correctly diagnosed 13 of these thromboses. The segments involved are listed in Table I. There were three false negative duplex ultrasound scans (Table II): in one patient venography identified anterior tibial and gastrocnemius muscle vein thrombus, but no extension into the popliteal vein. In two other patients isolated calf vein thrombus was missed, but both of these scans were recorded as inadequate at the time of examination. There were four false positive scans; three of these cases occurred in the first 11 patients examined, and were probably due to misinterpretation of muscle bundles in the calf as dilated non-compressible veins. The fourth false positive was convincing on ultrasound as a segment of peroneal vein thrombus, but was not visualized on venography.

TABLE I

Segments of deep veins involved by thrombus, as shown by venography

Normal	22
Calf	4
Calf to popliteal	4
Calf to frmoral	5
Calf to iliac	2
Femoral	1
Popliteal to femoral	1

The total number of segments involved by thrombus is 17 because one patient had a calf vein thrombus and a separate, isolated superficial femoral vein thrombus.

TABLE II

	positive venogram	*negative venogram*
positive duplex	13	4
negative duplex	3	18

Comparison of duplex ultrasound with contrast venography for lower limb DVT. Sensitivity 81%, specificity 82%, accuracy 84%.

Of the 16 limbs with DVT, 15 had thrombus in the calf. Four of these 15 had thrombus involving the calf veins only. Two of the fifteen patients did not have their calves examined by ultrasound due to marked immobility. Of the remainder (i.e. 13 patients), 8 calf thromboses were positively identified and five were missed. Of the five missed thromboses, two further patients were the cases described in the preceding paragraph, which were recorded as inadequately visualized at the time of the examination.

A total of four calves were recorded as inadequately visualized: calf tenderness in three patients resulted in the sonographer being unable

to adequately compress the leg to allow detection of incompressibility of the vein. The cause of the tenderness was fracture of the fibula, an overlying soft tissue wound, and superficial thrombophlebitis respectively. One of these three patients was also quite immobile. The fourth patient was relatively immobile which prevented optimal probe positioning. If these patients are excluded from the study then the sensitivity and specificity are 93% and 80% respectively. The average time taken for the examination was 20.1 minutes; however this decreased as the study progressed: the average time taken for the first 19 patients was 22.6 minutes, whilst it was 17.9 minutes for the second half of the study (p=0.044, two sample t test).

DISCUSSION

Deep venous thrombosis (DVT) is a common condition with potentially fatal sequelae, and clinical diagnosis is insensitive.[1] Contrast venography has long been the definitive investigation, but several other less invasive modalities have been developed. Duplex ultrasound, the combination of grey scale, real time ultrasound with pulsed doppler to provide spectral blood flow information, has emerged as an accurate alternative. A recent survey showed that it is used by 46% of UK radiology departments as their first line investigation.[2] Colour flow ultrasound and power doppler have also been advocated[3] as a means of improving the accuracy of the technique. Duplex ultrasound for suspected DVT was initially unpopular because it was a time-consuming technique with poor visualization

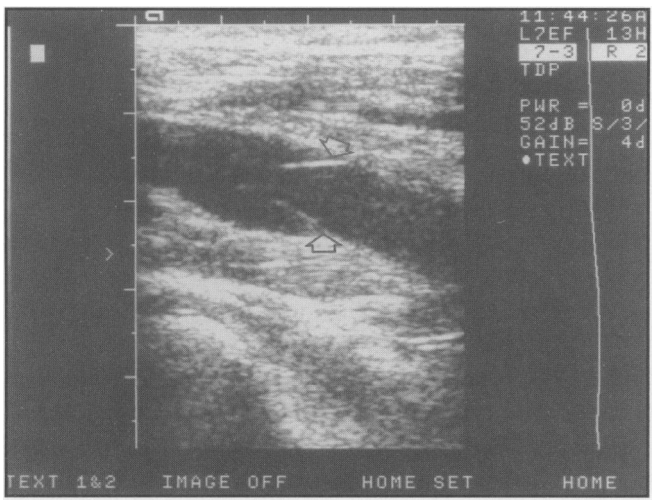

Fig 1. *A longitudinal section, showing resolutiuon* sufficient to clearly demonstrate valve leaflets within the popliteal vein (arrows).

of the calf veins. However image quality has improved (figures 1, 2 and 3), as a consequence of technological advance and improved scanning protocols, and these disadvantages have therefore diminished.[4] Duplex ultrasound is accurate in diagnosing femoropopliteal thrombus, and some groups argue that isolated below-knee thrombus is a rare event which does not require anticoagulation and therefore diagnosis of thrombus in this segment is not necessary.[5] However up to a third of isolated below-knee thrombus propagates,[6, 7] and since it can be diagnosed by duplex ultrasonography then it is sensible to include an assessment of the below - knee segment when performing ultrasound for suspected DVT.[8]

We have confirmed the accuracy of duplex ultrasound in assessing above-knee DVT: we had one false negative duplex in this segment which failed to identify a 1 cm thrombus lodged behind a valve leaflet in the mid superficial femoral vein; however calf vein thrombus was correctly identified in this patient, so that the correct diagnosis was made when the limb was considered as a whole. Due to the relatively small numbers in our study this gives a sensitivity of 92% for above-knee thrombus, which is slightly low when compared to similar studies in the literature which show a sensitivity of 96-100%.[3, 9, 10, 11]

When including the assessment of the below-knee veins we have returned a sensitivity of 81% and specificity of 82%. These figures are below average when compared to the literature, which indicates a sensitivity of 92-98% and specificity of 86-100%,3, 10, 12, 13 but when the technically inadequate scans are excluded our figures are 93% and 80% . Our reason for excluding the technically inadequate scans is that in clinical practice these patients would be referred for contrast venography. Four (13%) of our duplex examinations were considered technically inadequate, which is in line with other studies,[3, 10] although this figure should diminish as further experience is gained.[14] Our false positive rate is high when compared to the literature, and this was due to misinterpretation of muscle bundles for dilated non-compressible veins in three patients early in the study. A later false positive showed what appeared to be thrombus isolated to the peroneal vein, and although this was not confirmed by venography, review of the venogram shows underfilling of some of the peroneal vein branches.

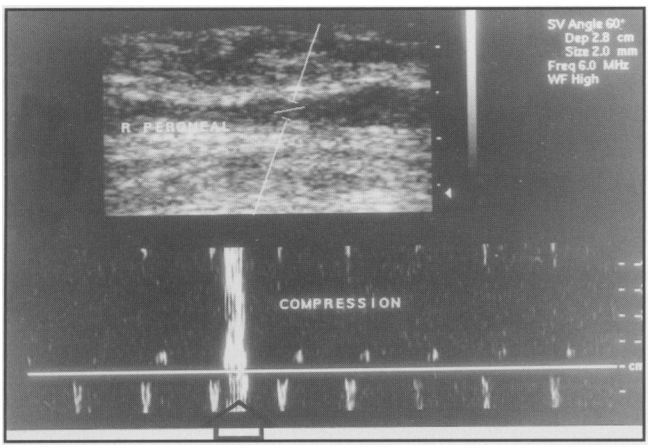

Fig 2. Longitudinal image depicting the peroneal vein. The doppler gate has been positioned over the vein whilst the sonographer simultaneously squeezes the patient's calf to augment blood flow within the vessel. This results in a sudden movement of the blood column of over 40 cm/ sec. (Arrow).

Contrast venography is not a perfect test, and there are many documented examples of DVT demonstrated by duplex ultrasound, confirmed by another technique (e.g. MRI) but not shown on contrast venography.[4, 12] We, like many other groups, did not routinely examine the calf for anterior tibial vein thrombosis since isolated thrombus in this segment is quite rare.[14] We did find that colour and power doppler were useful, particularly for identifying calf vessels, but we did not record sufficient data to determine whether they increased sensitivity or specificity.

A great advantage of duplex ultrasound in assessing suspected DVT is its ability to provide an alternative diagnosis such as popliteal (Baker's) cyst, haematoma, superficial phlebitis and subcutaneous oedema. Such an alternative diagnosis is typically made in 9-11% of patients scanned.[9, 10, 15] Duplex ultrasound is also a cheaper option than venography, avoiding the need for using expensive iodinated contrast media and requiring less acetate sheets for image storage.

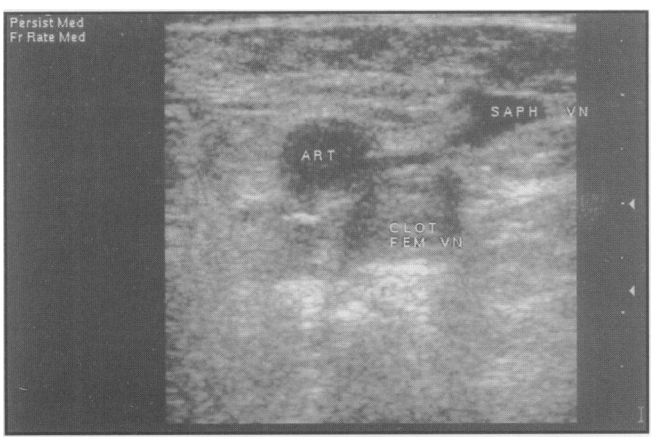

Fig 3. Transverse section through the superficial femoral vein demonstrating echogenic thrombus. Note a patent adjacent long saphenous vein.

Fig 4. Contrast venogram demonstrating the superficial femoral vein dividing into two venae commitantes, and then rejoining.

There are a number of recognised pitfalls, and the most common of these is the presence of a duplicated superficial femoral vein (fig. 4). The risk is that the sonographer correctly identifies the normal superficial femoral vein, but fails to recognise the second, thrombosed vein. This is the most common cause of a false negative examination in the femoropopliteal segment.[16] A further area of difficulty occurs in patients who have had previous DVT presenting with new symptoms suggesting a further episode.

In conclusion, duplex ultrasonography is a useful technique in the assessment of limbs with suspected DVT. We have obtained reasonable results with little prior experience of the technique; however it is clear that there is significant learning curve, and highly accurate results should be obtained with experience. We advocate that a sonographer learning the technique should compare the results of their early examinations with a contrast venogram for each patient.[10] We also suggest that contrast venography remains the first-line investigation in patients who are particularly immobile or obese.

REFERENCES

1. Sandler D A, Duncan J S, Ward P *et al.* Diagnosis of deep-vein thrombosis: comparison of clinical evaluation, ultrasound, plethysmography and venoscan with x-ray venogram. *Lancet* 1984; **2**: 716-9.
2. Burn P R, Blunt D M, Sansom H E, Phelan M S. The radiological investigation of suspected lower limb deep venous thrombosis. *Clin Radiol* 1997; **52**: 625-8.
3. Baxter G M, Duffy P, Partridge E. Colour flow imaging of calf vein thrombosis. *Clin Radiol* 1992; **46**: 198-201.
4. Bradley M J, Spencer P A, Alexander L, Milner G R. Colour flow mapping in the diagnosis of calf deep vein thrombosis. *Clin Radiol* 1993; **47**: 399-402.
5. Cogo A, Lensing A W, Prandoni P, Hirsh J. Distribution of thrombosis in patients with symptomatic deep vein thrombosis: implications for simplifying the diagnostic process with compression ultrasound. *Arch Inter Med* 1993; **153**: 2777-80.
6. Giannoukas A D, Labropoulos N, Burke P, *et al.* Calf deep venous thrombosis: a review of the literature. *Eur J Vasc Endovasc Surg* 1995; **10**: 398-404.
7. Lohr J M, Kerr T M, Lutter K S, Cranley R D, Spirtoff K, Cranley J J. Lower extremity calf thrombosis: to treat or not to treat? J Vasc Surg 1991; 14: 618-23.
8. Dauzat M, Laroche J P, Deklunder G, Ayoub J, Quere I, Lopez F M, Janbon C. Diagnosis of acute lower limb deep venous thrombosis with ultrasound: trends and controversies. *J Clin Ultrasound* 1997; **25**: 343-58.
9. Labropoulos N, Leon M, Kalodiki E, Al Kutoubi A, Chan P, Nicolaides A N. Colour flow duplex scanning in suspected acute deep vein thrombosis; experience with routine use. *Eur J Vasc Endovasc Surg* 1995; **9**: 49-52.
10. Miller N, Satin R, Tousignant L, Sheiner N M. A prospective study comparing duplex scan and venography for diagnosis of lower-extremity deep vein thrombosis. *Cardiovasc Surg* 1996; **4**: 505-8.
11. Rose S C, Zwiebel W J, Nelson B D, *et al.* Symptomatic lower extremity deep venous thrombosis: accuracy, limitations, and role of color duplex flow imaging in diagnosis. *Radiology* 1990; **175**: 639-44.
12. Becker D, Gunter E, Strauss R, *et al.* Color doppler imaging versus phlebography in the diagnosis of deep leg and pelvic vein thrombosis. *J Ultrasound Med* 1997; **16**: 31-7.
13. Comerota A J, Katz M L, Greenwald L L, *et al.* Venous duplex imaging: should it replace haemodynamic tests for deep venous thrombosis? *J Vasc Surg* 1990; **11**: 53-9.
14. Mattos M A, Melendres G, Sumner D S, *et al.* Prevalence and distribution of calf vein thrombosis in patients with symptomatic deep venous thrombosis: a color-flow duplex study. *J Vasc Surg* 1996; **24**: 738-44.
15. Langsfeld M, Matteson B, Johnson W, Wascher D, Goodnough J, Weinstein E. Baker's cysts mimicking the symptoms of deep vein thrombosis: diagnosis with venous duplex scanning. *J Vasc Surg* 1997; **25**: 658-62.
16. Screaton N J, Gillard J H, Berman L H, Kemp P M. Duplicated superficial femoral veins: a source of error in the sonographic investigation of deep vein thrombosis. *Radiology* 1998; **206**: 397-401.