Loss of compressibility by ultrasonography in deep venous thrombosis of the lower extremities: a prospective evaluation.

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Abstract:

Compressibility of the deep veins of the lower extremities by real time ultrasonography, in the cases suspected to have deep vein thrombosis was analyzed, using contrast venography as the standard in the diagnosis of the deep venous thrombosis. A prospective study was performed in 25 cases. There was no false positive cases. Thirteen contrast venography diagnosed DVT showed 11 positive ultrasonography. The sensitivity was 87% and the specificity was 100%. The false negative studies should be avoidable if more careful examination was performed. The diagnosis of DVT by determination of the loss of compressibility by ultrasonography was very simple and accurate. With careful examination, it should obviate the need to performed more traumatic contrast venography, at least in the ultrasonographic DVT positive cases.

Key words: deep vein thrombosis, Ultrasound, venous compressibility

Deep vein thrombosis (DVT) is an important disease because of its two major sequelae; chronic venous insufficiency and pulmonary embolism. Pulmonary embolism is potentially lethal and the vast majority of them originate from the pelvis and lower extremities. Clinical diagnosis of DVT is unreliable. In a group of more than 1000 patients who were suspected to have DVT clinically, only 30% was found to have DVT, according to Hirsh et al (1). Contrast venography was considered to be the diagnostic tool for determination of DVT with good demonstration of the anatomic detail. Its disadvantages include invasiveness, contrast material toxicity, local irritation and contrast induced thrombus formation (2). The non invasive imaging methods to detect DVT include technetium-99m- labeled red blood cell venography, iodine-125-labeled fibrinogen scintigraphy, impedence plethysmography (IPG) and ultrasonography.

Real-time compression ultrasonography has been shown to be effective in the assessment of the DVT (3, 4). We assessed the ability of the high resolution ultrasonography to demonstrate the presence and absence of DVT in the lower extremities on the basis of the compressibility of the vein. Simplicity of the examination was considered paramount, since the on-call examination could be performed.

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Materials and methods

During February 1994 to October 1994, every patient who was sent to the Department of Radiology, Ramathibodi hospital, for contrast venography of the lower extremities with the possible diagnosis of DVT, was performed with the compressive ultrasonographic study within 4 hrs after contrast venography. Both studies were performed by different radiologists and were interpreted independently.

The contrast venography was performed using the technique, modified from that described by Rabinov and Paulin (5). 100-150 ml of 40% water soluble contrast medium was injected into a dorsal pedal vein while the patient was examined on the moving tabletop fluoroscopic-radiographic unit. The examination was interpreted by the vascular radiologists. The criterias for the diagnosis of DVT by venography included a constant filling defect or thrombus in the lumen, persistent nonfilling of a venous segment despite adequate technique, or the abrupt termination of the opaque column of the contrast medium in the venous segment.

The ultrasonographic evaluation of the lower extremity was performed with 7.5 MHz linear-array transducer. The examination began with the patient in a supine position with the leg in slight external rotation. Assessment included the common femoral veins down to the level of the adductor hiatus. Effort was made to image the femoral vein within the hunter canal and at the adductor hiatus, but this was not always possible. The saphenous vein was also visualized and the point of the union was always observed. The position and the appearance of the femoral artery was also noted, as well as any mass or fluid collection in the perivascular area. The deep femoral vein and the iliac vessels were not studied. After direct visualization of the veins in both transverse and longitudinal projections, the compression was applied. The degree of compression normally required to collapse the vein is small, only to dimple the skin; this has been estimated to be equal to 10^4 dyne/cm^2. The compression was routinely applied while the transducer was transversely oriented, so that the transducer did not roll off the vein. The vein was compressed and released at approximately 1 cm intervals.

After evaluation of the common femoral, superficial femoral and saphenous veins, the patient was placed in a prone position. The knee was bent about 30 degree and the distal part of the leg was supported with the towels for the optimal visualization of the venous lumen. The popliteal vein, both above and below the knee was studied to the region of its trifurcation. Routine imaging and compression of the proximal 1-2 cm of the posterior tibial vein was also performed. A decubitus position, opposite to the side examined was another alternative position if the patient could not be in the prone position. The distal aspect of the leg to be examined was elevated with towels so that it was in the same level as the femoral vein. The interpretation of the ultrasonographic studies was based on the compressibility alone. A complete compressible vein was interpreted as normal. Partial or noncompressible vein was compatible with DVT.

The results of the compressive sonography was compared with those obtained from the contrast venography. The causes of the false positive and false negative ultrasonographic results was analyzed.

Results

Twenty-five contrast venographies were performed, 13 studies were interpreted positive for DVT and 12 studies negative for DVT. In the venographic positive DVT patients, the ultrasonography showed 11 DVT positive studies and 2 DVT negative studies. All of the venographic negative studies also showed to be negative ultrasonographic studies. So, the compressive ultrasonography has a sensitivity of 86% and a specificity of 100%.

In one of the two false negative ultrasonographic studies, the venogram showed only non-filling of the anterior tibial vein but the popliteal vein was normal. Another ultrasonographic false negative patient showed occlusion of the superficial femoral vein and a patent saphenous vein was misinterpreted as a patent superficial femoral vein.

Visualization of the vein below the popliteal vein was poor. Only few cases that the proximal tibial or peroneal veins were observed and it was difficult to assess the compressibility of the lumen.

The normal ultrasonographic study was shown in Figure 1, one of the ultrasonographic positive case was shown in Figure 2 and the one false negative case was illustrated in Figure 3.

Discussion

Venous thrombi will typically form within the muscular venous plexi of the calf and spread contiguously to the tibioperoneal veins. In 20% of cases they spread to the popliteal venous segment and the superficial femoral vein, and finally involve the common femoral vein. This pattern of involvement is thought to occur in the majority of lower extremity DVT cases. Occasionally, there is thrombus spreading to the iliac veins and into the inferior vena cave (6). Studies looking into the location of DVT after an episode of symptomatic pulmonary embolism have shown the involvement of femoral or popliteal veins in most instances (7). In 10 to 20% of cases, only calf vein thrombi have been observed. The presence of obstructive venous thrombosis helps to stimulate the development of collateral pathways for blood flow. The perforating veins that communicate between the superficial and deep veins help to shunt the blood flow into the

greater and lesser saphenous veins. A collateral pathway through the deep muscular branches of the thigh often forms a path between the popliteal vein and the profunda femoris vein.

Venous ultrasound uses three important diagnostic criteria to determine the presence of acute deep vein thrombosis (8). The first is the direct visualization of thrombus as an echogenic structure lying within the lumen of the vein. The second is the measurement of the changes caused by the presence of thrombosis within the vein lumen. These indirect signs are passive distention of the vein by the acute thrombus and loss of normal venous compressibility when slight pressure is exerted on the skin overlying the vein. The third relies on the detection of a change in the flow dynamics within the vein.

The single most important criterion for making the diagnosis of acute deep vein thrombosis remains to be the loss of compressibility of the vein. A normal response is complete collapse of the lumen of the vein before any distortion in the artery. Loss of venous compressibility or failure to appose the luminal surfaces of the walls of a vein is considered diagnostic of acute vein thrombosis. This simple observation remains the most sensitive and most specific criterion for diagnosing acute obstruction and nonobstructing deep venous thrombosis of the femoral and popliteal venous segments.

The sensitivity of 87% and specificity of 100% was quite similar to the reports from many authors (3, 9 ,10, 11, 12) One of the false negative ultrasonographic study was that the patient had thrombosis in anterior tibial vein only. Many investigators believed that clot limited to a calf location was ultimately of little clinical significance, but the possibility of extension to the popliteal system did exist. (13) The another false negative case of us could actually not have happened if we examined the misinterpreted veins more carefully.

The sources of error during venous compression ultrasound stated by Polak (8) were 1. below-knee (infrapopliteal) thrombus 2. segmental vein incompressibility (adductor canal) 3. possible chronic DVT 4. nonobstructing focal DVT 5. vein duplication 6. iliac vein thrombosis and 7. Profunda femoris DVT.

References

1. Hirsh J, Hill RD, Raskob GE. Clinical features and diagnosis of venous thrombosis. J Am Coll Cardiol 1986: 8: 114B-127B.
2. Bettmain MA, Robbins A, Braun SD, et al: Contrast venography of the let: Diagnostic efficacy, tolerance and complications ratio with ionic and non-ionic contrast media. Radiology 1987, 165: 113-116.
3. Cronan JJ, Dorfman GS, Scola FH, Scheppes B, Alexander J. Deep vein thrombosis: US assessment using vein compression. Radiology 1987; 162: 191-194.
4. Raghavendre BN, Horh SC, Hilton S, Subramanyam BR, Rosen RJ, et.al. Deep venous thrombosis: Detection by probe compression of vein. J Ultrasound med 1986; 5: 89-95.
5. Rabinov K, Paulin S. Roentgen diagnosis of venous thrombosis in the leg. Arch Surg 1972; 104: 134-144.
6. Browse N. Diagnosis of deep vein thrombosis. Br Med Bull 1978; 34: 163-167.
7. Browse NL, Thomas M. Source of non-lethal pulmonary emboli. Lancet 1974; 1: 258-259.
8. Polak JF. Peripheral vascular sonography. A practical guide. Baltimore: Williams & Wilkins, 1992.
9. Sullivan ED, Peter DJ, Cranley JJ. Real-time B mode venous ultrasound. J Vasc Surg 1984; 1: 465-471.
10. Ragjavendra BN, Rosen RJ, Lam S, Rile S, Horii SC. Deep venous thrombosis: Detection by high-resolution real-time ultrasonography. Radiology 1984, 152: 789-793.
11. Ojarasporn V, Ekmahachai M., Sivasomboon C, Prapakorn V. Ultrasound diagnosis of deep vein thrombosis. Thai J. of Radiology 1990, 27: 101-109.
12. Salzman EW. Venous thrombosis made easy. N Engl J Med 1986; 314: 847-848.
13. Moreno-Cabral R, Kistner RL, Nordyke RA. Importance of calf vein thrombophlebitis. Surgery 1976, 80: 735-742.

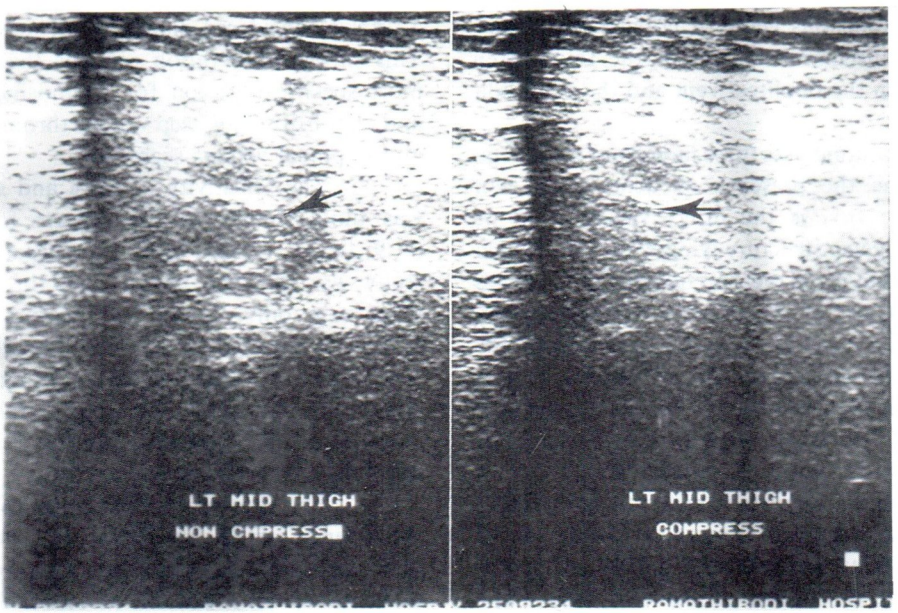

Fig. 1a left - non compressed ultrasonographic study of the femoral vein at mid thigh
right - compressed ultrasonographic study of the femoral vein at mid thigh showed completely collapsed venous lumen (arrow).

Fig. 1b normal venography at mid thigh, the level of the above ultrasonographic study.

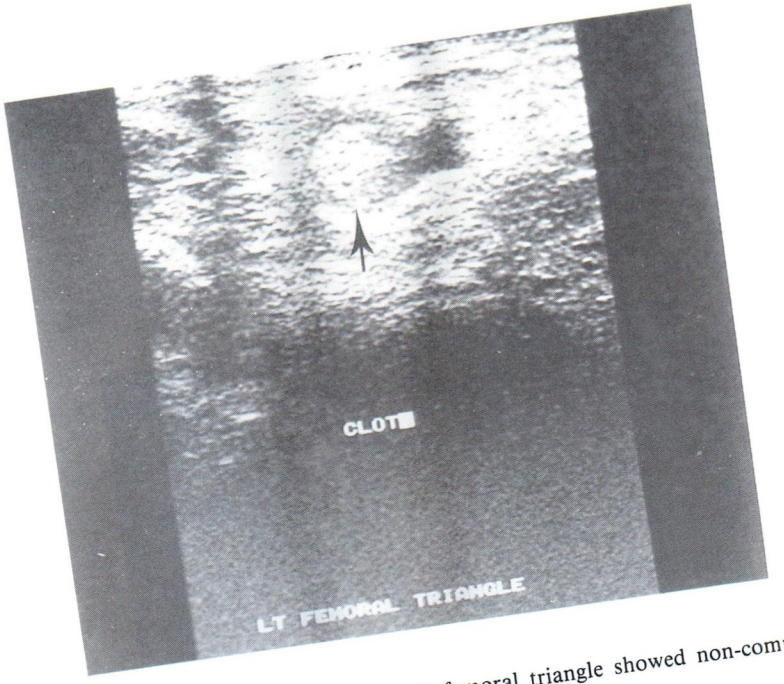

Fig. 2a Compressed ultrasonographic study of the lt femoral triangle showed non-compressible vein with clot inside, a true positive case.

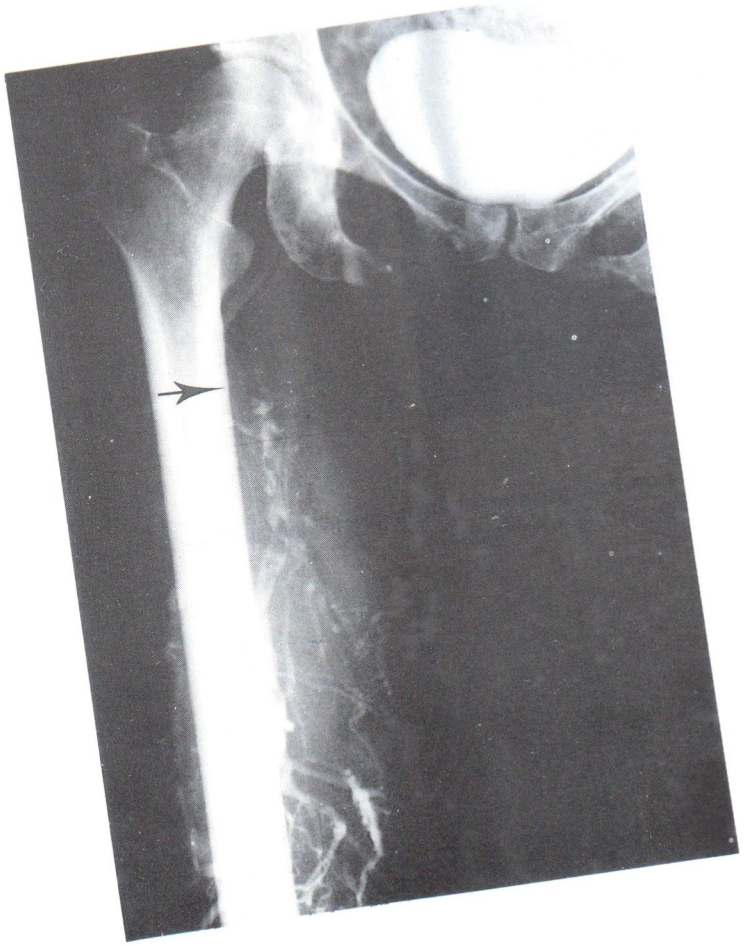

Fig. 2b Contrast venography, corresponding level of sonography was arrowed.

Fig. 3 contrast venography showed complete occlusion of the anterior tibial artery at its origin only and the rest of the deep vein appeared normal, producing false negative ultrasonography.