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Ultrasound in the diagnosis of deep vein thrombosis

D. S. Evans

At least 1 in 20 of hospital deaths is due to massive pulmonary embolism. Examination of hospital records suggests 6 out of 10 of those dying might have returned home but for the fatal incident. Post-mortem studies show that fatal emboli in nearly all cases come from the popliteal or more proximal veins. In a collected series of around 1500 post-mortem studies, the ante-mortem incidence of warning signs such as deep vein thrombosis or minor pulmonary emboli was less than 15% [3]. The inadequacies of clinical diagnosis are thus underlined, and the need for a simple diagnostic test emphasized.

In 1967 Strandness et al. [7] first suggested ultrasound for the diagnosis of venous disease. Sigel et al. [6] further extended this application in the following year. Both teams were able to examine directly venous flow from the calf to the groin. The technique was further modified by Evans and Cockett in 1969 [1] who changed the transmission frequency to 2 MHz. This increases tissue penetration and allows direct examination of the iliac veins and the inferior vena cava.

The apparatus used (Sonicaid D. 205) consists of a portable box weighing about 3 kg that contains a transmitter, a receiver, an audio-amplifier and a loud-speaker. The box is connected by a lead to a transducer which contains two crystals. One crystal when excited emits ultrasound, while the other acts as a receiver for the reflected signal. When a stationary column of blood is examined, the reflected signal is identical to the transmitted and no sound is heard from the loud-speaker. When moving blood is examined, there is a shift in the frequency of the reflected signal proportional to the velocity of flow due to the Doppler effect. This shift in frequency is within the audible range and with suitable amplification can be heard. Moving blood is thus indicated by sound from the loud-speaker while in venous obstruction there is silence.

Sigel et al. [6] showed that if a squeeze was applied to the leg distal to the site of the transducer, augmentation of venous flow velocity would occur and a roar would be heard from the loud-speaker. This is termed the augmentation wave or A wave, and its presence indicates deep venous flow between the site of the squeezing and the transducer.

Method of patient examination

Patients are examined in bed in the ward, sitting propped up and flexed at the hips to 45° or more. The lower limbs are straight and the ankles supported to allow good passive

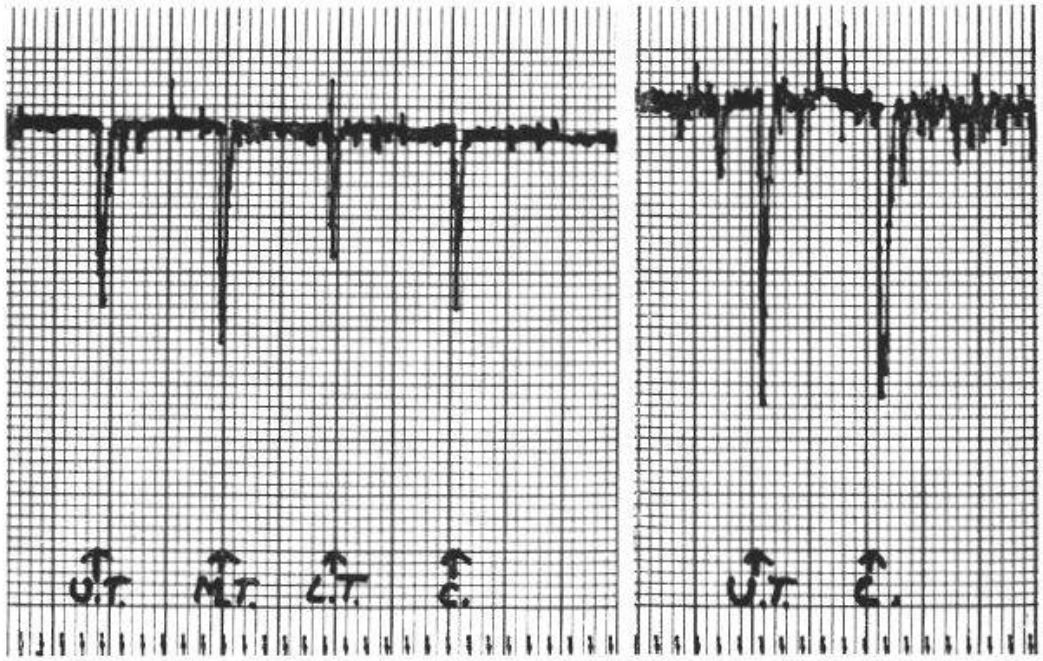


Fig. 1. A normal Dopplergram showing A waves from the thigh and calf. The transducer was over the common femoral vein in the left trace and external iliac in the right. – Abbreviations for site of squeeze: U.T. = upper thigh, M.T. = mid thigh, L.T. = lower thigh, C. = calf.

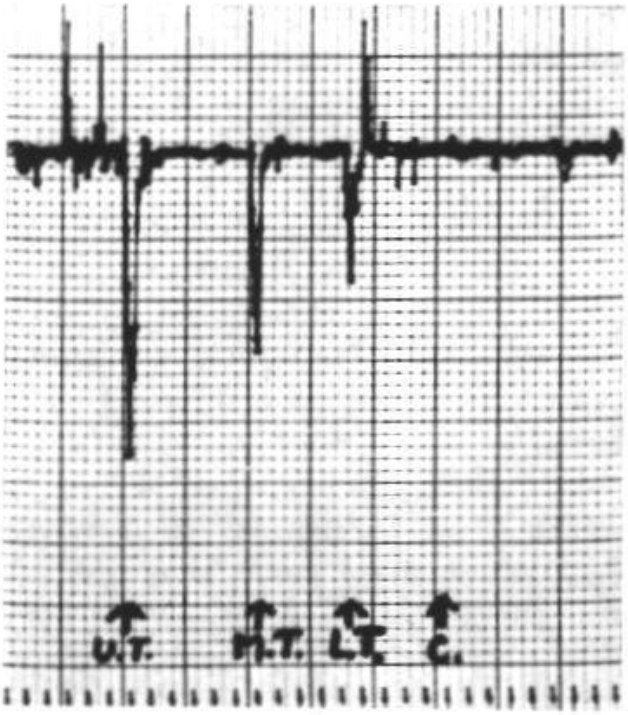
filling of the calf veins. The transducer is applied to the skin using a suitable coupling medium. Routinely, the transducer has been applied over the superficial femoral veins, 4″ below the inguinal ligament, over the common femoral veins, over the external iliac veins and over the inferior V. cava. At first, there may be difficulty in detecting flow through the inferior V. cava, but with practice the presence of flow will be elicited in most cases. A-waves are produced by squeezing the lower limb lightly along the line of the superficial femoral vein on the mid-thigh, and at the level of the adductor canal, and on the calf. Permanent visual recordings of the sounds heard may be made by attaching the lead of a pen recorder to the back of the Sonicaid D. 205 box. The write out is called a Dopplergram (see Fig. 1 and 2).

Discussion

In two trials [2, 5] ultrasound examination has been found to compare favourably with peripheral phlebography in the detection of deep vein thrombosis in the popliteal and more proximal veins. In both series 95% of thrombi shown on phlebography to be present were detected by ultrasound. Ultrasound examination was however found to be inaccurate for the detection of minor calf thrombosis.

Patient examination with ultrasound is very rapid, it being possible to examine a patient fully in 2–3 min. This means that all the patients in a thirty-bedded ward can be examined in little over an hour.

Post-mortem studies, peripheral phlebography, ^{125}I labelled fibrinogen studies and ultrasound examination have all shown the inaccuracy of bedside clinical examination. This is particularly so where thrombus is floating and probably more likely to embolise.



a

b

Fig. 2. – a) Dopplergram showing an absent A-wave from the calf of the right leg. – b) The phlebogram shows thrombus in the popliteal vein and both limbs of a superficial femoral vein. Detected on ward screening with ultrasound. – Transducer over common femoral vein.

The three physical tests currently in use for diagnosis namely phlebography, isotope studies and ultrasound should be regarded as complementary in patient management [4]. Overall, phlebography is the most accurate method giving information about the deep veins from the ankle to the inferior V. cava. However, it is time consuming to do and requires specialist techniques. It is probably best used in patients in the acute phase to gain additional information about thrombus after previous screening diagnosis by isotopes or ultrasound. ^{125}I labelled fibrinogen studies used prospectively are accurate in the leg to 4″ below the inguinal ligament. However, they are time consuming, expensive and require a trained technician. They appear best used for research or monitoring the high risk patient, in which case they should be done in conjunction with ultrasound. Ultrasound examination is simple, rapid, repeatable and inexpensive. As it is capable of detecting potentially hazardous thrombi in the popliteal and more proximal veins it is useful for diagnosis in the doubtful limb and the routine ward screening of patients at risk.

Summary

1 in 8 of hospital deaths have been reported to be due to massive pulmonary embolism [8]. Examination of hospital records suggests that 6 out of 10 of those dying might have returned home but for the fatal incident. Post-mortem studies show first, that fatal emboli in nearly all cases come from the popliteal or more proximal veins and secondly that the chances of detecting deep-vein thrombosis by clinical assessment alone before embolism are poor. The method of ultrasound examination is described and the importance of patient positioning stressed. When compared with phlebography and ^{125}I labelled fibrinogen studies, ultrasound detected thrombus in the popliteal or more proximal veins in 95% of legs examined. As ultrasound examination is simple, rapid, reliable and repeatable, it is suggested as a good method for the routine screening of patients at risk of massive pulmonary embolism.

Zusammenfassung

Unter 8 Hospitaltodesfällen fanden Morrell und Dunnill [8] 1 Fall von massiver Lungenembolie. Die Prüfung der Krankengeschichten macht es wahrscheinlich, dass 6 von 10 solcher Patienten ohne den tödlichen Zwischenfall gesund hätten nach Hause zurückkehren können. Sektionsbefunde zeigen erstens, dass tödliche Emboli in fast allen Fällen aus der V. poplitea oder proximaleren Venen kommen, und zweitens, dass die Aussicht, durch klinische Untersuchung allein vor der Embolie die tiefen Venenthrombosen zu entdecken, schlecht sind. Die Methode der Ultraschalluntersuchung wird beschrieben und die Bedeutung der Körperstellung des Patienten dabei betont. Im Vergleich mit Phlebographie und mit Tests mit ^{125}I-markiertem Fibrinogen deckte die Ultraschallmethode in der V. poplitea oder proximaleren Venen Thromben in 95% der Beine auf. Da die Ultraschallmethode

einfach, schnell, zuverlässig und wiederholbar ist, wird sie als gute Methode für die Routineuntersuchung von Patienten vorgeschlagen, die einem Risiko massiver pulmonaler Embolien ausgesetzt sind.

Résumé

Dans 8 cas de mort à l'hôpital, MORRELL et DUNNILL [8] ont trouvé en 1968 un seul cas d'embolie pulmonaire massive. En examinant leurs histoires de malade on pourrait admettre que, sans l'épisode fatal, 6 sur 10 de ces malades auraient pu rentrer sains et saufs à la maison. Les examens autoptiques ont montré d'abord que dans la presque totalité des cas les embolies mortelles viennent de la veine poplitée et de veines proximales, ensuite que les possibilités de diagnostiquer les thromboses veineuses profondes avant une embolie, par un examen clinique seulement, sont très restreintes. La méthode de diagnostic par l'ultra-son est ensuite décrite, et l'auteur souligne l'importance que prend la position du malade pour cet examen. Comparé à la phlébographie et dans la recherche faite à l'aide de fibrinogène marqué par l'iode^{125} radioactif, l'on a pu montrer que les ultra-sons ont permis de mettre en évidence les thromboses de la veine poplitée ou de veines proximales dans 95% des cas. Cette méthode par les ultra-sons étant simple, rapide, sûre et recontrôlable on peut la proposer comme méthode de routine de choix chez des malades qui sont menacés par le risque d'embolie pulmonaire massive.

Riassunto

Nel 1968 MORRELL e DUNNILL [8] trovarono che per 8 pazienti deceduti all'ospedale c'era 1 caso di grossa embolia polmonare. L'esame delle cartelle cliniche suggerisce che con ogni probabilità 6 su 10 di questi pazienti avrebbero potuto venir rimandati a casa in buona salute. Gli esami necroscopici mostrano che: 1. gli emboli mortali hanno preso origine in quasi tutti i casi dalla vena poplitea o da una vena più prossimale; 2. le possibilità di scoprire la trombosi venosa profonda prima dell'embolia con soli mezzi clinici sono scarse. Viene descritto il metodo d'esame con ultrasuoni e si sottolinea l'importanza della posizione del corpo del paziente. Comparato alla flebografia ed agli studi con fibrinogeno marcato con ^{125}I, il metodo utilizzante gli ultrasuoni ha permesso la scoperta di trombi venosi a livello della poplitea o di vene più prossimali nel 95% dei casi. Dato che il metodo agli ultrasuoni è semplice, rapido, sicuro e ripetutamente utilizzabile, esso viene raccomandato come esame abituale da applicare ai pazienti particolarmente esposti al rischio di embolia polmonare grave.

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