investigating the effects of home storage of frozen milk. Although lower bacterial counts might be expected, this benefit needs to be weighed against the possible damage incurred by excessive freezing to protective components in milk.[1]

We conclude that if milk is collected in the way we have described, into vessels sterilised at home with hypochlorite solution, precise pasteurisation results in a bacteriologically acceptable product and obviates the need for complex and expensive milk-banking procedures.

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Detection of deep venous thrombosis by scanning of ^{99m}technetium-labelled red-cell venous pool

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Summary and conclusions

A comparative study of 32 patients with suspected deep venous thrombosis was carried out using blood-pool radionuclide scanning and conventional *x*-ray phlebography. Results of the two methods showed close agreement, the sensitivity (positive correlation) of the scan being 100% and its specificity 89%.

We conclude that a patient's red cells labelled with ^{99m}technetium (^{99m}Tc) provide an excellent medium for this type of scanning. The technique has particular advantages in visualising the whole venous system, giving a persisting image, and obviating the need to inject into a vein of the affected limb. In view of the inherent disadvantages of contrast phlebography, ^{99m}Tc-red-cell scanning is clearly an acceptable alternative.

Introduction

The detection of deep venous thrombosis poses a definite diagnostic problem. Prospective isotopic screening of patients at risk of developing thrombosis has shown that clinically silent venous thrombosis is common. Furthermore, over 45% of patients with symptoms suggestive of deep venous thrombosis have no phlebographically detectable thrombus.[1] Ascending phlebography remains accepted as the most reliable investigation available but is an unpleasant procedure that is technically demanding and in a few cases may be responsible for initiating venous thrombosis.[2 3]

Red blood cells are quickly and easily labelled with ^{99m}technetium (^{99m}Tc).[4] One of us (RC) has found that labelled cells outline the blood pool in the venous system with such resolution that venous anatomy is delineated and thrombi localised with good accuracy. We carried out this study to compare the results obtained by scanning the ^{99m}Tc-labelled red-cell blood pool with those obtained by *x*-ray contrast phlebography in 32 patients investigated for deep venous thrombosis over seven months.

Patients and methods

We included in the study patients who were referred to the diagnostic services of the radiology and nuclear medicine departments between July 1977 and February 1978 for investigation of possible deep venous thrombosis. These patients underwent ^{99m}Tc-red-cell scanning and ascending phlebography.

^{99m}TC-RED-CELL SCANNING

We mixed 3-5 ml of venous blood from the patient with 1 ml of acid-citrate-dextrose anticoagulant and incubated this for five minutes at room temperature with two drops of pyrophosphate (Mallinckrodt Pyrophosphate Kit reconstituted with 2 ml of 0·15 M NaCl). The cells were washed twice with 0·15 M NaCl and incubated with 10 mCi $^{99m}TcO_4$ for five minutes at room temperature. The labelled cells were again washed twice and made up to 3 ml with 0·15 M NaCl before injection.

For imaging we used a gamma-camera with a large field of view (Toshiba GCA 401). In general, the ^{99m}Tc-labelled red cells were injected into an antecubital vein and imaging begun after five minutes. When dorsal veins of the foot were easily accessible we used these for injection so that the progress of blood flow through the upper femoral and iliac areas could be viewed with the gamma-camera. After injection into the foot 10 minutes elapsed before blood-pool imaging was begun to permit equilibration. Images of the blood pool were obtained in three views: an anterior view of the iliac and upper femoral area, an anterior view of the thighs, and a posterior view of the calves including the popliteal vessels.

A normal pattern was easily recognisable (fig 1). Partial obliteration of segments along the major vessels was interpreted as deep venous thrombosis. This appearance was generally accompanied by increased

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tracer concentration in the superficial veins and collateral vessels in the region, and sometimes by an overall increase in blood pool in the limb below the level of thrombosis. Even with complete venous obstruction a blood-pool channel was always seen in the line of the major vessels from the iliac to the popliteal due to the accompanying artery. The scan was reported independently by one observer (RC) who was unaware of the result obtained on phlebography.

ASCENDING PHLEBOGRAPHY

When possible we carried out the phlebography on the same day as the ^{99m}Tc-red-cell scan. The method used was that described by Hume *et al*,[5] and in almost all cases the investigation was restricted to the symptomatic limb. Criteria for thrombosis on phlebography were intraluminal filling defects and occlusion of blood flow with visualisation of collateral channels. The phlebograms were reported as negative —that is, showing no signs of thrombosis—or positive—that is, showing proximal vein thrombosis, calf vein thrombosis, or combinations. They were reported independently by two observers (EG and CNC) who were unaware of the results of the scanning.

ANALYSIS OF RESULTS

The findings from both studies were classified as normal or abnormal. The abnormal results were divided into those showing anatomical variations or abnormalities—for example, varicose veins—and those showing evidence of venous thrombosis. The site of the thrombosis was classified as calf, proximal, or combinations of sites. Two patients who had signs of axillary vein thrombosis were also studied. The results were expressed in terms of sensitivity (proportion of positive scans (those with evidence of thrombosis) among patients with positive phlebograms), specificity (proportion of negative scans

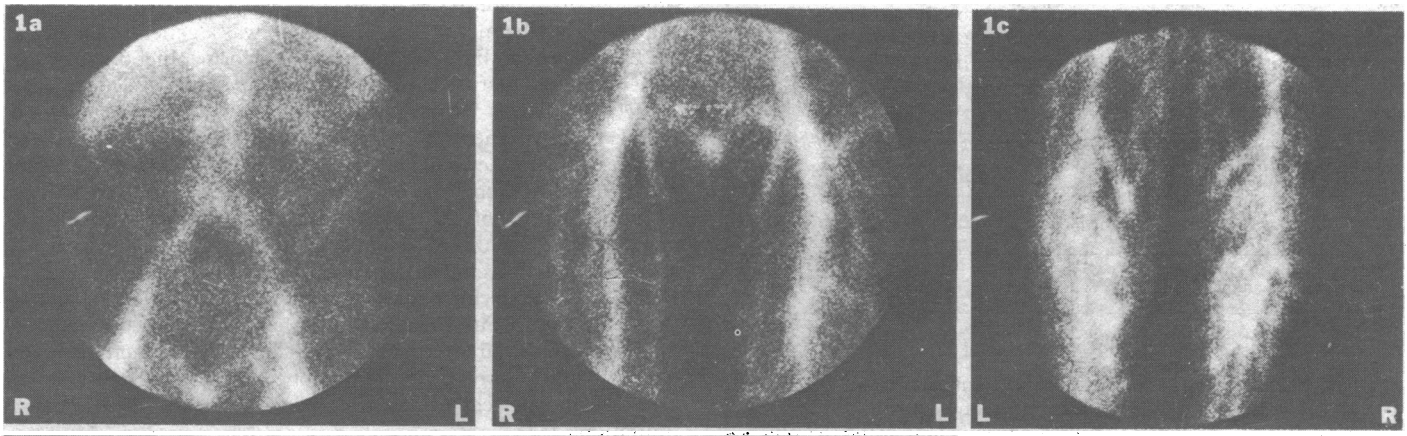

FIG 1—Normal vascular pattern, showing (*a*) anterior view of pelvis, (*b*) anterior view of thighs, and (*c*) posterior view of calves.

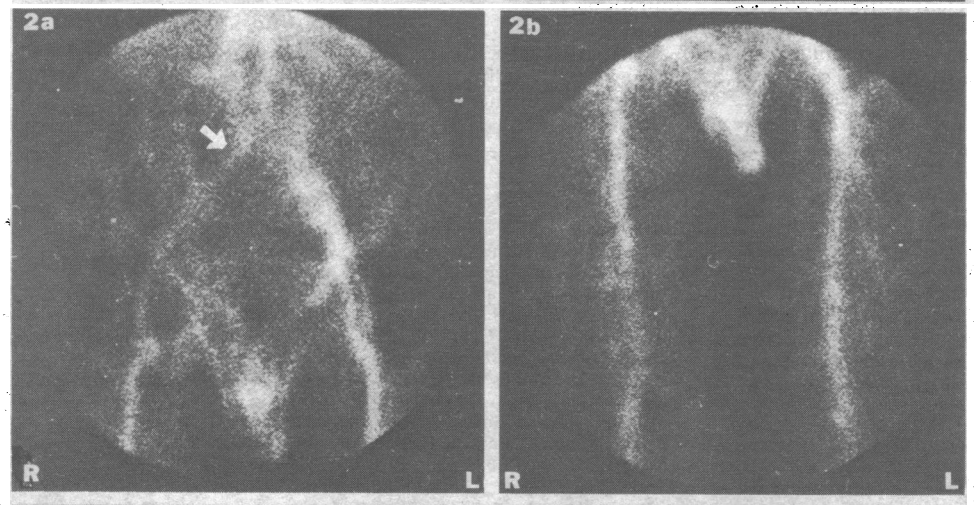

FIG 2—Scan showing abnormal vascular pattern due to thrombosis of right proximal and calf veins. (*a*) Anterior view of the pelvis, the arrow denoting the upper limit of the obstruction. The right iliac artery is seen below this but has lower intensity than the iliac artery and vein on the left side. (*b*) Anterior view of the thigh. (*c*) Posterior view of the calves (note the collateral circulation in the right calf). (*d*) Anterior dynamic radioisotope phlebogram of the same patient showing obstruction of the right iliac vein and collateral channels across the pelvis to the left iliac vein.

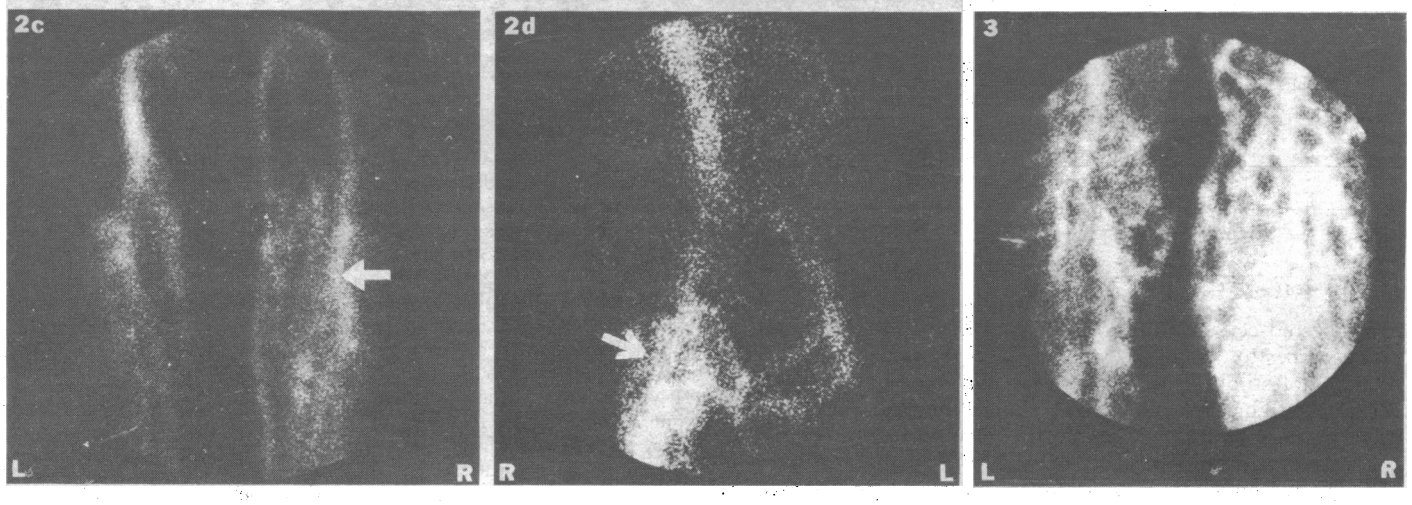

FIG 3—Scan of calves showing varicose veins.

(those with no evidence of thrombosis) among patients with negative phlebograms), and predictive value (likelihood that patients with positive or negative radioisotopic scans would or would not have evidence of venous thrombosis on phlebography).[6]

Results

We obtained 32 complete sets of data over the seven-month study period.

Phlebography—Results of phlebography were negative in nine patients (28·1%). Proximal venous thrombosis was detected in 19 patients (59·4%), four of whom had this alone and 15 calf vein thrombosis as well. In two patients (6·3%) venous thrombosis was limited to the calf. Axillary vein thrombosis was present in one patient, and another had axillary vein obstruction due to thoracic outlet syndrome (6·3%).

^{99m}Tc-red-cell scan—Of the 19 patients with proximal venous thrombosis on phlebography, all had positive ^{99m}Tc-red-cell scans. Figure 2 shows an example of thrombosis of the proximal and calf veins. In 18 cases the site and extent of the thrombosis on scanning correlated with the site seen phlebographically (table I). Similarly, in the two patients with isolated calf vein thrombosis the site on the scan correlated with that on the phlebogram. In one patient the ^{99m}Tc-red-cell scan detected proximal venous occlusion alone while the phlebogram showed calf and proximal thrombi. Axillary vein thrombosis was diagnosed in one patient, and another had positional axillary vein obstruction due to thoracic outlet syndrome. These findings correlated with those on the phlebogram. One patient, in whom varicose veins were detected on scanning and phlebography, had no apparent venous thrombosis (fig 3).

TABLE I—*Site and extent of thrombosis on scanning and phlebography. Figures are numbers of patients*

	Proximal only	Proximal and calf	Calf only	Axillary
Phlebography	4	15	2	2
Radioisotope scanning ..	6	14	2	2

Sensitivity, specificity, and predictive value of ^{99m}Tc-red-cell scan—Table II shows the overall correlation between the results of ^{99m}Tc-red-cell scanning and contrast phlebography. The scan detected all patients (23) with phlebographically detectable deep venous thrombosis, giving a sensitivity of 100%. It identified eight of the nine patients with no evidence of deep venous thrombosis—that is, it had a specificity of 88·9%. The scan was abnormal in 24 patients, of whom 23 had positive phlebograms (table I), giving a positive predictive value of 96%. Of the eight patients with a negative ^{99m}Tc-red-cell scan, all had a negative phlebogram, giving a negative predictive value of 100%.

TABLE II—*Overall correlation between results of ^{99m}Tc-red-cell scanning and contrast phlebography*

Results of scanning	Results of phlebography		Total
	Positive	Negative	
Positive	23	1	24
Negative		8	8
Total	23	9	32

Discussion

^{99m}Tc-red-cell scanning represents a new approach to using radioisotopes to diagnose venous disease. Previous radionuclide methods of studying venous disease may be divided into two categories. The first comprises uptake methods relying on specific tracer concentration in the thrombus—for example, ^{125}I-fibrinogen and ^{99m}Tc-urokinase.[7 8] The other category—namely, radionuclide phlebography—entails using dynamic imaging of tracer distribution with either ^{99m}Tc-albumin macroaggregates or ^{99m}Tc-albumin microspheres.[9] These agents are trapped in lung capillaries and are therefore not recirculated. The ^{99m}Tc-red-cell scan differs from the radionuclide phlebogram in that the labelled cells are distributed throughout the vascular system and the venous blood pool is outlined with a gamma-camera. Since the autologous red cells remain in the circulation a persisting image is obtained. When a distal vein of the affected limb is injected a radionuclide phlebogram may be obtained in addition to the blood-pool pattern (fig 2(*d*)).

The results of this study indicate that ^{99m}Tc-red-cell scanning is extremely accurate in evaluating patients with clinically suspected venous thrombosis. The technique had a sensitivity of 100% and a specificity of 88·9% when compared with *x*-ray contrast phlebography. Results of scanning were at variance with those of phlebography in only two of the 32 patients studied (table I). Of the 32 patients, only nine had negative phlebograms, resulting in a clinical diagnosis rate of 72%. This high rate may be misleading since there was a general reluctance on the part of individual doctors to perform phlebography on patients with negative ^{99m}Tc-red-cell scans.

^{99m}Tc-red-cell scanning offers simultaneous bilateral delineation of the venous system and, in addition, good visualisation of the iliac and superficial veins. There is no risk of transmitting hepatitis, and the whole-body radiation dose is estimated to be 150-200 mrads compared with 1-2 rads to the affected part with conventional phlebography. ^{99m}Tc-red-cell scanning is not technically demanding and is quick (taking 45 minutes), and the injection may be given into any vein if it is difficult to inject into the affected limb. With such a high degree of diagnostic accuracy it would appear that this method is an alternative to *x*-ray contrast phlebography and preferable to other diagnostic techniques, each of which has well-recognised limitations.[9 10]

We wish to express our thanks to the consultant physicians and surgeons and the director of casualty of St Vincent's Hospital for allowing their patients to be studied.

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ONE HUNDRED YEARS AGO Dr C W Chubb (Torpoint, Devonport) writes: On Christmas-day, 1852, I attended a patient in her confinement, and the newly born child weighed *twenty-one* pounds. I had attended the same patient in some previous confinements, and all the children were exceptionally large when born; but the one born in 1852 appeared to be considerably larger than the others, and I requested that it might be weighed. Not long after its birth, the child was taken to the house of a neighbouring farmer, and the farmer's wife, who was pregnant at the time, was so struck with the size of the child that she burst out crying when she thought of what the mother must have gone through in giving birth to such a child. On this point, I would only say that the labour was not by any means a very severe one. Several of the members of this family and all the brothers are very tall and very large. The weight of the largest new-born children which I find recorded is eighteen to twenty pounds. I have never heard or read of any case beyond twenty pounds, and that in only two or three cases. (*British Medical Journal*, 1879.)