AN INVESTIGATION INTO THE VALUE OF VENOGRAPHY; WITH SPECIAL REFERENCE TO VARICES IN THE LOWER LIMB.

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C O N T E N T S.

PART I. INTRODUCTION. Page.

I N T R O D U C T I O N.

The radiological representation of the venous channels can be called either venography or phlebography. Although the latter term is etymologically more correct, the former has been used consistently in this country and will accordingly be employed here. As, in most instances, the veins are not opaque a contrast medium must be introduced to visualise them, and, according to the method by which this is done, the terms indirect and direct venography are applied.

In indirect venography, the contrast medium is introduced into the arterial system and photographed when it is estimated to be returning through the venous channels. During its passage through the arterial and capillary systems, however, the medium becomes markedly diluted and the resulting pictures are not satisfactory.

In direct venography, the contrast medium is introduced directly into the venous system and photographed either during, or at the end of, the injection. This is the method usually used for the examination of the peripheral vascular system, and it is the only one which will be considered in the following investigations.

THE HISTORY OF VENOGRAPHY.

The history of venography is almost as old as that of radiology itself, for in 1896, Haschek & Lindenthal injected Teichman's mixture (lime, cinnabar and petroleum) into an amputated hand and demonstrated the vessels clearly on a radiograph. The distinction of being the first to describe an opaque substance within the circulating blood belongs to Trendelenburg (1902), who observed, on a fluorescent screen, a bullet being agitated to an fro by the moving blood in the heart of a patient who had been shot; while in the same year, Riëthus gave a description of the movements of shot and other foreign bodies introduced into the hearts of dogs by way of the jugular vein.

The development of venography, however, has been intimately linked with the production of a suitable contrast medium; such a medium must satisfy at least the following requirements.

(1). It must be sufficiently opaque, even when diluted with blood.

(2). It must not be toxic, either locally or generally throughout the body.

(3). It must be freely miscible with blood.

Of these three conditions a good contrasting capacity is the easiest to fulfil, and the earlier investigations were performed only on experimental animals using opaque fatty emulsions. These broke into droplets in the blood

and, of course, were accompanied by grave danger of fat embolism. The first experiments with such a liquid medium were carried out by Franck & Alwens (1910) on dogs and rabbits. After exposing the heart and great vessels they injected a 10% bismuth oil emulsion into the superior vena cava for the investigation of the right side of the heart, and directly into the left ventricle for the left side. The course of the droplets of this suspension was then followed through the heart chambers and into the lungs on a fluorescent screen. The contrast was satisfactory, but the animals died, either of fat embolism or coronary thrombosis. Fischer (1921) injected a 10% camphor oil emulsion into the peripheral veins of experimental animals and by using very small quantities, 1-2 ccs, minimised the dangers of fat embolism, although the method was still not capable of clinical application. But two years later, lipiodol, an oil containing organic iodine compounds which eliminated the possibility of fat embolism, was introduced by Sicard & Forestier (1923), who injected small quantities into the peripheral veins and observed the direction of flow by means of serial radiographs.

The names of Berberich & Hirsch (1923), are chiefly associated with the search for a water soluble medium, which was freely miscible with blood. These authors, after a lengthy investigation, reported good results using a 10-20% solution of strontium bromide, which, at the time, they

believed to be innocuous. They injected the solution directly into the vein concerned, and described the course of the veins of the arm, as seen on a venogram, and the appearances of valves. Later, unfortunately, it was found that the solution was not completely harmless. Extensive thrombosis developed in the injected veins, so that McPheeters & Rice (1929), investigating varicose veins, had to return to the use of lipiodol. They injected this solution into the upper end of incompetent internal saphenous veins, watched, on a fluorescent screen, the droplets descend to the region of the ankle, and so provided one of the first experimental proofs of Trendelenburg's test.

It was the developments in another branch of radiology, namely pyelography, which first supplied contrast media suitable for venographic investigations. In 1929, Binz & Rath introduced Uroselectan (the Disodium salt of N - methyl - 3: 5 - diiodo - 4 - pyridone - 2: 6 - dicarboxylic acid), and in 1930, Bronner, Hecht & Schüller produced a preparation called Abrodil (Monoiodomethane sulphonate).

Applications of Venography to Circulation in leg.

Following the introduction of these media, venographic investigations were given fresh impetus and a number of papers appeared. Ratschow (1930a, 1930b), was the first to use uroselectan, when he described the appearances of varices on radiographs and investigated the possibility of varicose degeneration of the deep veins; and Schmidt, in the same year,

described retrograde flow in incompetent veins and commented on the extent of varices on a film compared with those visible on clinical examination. In 1931, Schmier pointed out that the venous flow in varices with incompetent valves did not always occur in a retrograde direction, and Sgalitzer, Kollert & Demel (1931), gave a clear description of the appearances of the venous valves in the normal patient. They mentioned that with the leg in a dependent position the valves could be identified easily but that when it was horizontal they could not, unless a tourniquet was applied above the knee; and they were also the first to illustrate the fact that the opaque medium did not always take the shortest route to the heart, but frequently proceded by rather a tortuous course. They described narrowing of veins which they attributed to spasm, and they showed that the more rapid current in the middle of the venous stream frequently produced slight thinning of the contrast medium in this situation.

Following these publications a number of other articles appeared. In this country, Barber & Orley (1932), investigating normal patients, concluded that with the patient supine no flow occurred from the superficial to the deep circulation of the leg, and that in patients with varices, the rate of flow was influenced by posture, muscular activity and respiration; while Patey, Tatham & Nicholas (1933) indicated that venography might be of considerable assistance to the clinician in

investigating the relationship to each other, and to the main venous channels, of apparently scattered collections of varices. In America, Edwards (1933) and Pomeranz & Tunicke (1933), confirmed previous investigations regarding the direction of blood flow and the radiological anatomy of varices, and Edwards stated that "the technique of venography is simple and the interpretation of the films easy".

In 1935, Friman-Dahl, in an investigation into the causes of thrombosis in veins, illustrated the slowing of the blood stream which occurs in post-operative cases by venography; and in 1936, Barker & Camp were the first to enquire into the possibility of venography as a diagnostic aid in thrombophlebitis. Venograms were performed only on cases which were clinically definite, but as the venographic results were found to coincide closely with the clinical diagnosis, they concluded that the method might be of considerable value. Their work, however, received little attention and it was left to Dos Santos, in 1938, to provide the main impetus towards the venographic diagnosis of thrombophlebitis and phlebothrombosis.

More Recent Applications.

Up to this time, as has been indicated, venographic investigations had been concerned mainly with anatomical and physiological enquiries into the appearance of normal veins and the rate and direction of blood flow in varices etc., but with the publication of Dos Santos' paper, attention was

directed to the possibility of early, accurate, venographic diagnosis of acute deep thrombophlebitis, and, with few exceptions, interest has remained focussed on this problem ever since.

In this important article, Dos Santos (1938), investigated 20 cases of acute thrombophlebitis of the deep leg veins by means of venography. His clinical and venographic results were in close agreement and he believed that in venography a method had been found of making an early and accurate diagnosis of the site and extent of deep thrombophlebitis. The work was taken up enthusiastically in the Scandinavian countries where Bauer (1940), Hellstein (1942) and Sorenson (1943) described in great detail the venographic appearances in this disease. Bauer's name is especially linked with this work and he considered that the whole course of thrombophlebitis from the earliest formation of the mural thrombus, to the final complete thrombosis of the vein, could be determined accurately and easily by venography. In the succeeding years a large number of papers in general agreement with these views were published in the American literature - Starr et al. (1942), Fine et al. (1942), De Bakey et al. (1943), Baker (1945), Lesser & Danelius (1944).

As early as 1941, however, dissident opinions were expressed. Lindblom (1941a, 1941b) considered that certain of the appearances described by Bauer as being due to thrombophlebitis were in reality normal. Allen et al. (1943) found positive

clinical evidence of thrombosis, with negative venograms, in 33% of their cases and on this basis stated that "venograms are difficult to interpret and may be misleading", while in 1946, Allen, Barker & Hines remarked that opinion was still divided as to the value of the procedure.

Compared with the number of publications on acute deep thrombophlebitis there have been relatively few contributions to other aspects of venography, since 1938. By far the most important was that of Bauer (1942), who followed up the series of acute deep thrombophlebitis on which he had reported two years earlier, and in addition investigated, by means of venography, cases of post-phlebitic and varicose ulceration. He found no evidence of patency of the deep circulation and concluded that "varices have almost nothing to do with the formation of ulcers - deep seated thrombosis everything". Bauer's work, however, will be considered in more detail in Part III and need not, therefore, be further elaborated here.

In support of Bauer's theory, Imler et. al. (1944) and Anderson & Patterson (1945), published illustrations demonstrating blockage of the deep circulation following deep thrombophlebitis and the latter also described varicose degeneration of the deep veins. Finally, Jenny (1947), after reviewing the subject came to the conclusions that varicosity of the deep circulation was extremely rare, and that the cause of the post-thrombotic syndrome was lack of recanalisation of the deep veins destroyed by a previous deep thrombophlebitis.

THE SCOPE OF THE WRITER'S INVESTIGATIONS.

The purpose of the investigations to be described was to try to determine whether or not venography could be of material assistance to the clinician in the management of cases with varicose veins, and the complications frequently associated with them.

The mere representation of varices in a radiograph, as in Ill. 1, is of no practical significance, and any value in venography, as in all other specialised procedures, must rest on whether it can provide information which is not readily obtainable by careful and accurate clinical examination. Now, in dealing with varices, and more especially with their associated complications, there are three clinical problems, the solution of which has been the subject of innumerable papers in the literature, and of considerable controversy for many years, and on which there does not yet appear to be any unanimity of opinion. They concern, (1). The state of the deep circulation when oedema, induration or ulceration are present, and especially when there is a history of thrombophlebitis in the deep veins of the leg concerned.

Ill. 1.

(2). The presence or absence of incompetent communicating veins, and their exact location.

(3). The diagnosis of the method of recurrence, in individual cases, after surgical treatment has been carried out.

It is with the information that venography provides on these questions, compared with the results of careful clinical examination, and checked as far as possible by operative findings, that Parts III, IV, & V, respectively, of this paper are concerned.

As the literature is full of contradictory statements on what constitutes normal appearances in a venogram, a considerable number of venographic examinations were carried out with different techniques on normal patients, and, as the results were found to differ considerably from accepted beliefs, the findings have been incorporated in Part II.

General Observations on Technique.

The technique of venography varies according to the nature of the information required and these various techniques will be considered separately in the individual sections, but some general observations may conveniently be made here.

If venography is ever to be used as a routine diagnostic procedure, it must have as simple an injection technique as possible. For this reason, and because a busy X-ray Department is not the place to be engaged in cutting down on veins, with all the attendant risks of sepsis, injections of opaque media have been made by percutaneous puncture in every

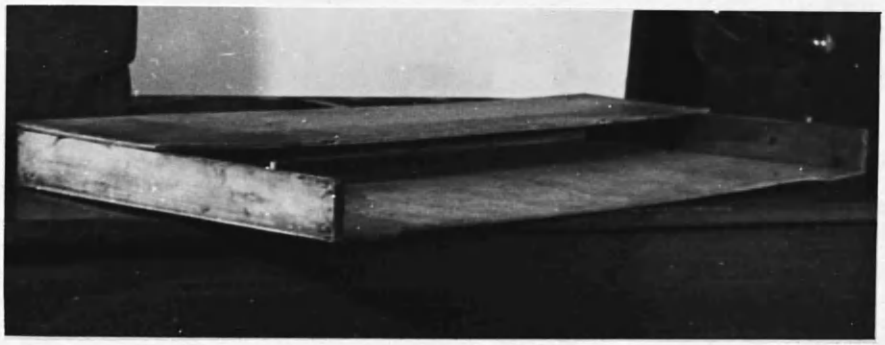
case, with the single exception of retrograde venography of the deep leg veins.

All patients were examined as out-patients. No special preparation is required and the patients were allowed to leave the department immediately after the films had been developed and checked.

The opaque medium used in nearly every instance was 35% Pyelosil (the diethanolamine salt of 3: 5 - diiodo - 4 - pyridone - N - acetic acid: supplied, sterile, in glass ampoules containing 20 ccs). In a few of the earlier examinations 50% and 70% Pyelosil were employed, but as quite frequently these solutions gave rise to such severe pain that the injection had to be stopped, their use was discontinued. The volume injected was usually 20 ccs., but on occasion as much as 80 ccs. has been given. In no single instance were any ill effects observed, and accidental leakage into the perivenous tissues on several occasions gave rise to only very mild and transient discomfort. After some experimentation the best films were found to be obtained when the contrast medium was injected as quickly as possible through a No. 14 'Record' hypodermic needle. This size was chosen because it combined an adequate bore, and so fairly rapid injection time, with a needle small enough to puncture the small veins in the foot. A syringe with an eccentric nozzle was found to be an advantage.

Again with the single exception of retrograde venography

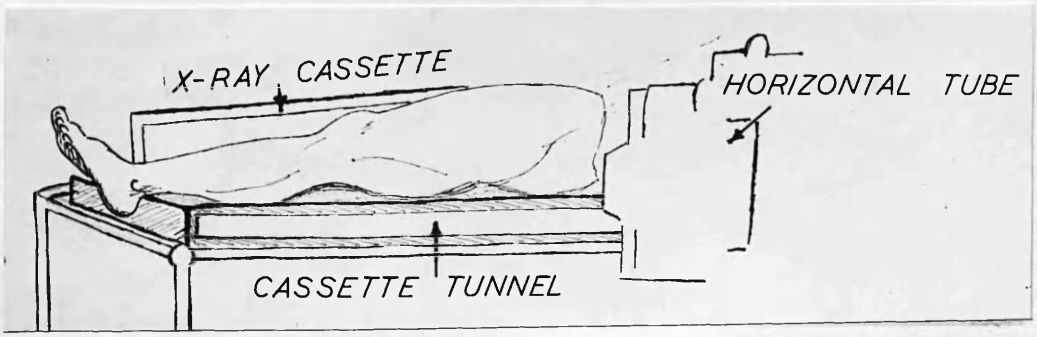
of the deep veins of the leg, every patient was examined supine, lying on a wooden cassette tunnel (Ill. 2), which



Ill. 2.

measured 3' 6" in length, 1' 4" in width and 2" in depth. The upper surface was only 10" in width and the space between it and the base allowed easy access for rapid changing of the antero-posterior films.

In accordance with well proved radiographic principles, views in two planes were always employed. The antero-posterior projections were exposed by the overhead tube of the



Ill. 3.

couch on which the patient was lying, the laterals by a portable set, the cassette containing these films (Ill. 3) being

steadied against the table and held in position by an assistant, suitably protected by lead rubber gloves and apron.

Films were exposed during the second half of the injection, the last film being taken as the injection ended. The number of films used varied according to the length of the part in which the veins were to be visualised, but in general, two films were always taken of each area.

For the sake of completeness, the technical factors used are given at the end of this chapter.

List of Abbreviations.

Venograms are difficult to reproduce owing to lack of contrast between veins filled with dye and the surrounding soft tissues. Accordingly, most of the illustrations have been annotated, and the abbreviations which have been used are as listed below.

I.S. = Internal saphenous vein.

E.S. = External saphenous vein.

S.C. = Superficial circulation.

P. = Peroneal vein.

P.T. = Posterior tibial vein.

Pp. = Popliteal vein.

F. = Femoral vein.

D.C. = Deep circulation.

C.V. = Communicating vein.

V. = Valve.

TECHNICAL FACTORS.

Antero-Posterior Films.

Unit - 6 valve, working from a 3 phase supply.

Constant Factors.

Distance.	110 cms.
Ma.	200
Time.	.1 secs.

Variable Factors.

For lower leg.	55 - 60 K.V.
For region of knee.	60 - 65 K.V.
For thigh.	65 - 70 K.V.

Lateral Films.

Unit - D 3 Victor X-ray Portable.

Constant Factors.

Distance.	90 cms.
Ma.	20

Variable Factors.

For lower leg.	K.V. 55 - 60	Time .5 secs.
For region of knee.	K.V. 55 - 60	Time .75 secs.
For thigh.	K.V. 60 - 65	Time 1 sec.

With both antero-posterior and lateral films, Paterson 'Par-Speed' screens were used.

PART II. THE NORMAL VENOGRAM. Page.

THE NORMAL VENOGRAM.

The divergencies of opinion which appear in the literature regarding pathological appearances in a venogram are largely concerned with two associated conditions. These are, (1). Absence of filling of veins, and, (2). Partial or irregular filling of veins. If the technique employed in the production of the venogram is one which normally demonstrates a well filled vein, then the presence of either of these two conditions has usually been accepted as being evidence of a pathological process in the vein concerned. Obviously, therefore, the technique utilized is of the greatest importance in the interpretation of any venogram and deserves the closest scrutiny.

Prior to the publication by Dos Santos (1938) on the venographic diagnosis of acute deep thrombophlebitis, investigations were primarily concerned with the superficial venous system of the leg, the technique involved being of the simplest. The opaque medium was injected directly into the vein concerned, anywhere in the leg, and either its progress was watched on a fluorescent screen or radiographs were taken. Few authors made any attempt to fill the deep circulation and absence of this on a film was not considered abnormal.

The interest in Dos Santos' technique, which consisted of exposing and injecting the external saphenous vein where it runs behind the external malleolus, was that he believed this

procedure resulted, in the normal leg, in filling of the deep veins in every instance, implying, of course, the corollary that lack of filling in any individual case indicated the presence of a pathological process; and the importance of his contribution lay in the fact that this belief was for a considerable time generally accepted. Thus Bauer (1940), using this technique, described 40 cases of acute deep thrombophlebitis of the lower leg, basing his venographic diagnosis on non-filling and partial filling of the deep veins, and similar work was performed by many other authors. In 1942, however, Hellstein recommended that a tourniquet be applied around the ankle to obliterate the superficial system and ensure that the deep veins filled, and in the same year Bauer (1942) adopted this procedure. Nevertheless in his final conclusions he included his original cases in the total, and it must be assumed, therefore, that he did not consider a tourniquet to be an essential.

In America, many authors used this technique which came to be known as "Bauer's", but in 1942 Welch et. al., criticized it, stating that "the deep circulation may not be delineated accurately", and illustrating a normal case in which the deep veins did not fill. They commented on the inconvenience of having to cut down on a vein in every case, and recommended that injection be made into any superficial vein in the foot, and that a tourniquet should be placed at mid calf level to obliterate the superficial circulation;

and in 1943, De Bakey et. al., supported this view, except that they stated that the tourniquet should be at the level of the saphenous opening.

From this time on, the literature presents many confused and contradictory statements regarding technique. Some authors continued to use the method of Bauer, others to follow the recommendations of Welch or De Bakey, while others again instituted new systems of their own. For example, Baker (1945, 1947) merely injected any vein on the dorsum of the foot and, as late as 1947, stated that "with a tourniquet there was no indication that visualisation of the deep veins was improved".

The second condition mentioned, partial or irregular filling of veins, has been regarded by nearly all authors as being of pathological significance. One exception was Lindblom (1941a, 1941b), who remarked that partial filling occasionally occurred normally, and was not always an indication of a pathological process in the vein concerned.

The Writer's Investigations.

This state of affairs regarding technique and what exactly does and does not constitute abnormality in a venogram is obviously extremely unsatisfactory. Most authors appear to have performed venograms on cases suspected clinically of deep thrombophlebitis, and not on normal patients, so that their results, when confirmed by operation, are an index

rather of the accuracy of their clinical diagnosis than of the reliability of the venographic findings. Accordingly as it was felt that an adequate knowledge of the normal was essential before investigating possible abnormalities, a series of venograms was performed on patients with normal legs, using varying techniques.

The Clinical Material.

The patients on whom this investigation was carried out were among those referred routinely from the Dispensaries to the X-ray Department, for intravenous pyelograms. Instead of using the veins in the antecubital fossa, the Pyelosil was injected into a vein in the foot, films of the leg were taken during the injection, and thereafter the pyelographic examination was carried out in the usual way.

In an effort to ensure that only normal legs were investigated, patients who came into any of the following categories were rigidly excluded.

(1). Those in whom there was a history of deep thrombophlebitis in the leg concerned.

(2). Those showing evidence of varices, induration, ulceration or oedema.

(3). Those with a history of fracture in the limb concerned.

(4). Those women who had borne a child, whether or not there was a history of phlegmasia alba dolens.

(5). Those patients who gave a history of any abdominal operation.

Observations on Technique.

The general method was described in Part I. Six films were taken in each case - antero-posterior and lateral projections centred on the mid leg, knee, and mid thigh respectively. These provided sufficient overlapping to produce two films of most of the area of the leg.

Since the deep circulation of the whole leg was to be given every opportunity to fill, all injections were made into veins in the foot, distal to the level of the malleoli.

Four different techniques were employed. They were,

(1). Injection without a tourniquet.

(2). Injection with a tourniquet at the knee.

(3). Injection with a tourniquet at the ankle.

(4). Injection with a tourniquet at the ankle and another at the knee.

Originally it was intended to divide each of these groups into three subdivisions, according to whether the injection was made on the medial or lateral sides, or on the dorsum of the foot, but as it was found by experience that injection on the dorsum gave similar results to injection on the medial side, only two subgroups have been described - dorso-medial and lateral. The area included under "lateral" comprises the skin surface posterior and inferior to the lateral malleolus, extending along the lateral border of the foot and limited on the dorsum to that part overlying the 5th metatarsal; dorso-medial comprises the remainder of the foot.

The total number of venographic examinations carried out was 134; the numbers with different techniques are as set out below.

No.	Technique.	A. Dorso-Med.	B. Lat.	Total.
(1).	No Tourniquet.	25	18	43
(2).	Tourniquet at Knee.	14	12	26
(3).	Tourniquet at Ankle.	18	16	34
(4).	Tourniquet at Ankle and Knee.	16	15	31

The primary objects of this investigation were to determine,

(1). Whether absence of filling of any deep vein on a radiograph by any particular technique could be regarded as being abnormal. (Section I).

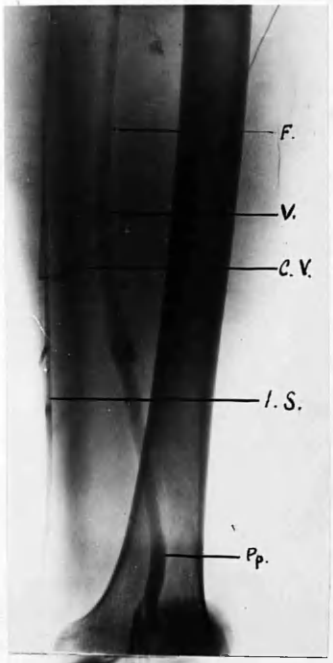
(2). Whether partial or irregular filling was of the same significance. (Section II).

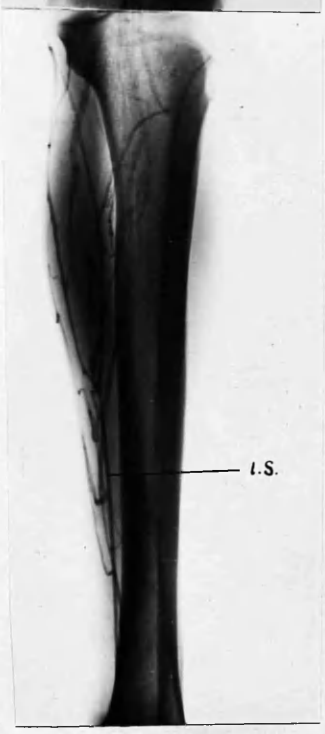
SECTION I. Absence of Filling of Deep Veins.

Technique No. 1A. No Tourniquet. Injection, dorso-medial.

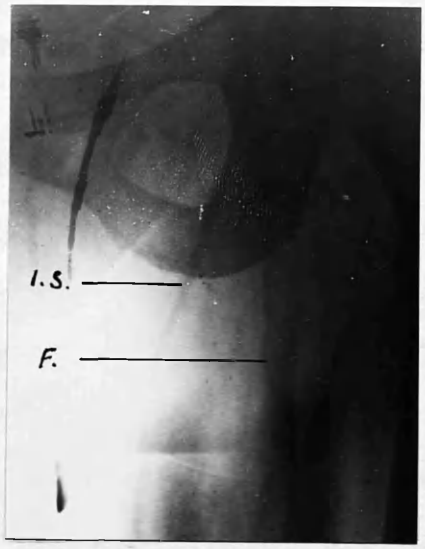
Injection on the dorso-medial aspect of the foot demonstrates, to a varying degree in individual cases, the internal saphenous, posterior tibial, popliteal and femoral veins, and variable communicating veins between the internal saphenous and the deep circulation; occasionally, the peroneal vein is also seen, in part or in whole.

It will be convenient at this point to describe briefly these individual trunks.





Ill. 4.



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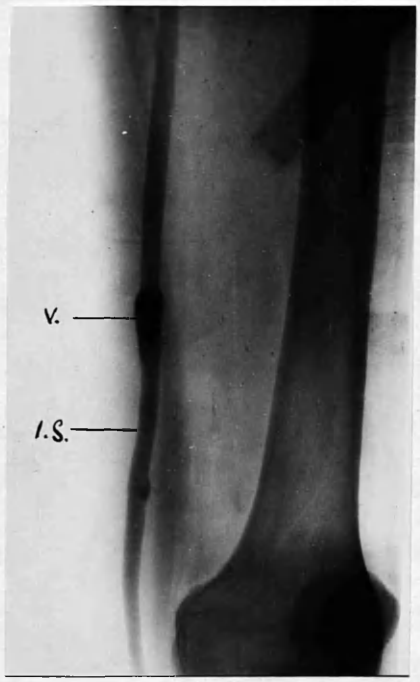
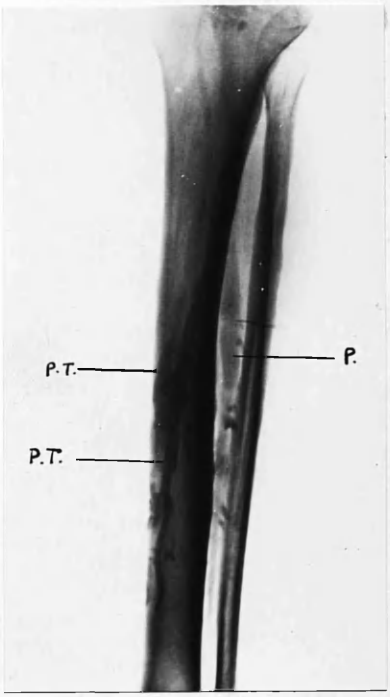


Ill. 6.

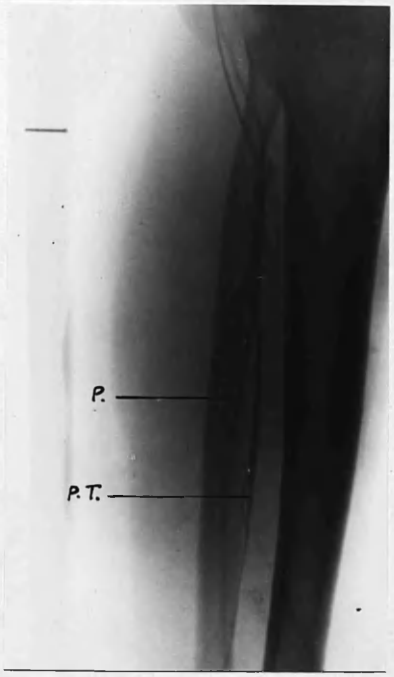
The internal saphenous, arising as it does from the medial end of the dorsal venous arch, can be seen from the point of injection, either as a single trunk or as a plexus, Ill. 4, passing anterior to the internal malleolus across the medial surface of the distal quarter of the tibia to the medial aspect of the leg, where it ascends lying posterior to the inner condyle of the femur; continuing proximally with a forward and lateral inclination, Ill. 4, near its termination it bends medially to enter the saphenous opening and end in the femoral vein, Ill. 5. Valves are not usually visible in the superficial circulation, but occasionally they can be identified, Ill. 6. At variable points, communicating veins can be seen between the internal saphenous and the deep circulation, as in Ill. 4.

Ill. 7.

The posterior tibial vein, Ill. 7, usually a single trunk, but occasionally double, lies posterior to the tibia in its whole length, although it can be thrown clear of the tibial shadow for part of its course by externally rotating the leg slightly, as was done in this case. It extends from the ankle to the point where it joins the peroneal vein to form the popliteal, on the average about 2 inches below the knee joint, and is richly valved,



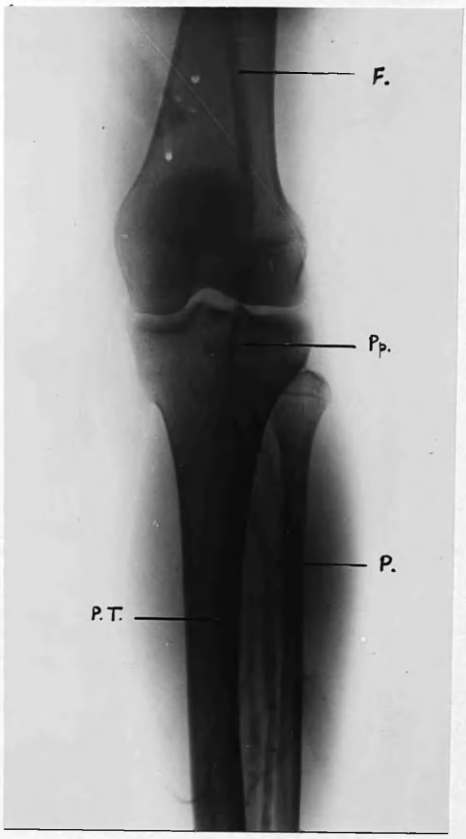
Ill. 8.



Ill. 9.

there being about 6-8 valves in its entire length. If a double vein has been seen, Ill. 8, these usually unite to form a single trunk before joining the peroneal which shows a similar arrangement. In the lateral view, Ill. 9, the posterior tibial can be seen lying parallel to the tibia from which it is separated by the deep calf muscles, and in this position it is sometimes superimposed on the peroneal vein from which it can be distinguished only with difficulty if both deep veins are filled. The posterior tibial, and, indeed, all the veins of the leg, appear much more narrow in the lateral than in the antero-posterior view. This, and the variations in density which occur, will be discussed later. (P. 52).

The peroneal vein, when filled by this technique, Ill. 8 & 10 (see also Ill. 23), occupies the space between the tibia and fibula, from immediately above the ankle joint to

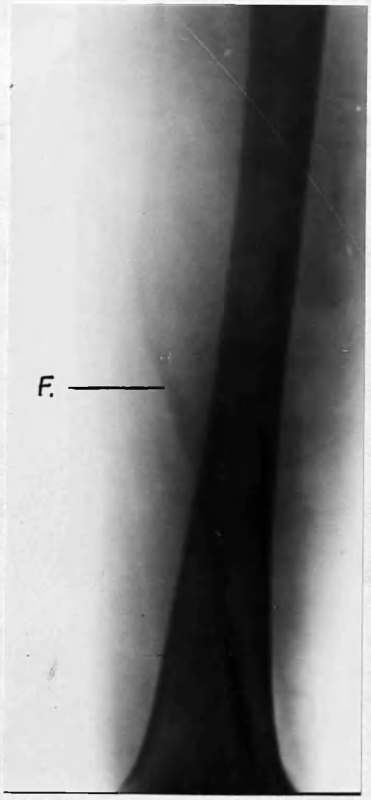


Ill. 10.

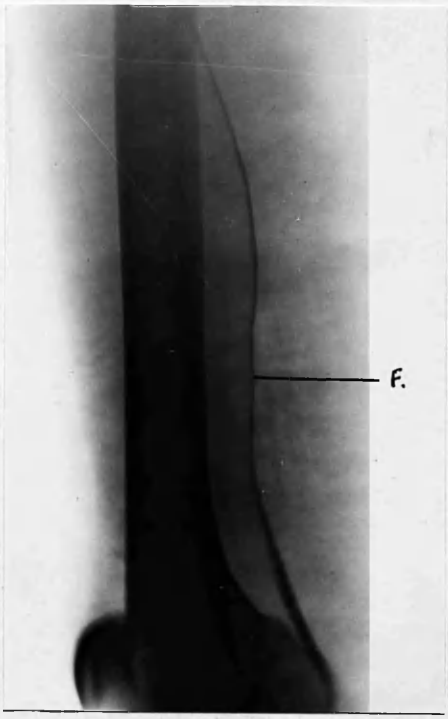
the point where it joins the posterior tibial vein to form the popliteal. It appears as a double vein, usually with a considerably wider calibre than the posterior tibial, and it also is richly valved, there being usually between 8-10 valves in its course. In the lateral view it can be seen lying posterior to the interosseous membrane from which it is separated by the deep calf muscles, Ill. 9.

The popliteal vein, Ill. 10, can be seen running upwards through the popliteal space, from its formation at the junction of the posterior tibial and peroneal veins, to the upper end of the space, where it passes through the adductor magnus muscle to become the femoral vein. The popliteal vein is sometimes wide, sometimes narrow and shows considerable variation in density. In the lateral film, Ill. II, it can be identified as a narrow streak arching behind the condyles of the tibia and femur. Occasionally a valve is visible at the junction of its middle and distal thirds, but in most instances no valves can be seen.

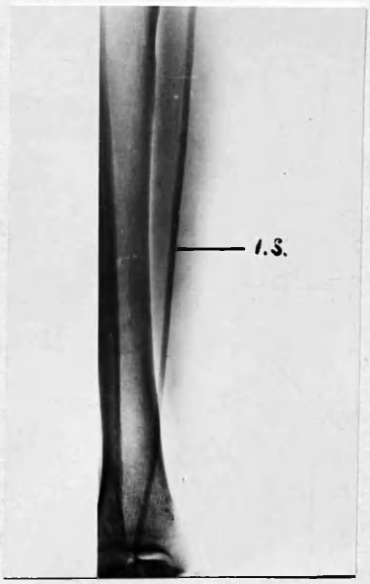
Ill. 11.



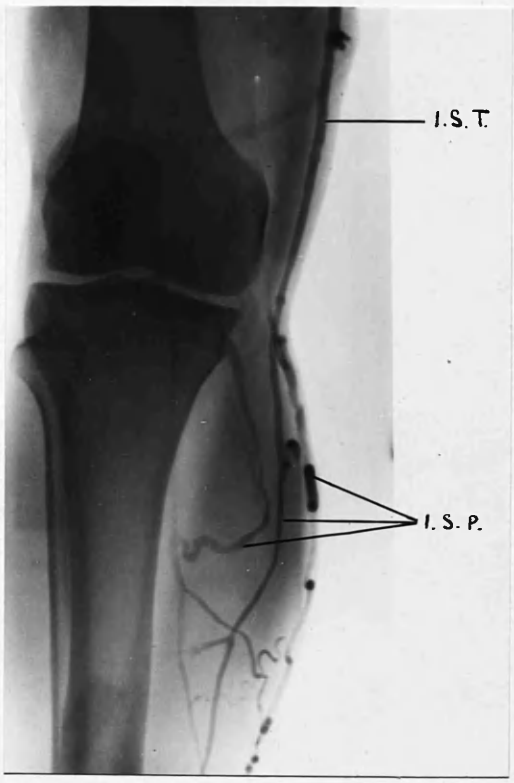
Ill. 12.



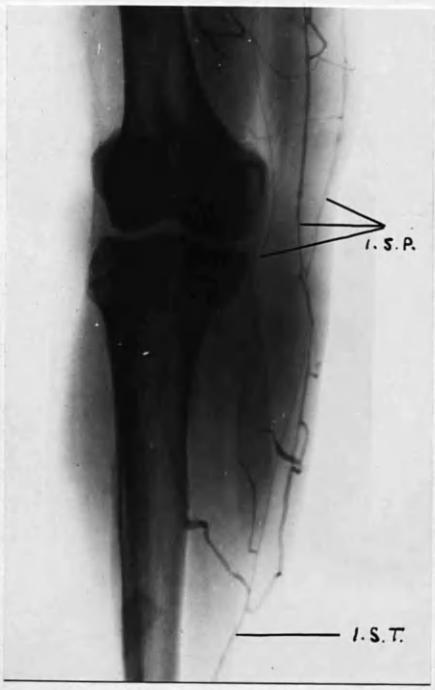
Ill. 13.



Ill. 14.

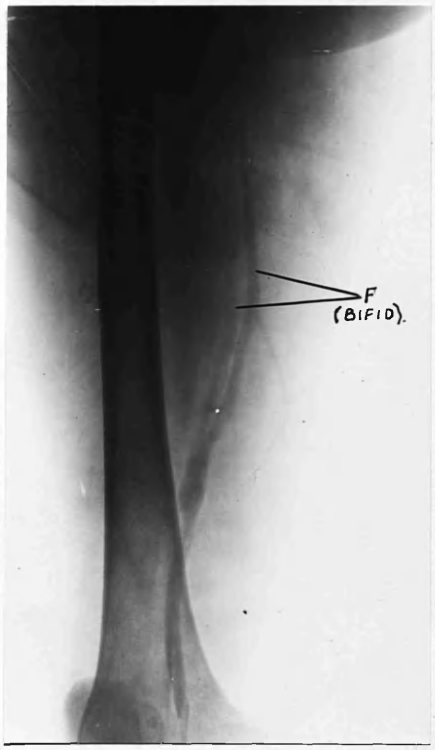


Ill. 15.



Ill. 16.

The femoral vein, Ill. 12 & 13, the continuation in a proximal direction of the popliteal, is visible as a parallel walled opacity running upwards in the thigh with an anterior and slightly medial inclination, until it gradually fades out, due to increasing dilution of the opaque medium, in the region of the inguinal ligament where it becomes the external iliac vein. Like the popliteal, valves can seldom be identified but occasionally two are seen, Ill. 4. The first lies immediately above the point where the popliteal becomes the femoral, the second in the middle third of the thigh. That there are many more valves in the popliteal and femoral than those described is shown by the anatomical dissections of Kampmeier & Birch (1927), and by retrograde venography of the deep veins, but these are the only two which can be



Ill. 17.

identified, and only occasionally, by injection in the veins of the foot.

These, then, are the common appearances of the individual veins of the lower limb when filled by this technique. But considerable anatomical variation may occur.

In the superficial system the internal saphenous may be in the form either of a single trunk, Ill. 14, or of a plexus, in its whole length; or, as in Ill. 15, it may appear as a plexus (marked I.S.P.) in the leg continuing upwards as a single trunk (marked I.S.T.) in the thigh, or vice versa, Ill. 16. At almost any level it may empty, either completely or partially, via a communicating vein, into the deep circulation.

In the deep system either the popliteal or femoral, Ill. 17, or both, may be bifid for a considerable part of their course. The posterior tibial may be represented only as a single vein; if double it may not unite into a single trunk, but one vein join the peroneal to form the popliteal and the other join the popliteal at a variable level further up in the popliteal fossa. Apart from the fact that the peroneal always appears as a double vein it may show similar anomalies in the formation of the popliteal.

Results. (Techn. No. 1A.)

Twenty-five patients were examined by this technique. The results regarding filling of the individual trunks are as shown in Table I.

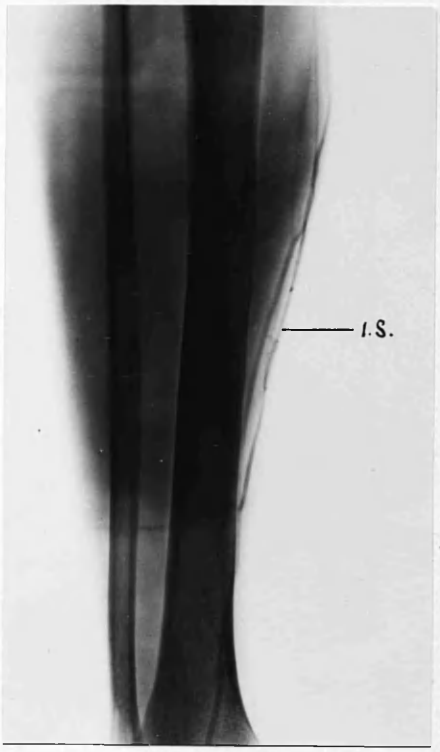
TABLE 1. VEINS FILLED.

Cases No.	Int. Saph. In leg	Int. Saph. In Thigh	Post. Tibial Whole	Post. Tibial Prox Half	Peroneal Whole	Peroneal Prox Half	Popliteal	Femoral
1.	+	-	-	+	-	-	+	+
2.	+	-	-	+	-	-	+	+
3.	+	-	+		+		+	+
4.	+	+	-	-	-	-	+	+
5.	+	-	+		-	-	+	+
6.	+	-	+		-	+	+	+
7.	+	-	-	+	-	-	+	+
8.	+	+	-	-	-	-	-	-
9.	+	+	-	+	-	-	+	+
10.	+	-	-	+	-	-	+	+
11.	+	-	-	+	-	-	+	+
12.	+	+	-	+	-	-	+	+
13.	-	-	+		-	+	+	+
14.	+	+	+		-	-	+	+
15.	+	+	-	+	-	-	+	+
16.	+	+	+		+		+	+
17.	+	-	+		-	+	+	+
18.	+	-	+		-	-	+	+
19.	+	+	-	-	-	-	-	-
20.	+	-	+		+		+	+
21.	+	-	-	-	-	-	+	+
22.	+	-	-	+	-	-	+	+
23.	+	+	-	-	-	-	-	+
24.	+	+	+		-	+	+	+
25.	+	-	-	+	-	-	+	+

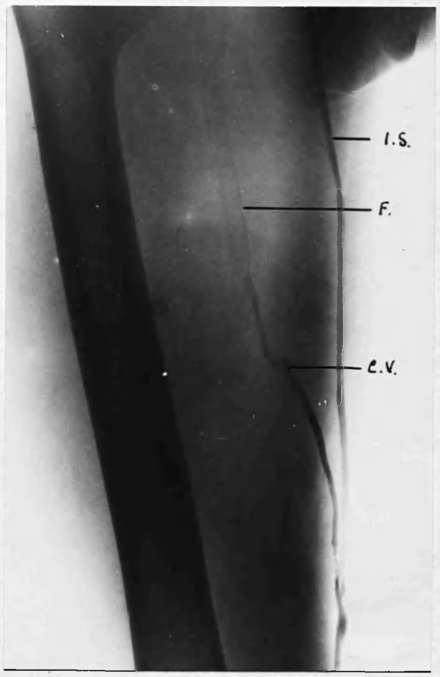
+ = Vein filled. - = Vein not filled.

TABLE 1.

It will be seen that the internal saphenous may fill in its entire length from the ankle to the groin (in 10 cases, Nos. 4, 8, 9, 12, 14, 15, 16, 19, 23, 24), or that at almost



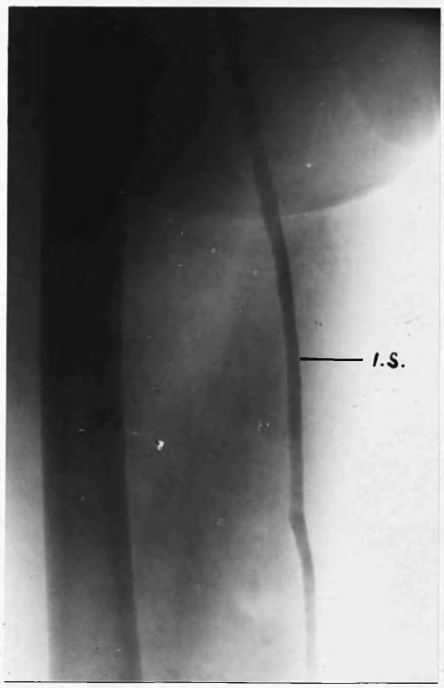
Ill. 18.



Ill. 19.

any level the dye may pass either completely or partially into the deep circulation; if the former, (in 15 cases, Nos. 1, 2, 3, 5, 6, 7, 10, 11, 13, 17, 18, 20, 21, 22, 25) no superficial circulation can be seen above that point; if the latter (in 8 cases, Nos. 4, 9, 12, 14, 15, 16, 23, 24,) both superficial and deep circulations can be identified.

With regard to the deep circulation, in only 10 cases (Nos. 3, 5, 6, 13, 14, 16, 17, 18, 20, 24) did the whole of the posterior tibial, popliteal and femoral veins fill; and in only 3 of these (Nos. 3, 16, 20) did the whole of the peroneal fill also. In a further 10 cases (Nos. 1, 2, 7, 9, 10, 11, 12, 15, 22, 25,) only the proximal half of the posterior tibial filled in addition to the popliteal and femoral. In two cases (Nos. 4 and 21), as in Ill. 18, no deep circulation filled below the knee; in one case, Ill. 19,



(Case, No. 23), only the proximal half of the femoral vein filled, and finally, in two cases (Nos. 8 and 19), as in Ill. 20, no deep circulation whatsoever filled in the whole leg, the dye running up in the internal saphenous as far as the saphenous opening before entering the deep circulation.

Ill. 20.

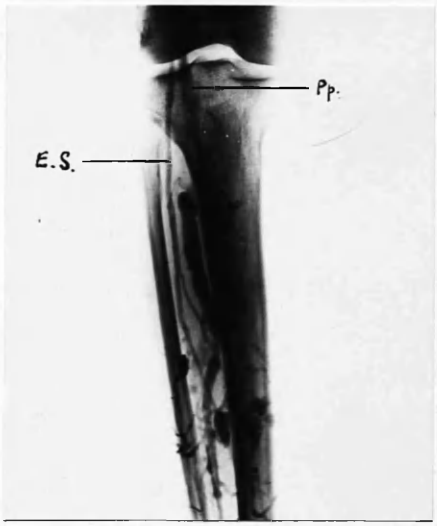
Summary.

It is at once obvious that this method is of little value for demonstrating the deep circulation of the leg, and that absence of the deep circulation in any venogram done by this technique cannot be regarded as being abnormal.

Technique No. 1B. No Tourniquet. Injection, lateral.

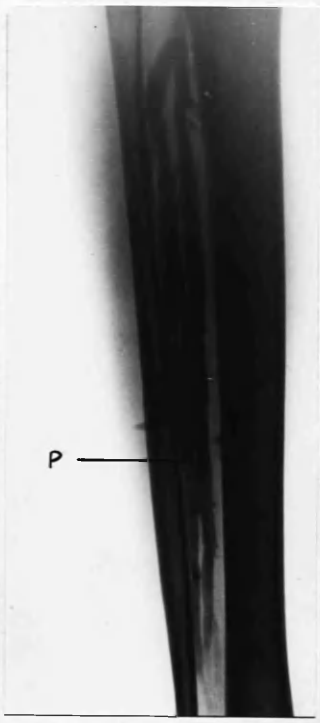
Injection on the lateral aspect of the foot demonstrates to a varying degree in individual cases, the external saphenous, the peroneal, posterior tibial, popliteal and femoral veins, variable communicating veins between the external saphenous and deep circulation, and, rarely, the internal saphenous vein.

Apart from the external saphenous, the other veins have already been described.



Ill. 21.

Ill. 22.



Ill. 23.

The external saphenous, arising as it does from the lateral extremity of the dorsal venous plexus of the foot, can be seen from the point of injection passing behind the external malleolus and running upwards, initially on the lateral, and then on the posterior aspect of the calf, until it pierces the deep fascia of the popliteal space to terminate in the popliteal vein at the level of the knee joint. In the antero-posterior view, Ill. 21, the external saphenous is somewhat obscured by the deep veins of the leg and it is seen best in the lateral film, Ill. 22, where the relatively acute bend from its superficial situation,

through the deep fascia, to the popliteal vein, is quite characteristic. The vein may be in the form of a single trunk or as a plexus, the latter appearance being more common.

The richly valved double trunk of the peroneal vein is usually seen more clearly with this technique, as in Ill. 23, than with Technique 1.A.

Results. (Techn. No. 1B.)

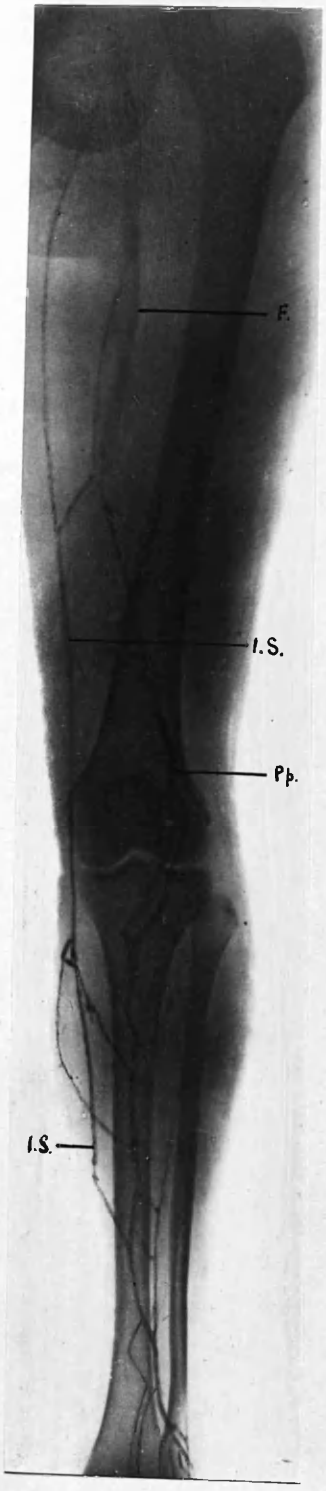
Eighteen patients were examined by this technique. The results regarding filling of the individual trunks are as shown in Table II.

TABLE 2.

Cases No.	VEINS FILLED. Ext. Saph. Whole	Ext. Saph. Distal ½ only.	Int. Saph. In Leg	Int. Saph. In Thigh	Peroneal Whole	Peroneal Prox Half.	Post. Tibial Whole	Post. Tibial Prox Half.	Popliteal	Femoral
1.	-	+	-	-	+		-	+	+	+
2.	+		-	-	-	+	-	-	+	+
3.	+		-	-	-	-	-	-	+	+
4.	-	+	+	+	-	-	-	-	+	+
5.	+		-	-	+		-	+	+	+
6.	+		-	-	-	-	-	-	+	+
7.	+		-	-	+		-	-	+	+
8.	-	-	-	-	+		-	+	+	+
9.	+		+	-	+		-	+	+	+
10.	-	+	-	-	+		+		+	+
11.	+		-	-	-	-	-	-	+	+
12.	-	+	-	-	-	+	-	-	+	+
13.	-	+	-	-	-	+	-	-	+	+
14.	+		-	-	-	+	-	-	+	+
15.	-	+	-	-	+		+		+	+
16.	+		+	-	+		-	-	+	+
17.	+		-	-	-	+	-	-	+	+
18.	+		-	-	+		-	+	+	+

+ = Vein filled. - = Vein not filled.

TABLE II.



Ill. 24.

The external saphenous, like the internal, may fill in its entire length (in 11 cases, Nos. 2, 3, 5, 6, 7, 9, 11, 14, 16, 17, 18), or it may empty completely (in 5 cases, Nos. 1, 10, 12, 13, 15) into the deep circulation below the knee. In one case (No. 8) no filling of the external saphenous occurred, all of the dye entering the peroneal vein at the level of the ankle joint; while in the remaining case (No. 4), Ill. 24, the dye ran from the external to the internal saphenous without entering the deep trunks below the knee. In 8 (Nos. 2, 5, 7, 9, 14, 16, 17, 18) of the 11 cases in which the whole of the external saphenous was filled, dye passed from the superficial into the deep veins below the knee, so that both superficial and deep systems were visible from that point proximally.

With regard to the deep system, the popliteal and femoral veins were visible in every instance. In only 9 cases (Nos. 1, 5, 7, 8, 9, 10, 15, 16, 18,) did

the whole of the peroneal vein fill in addition, and in only 2 of these (Nos. 10 and 15) did the whole of the posterior tibial fill as well. In a further 5 cases (Nos. 2, 12, 13, 14, 17) only the proximal half, or less, of the peroneal filled, in addition to the popliteal and femoral, and in 4 cases (Nos. 3, 4, 6, 11) no deep circulation whatsoever was seen below the knee. (Ill. 24)

In seven, (Nos. 1, 5, 6, 9, 12, 15, 17) of these 18 cases, injection was made into the vein behind the lateral malleolus, the one which was utilised initially by Dos Santos and which, Bauer claimed, had special properties regarding filling of the deep circulation. As can be seen the results were indistinguishable from those obtained by injecting any other superficial vein on the lateral aspect of the foot, and there does not appear to be any particular advantage in using this vein which frequently has to be exposed before it can be identified and injected.

Summary.

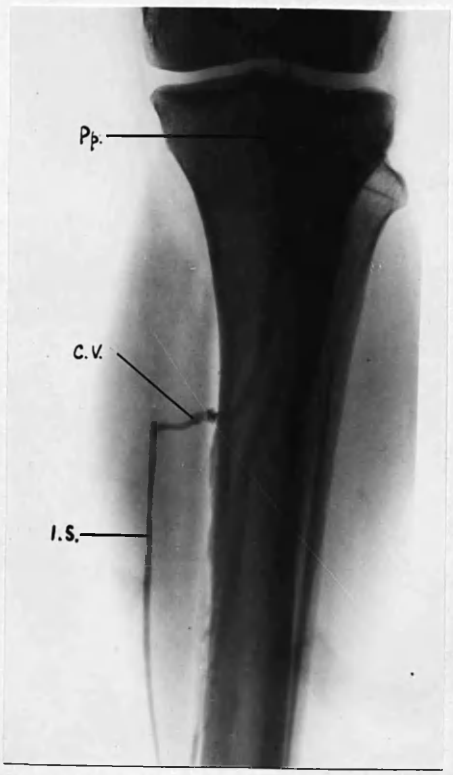
Although this method results in filling of the popliteal and femoral veins on every occasion, it is obvious that it is of little value in demonstrating the deep circulation below the knee, and that absence of this in any venogram done by this technique cannot be regarded as being abnormal.

Conclusions. (Techn. Nos. 1A. & 1B.)

This finding, that injection of any vein in the foot

without a tourniquet to obliterate the superficial circulation is completely unreliable regarding filling of the deep circulation, is contrary to the opinions of Dos Santos (1938), Dougherty & Homans (1940), Mark (1943), Baker (1945, 1947), Lesser & Raider (1943), and Lesser & Danelius (1944), who all used this method in reporting on the venographic diagnosis of acute deep thrombophlebitis.

As these techniques are the only two in which the superficial circulation is free to fill, unimpeded by a tourniquet, it is of interest to observe at this point that Baker (1945, 1947, Baker & Miller 1944, Sedwitz & Baker 1944), using these methods has recommended that venograms should be classified into those in which the superficial and deep circulations are blocked, each group being subdivided into acute and chronic. The basis of his diagnosis of a block in the superficial circulation, both acute and chronic, rests on the observation of all the dye passing via a communicating vein to the deep circulation, leaving the superficial system proximal to that point empty of dye. This interpretation coincides with the view of several other authors, notably Lesser & Raider (1943).



Ill. 25.

As has been observed, this occurred in 15 out of 25 cases when injection was made on the dorso-medial side of the foot (P. 30), as in Ill. 25, and in 5 out of 18 cases on the lateral side (P. 34). It must therefore be considered to be a normal finding and should not be regarded as evidence of a block proximally. Indeed, in my opinion, venography is totally unnecessary and should play no part in the diagnosis of thrombosis of the superficial system, which is amenable to clinical methods of examination.

Two further points should be noted. The first is that once the dye has entered the deep circulation it ascends in it, and does not pass out again into the superficial. In other words, the communicating veins are competent, and allow flow to occur only from superficial to deep and not vice versa. This obtained in all the normal legs examined, and is in sharp contradistinction to what occurs in patients with varices, when the deep circulation may empty into the superficial at any level via incompetent communicating veins, and so simulate a block in the deep circulation above that point, as will be shown later. (P. 76).

Secondly, with injection on the medial side of the foot, the peroneal vein only fills, in whole or in part, when the posterior tibial is well filled (TABLE I, Nos. 3, 6, 13, 16, 17, 20, 24). This is due to the fact that the communicating veins from the internal saphenous below the knee drain only to the posterior tibial, and only when this vein is filled

does the peroneal fill from it by intercommunicating veins. In the same way, with injection on the lateral aspect of the foot, the external saphenous drains to the peroneal, from which the posterior tibial may fill (TABLE II, Nos. 1, 5, 8, 9, 10, 15, 18). The way in which each of these deep veins fills from the other by intercommunicating veins is of importance in the production of apparent filling defects, as will be shown in SectionII. (P. 53).

Technique No. 2A. Tourniquet above knee. Injection, Dorso-medial aspect of Foot.

With this technique, a tourniquet, in the form of a piece of rubber tubing, is placed around the thigh above the knee sufficiently tightly to obliterate the superficial circulation without impeding venous return in the deep circulation. That there is a certain amount of difficulty in obliterating the superficial circulation without hindering passage of blood in the deep, will be shown later. (P. 73).

Injection in the dorso-medial aspect of the foot with this technique demonstrates, to a varying degree in individual cases, the internal saphenous, posterior tibial, peroneal, popliteal and femoral veins.

Results.

A total of fourteen patients were examined. The veins filled in each individual case were as shown in Table III. The heading 'Int. Saph.' in this table refers only to that

TABLE 3. VEINS FILLED.

Cases No.	Int. Saph. To Tourniquet.	Int. Saph. Distal Half.	Post. Tibial. Whole	Post. Tibial. Prox. Half.	Peroneal. Whole	Peroneal. Prox. Half.	Popliteal	Femoral
1.	-	+	-	+	-	-	+	+
2.	+		-	-	-	-	+	+
3.	+		+		+		+	+
4.	+		-	+	-	-	+	+
5.	-	+	+		+		+	+
6.	+		-	+	-	-	+	+
7.	+		-	+	-	-	+	+
8.	-	+	+		-	+	+	+
9.	+		+		+		+	+
10.	+		-	+	-	-	+	+
11.	+		-	-	-	-	+	+
12.	-	+	+		-	+	+	+
13.	+		-	+	-	-	+	+
14.	-	+	+		-	+	+	+

+ = Vein filled. - = Vein not filled.

TABLE III.

Ill. 26.

part of the internal saphenous from the point of injection to the level of the tourniquet, and consequently 'Distal Half' refers only to that part from the point of injection to approximately the mid shaft of the tibia.

With regard to the deep circulation, the popliteal and femoral veins filled in every instance. It will be seen, however, that in only six cases (Nos. 3, 5, 8, 9, 12, 14) did the whole of the posterior tibial vein fill

as well; and in only three of these (Nos. 3, 5, 9), did the whole of the peroneal fill also. In six cases (Nos. 1, 4, 6, 7, 10, 13) only the proximal half of the posterior tibial filled, and in two cases (Nos. 2 & 11) the dye emptied from the internal saphenous via communicating veins directly into the popliteal, without filling either of the deep trunks below the knee, as in Ill. 26.

Summary.

It is obvious then, that although this method can be relied on to fill the popliteal and femoral veins on every occasion, it is no more reliable than injections without a tourniquet so far as visualisation of the deep veins below the knee is concerned.

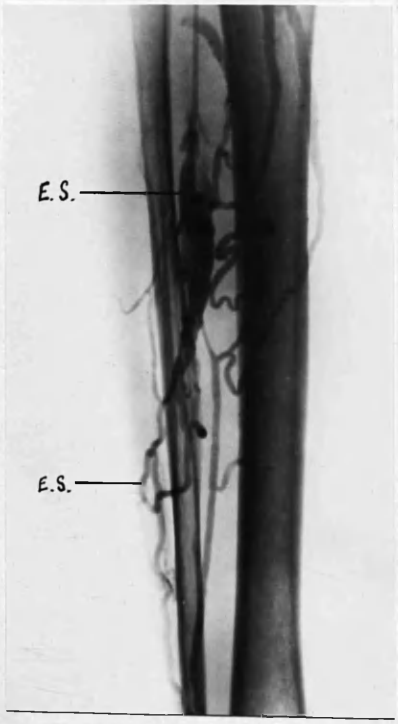
Technique No. 2B. Tourniquet at knee. Injection, Lateral aspect of Foot.

With this technique the tourniquet was applied immediately below the patella so that it compressed the external saphenous vein before its junction with the popliteal.

The veins filled were the external saphenous, peroneal, posterior tibial, popliteal and femoral.

Results.

A total of 12 cases was examined,



Ill. 27.

TABLE 4. VEINS FILLED.

Cases. No.	Ext. Saph. To Tourniquet.	Ext. Saph. Distal. Half.	Peroneal. Whole	Peroneal. Prox. Half.	Post. Tibial. Whole	Post. Tibial. Prox. Half.	Popliteal	Femoral
1.	+		-	-	-	-	+	+
2.	-	+	+		+		+	+
3.	-	+	+		-	+	+	+
4.	-	+	-	+	-	-	+	+
5.	+		+		-	+	+	+
6.	-	+	+		+		+	+
7.	+		-	+	-	+	+	+
8.	+		+		+		+	+
9.	-	+	-	+	-	-	+	+
10.	-	+	-	+	-	-	+	+
11.	-	+	+		-	+	+	+
12.	+		+		+		+	+

+ = Vein filled. - = Vein not filled.

TABLE IV.

and the filling of veins which occurred in each individual case was as indicated in Table IV.

Regarding the deep circulation, the popliteal and femoral veins again filled in every instance. In only seven cases (Nos. 2, 3, 5, 6, 8, 11, 12) did the peroneal vein fill in its entire length as well, and in only four of these (Nos. 2, 6, 8, 12) did the whole of the posterior tibial fill also. In four cases (Nos. 4, 7, 9, 10) only the proximal half of the peroneal filled, and in one case (No. 1), Ill. 27, no deep circulation filled below the level of the knee.

Summary.

Once again, then, absence of filling of the deep veins

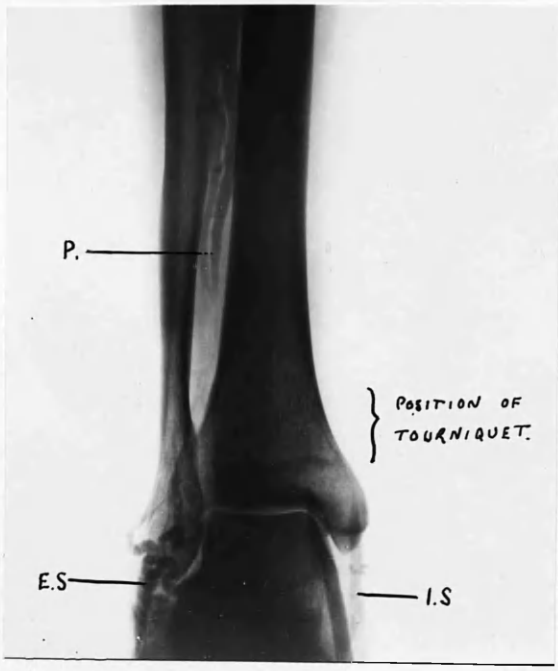
below the knee cannot be regarded as being abnormal in any venogram done by this technique.

Conclusions. (Techn. Nos. 2A. & 2B.)

This method, injection into any vein of the foot supplemented by a tourniquet in the region of the knee, was the one utilised by Welch et al. (1942), Zax (1943), De Bakey et al. (1943), Allen et al. (1946), and Jenny (1947). As has been shown this method is quite unreliable regarding constant filling of the deep veins below the knee and it is not altogether surprising that Allen et al. (1946), as was mentioned in Part I, were dissatisfied at the discrepancies between their venographic findings and eventual clinical results.

Technique No. 3. Tourniquet at ankle. Injection, Dorso-medial and Lateral aspects of Foot.

As it is not easy to keep a rubber tubing tourniquet in position at the ankle unless it is held by an assistant, when her hand receives too much radiation, a 2 inch crêpe bandage was used instead. This was bound very tightly around the ankle immediately above the malleoli prior to the injection. Crêpe bandage has the added advantage of being radio-translucent and so does not obscure the films.



Ill. 28.

Ill. 29.

Results.

A total of 34 patients was investigated in this way; 18 were injected on the dorso-medial side of the foot, and 16 on the lateral side. The tourniquet around the ankle obstructs flow in the superficial circulation, both internal and external saphenous, as in Ill. 28, and at the same time compresses the lower end of the posterior tibial vein against the posterior aspect of the tibia, so that the dye runs via the deep anastomosis around the ankle joint to the only remaining outlet, the peroneal vein, which, because of its situation between the tibia and fibula escapes compression by the tourniquet. Consequently, injection on the dorso-medial and lateral aspects of the foot produce exactly the same results regarding the deep circulation, and, therefore, both groups will be considered together.

Of the 34 cases examined, the whole of the peroneal, popliteal and femoral veins were seen in every instance. In 8 cases nearly the whole of the posterior tibial was seen also; in a further 13 cases the proximal part of the posterior tibial was filled and in the remaining 13 cases no filling whatsoever of the posterior tibial vein could be identified, as in Ill. 29.

Conclusions (Techn. No. 3)

It is at once apparent that this technique, which is the one recommended by Hellstein (1942), and in the later publications of Bauer (1942, 1945, 1946), is a considerable improvement on any tried hitherto, regarding reliability in filling the deep veins; but at the same time it is obvious that it does not fill all the deep veins of the leg. Complete absence of filling of the posterior tibial, by this technique, cannot be regarded as being abnormal.

Ill. 30.

The tourniquet around the ankle blocked the superficial circulation completely in 25 of the 34 cases. In the remaining 9 cases a trickle of dye passed under the tourniquet and ascended, in six cases injected on the dorso-medial aspect of the foot, in the internal saphenous, as in Ill. 30, and in 3 cases injected

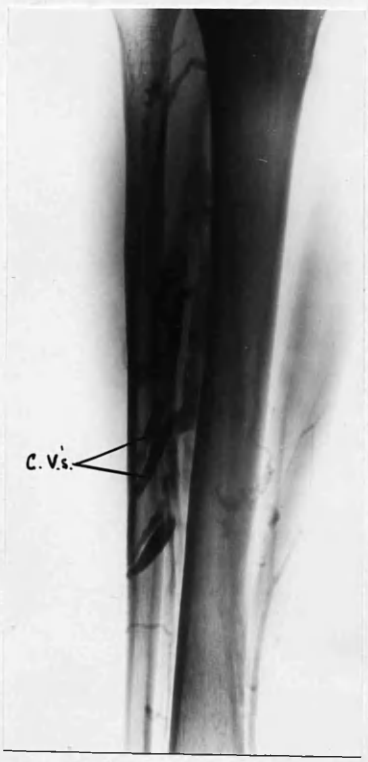
on the lateral side of the foot, in the external saphenous. It was observed that this tended to occur, not in lean ankles with little subcutaneous tissue, but in the more fleshy type, and even with very firm application of the tourniquet it could not be prevented entirely. While it is of no significance in regard to this series of cases, it becomes particularly important when the ankle region is either oedematous or indurated, or when a varicose ulcer is present, as under these circumstances the tourniquet around the ankle may not force the dye into the deep veins at all. Only the superficial circulation may fill, thus suggesting thrombosis in the deep veins, and this, as will be shown later (Part III, p. 77) has been one of the commonest causes of errors in venographic diagnosis.

Technique No. 4. Tourniquet at ankle and above knee. Injection, Dorso-medial and Lateral aspects of Foot.

As was illustrated in Technique 1A, only when the posterior tibial is well filled does the peroneal appear; and, as in Technique 1B, only when the peroneal vein is well filled does the posterior tibial appear. In other words one deep vein, when it is filled, empties into the other by intercommunicating veins. Since this appears to be the case, it seemed that it might be possible, by obstructing return from the deep veins below the knee, to increase this

flow through the intercommunicating veins, and so fill both of the main trunks.

As Technique III was the only one which filled at least one of the deep veins of the leg, the peroneal, in every instance, a number of cases were investigated using this method, with the addition of a tourniquet, in the form of rubber tubing, applied above the knee, sufficiently tightly to produce at least partial obstruction to the return of blood in the deep veins. The tourniquet was kept in position until the first 15 ccs. of dye were injected, when films of the lower leg were taken; it was then released, the injection continued and films of the thigh exposed as the injection was being completed.



Ill. 31.

Results.

In all, 31 examinations were carried out by this method. For the same reason as with Technique III, they have not been subdivided into dorso-medial and lateral.

The whole of the peroneal, popliteal and femoral veins filled in every case. In 22 cases, the whole of the posterior tibial filled; in 7 cases only the proximal half filled, and in 2 cases no filling whatsoever occurred in the posterior tibial.

Conclusions (Techn. No. 4)

It is therefore obvious, that although this method produces a higher proportion of cases in which all the deep veins are demonstrated than any other, complete absence of the posterior tibial in any individual venogram cannot be regarded as being abnormal.

As a result of the partial obstruction to the deep circulation due to the tourniquet above the knee, communicating veins in the lower leg are frequently seen with this technique. They may arise from the peroneal vein, as in Ill. 31, in which three pairs are visible, or from the posterior tibial, and present quite a characteristic appearance. They are nearly always paired, and the dye runs into them only as far as their valves, which, being competent, do not allow flow to the superficial circulation.

Conclusions. SECTION 1.

One is forced then, to the conclusion that none of the techniques investigated will fill all the deep veins of the leg in every case.

What is, technically, a normal venogram, with complete filling of the peroneal, popliteal and femoral veins cannot be regarded, in any individual case, as excluding acute deep thrombophlebitis, which may, at the time the venogram was performed, be developing either in the posterior tibial vein, or in the deep intermuscular plexuses of the calf or thigh,

which never fill at all with dye. In addition, it must be remembered that the third main venous trunk of the lower leg, the anterior tibial vein, is not represented at all on a venogram. This absence of the anterior tibial vein is very puzzling. At one time I thought it might be due to the fact that Pyelosil, being heavier than blood, tended to gravitate to the more posterior deep veins; and so I performed several venograms - seven to be exact - with the patient lying prone. In none of these did the anterior tibial fill, and in no venogram which I have done, either normal or abnormal, has a shadow been seen in the anatomical position of the anterior tibial. It is of interest to note that Bauer (1942) also remarked on this and after performing venograms on the legs of cadavers and dissecting out the veins afterwards, came to the conclusion that the anterior tibial vein played little part in draining the superficial tissues of the foot. At anyrate, whether this explanation is correct or not, the vein does not fill in a normal case, and consequently, deep thrombophlebitis in it cannot be excluded.

Only, then, if defects are seen in the peroneal, popliteal or femoral veins, which are always visualised by Techniques III & IV, can the possibility of a phlebitic process be considered from a venographic point of view; and even then, partial or irregular filling cannot always be regarded as abnormal, as will be shown in the next section.

What a normal venogram done by these two techniques can demonstrate, however, is patency of the deep circulation of

the leg, from the ankle to the groin. While this is of no interest in acute deep thrombophlebitis, it may be of considerable value in cases of induration, ulceration or chronic oedema of the lower limb, especially when there is a history of deep thrombophlebitis, and this aspect will be considered in Part III.

SECTION II. Partial or Irregular Filling of Deep Veins.

Incomplete filling of deep veins has been regarded by almost all authors as indicating a pathological process in the vein concerned. Bauer (1940, 1945) has contributed the most detailed account of the radiological appearances considered to be due to thrombosis. The earliest stage of the disease, when the propagating thrombus is lying loose in the blood stream, attached only at its base, is characterised by thinning of the shadow of the dye in the centre of the vessel - the propagating thrombus is lying in the centre of the vessel and the dye runs proximally in a thin sheath around it; in the next stage the thrombus becomes adherent to the vessel wall, without producing complete occlusion, and this is represented radiologically by an irregular appearance of the dye along one wall of the vessel; when the thrombus produces complete occlusion, a filling defect of varying size is visible radiologically, and when the thrombophlebitis process has involved the whole vein no filling whatsoever occurs in the venogram. These interpretations of the radiological

appearances have been widely accepted and De Bakey et. al. (1943) summed up the general attitude when they stated that "Incomplete or irregular filling, or absence of filling of the deep veins is an indication of thrombosis."

Few authors dissented from these views. Lindblom (1941a, 1941b), however, pointed out that the specific gravity of any opaque medium was considerably higher than that of blood and that sometimes, instead of mixing uniformly with the blood, it lay on the dependent wall of the vein when films were taken with the patient supine. This he called "sedimentation". In the lateral view, then, the vessel was represented by a thin streak on the posterior wall of the vein while in the antero-posterior view, since there was less depth of opaque medium, the opacity of the vein was lessened. This thinning of the shadow of the dye, Lindblom claimed, could be confused with the appearances seen in the early stages of deep thrombophlebitis, as described by Bauer. Lindblom's work was repeated and confirmed by Kjellberg (1943). The only other authors to doubt that irregular vein filling was due to thrombophlebitis were Fine & Starr, (1945) who, after operating on several cases of suspected deep thrombophlebitis which had been apparently confirmed by venograms showing filling defects, and finding normal veins, suggested that possibly pseudo filling defects were produced by spasm in the veins concerned.

In the investigations described on normal patients in Section I, many irregularities were observed in the veins,

and, on the basis of the appearances seen in these venograms, I have classified the filling defects which may occur in normal veins into four groups.

Group A. Those due to sedimentation, as described first by Lindblom.

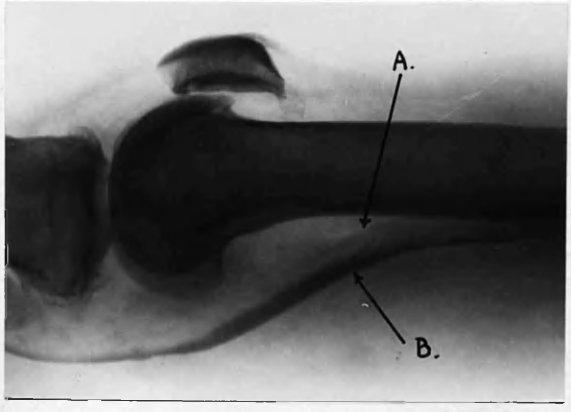
Group B. Those due to intercommunicating veins between the deep veins of the leg.

Group C. Those due to the entry of tributaries into the main deep veins.

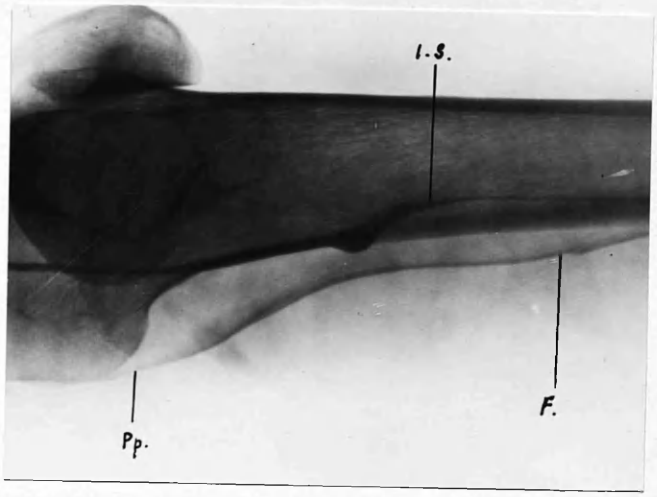
Group D. Those due to variations in the rate of blood flow within veins, and to lack of miscibility of the opaque medium with the blood.

Group A. Due to sedimentation.

That sedimentation of the opaque medium, Pyelosil in these cases, does occur, can be demonstrated by looking at almost any lateral venogram. The inferior border of the shadow cast by the dye is clearly demarcated where it is bounded by the dependent wall of the vein, as in area B, Ill. 32; while the upper border is irregular and gradually diminishes in density towards the superior wall of the vein, area A. In Ill. 33, a similar

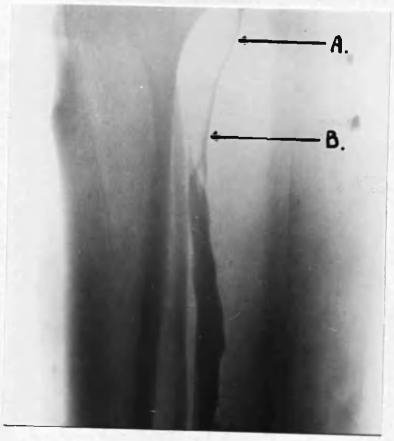


Ill. 32.



Ill. 33.

Ill. 34.



Ill. 35.

appearance can be seen in the internal saphenous, popliteal and femoral veins and, as was remarked on P. 24, any or all of the veins of the leg may show this appearance. Consequently, veins, in the lateral view, which are represented by an opacity of little more than 2 millimetres should not be regarded as abnormal.

As Lindblom claimed, sedimentation may, in the antero-posterior projection, produce such a diminution in density as to simulate a filling defect. In Ill. 34, such an appearance is shown between the points A and B at the junction of the two branches of the peroneal. In the lateral view, however, Ill. 35, the fact that this is due to sedimentation can be identified.

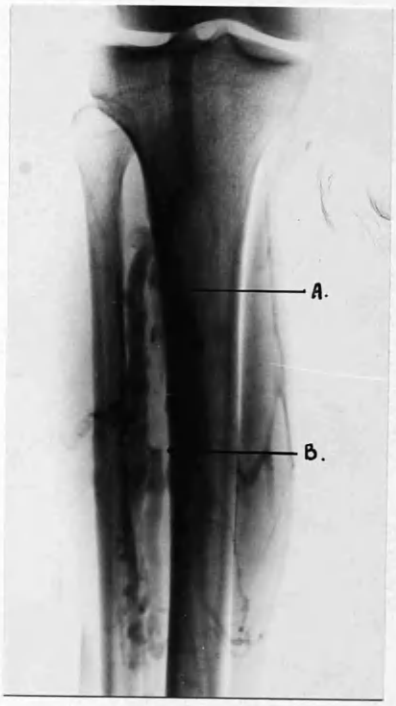
It would appear then, that so long as lateral views are taken in conjunction with antero-posterior projections, little difficulty need be experienced in distinguishing the appearances due to sedimentation from those ascribed to deep thrombophlebitis.

Group B. Due to Intercommunicating Veins.

As has been described on pages 37 and 38, intercommunicating veins occur between the deep trunks of the leg, so that the posterior tibial may fill, by means of these veins, from the peroneal, and vice versa. In the same way intercommunications exist between the two main trunks of the peroneal, so that one may fill from the other, and a similar arrangement obtains in the posterior tibial when it is double.

Ill. 36.

That this occurs is shown very clearly in Ill. 36, where the dye, running up from ankle level in the medial trunk of the peroneal vein, has passed into the lateral trunk of the peroneal at mid leg level via intercommunicating veins which can be identified quite easily. In this case the proximal half of the lateral branch of the peroneal vein is completely filled

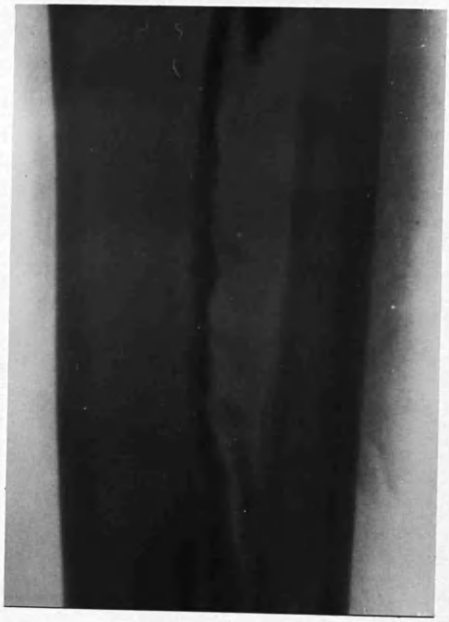


Ill. 37.

Ill. 38.

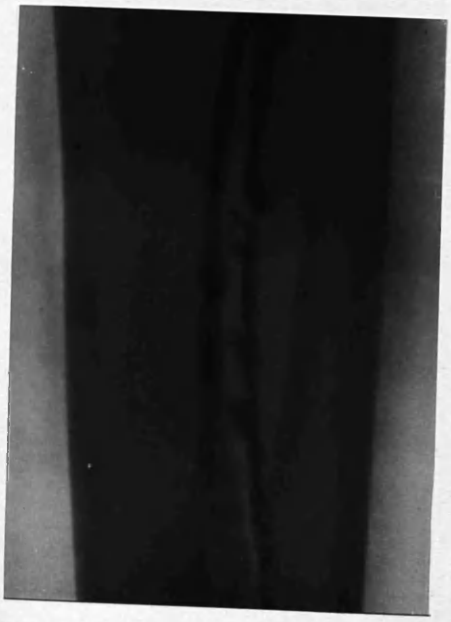
Ill. 39.

and presents no abnormality; but if the dye had entered that vein from intercommunicating branches at only two points several inches apart, and if the film had been taken at that time, an apparent filling defect would be produced. Such a defect is shown in Ill. 37, between the points A and B in the medial branch of the peroneal; and in Ill. 38, again in the medial branch of the peroneal. This last film was repeated a moment later, Ill. 39, and in this it can be seen



Ill. 40

Ill. 41



Ill. 42.

that both branches of the peroneal are now filled, there being no organic occlusion. The three illustrations 40, 41, 42, were taken immediately after each other during the same injection, and in them the gradual filling up of a defect can be observed. For clarity, these prints show only the area of the defect. In the first film taken, Ill. 40, a filling defect is visible in the lateral branch of the peroneal, in the second film, Ill. 41, more dye has run into the area of the defect and the faint shadow of the

vein can be identified, while in the third film, Ill. 42, the vein is quite well filled.

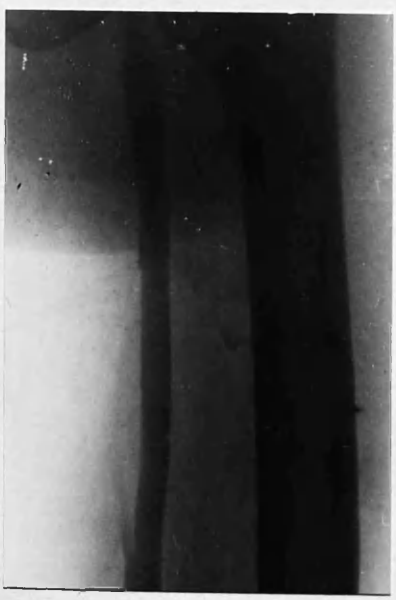
Similar defects can be observed in the posterior tibial vein when it is double, and more rarely, defects may occur in the peroneal vein by intercommunicating branches from the posterior tibial, and vice versa. Such defects may vary from half an inch to several inches in length. In Ill. 37, the defect was two and a half inches on the original film, and in Ill. 38, four and a half inches.

These defects are quite indistinguishable from the appearances, ascribed by Bauer, and by all other writers on this subject, to obliteration of a segment of a vein by deep thrombophlebitis. Even rapid serial radiography, as in Ill. 40, 41, and 42, must fail in many cases to distinguish between the two, as complete filling of the suspected segment often does not occur since insufficient dye enters from the parallel vein, via the intercommunicating veins, to delineate the area clearly. After careful study of the illustrations in most of the articles published on the venographic diagnosis of acute deep thrombophlebitis, I feel that in not a few cases appearances attributed to deep thrombophlebitis were in reality due to this mechanism, and were therefore within normal limits.

Group C. Due to entry of tributaries.

As a result of dilution with blood, the concentration of dye in veins gradually diminishes from the point of injection, so that, with injection in the foot, the shadow cast by the femoral vein on a film is usually much less dense than that of the veins of the lower leg. In many such films, irregular defects are visible along one wall of the femoral vein, as in area A of Ill. 43. If, however, the venogram is repeated, as was done immediately in this case, with a technique which ensures better filling of the femoral vein, Ill. 44, no such filling defect is visible.

Ill. 43.



Ill. 44.

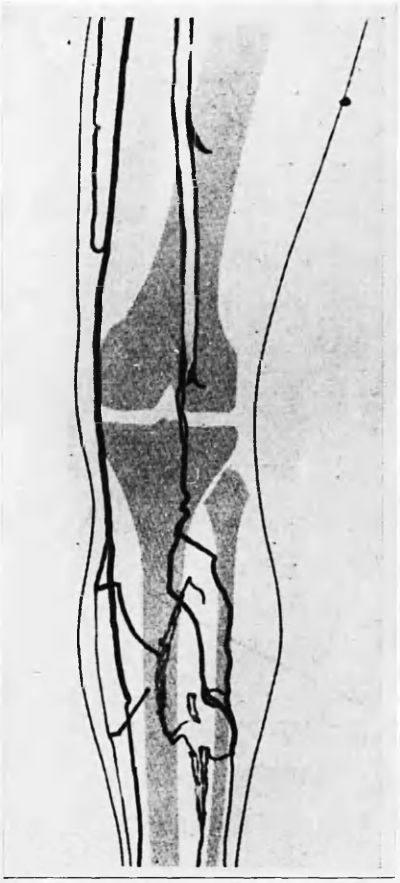
Defects of this type have been attributed, by almost all authors, to the formation of a mural thrombus, projecting into the lumen of the vein and so causing irregularity of the column of dye. A much more likely explanation appears to be the entry of a large tributary into the main vein with resultant local dilution of the opaque medium to such an extent that an irregular defect is produced on the film. The fact that these defects are seldom, if ever, observed below the knee supports this explanation. Here

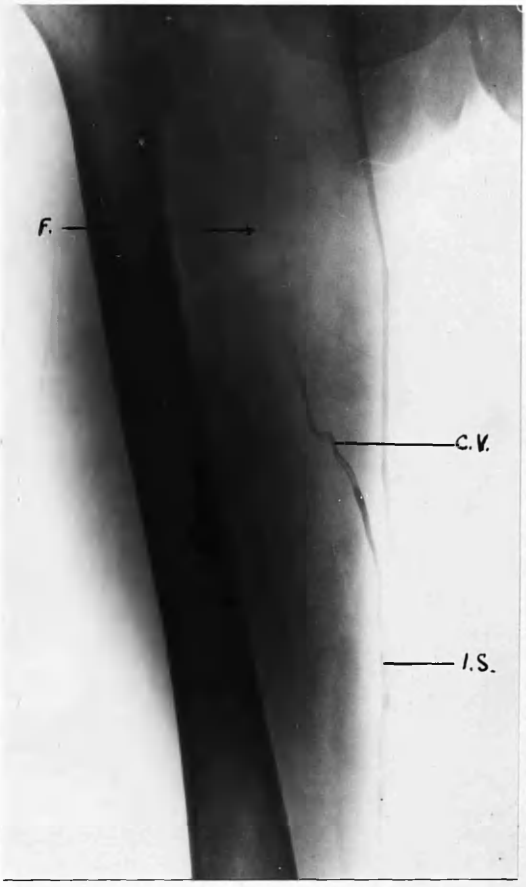
the concentration of dye is high so that the entry of a tributary would be unlikely to produce marked local dilution; while in the femoral vein, where concentration is less good, such an eventuality would be more likely to arise. This theory is supported by the cinematographic studies of Franklin & Janker (1936), when they observed indentations, produced by inflow from the renal veins, on the shadow of the inferior vena cava.

At anyrate, even if this explanation is incorrect, such defects in the femoral vein have been observed so frequently in normal cases that there is no doubt that they are not due to deep thrombophlebitis.

Group D. Due to variations in the rate of blood flow, and to lack of miscibility of the opaque medium.

It is generally accepted that blood flows more rapidly in the centre of a vein than at the periphery, and consequently, any opaque medium will tend to be cleared from the centre of a vein before all traces of it are washed away from the periphery. When the concentration of dye in the blood is high this effect passes unnoticed on a film; but when concentration of dye is poor the diminution in contrast in the middle of the vein may be quite marked. As long ago as 1931, Sgalitzer et. al. commented on the slight thinning which could occur in the contrast medium in this situation.

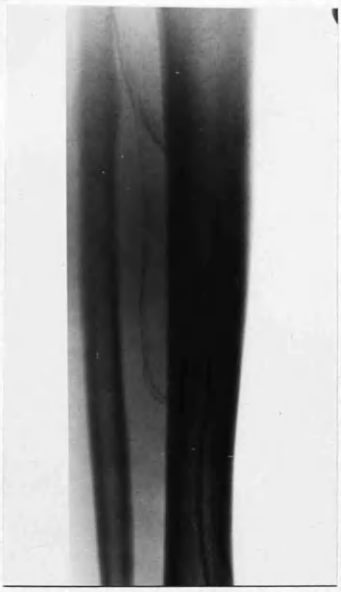




Ill. 45. Ill. 46.

Ill. 45, is a photograph of Fig. 13, from Bauer's original work, (1940), on acute deep thrombophlebitis. Bauer called this appearance the 'Mantle shadow' and interpreted it as being due to a propagating thrombus lying in the blood stream and so causing the central rarefaction, while the dye ran proximally in a sheath around it. The caption of Fig. 13, reads "Mantle shadow in the femoral vein, indicating the presence there of a waving, non-adherent thrombus". This 'Mantle shadow' has been similarly interpreted as being due to deep thrombophlebitis by other authors (Baker, 1945, Welch et al. 1942).

Ill. 47.



Ill. 48.

Ill. 49.

In normal veins this appearance is not uncommon. It always occurs where concentration of the dye is poor and is shown in Ill. 46, in the femoral vein, which has filled via a communicating vein from the internal saphenous. Ill. 47, demonstrates a similar appearance in the popliteal vein, and Ill. 48, shows it in superficial veins in the leg.

It would seem, then, that this appearance is merely an exaggeration of that described first by Sgalitzer et al. and that it is due,

not to deep thrombophlebitis, but to the more rapid current in the centre of the vein washing the opaque medium away before it disappears from the periphery.

As was mentioned on page 2, one of the main requirements of any opaque medium is that it should be freely miscible with blood. Even Pyelosil, although it appears to be the best available, does not mix entirely homogeneously and because of this, where concentration of dye in the vein is poor, irregular patches of increased and diminished density can be identified, as in Ill. 49, in the femoral vein. These appearances are very similar to those described as being due to thrombotic masses partially occluding the lumen of the vein.

Conclusions. Section II.

One is forced, then, to the conclusion that partial or irregular filling of veins by no means always indicates a pathological process in the vein concerned.

In this secion illustrations have been given, from normal venograms, of the appearances which have been attributed to the presence of deep thrombophlebitis, and on which the venographic diagnosis of this condition has been based. It would seem therefore, since these appearances occur frequently in normal veins, that venography, in its present state of development, is quite unreliable in the diagnosis of acute deep thrombophlebitis.

CONCLUSIONS. PART II.

(1). None of the techniques investigated will fill all of the main deep veins of the leg, and therefore, what is technically a normal venogram cannot be held to exclude acute deep thrombophlebitis.

(2). Four different ways in which incomplete filling of veins can occur in normal legs have been described, and therefore partial or irregular filling of veins in a venogram cannot be held to indicate acute deep thrombophlebitis.

(3). Consequent on conclusions (1) and (2), the diagnosis or exclusion of acute deep thrombophlebitis by venography must always be suspect, and in the present state of knowledge venography should be used very sparingly, if at all, for this purpose.

(4). Venography is quite unreliable in the diagnosis of obstructive lesions of superficial veins, and ought not to be employed to this end.

(5). Using either Techniques No. 3 or No. 4, patency of the deep circulation can be demonstrated from the ankle to the groin, in every instance in normal legs.

PART III. THE DEEP CIRCULATION OF THE LEG IN VARICOSE AND POST-PHLEBITIC ULCERATION. Page.

THE DEEP CIRCULATION OF THE LEG IN VARICOSE AND POSTPHLEBITIC ULCERATION.

Varicosities in the lower limb can be divided into two types, primary or idiopathic, and secondary or compensatory, (Payne, 1936), the latter group occurring when the deep circulation has been involved in a previous deep thrombophlebitis, either post-partum, post-operative or idiopathic. Ulcers developing in the first group are termed varicose ulcers; in the second group post-phlebitic ulcers.

The initial treatment of choice in varicose ulceration is generally agreed to be high ligation of the internal saphenous vein, when Trendelenburg's test is positive, followed where necessary by obliteration of any remaining varices either by further ligations at a lower level, or by the injection of sclerosing solutions.

With regard to post-phlebitic ulceration, the majority of writers, Rogers (1939), Foote (1944), Franklin (1937), Ochsner & Mahorner (1939), Coombs (1940) etc., maintain that the deep circulation remains blocked, and that consequently, since the superficial circulation is the sole means of venous return from the leg, to obliterate this superficial system by radical measures would be most unwise. Accordingly, they advocate only conservative treatment, in the form of supportive bandages etc. On the other hand, a minority of writers, of whom Warwick (1931), Meisen (1932) and

Dickson Wright (1940a, 1940b), are the most prominent, differ from these more generally accepted views. While admitting that in certain instances the deep circulation may remain thrombosed after deep thrombophlebitis, they maintain that in others considerable recanalisation does occur, and that the condition then present is incompetence of the deep circulation due to destruction of valves in the thrombophlebitic process. Regarding treatment, they agree that it should be confined to supportive measures when the deep circulation is blocked; but when recanalisation has occurred Turner Warwick (1931), recommends that the superficial circulation should be obliterated in the same way as in varicose ulceration since "the superficial circulation is of no value to a hard pressed deep circulation, but rather an encumbrance".

The venographic evidence so far published has been entirely in favour of the theory that no recanalisation does occur. Thus, Anderson & Patterson (1945), described several cases of post-phlebitic ulceration in which, by venography, they found complete obstruction in the deep circulation. They remark that this series "emphasises the fact that considerable deep thrombosis may persist without evidence of recanalisation after many years". Fine et al. (1942), and Lesser & Danelius (1944), both include in their papers similar descriptions of complete blockage of the deep circulation in cases of leg ulcers. By far the most

important contribution to this subject, however, was that of Bauer, who, in 1942, performed venograms on 45 cases in whom deep thrombophlebitis had occurred from one to twenty years previously. He found that "recanalisation was a rare phenomenon, involving only small sections of the deep system and in no case was there any question of a reconstruction of the deep venous track as a whole". In addition, he observed, in this group, that ulceration of the leg occurred in four fifths of patients between 10 and 20 years after the attack of deep thrombophlebitis, and he wondered in what proportion of leg ulcers similar deep thrombosis existed. Accordingly, he investigated by venography, thirty eight cases diagnosed as varicose ulcer, in whom there was no previous history of deep thrombophlebitis, and found evidence of complete block in the deep circulation in thirty three. He concluded that "varices have almost nothing to do with the formation of ulcers - deep seated thrombosis everything".

On the other hand, evidence has accumulated recently in the American literature that a certain amount of recanalisation does occur. Buxton and his colleagues (1944), Buxton & Coller (1945), and Linton & Hardy (1947), have resected a portion of the femoral vein in cases of chronic ulceration of the leg, and on microscopic examination of the resected specimen have found that recanalisation had occurred in a high proportion of cases. As Homans (1946), has pointed out, however, this is no proof that the deep venous trunks as

a whole have recanalised, or that the deep circulation is patent, and it is interesting to note that Buxton et al. (1944), mention the demonstration, by venography, of a block in the deep circulation, as an indication for femoral resection

Apart from this recent, and rather extreme treatment by femoral resection, the general concensus of opinion appears to be, then, that the treatment of leg ulcers depends on the state of the deep circulation. When this is patent - that is, either normal or completely recanalised - treatment should be directed to complete obliteration of the superficial varices; when it is thrombosed, treatment should be much more conservative.

It is frequently very difficult, on clinical grounds alone, to be certain when the deep circulation is or is not blocked, and it was to try to determine whether or not venography could provide any refinement in diagnosis that this investigation was instituted.

Site of Deep Thrombophlebitis.

Since the time of Virchow, up to the last decade or so, it was generally accepted that the femoro-iliac region was the commonest site of origin of deep thrombophlebitis in the lower extremity, and that thrombosis of the leg veins occurred by retrograde extension from that area. In 1937 however, Roessle dissected out the veins of the legs and thighs of 324 cadavers at post mortem. He found that 88 had thrombosis

of the deep veins of the calf, and that of these, 38 showed concomitant thrombosis of the femoral vein, while in only 7 instances was the femoral vein involved without thrombosis of the veins lying distally. On the basis of these findings, he queried the beliefs held hitherto, and suggested that the lower leg was the commonest site for deep thrombophlebitis, and that the femoro-iliac region was, in the majority of cases, involved by proximal extension of the clot. In 1938, Neumann repeated this investigation in 165 consecutive autopsies, and found no case in which thrombosis was limited to the femoro-iliac region, and similar results have been reported by Frykholm (1940), and Hunter et al. (1941). These pathological findings are in accord with the clinical observation that one of the earliest signs of deep thrombophlebitis is tenderness on pressure over the calf muscles when the foot is dorsi-flexed (Homan's sign).

It would appear, then, that deep thrombophlebitis, especially when the cause is post-operative or idiopathic and not post-partum, when the commonest site of origin may still be the femoro-iliac region, may be confined to the lower leg, and that in any case of leg ulceration the demonstration of the femoral vein alone, in a venogram, could not be held to exclude thrombosis distally. It was for this reason that such emphasis was placed in Part II, on finding a technique which would demonstrate patency of the deep veins from the ankle to the groin.

The Writer's Investigations.

The patients on whom this investigation was carried out were those attending the Varicose Vein Clinic during a period of ten months in 1948, complaining of ulceration of the leg.

The routine of investigation was the same in all instances. The patients were first seen at the Dispensary where cases of ulceration not associated with varicose veins, such as syphilitic and ischaemic ulcers etc., were excluded. The remaining patients were then examined carefully, the state of the deep circulation being evaluated and recorded. They were then referred to the X-ray Department for venography of the deep leg veins.

The clinical criteria on which a diagnosis of deep venous insufficiency was made were those usually accepted, and were based on, (1), the patient's complaint and history, (2), the result of the clinical examination, and (3), the result of clinical tests.

(1). Complaint and History.

The complaint generally regarded as being most significant was a tendency to aching distress in the limb when the patient was in the erect posture, the distress becoming more marked the longer this position was maintained.

A history of previous deep thrombophlebitis was always considered as being of considerable importance, especially

when marked oedema was present. The absence of such a history, however, was not believed to be of the same significance because, firstly, many patients with varices suffer from attacks of superficial phlebitis with which deep phlebitis may be associated, and, secondly, it is generally agreed that deep thrombophlebitis may develop insidiously without confining the patient to bed with an acute illness, so that no history may be obtained.

(2). The Clinical Examination.

On clinical examination the presence of a considerable amount of oedema, extending at least to the mid point between the ankle and the knee, was considered essential before inferring deep venous insufficiency. In association with marked oedema, in these cases, induration and ulceration were always present; very extensive induration, and large or multiple ulcers, were regarded as pointers, no more, towards inadequacy of the deep veins. The presence of extensive oedema, induration, and ulceration, in the absence of incompetent superficial varices, was regarded as indicating the possibility of deep vein involvement.

Varicose ulcers are often described as being supramalleolar in position, while post-phlebitic are stated to be either malleolar or below. In this series, several ulcers, which had developed after classic histories of deep thrombophlebitis, were found to be supramalleolar, and, in general, although the position of the ulcer was taken

into consideration, it was not regarded as being a reliable guide in determining whether or not a previous deep thrombophlebitis had occurred.

(3). The Clinical Tests.

The two clinical tests which are described as being of value in estimating the state of the deep circulation are Perthes test and the Bandage test.

In Perthes test a tourniquet is applied above the knee sufficiently tightly to obliterate the superficial circulation without impeding the return of blood in the deep veins. The patient is then instructed either to walk about or to go up and down on his toes for one minute. If at the end of this time the superficial varices below the tourniquet have emptied, this is taken as an indication that the blood has drained from the superficial to the deep circulations and that therefore the latter is adequate, (negative result); if, on the other hand, the superficial varices remain filled or distend further, (positive result), there are two possibilities. The first is that the deep circulation is blocked and cannot empty the superficial system; the second is that the communicating veins between the two systems are incompetent, and that blood is running from deep to superficial.

To differentiate these two possibilities the Bandage test is performed. The patient's leg is wrapped from the ankle to the groin in a stoakinette bandage, applied

sufficiently tightly to obliterate the superficial circulation without impeding the deep circulation. The patient is then asked to walk about for 15 minutes. If the deep circulation is inadequate, since the superficial is obliterated, cramping pains develop in the leg, (positive result); if the deep circulation is adequate, no disability ensues (negative result).

In theory, these tests are perfect. In practice, the Bandage test is so unsatisfactory as to be valueless.

Ill. 50.

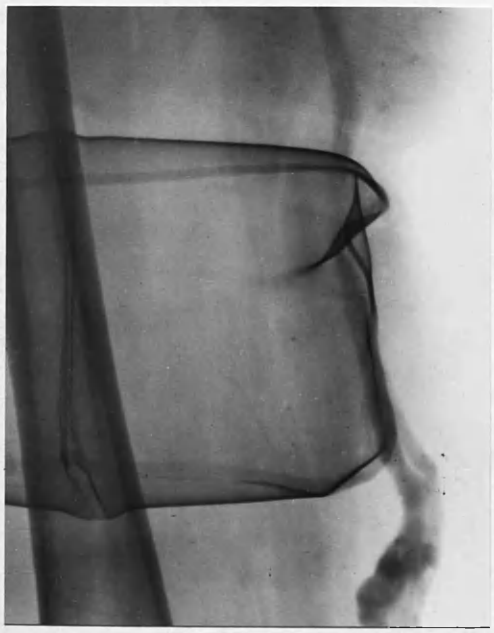
It is very doubtful whether a varicose superficial circulation, with thickened and sclerosed veins can ever be obliterated completely without hindering venous return in the deep circulation. In Ill. 50, (a duplicate of Ill. 55 ; for details see p. 77), dye can be seen ascending in such a superficial circulation without entering the deep, even although in this case, a tourniquet had been applied around the ankle as tightly as possible and, in addition, the entire limb had been firmly bandaged from the ankle to the groin. This is, of course, the equivalent of a rather rigorous application of the Bandage test, and the pressure so exerted had been

insufficient even to force any of the dye into the deep veins, which were patent, far less obliterate the superficial system. This, and several other similar cases, caused me to wonder what pressure was required to obliterate gross superficial varices.

It is well known (Adams, 1939, Mayerson et al. 1943), that with a patient erect, immobile and breathing quietly, the pressure at any point in an incompetent internal saphenous vein corresponds closely to the hydrostatic pressure measured between that point and the level of the left auricle. In a patient of average height, the pressure in such an internal saphenous above the knee would be between 50 and 60 mm. Hg., and as McPheeters et al. (1932) have shown, this pressure is only a little below that in the deep veins. These pressures are, however, intraluminal and do not take into account the resistance to compression of the thickened and sclerosed walls of varicose veins; nor was I able to find any reference in the literature to what pressure would be required to obliterate such varices.

Accordingly, in the screening room, I investigated seven patients, each of whom had extensive varicose degeneration of the internal saphenous, with marked thickening of its walls, in the following manner. With the patient standing behind the fluorescent screen, a sphygmomanometer cuff was placed above the knee and inflated to 150 mm. Hg. Ten ccs. of Pyelosil was then injected into the internal saphenous

Ill. 51.



Ill. 52.

above the cuff, where, since the saphenous was incompetent, and the patient immobile, it remained, Ill. 51. Under the screen, then, the cuff was slowly deflated until the Pyelosil, being heavier than blood ran distally beneath it, indicating that the vein was no longer obliterated, Ill. 52, and this pressure was recorded.

The average pressure recorded in these cases was 75 mm. Hg., the extremes being 70 and 95 mm. Hg.

These pressures appear to be at least as high as, if not higher than venous pressures in the deep circulation, and their importance with regard to the Bandage test can readily be appreciated. Unless the pressure produced by the bandage is high, it will not obliterate the superficial system and a false result will ensue; if it is sufficiently high to do this, it will almost certainly interfere with venous return in the deep circulation, again

with the production of a false result.

These findings probably account for the fact that, among clinicians, the Bandage test has enjoyed little popularity in this country. In the series to be described it was found to be valueless and its use was discontinued after a short time.

Even Perthes test, which is used extensively in this country, is not always entirely satisfactory. A clearly negative result can be regarded as indicating a normal deep circulation, but frequently, owing to the lack of elasticity in the walls of varicose veins, it is difficult to be certain whether or not they have emptied, and the result is equivocal. Further, for the same reasons as with the Bandage test, when the superficial varices in the thigh have markedly thickened walls, false positive results may be obtained, although this is less likely to occur because of the more localised application of the tourniquet.

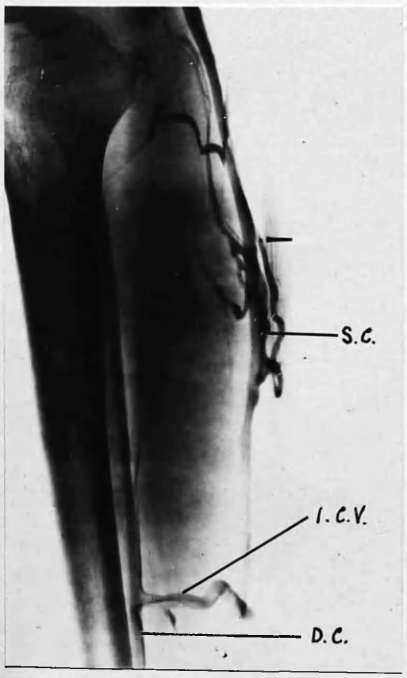
Summary.

These, then, were the clinical criteria. The points on which most reliance was placed in concluding that permanent obliteration of the deep veins could not be excluded in any individual case, were (1), a previous history of deep thrombophlebitis, (2), the presence of marked oedema, associated with induration and ulceration, and (3), a positive result in Perthes test, when the state of the superficial varices in the thigh appeared to preclude the possibility of a false result.

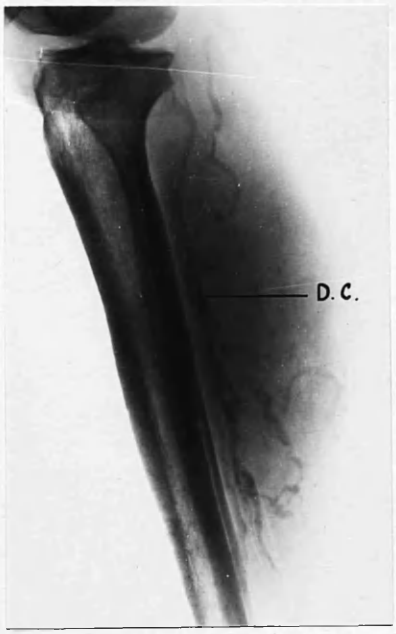
Venographic Technique.

The technique employed initially was the one which had proved most satisfactory in demonstrating the deep circulation in normal cases - injection into any suitable vein in the foot with a tourniquet applied around the ankle and another above the knee. (Technique No. 4, p. 45).

Very soon, however, it became apparent that this method was not satisfactory in abnormal cases. Ill. 53, shows a venogram performed in this way. It will be seen that the dye has entered the deep circulation, but that almost all of it has run out again via an incompetent communicating vein and ascended in the superficial veins. This is the appearance which has been illustrated frequently in the literature as being due to a block in the deep circulation. However, in this case there was no particular clinical evidence of deep thrombosis, and, remembering that the patient was supine during the examination, an alternative explanation appeared to be that the Pyelosil, being heavier than blood, had tipped out of the deep circulation posteriorly via the first suitable incompetent communicating vein. The remedy appeared to be to compress



Ill. 53.

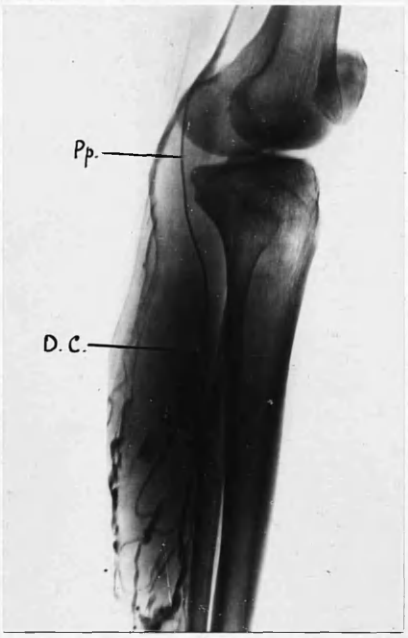


Ill. 54.

Ill. 55

the superficial system sufficiently to prevent this happening, and, accordingly, a crêpe bandage was applied tightly to the limb from the ankle to the groin, the tourniquets were replaced, and the injection was repeated. In Ill. 54, it can be seen that the deep circulation has filled well and that in actual fact no block was present.

Then a further difficulty arose. As will be seen in Ill. 55, despite the crêpe bandage and two tourniquets, only the superficial circulation has filled below the knee. This, I thought, must be due to deep thrombosis. On the other hand, as was pointed out on page 44, even in some normal legs a trickle of dye passed under the tourniquet and ascended in the internal saphenous. In this case the ankle was oedematous and the skin indurated, with ulceration; in addition, the internal saphenous was varicose, with thickened and sclerosed walls, and it was into the distal end of this vein,



Ill. 56.

on the medial side of the foot, that the injection had been made. It appeared to me that if the pressure of a tourniquet was insufficient to obliterate completely the internal saphenous in normal cases, even the combination of a tourniquet and a crêpe bandage might not obliterate it when its walls were inelastic, and the ankle indurated and oedematous. Accordingly, this venogram also was repeated, using the same technique, but injecting into a small nonsclerosed, easily compressible, vein, on the lateral aspect of the foot. As will be seen in Ill. 56, the deep circulation on this occasion filled well and appeared normal.

In my opinion, lack of appreciation of this fact, that a tourniquet about the ankle will not obliterate varices with thickened and sclerosed walls, especially when the ankle is oedematous, accounts to a very large extent for the number of venographic reports in the literature of thrombosis of the deep veins in association with ulcers of the leg.

Summary.

The technique employed, then, in the cases to be described was as follows. The patient lay supine on the cassette tunnel; the limb was elevated to empty the

superficial varices and a crepe bandage was applied firmly from ankle to groin; tourniquets were then placed around the ankle and above the knee, and the opaque medium was injected into any nonsclerosed, easily compressed vein, preferably on the lateral side of the foot. After 10 - 12 ccs. had been injected, films of the lower leg were taken, the tourniquet above the knee removed, and films of the knee and thigh regions exposed as the injection was completed. With a little practice on the part of the radiographers assisting, the injection need not be halted at any point, the time of the whole procedure being between 30 and 40 seconds.

The Clinical Material.

A total of 62 cases was examined using this technique.

The cases have been subdivided, according to whether or not a history of an attack of deep thrombophlebitis could be elicited. In 36 cases no such history was obtained and they have been classified under the heading, 'Varicose Ulceration'; in 26 cases such a history was forthcoming and they have been classified under the heading 'Postphlebitic Ulceration'.

Varicose Ulceration.

Of the 36 cases examined, 25 were females and 11 males.

Taking the group as a whole, the average age was 52 years, the extremes being 30 and 68 years. The length of time the ulcer had been present ranged between 2 weeks and 30 years, the average being 4 years 1 month. In every case

there was surrounding induration. Considerable oedema, extending almost to knee level was evident in 7 instances; in the remaining cases a variable amount of oedema was present, but in the majority it was confined to the ankle region, and was often slight. In 32 cases the superficial veins were varicose and incompetent; in the remaining 4, Trendelenburg's test was negative although there were varices visible below the knee.

As a result of the clinical assessment, 31 of these cases were considered to have a normal deep circulation.

In 5 instances it was considered that thrombosis of the deep circulation could not be excluded, and details of these cases are shown in Table V.

In this table, and in the three others which follow, 'Int. Saph.' implies internal saphenous vein, and 'Ext. Saph.', external saphenous vein. '+' under either of these headings, indicates that the vein was incompetent; '++' indicates that marked varicosities with thickened and sclerosed walls were present. Under the heading 'Perthes Test', '+' implies a positive result, '-' a negative result, and '?' that the result was equivocal. In Tables Vl, Vll, and Vlll, under the heading deep thrombophlebitis, 'P.A.D.' indicates phlegmasia alba dolens and 'Sup. Phleb.', superficial phlebitis with which a deep thrombophlebitis was associated, while the date indicates the year in which the condition occurred.

TABLE. V

Case No.	Sex.	Age.	Durn. ulcer (Years).	Indurn.	Oedema.	Sup. Varices. Int. Saph.	Ext. Saph.	Perthes Test.
1.	M.	47.	4.	+	To knee.	Below knee.	-	+
2.	F.	42.	2½	+	To mid leg.	Below knee.	-	+
3.	F.	61.	7	+	To knee.	Below knee.	-	?
4.	F.	53.	8.	+	To knee.	+	-	+
5.	F.	52.	1½	+	To mid leg.	++	+	?

TABLE V.

As will be seen from Table V, in all cases there was marked oedema, extending almost to the knee, in addition to induration and ulceration. In the first three instances, although varices were visible below the knee, the internal saphenous in the thigh appeared to be normal, Trendelenburg's test being negative. In the fourth case the amount of oedema appeared to be out of all proportion of the degree of varicosity of the superficial system, while in the remaining case, although there was no definite history of deep thrombosis, four attacks of superficial phlebitis had occurred. One of these was associated with gross swelling of the leg and as the history was rather indefinite it was thought possible that the deep circulation might have been involved. Perthes test was positive in three instances and indefinite in two. In no case was the test definitely negative.

Venographic Results in Varicose Ulceration.

In all 36 cases examined, by the technique described, the deep circulation was found to be patent and normal, from the ankle to the groin. The peroneal, popliteal and femoral veins filled in every case and in 27 instances the posterior tibial vein was also visualised.

It would appear therefore, on the basis of this series, that descriptions of thrombosis of the deep veins in association with varicose ulceration, have been due largely to errors in venographic technique.

In view of recent reports, (Boyd & Robertson 1947, and Kinmonth & Robertson 1949), and correspondence in the literature, on the danger of causing deep thrombophlebitis by injections of sclerosing solutions into superficial varices, it is of interest to note that eleven cases in this group had previously been treated in this way. In these cases, as in all the others, the deep circulation appeared normal, and showed none of the changes which frequently occur in the veins after deep thrombophlebitis (as described on p. 88).

The relationship between the venographic finding of a normal deep circulation, and the result of the clinical examination when deep thrombosis could not be excluded, will be considered later (p. 91). In addition, the apparent dilatation of the deep veins of the leg which was observed in two cases of varicose ulceration will also be considered subsequently (p. 98).

Post-phlebitic Ulceration.

In all, 26 cases were examined.

They have been subdivided into three groups, according to the clinical assessment of the deep circulation and the venographic results. Namely,

Group (1). Clinically normal; venographically normal.

Group (2). Clinically thrombosed; venographically normal.

Group (3). Clinically thrombosed; venographically abnormal.

Group (1).

In all, 7 cases fell into this category. The clinical details are as shown in Table Vl.

TABLE. Vl

Case No.	Sex.	Age.	Durn. ulcer (Years).	Indurn.	Oedema.	Deep Thr'phleb. Due to.	Sup. Varices. Int. Saph.	Ext. Saph.	Perthes Tests.
1.	F.	35.	1.	+	Slight.	P.A.D. 1935.	++	-	+
2.	F.	38.	3.	+	Slight.	P.A.D. 1935. 1938.	++	-	?
3.	F.	45.	6/12	+	Ankle.	P.A.D. 1928.	+	+	-
4.	F.	51.	1.	+	Slight.	P.A.D. 1929. 1931. 1938.	++	+	+
5.	F.	53.	4.	+	Ankle.	P.A.D. 1937.	++	-	+
6.	F.	34.	3/12	+	Slight.	P.A.D. 1940.	+	-	?
7.	M.	45.	5.	+	Ankle.	Sup. Phleb. 1933.	+	+	-

TABLE Vl.

It will be seen that the average age was 43 years, and the average duration of ulceration 2 years 1 month. Induration and oedema were present in every case, but the

amount of oedema was slight. In every case, also, the internal saphenous system was incompetent, and in 4 instances the degree of varicosity was marked. In 3 cases where extensive varices were present, Perthes test was positive; in 2 the result was equivocal while in the remaining 2 it was negative. On the average, the length of time which had elapsed since the deep thrombophlebitis was 14 years, while the period between its occurrence and the development of ulceration was 12 years.

Despite the history of deep thrombophlebitis, and a positive result from Perthes test on three occasions, these cases were considered to have a normal deep circulation clinically, mainly because, in the presence of a varicose superficial system which must have been hindering rather than helping venous return from the leg, the amount of oedema was slight.

Group (2).

In all, 8 cases came into this category. The clinical details are as shown in Table Vll.

The average age was 44 years and the average duration of ulceration 3 years. Induration and oedema were present in every case, the amount of oedema being marked. The superficial system was always incompetent and in 5 cases it was markedly varicose. In 4 cases Perthes test was positive, while in 3 the result was equivocal. In no case

TABLE. VII.

Case No	Sex.	Age.	Durn. ulcer (Years).	Indurn.	Oedema.	Deep Thr'phleb. Due to.	Sup. Varices. Int. Saph.	Ext. Saph.	Perthes Test.
1.	F.	28.	1/12	+	To mid leg.	Sup. Phleb. 1944.	+	-	?
2.	F.	48.	3.	+	To knee.	P.A.D. 1937.	++	+	+
3.	F.	49.	2.	+	To knee.	P.A.D. 1934.	++	-	+
4.	M.	40.	1/12	+	To mid leg.	Appendicectomy. 1939.	+	-	?
5.	F.	49.	1 6/12	+	To mid leg.	P.A.D. 1939.	++	+	+
6.	F.	28.	1/12	+	To knee.	P.A.D. 1938.	+	-	?
7.	F.	56.	7.	+	To knee.	P.A.D. 1932.	++	+	+
8.	F.	56.	10.	+	To knee.	P.A.D. 1926.	++	+	?

TABLE. V11.

was the test definitely negative. On the average, the length of time which had elapsed since the deep thrombophlebitis was 12 years, while the period between its occurrence and the development of ulceration was 9 years.

In these cases it was considered that permanent obliteration of the deep circulation could not be excluded since they fulfilled the clinical criteria of a definite history of deep thrombophlebitis, followed by gross oedema associated with induration and ulceration. A positive result from the clinical tests was considered to be further evidence in favour of deep thrombosis, while an equivocal result was not held to exclude it.

Group (3).

In all, 11 cases came into this category. The clinical details are as shown in Table Vlll.

TABLE. Vlll.

Case No.	Sex.	Age.	Durn. Ulcer (Years)	Indurn.	Oedema.	Deep Thr'phleb. Due to.	Sup. Varices. Int. Saph.	Ext. Saph.	Perthes Test.
1.	F.	53.	10.	+	To mid leg.	P.A.D. 1931.	+	-	+
2.	F.	36.	4.	+	To knee.	P.A.D. 1941.	++	-	?
3.	M.	43.	11.	+	To mid. leg.	Sup. Phleb. 1938.	+	+	?
4.	M.	38.	4.	+	To mid. leg.	Sup. Phleb. 1940.	+	-	+
5.	M.	52.	11.	+	To knee.	Typhoid. 1932.	++	+	+
6.	F.	37.	4.	+	To mid. leg.	P.A.D. 1940.	+	+	?
7.	F.	48.	19.	+	To knee.	P.A.D. 1929, 1933.	++	+	+
8.	F.	60.	15.	+	To knee.	Erysipelas. 1930.	++	+	+
9.	F.	64.	32.	+	To knee.	P.A.D. 1913.	++	+	+
10.	M.	54.	12.	+	To knee.	"Septic Leg." 1936.	++	-	?
11.	M.	56.	2.	+	To knee.	Sup. Phleb. 1946.	+	-	+

TABLE Vlll.

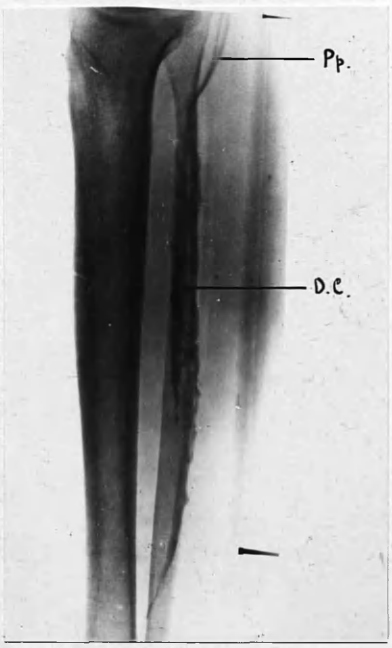
The average age was 49 years and the average duration of ulceration 11 years. As in the other groups induration was present in every case, and the occurrence of oedema almost to knee level was more frequent. The superficial veins were always incompetent, and in 6 cases very marked varicosities were present. In 7 instances Perthes test was positive, while in 4 the result was indefinite; in no case was the test definitely negative. On the average, the length of

time which had elapsed since the deep thrombophlebitis was 15 years, while the period between its occurrence and the development of ulceration was 2½ years.

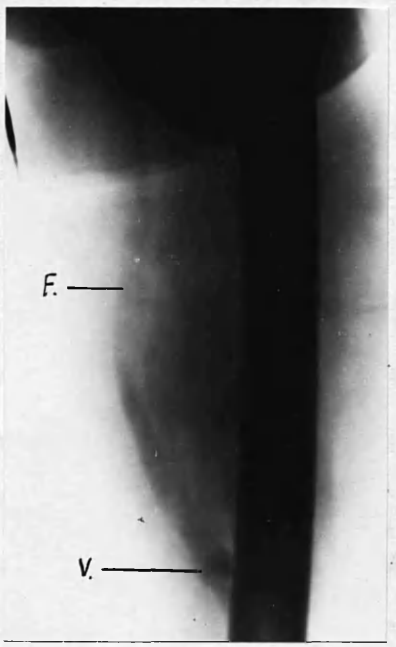
For the same reasons as in Group (2), it was considered that, on clinical grounds, thrombosis of the deep circulation could not be excluded.

Venographic Results in Post-phlebitic Ulceration.

In Groups (1) and (2), a total of 15 out of the 26 cases investigated, the deep circulation was found to be



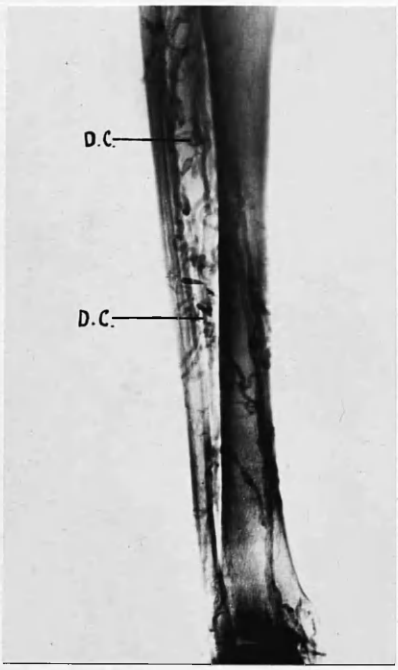
Ill. 57.



Ill. 58.

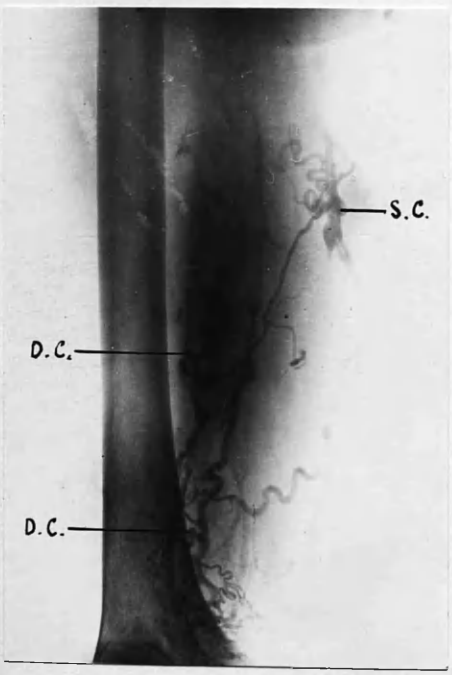
patent and normal from the ankle to the groin. The peroneal, popliteal and femoral veins filled in every instance, and in 10 cases the posterior tibial vein was also seen. In all of these cases valves were visible in the deep veins below the knee, and in several, valves could be identified also in the femoral vein. Ill. 57, and Ill. 58, are of case No. 4,

Table Vl. Although this patient suffered three attacks of phlegmasia alba dolens, no abnormality, demonstrable by venography, can be identified in the deep circulation.

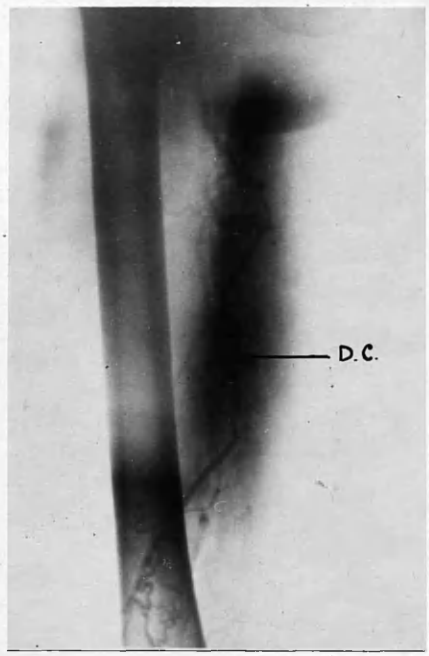


Ill. 59.

In Group (3), the remaining 11 of the 26 cases investigated, the deep circulation was found to be patent in every case, from the ankle to the groin, but was otherwise abnormal. Ill. 59, and Ill. 60, are of Case No. 5, Table Vlll, and they demonstrate the typical appearance seen. A patent deep circulation is present, but the normal deep veins have been replaced by tortuous leashes of blood vessels which show no evidence of valvular formations and are presumably, therefore, incompetent. In addition, in these illustrations, the wide and free anastomosis which has developed between the superficial and deep systems due to incompetent communicating veins, can also be identified. Ill. 61, is of another of these cases (No. 2), showing the replacement of the femoral vein by incompetent



Ill. 60.



Ill. 61.

Ill. 62.

Ill. 63.

Ill.64.

varicose vessels, while Ill. 62, (Case No. 7) demonstrates a similar appearance as shown by a different technique (see p.104).

These appearances were seen in 7 cases. In the remaining 4 cases the deep circulation was again patent in the whole length of the limb, but replacement of the normal deep circulation by leashes of blood vessels was less extensive. Thus, in 3 cases the incompetent deep circulation was confined to the lower leg, the popliteal and femoral veins appearing normal (Ill. 63, Case No. 8), while in the fourth case (Ill. 64, Case No. 9), the process involved primarily the popliteal, and lower part of the femoral, veins. In every case the area of abnormal deep circulation communicated freely with the superficial system by numerous incompetent communicating veins.

Summary.

Summing up the venographic findings, then, it can be said that complete recanalisation of the deep veins occurred in every one of the 26 cases of post-phlebitic ulceration investigated. In no case was a persistent block in the deep circulation demonstrated. In 15 of these cases no abnormality could be identified by venography; in the remaining 11 cases a variable length of the deep circulation had been replaced by tortuous incompetent veins which communicated freely with the superficial system by means of incompetent communicating veins.

Correlation of Clinical and Venographic Findings.

In the light of the venographic demonstration of a patent deep circulation in every case of ulceration investigated, the interpretation of the clinical findings is open to modification.

In Group (3), (Table VIII), venography has demonstrated the deep circulation to be incompetent as well as patent. In addition, free anastomosis has developed, between the superficial and deep systems, and since the dye has run from deep to superficial, these recently formed communicating veins must be incompetent. Now, many authors (Barrow, 1942, Linton, 1938b, Homans, 1939, etc.) have commented on the increase in amount of oedema which occurs when in addition to the superficial veins, the communicating veins are extensively incompetent; Holling et al. (1938), in a series of experiments, calculated that it was at least twice as much as when the superficial system alone was incompetent, and, without going into details of metabolism it is generally agreed that the presence of oedema devitalises the tissues, with resultant induration and finally, ulceration. The patients in this group all suffered from gross oedema and, also, the highest proportion of positive results from Perthes test occurred in these cases. It is, therefore, reasonable to suppose that marked oedema, associated with a positive Perthes test, indicates that the communicating veins of the leg are incompetent and not that the deep

circulation is permanently thrombosed. The fact that, in these cases, the deep circulation was also incompetent would, almost without doubt, increase the flow of blood from deep to superficial via the communicating veins, and so further increase the amount of oedema. This, and the additional fact that the number of incompetent communicating veins visible on the films was much greater when the deep circulation appeared abnormal than in those cases when it appeared normal, probably accounts for the more rapid development of ulceration following thrombophlebitis in this group as compared with the others, two and a half years as compared with ten years.

It would appear, then, that these cases are true examples of post-phlebitic ulceration following damage to the deep circulation, the oedema being produced by incompetence of the superficial, communicating, and deep veins.

In Group (2), (Table Vll), no abnormality could be identified in the deep circulation by venography, nor was there any evidence of the development of new, incompetent, communicating veins. It must be remembered, however, that on the average nine years elapsed from the attack of deep thrombophlebitis before ulceration developed, and that during this period the superficial circulation, which had dilated at the time of the deep thrombophlebitis, was becoming increasingly varicose, with consequent dilatation of the

ostia of those communicating veins which are normally present. The valves in these veins are situated very close to the point of junction with the superficial vein, and as Edwards (1934), has pointed out, a vein need only dilate to one and a half times its original diameter before the cusps of its valves are unable to meet, and consequently it becomes incompetent. Gradually, therefore, with increasing dilatation of the superficial system, the communicating veins become incompetent, with the production of increased oedema, and it is probable that the time which elapses before the communicating veins become incompetent accounts for the relatively long period in these cases between the occurrence of deep thrombophlebitis and the development of ulceration (nine years). The combination, then, of marked oedema and a positive result from Perthes test can again be attributed to extensive incompetence of the communicating veins, and not to permanent thrombosis of the deep circulation, and a similar explanation would account for those cases of varicose ulceration (Table V) in which deep thrombosis could not be entirely excluded clinically. In three of these cases, it will be remembered, the internal saphenous system in the thigh appeared to have competent valves, although varices were present below the knee. Since the deep circulation was demonstrated to be patent and normal by venography, the alternative explanation that the oedema and subsequent induration and ulceration were due

to primary congenital incompetence of the communicating veins, of the type described by Turner Warwick (1931), would appear to be correct.

Those cases in Group (1), (Table VI), which appeared to have a normal deep circulation clinically, despite a definite history of deep thrombophlebitis, can be explained in the same way - namely, that incompetence of the communicating veins had not yet developed, the relatively small amount of oedema present being due solely to stasis in the superficial system.

If this explanation is correct, it would appear that ulceration in Group (2) is produced in exactly the same way as varicose ulceration, by generalised incompetence of the superficial and communicating veins, and that the only connection the previous attack of deep thrombophlebitis has with the ulceration is to have produced the initial dilatation of the superficial system which eventually becomes varicose.

This explanation in these cases, Group (2), hinges entirely, of course, on whether the deep circulation is really normal, or whether it only appears to be so by venography. That it is completely patent there is no doubt, but it would be possible to argue that recanalisation had been good, single veins being re-established instead of leashes of blood vessels, but that the valves had been shrivelled by the deep thrombophlebitis and that, consequently,

the deep circulation was really incompetent. While this possibility can certainly not be excluded, three points can be raised against it. (1). That in Group (1), despite a history of deep thrombophlebitis and a varicose superficial system, there was little oedema indicating that the deep circulation was adequate; and the deep circulation appeared exactly the same on the venograms as in Group (2). (2). That in Group (3), where the deep circulation is demonstrably incompetent ulceration followed, on the average, two and a half years after deep thrombophlebitis, while in Group (2), nine years elapsed. (3). That in the venograms, valves can be demonstrated in every case below the knee and in many cases in the thigh, as in Ill. 58; in addition, in these cases, no newly developed communicating veins such as were visible in Group (3), can be identified.

Possibly in these cases (Groups (1) and (2)), the deep thrombophlebitis involved only a small segment of the vein so that when recanalisation occurred, few if any valves had been destroyed; or, alternatively, the thrombotic process may have been confined to the veins in the pelvis. Either of these explanations would account for the seemingly normal deep circulation visible on venography.

Conclusions Regarding Ulceration.

On the basis of the venographic findings which have been described, it would appear that the deep circulation of the leg is patent, not only in cases of varicose ulceration, but in those other cases in which the ulcer follows an attack of deep thrombophlebitis. The time taken for the deep veins to recanalise in these latter cases, must, of course, be variable, but the shortest period between the occurrence of deep thrombophlebitis and the demonstration of a patent deep circulation by venography, in the series which has been described, was twenty-six months, (Case No. 11, Table V111).

It would appear, therefore, that there is no reason why any patient, suffering from a varicose or post-phlebitic ulcer, should be denied the benefits of radical obliteration of superficial varices, since these incompetent veins are not compensatory, but must be hindering rather than helping an already hard pressed deep circulation.

The venographic results in this series, are, of course, in direct opposition to all those previously published in the literature. However, the actual demonstration of the deep circulation on a film, must be of more value than the inference that it is thrombosed because it is not visible; and, as was indicated under 'Technique', it is not always easy to demonstrate the deep veins in the presence of oedema and ulceration, so that it is possible that errors in

venographic technique played a large part in previous reports.

The finding of a patent deep circulation is in agreement with the recent articles, previously mentioned on page 66, in the American literature. I do not propose to go into the merits and demerits of femoral resection, but one point deserves mention. Linton & Hardy (1947), in discussing the selection of patients for this operation do not take into consideration a history of pre-existing deep thrombophlebitis. The sole criterion on which they base their decision to operate or not, is whether, after elevating the leg to empty the superficial varices, applying a tourniquet just distal to the knee sufficiently tightly to obliterate the superficial system, and then depressing the leg, the superficial veins below the tourniquet fill in a few seconds. When this occurs they consider that both the communicating and deep veins are incompetent, and they remark that "this observation is sufficient evidence to indicate the desirability of interrupting the superficial femoral vein".

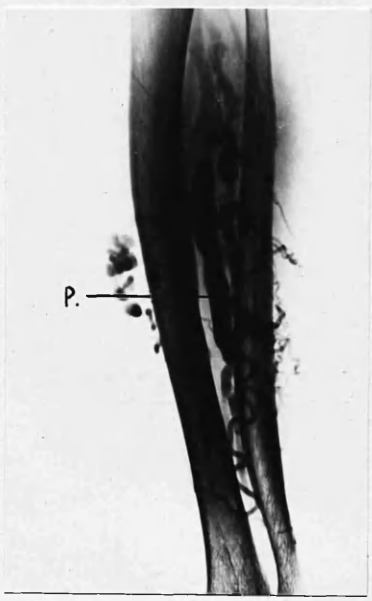
Selection on this basis alone, appears to me to be rather too sweeping. Apart from false positive results through non-obliteration of sclerosed superficial varices by the tourniquet, it must include many cases of varicose ulceration, such as those in Table V, and post-phlebitic ulceration such as those in Table Vll, where the extensive incompetent communicating veins which are present would

produce a positive result with this test, and where the deep circulation is almost certainly normal.

On the other hand, by venography, the state of the deep circulation can be estimated much more accurately, and it is worth considering, if femoral resection is contemplated, whether or not the indication for it should not be the demonstration of replacement of the normal deep circulation by tortuous leashes of blood vessels, in a venogram.

Congenital Incompetence of Deep Veins.

As was mentioned on page 82, in two cases of varicose ulceration some apparent dilatation was observed in the deep veins of the lower leg, as in Ill. 65, and Ill. 66. This appearance was first described by Imler et al. (1944), who considered it to be due to varicosity with resulting incompetence of the deep veins and since then it has been described by other authors, (Anderson & Patterson, 1945, Jenny, 1947, Boyd, 1948). Anderson & Patterson remark that "such deep venous dilatation is a not uncommon finding in association with superficial varices and is, in effect, varicosity of the deep circulation".



Ill. 65.

In a total of sixty-two venograms this appearance of dilatation of the deep veins has been seen on four occasions, the distribution being as follows. Two in those cases of varicose ulceration which were considered to have a normal deep circulation clinically; one in Group (1), post-phlebitic, and one in Group (2), post-phlebitic. Of these four cases, then, only one, the last mentioned, was associated with a sufficient amount of oedema to raise the question of insufficiency of the deep circulation.

Ill. 66.

It would appear, therefore, that widening of the deep veins in a venogram is not common; that it may be within normal radiological limits, and that it should not necessarily be regarded as indicating varicosity of the deep system.

Nevertheless, quite apart from the venographic appearance just described, the possibility of incompetence of the deep circulation due to congenital deficiency of the valves has been mentioned frequently in the literature (Meisen, 1932, Franklin, 1937, Homans, 1939). Homans has suggested that cyanosis of the foot when in the dependent position indicates incompetence of the deep veins, and he goes on to remark that it must be very rare. This condition,

if it occurs, is obviously difficult to diagnose clinically and it occurred to me that possibly venography might be able to assist. Accordingly, in several cases, the femoral vein was injected in a retrograde manner, as will be described below.

Retrograde Venography of Deep Leg Veins.

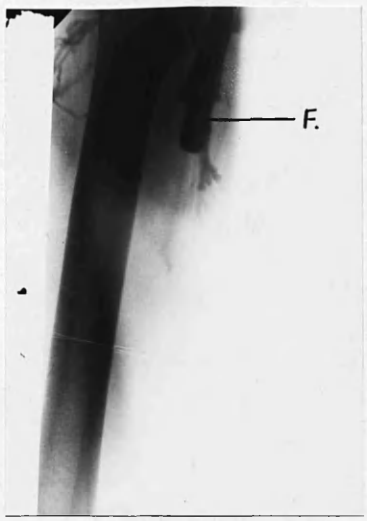
As is well known it is almost impossible to inject the internal saphenous vein ih a retrograde direction when the valves are competent. The solution injected is held up either by the first valve, or at most the second, and if the pressure of injection is raised sufficiently the vein will eventually rupture before the valves give way. On this analogy it appeared that if a retrograde injection of opaque medium was made into the femoral vein, in the normal case with competent valves the dye would be held up at the valves, while in an abnormal case retrograde flow would occur. In this way it might then be possible to determine incompetence of the deep circulation.

Technique.

The technique employed was as follows. The cassette containing the film was placed in position under the patient who lay supine on the table which was tilted, feet down, to an angle of 30^{o} with the horizontal. This was done to ensure that the valves were functioning and the cusps open. An assistant then compressed the femoral vein against the superior ramus of the pubis and 10 ccs. of Pyelosil was injected into the vein, in a retrograde direction, distal to that point.

The Clinical Material.

A total of 23 cases was injected in this way. These cases were all normal, none of them showing any evidence of cyanosis of the foot, or of oedema, induration or ulceration, to suggest an incompetent deep circulation in the leg.

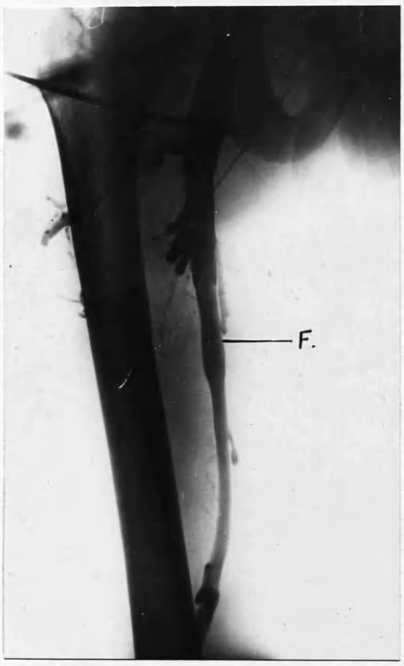


Ill. 67.

In 4 of these cases injection was made by percutaneous puncture. It is not always easy, however, to puncture the femoral vein through the skin, and it is even more difficult to persuade patients to allow it to be done. Consequently, advantage was taken of minor operative procedures in the region of the groin to expose and inject the femoral vein in the remaining 19 cases.

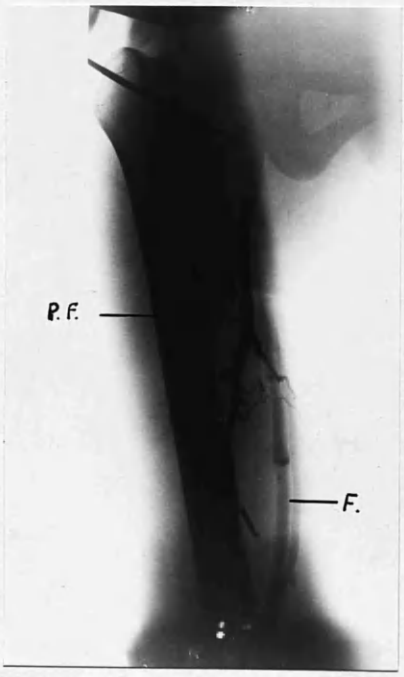
Venographic Results.

The venographic results can be divided into two groups.
Group (1). In these cases, 7 in all, the venographic appearances were as expected, on analogy with the superficial system. The opaque solution appeared to be held up at the first valve, as in Ill. 67, there being little retrograde flow distal to that point. The vein above the valve was distended owing to the pressure of the injection.
Group (2). In the remaining cases, a total of 16, the



Ill. 68.

Ill. 69.



Ill. 70.

venographic appearances were very different. As will be seen in Ill. 68, and Ill. 69, extensive retrograde flow occurred in the femoral vein, and, as in Ill. 70, not only in the femoral vein but in the profunda femoris (marked P. F.), and in many of its branches.

Conclusions Regarding Congenital Incompetence of Deep Veins.

An article has recently been published by Bauer (1948), in which, with an almost exactly similar technique, he described retrograde flow in the femoral vein in 30 cases of varicose ulceration. This retrograde flow he ascribed to valvular incompetence of the deep veins, and he recommended that ligation of the popliteal vein should be performed for this condition.

Now the 23 cases investigated in this series were all normal. None of them showed any evidence of venous insufficiency in the leg and it must be assumed, therefore, that retrograde flow in the femoral vein and its branches, with this technique, does not indicate valvular incompetence and is certainly not an indication for popliteal ligation.

A much more reasonable explanation for the retrograde flow would appear to be, that, in most cases, compression by the assistant of the femoral vein on the pubic ramus does not produce complete obliteration of the vein, so that blood still flows in a proximal direction, and consequently the valves are still opening and closing. The Pyelosil, then, being much heavier than blood, and being aided further by the pressure of the injection, passes distally through the valves during their normal action. Short of putting a ligature around the femoral vein, which is obviously impracticable, it is difficult to see how it can be

obliterated further, and it must therefore be concluded, that retrograde venography of the deep veins is of no value in determining congenital incompetence of the valves in the deep circulation, if such a condition actually does exist.

The method of retrograde injection may, however, be of value in demonstrating the changes which sometimes occur in the femoral vein after deep thrombophlebitis. Ill. 62, is of such a case done by this technique.

CONCLUSIONS. PART III.

(1). The pressure required to obliterate incompetent superficial varices, with thickened walls, is at least as high as, if not higher than, the pressure in the deep veins, and consequently, clinical tests, which rely on obliterating the superficial system without interfering with the flow of blood in the deep veins, are likely to be unreliable.

(2). The venographic techniques which have been used hitherto are not satisfactory in cases of chronic oedema of the lower limb, and errors in venographic technique probably account for previous reports in the literature of permanent thrombosis of the deep veins in association with ulcers of the leg.

(3). The deep veins of the leg were found to be patent from the ankle to the groin in every case of varicose and post-phlebitic ulceration investigated. Consequently, a history of deep thrombophlebitis in the leg should not be regarded as a contra-indication to radical obliteration of superficial varices, since these are not compensatory but must be hindering rather than helping an already embarrassed deep circulation.

(4). If, in cases of post-phlebitic ulceration, resection of the femoral vein is contemplated, it is suggested that one of the main indications for this procedure

should be the demonstration, by venography, of replacement of the normal deep circulation by tortuous leashes of incompetent blood vessels.

(5). The appearance of widening of the deep veins of the leg in a venogram may be within normal radiological limits, and should not necessarily be considered to indicate varicose degeneration of the deep circulation.

(6). Retrograde flow of an opaque medium in the deep veins, after retrograde injection, occurs in normal legs and is a normal finding. It should not be regarded as indicating incompetence of the valves of the deep circulation.

PART IV. THE COMMUNICATING VEINS OF THE LEG. Page.

THE COMMUNICATING VEINS OF THE LEG.

The importance of the communicating veins of the lower limb has been recognised for many years. When the valves of these veins are incompetent, retrograde flow occurs from the deep to superficial systems, and the back pressure so produced has profound effects on the superficial veins. In its mildest form it either produces varicosity of the superficial system, or renders more severe varicosities already present (Warwick, 1931); at its worst, as was pointed out in Part III, it leads to extensive oedema formation with eventual ulceration. In addition, such back pressure produces rapid recanalisation of thrombosed superficial varices, and so frequently nullifies the effect of surgical treatment. Thus, Faxon & Barrow (1938), reviewing the end results in 228 cases after such treatment, found that incompetence of the communicating veins was one of the main causes contributing to the number of recurrences, and they remark that, ".... unless retrograde flow of blood from deep to superficial veins is prevented by surgical ligation of the incompetent venous trunk .... patients with varicose veins tend to have early recurrences". Howard et al. (1931) in a further survey found the constant back pressure from incompetent communicating veins equally important in the production of recanalisation, and similar

results have been reported by other authors (Sherman, 1944, Barrow, 1940, Pratt, 1941). The general concensus of surgical opinion appears to be then, as was indicated as long ago as 1901 by Rémy, that when the communicating veins are incompetent they should be ligated; obliteration of the superficial system, either by ligation or the injection of sclerosing solutions, is not sufficient, as the back pressure from incompetent communicating veins leads to rapid recanalisation and recurrence of superficial varices.

Surprisingly little attention has been paid to the communicating veins of the leg by anatomists, there being little more than a few lines indicating their presence in most of the standard textbooks. In view of the surgical importance of these veins when incompetent, however, several descriptions, based both on anatomical dissections and on the findings at operation, have been given by surgeons, (Turner Warwick, 1931, Meisen, 1932, Linton, 1938b, Sherman, 1944). Thus Warwick, on the basis of anatomical dissections on 28 young subjects, subdivided the communicating veins into two groups; direct, when they pass straight from the superficial channels to the main venae comites as occurs with the internal saphenous system, and indirect, when they pass from the superficial to a muscular vein before joining the deep circulation, as occurs in the upper two-thirds of the external saphenous system. Below the knee, he described five groups of communicating veins at variable levels, in

association with the internal saphenous system and four groups related to the external saphenous system. On the other hand, Linton, on the basis of ten anatomical dissections and fifty operations, classified the communicating veins below the knee into three main groups, medial, anterior and lateral in relation to, respectively, the posterior tibial, anterior tibial and peroneal venae comites, and in each of these groups he described six or seven communicating veins, often paired. He recommended that these veins be ligated through three incisions, extending from the ankle to the knee, on the medial, lateral and anterior aspects of the leg. This, of course, would convert the treatment of communicating veins into a major surgical procedure and it is not surprising that it has been viewed with little favour by other writers.

Some difference of opinion exists regarding the importance of the communicating veins in the thigh. Homans (1939), remarks that "the communicating veins of the thigh are few in number, inconstant, and of little clinical importance". On the other hand Sherman (1944), following up 214 patients three and a half years after high ligation and retrograde injection of a sclerosing solution, ascribed a large proportion of the 46% of unsatisfactory results to recanalisation due to incompetent communicating veins in the thigh, and, on the basis of 137 anatomical dissections and 746 operations, he described three main groups of communicating

veins; namely, those connecting with the genicular plexus immediately above the knee, those in the mid-Hunter canal region and those in the region of the sapheno-femoral junction. He goes on to remark however, that "the location and number of the perforator veins connecting the saphenous system to the deep veins of the thigh vary greatly". Warwick (1931), considered that the most important communicating vein in the thigh arises about the middle of the internal saphenous and ends in a segment below the deep femoral valve.

On reviewing and comparing these careful anatomical and surgical dissections one is struck immediately by the discrepancies between the findings. This can only mean, as most of these authors admit, that considerable variation occurs both in the location and number of the communicating veins in the lower limb. Further, when the superficial system is varicose, other communicating veins hardly discernible in the normal subject may attain considerable size (Warwick, 1931).

To the clinician, then, faced with an individual case, the results of the dissections which have been described are really of little practical value. The communicating veins are inconstant in position and only some, or none of them may be incompetent; unless the technique for the lower leg as described by Linton is followed, and this still leaves any incompetent communicating veins which may be present in the thigh untouched, the clinician is forced to rely on the result of clinical tests to determine whether any incompetent

communicating veins are present, and if so what is their location.

Clinical Tests for Communicating Veins.

The clinical tests commonly employed for these purposes are the Modified Trendelenburg test, the Comparative Tourniquet test and the Two Finger test.

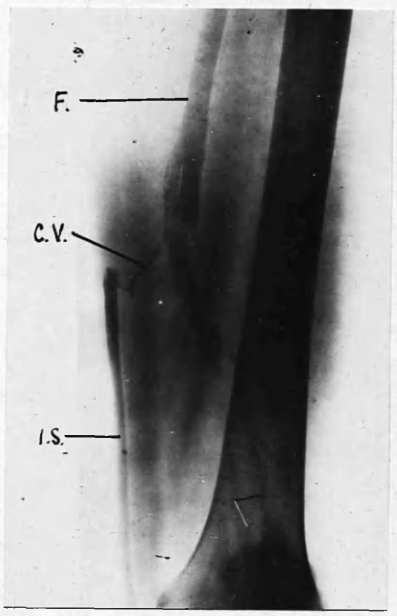
In the modified Trendelenburg test the limb is first elevated to empty the superficial varices; with the patient horizontal, a rubber tourniquet is applied around the thigh immediately below the sapheno-femoral junction sufficiently tightly to obliterate the superficial circulation and so prevent retrograde flow in the internal saphenous. The patient then stands up and the time the superficial varices take to fill is noted. If this time is less than 30 to 40 seconds the communicating veins are considered to be incompetent; if more than 30 to 40 seconds they are considered to be competent.

When this test is positive the rubber tourniquet tests elaborated particularly by Mahorner & Ochsner (1936), are used (the Comparative Tourniquet test). With the patient standing, a rubber tourniquet is applied around the upper third of the thigh sufficiently tightly to obliterate the superficial circulation, and the patient is asked to walk about. This procedure is then repeated with tourniquets around the mid and lower thirds of the thigh and the amount

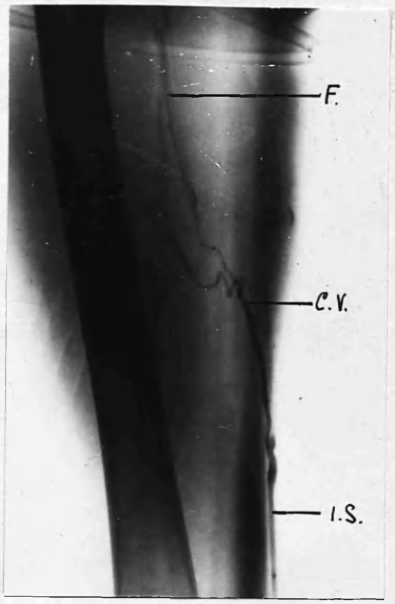
of diminution in prominence of the varicosities below the tourniquet is observed in each case. If the greatest improvement (less prominence) occurs with the tourniquet in the lower third of the thigh, then one or more incompetent communicating veins are present in the thigh, and, by varying the position of the tourniquet, their approximate positions may be established. If no improvement occurs with the tourniquet in the lower third of the thigh there are two possibilities - firstly, that the external saphenous is incompetent at its junction with the popliteal, and that retrograde flow is occurring from the popliteal through the external saphenous and so into the internal saphenous vein; secondly, that the communicating veins below the knee are incompetent. To distinguish between these two, a tourniquet is applied around the knee below the patella sufficiently tightly to obliterate the external saphenous, and the patient is asked to walk about. If marked improvement occurs the communicating veins below the knee are competent; if there is no improvement, they are incompetent.

Beyond this it is not easy to go, but the Two Finger test may be used to try to identify the location of incompetent communicating veins below the knee. With the patient erect a segment of vein is emptied by pushing proximally and distally with the fingers. The patient is then asked to cough. If an incompetent communicating vein is present the gush of blood into the emptied segment may be

observed. The Two Finger test can also be used to assist in identifying the site of incompetent communicating veins in the thigh.



Ill. 71.



Ill. 72.

These, then, are the tests in general clinical use. The main difficulties in association with them are similar to those mentioned with regard to Perthes and the Bandage tests, described in Part III, and can be listed as follows.

(1). The difficulty in obliterating the superficial system without hindering venous return in the deep.

(2). Retrograde flow in the superficial veins despite the tourniquet.

(3). The superficial veins may not be visible or they may have sclerosed walls; in either case, the alteration in their size may have to be estimated by palpation, which is even more unreliable than by sight.

(4). False negative results may be obtained with the rubber tourniquet tests for incompetent communicating veins in the thigh when similar

veins exist below the knee (Mahorner & Ochsner, 1936).

In addition, the type of communicating vein which is present may also influence the result. In a case such as Ill. 71, where the communicating vein concerned is short and horizontally placed, filling of the segment of the superficial vein with the production of a correct result is likely to occur; but in a case such as Ill. 72, where the communicating vein is long and obliquely placed, the tourniquet may well interfere with the flow of bllod in the communicating vein, producing an erroneous result.

It is generally agreed that these tests are frequently unreliable. Both false positive and false negative results may be obtained, and the point at which the communicating veins join the superficial circulation is very often not located accurately.

The Writer's Investigations.

It was to try to determine whether or not venography could provide more accurate information than that provided by the clinical tests, both regarding the location of communicating veins and whether or not incompetence was present, that this investigation was instituted.

The patients on whom this investigation was carried out were among those attending the Varicose Vein Clinic between May, 1947, and April, 1948.

The routine of examination was similar to that described in Part III. The patients were first seen and examined at the clinic, where the clinical tests which have been described for the identification of incompetent communicating veins were carried out and the results recorded. Thereafter, they were referred to the X-ray Department for Venography, and, finally, the clinical and venographic results were compared with the operative findings.

Venographic Technique.

A. Location of Communicating Veins.

Technique No. 1.

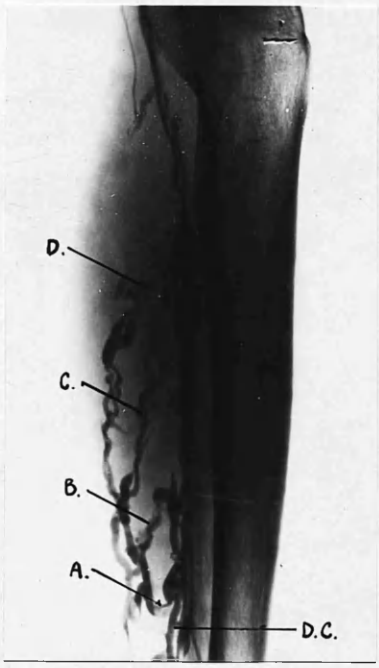
In theory, the ideal method of illustrating communicating veins would be to inject the deep circulation, and observe at what points the dye ran from deep to superficial. This would demonstrate, at the same time, the position of the communicating vein and the fact that it was incompetent.

This method was, accordingly, tried. The patient lay supine on the cassette tunnel and tourniquets were applied around the ankle and above the knee - the first to force dye into the deep circulation, the second to produce obstruction to the deep circulation, and so compel it to run through incompetent communicating veins to the superficial system. Injection was made into any small vein in the foot.

This method was found to be quite unsatisfactory for the following reasons. (1). Since the patient is supine, and Pyelosil is heavier than blood, it is unreasonable to

Ill. 73.

suppose that it can ever fill communicating veins on the medial, lateral, or anterior aspects of the leg. In actual fact, the only incompetent communicating veins ever identified by this method are those which emerge posteriorly from the deep veins so that they fill with dye under the influence of gravity, as in Ill. 73. (2). As was pointed out in Part II, it is not possible to fill all the deep veins of the lower leg; only the peroneal vein can be filled on every occasion. If the deep veins are not adequately filled, incompetent communicating veins associated with them cannot be excluded. (3). As was shown in Part III, when the ankle is oedematous and the superficial veins sclerosed, a proportion of the dye passes under the tourniquet into the superficial system. When this occurs, and communicating veins fill, it is impossible to know whether dye has run from superficial to deep, or vice versa - in



Ill. 74.

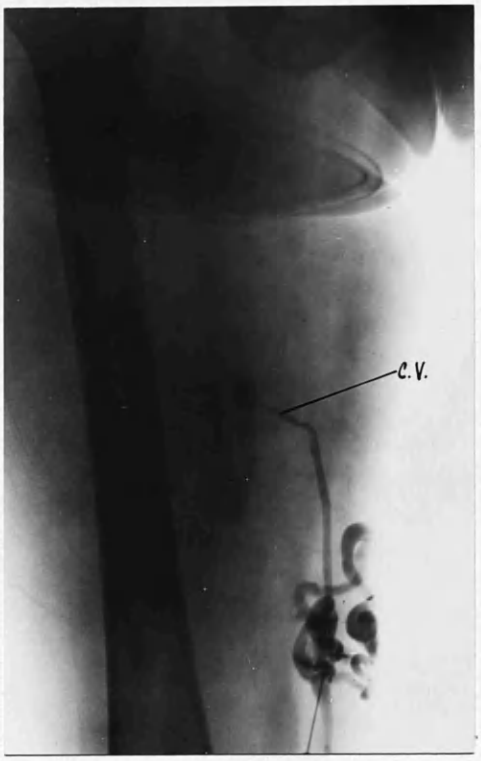
other words whether the communicating veins are competent or incompetent. (4). If the tourniquet is effective, allowing only the deep circulation to fill, and dye runs via an incompetent communicating vein from deep to superficial, as in Ill. 74, A, it will continue to ascend in this circulation. Consequently, any communicating veins demonstrated proximal to the first cannot be identified as being either competent or incompetent (Ill. 74, B,C, D). (5). Owing to dilution with blood, concentration of dye rapidly diminishes so that this method is valueless in the thigh.

Since this procedure of filling the communicating veins from the deep circulation was found not to be practicable, the only other possibility appeared to be by injection into the superficial system.

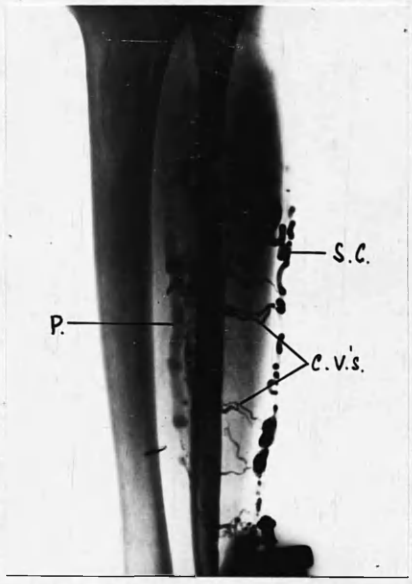
Technique No. 2.

Direct injection into a superficial vein, however, without any other aid will seldom demonstrate communicating veins. In Ill. 75, Pyelosil was injected into the incompetent internal saphenous in the region of the knee, with the patient lying supine on the cassette tunnel, and as will be seen, only the superficial system has filled without any evidence either of a communicating vein or of the deep circulation. If, however, as was done in this case, Ill. 76, a tourniquet is lightly applied around the limb above the level at which the communicating vein is suspected,

Ill.75.



Ill. 76.



Ill. 77.

sufficiently tightly to produce slight hindrance to venous flow in the superficial system, and the injection is repeated, the dye will run to the deep circulation via the communicating vein demonstrating it clearly.

Ill. 77, shows the application of this technique in the demohstration of communicating veins below the knee.

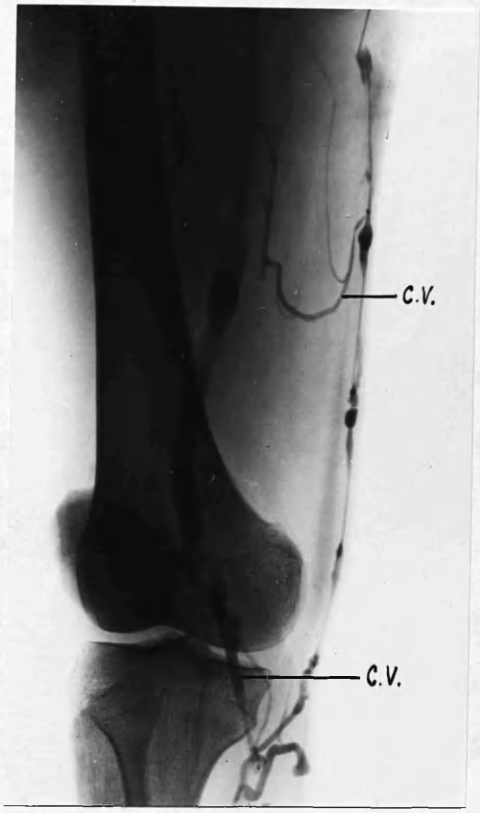
Ill. 78.

Although this method of demonstrating the position of communicating veins is satisfactory in the majority of cases, it has a limitation. As shown in Ill. 78, all the dye may run from the superficial to the deep circulation via a communicating vein leaving the superficial circulation above that point empty of dye. When this occurs the injection has to be repeated, proximal to the last communicating vein shown, to exclude further communicating veins in the area above, and if this occurs more than once in the same patient, as sometimes happens, it can become rather tedious.

Technique No. 3.

Accordingly, a third method was tried. As before, the patient lay supine but this time injection was made into the superficial circulation in a retrograde direction. The superficial veins being incompetent, the opaque medium, under the pressure of injection runs distally very easily; at the same time, the slow proximal current which occurs in varices tends to force the dye into the communicating veins which,

Ill. 79.



Ill. 80.

Ill. 81.

by this technique are delineated beautifully. Ill. 79, is of the same patient as Ill. 78. The same communicating vein can be identified, and in addition it can be seen that no other communicating vein exists proximal to it.

With this technique a single injection into the proximal part of the internal saphenous will demonstrate the communicating veins in the whole of the

thigh and often in the upper part of the leg also, as in Ill. 80.

With regard to the lower leg, retrograde injection into the internal saphenous at the level of the knee will show clearly those communicating veins in the medial side of the leg, as in Ill. 81. Since the upper end of the external saphenous lies deep in the tissues and cannot be injected in this way, communicating veins associated with it are most easily demonstrated by Technique No. 2, as in Ill. 77.

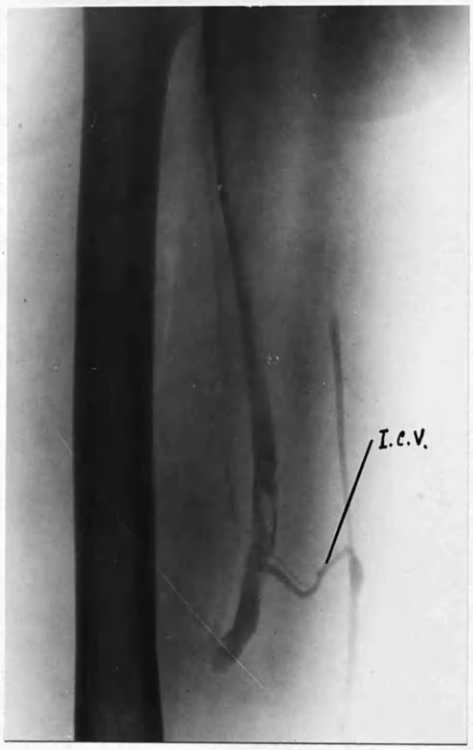
There is only one difficulty associated with this technique of retrograde injection, and it is that, in the very obese, it may be difficult to inject the internal saphenous high up in the thigh. In these cases, Technique No. 2, has to be used.

By combining Techniques No. 2 and No. 3, then, the position of communicating veins in any part of the leg can be identified with the greatest accuracy.

B. Competence of Communicating Veins.

The techniques which have been described, however, would lose much of their value if it were not possible to give an opinion as to whether the communicating veins demonstrated were competent or incompetent. Fortunately, this can be done in the great majority of cases.

When a communicating vein is incompetent blood spurts through it into the superficial system with every muscular

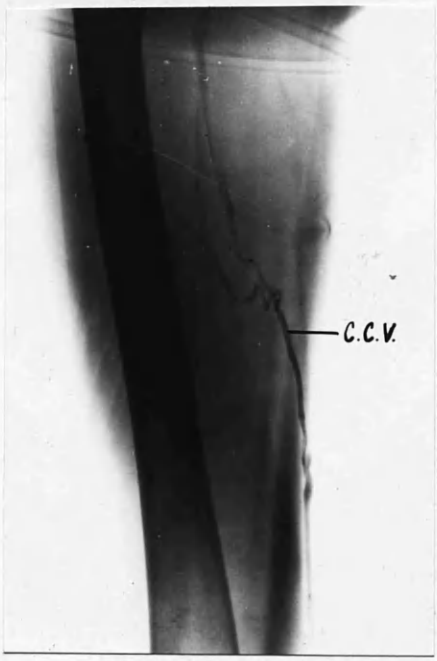


Ill. 82.

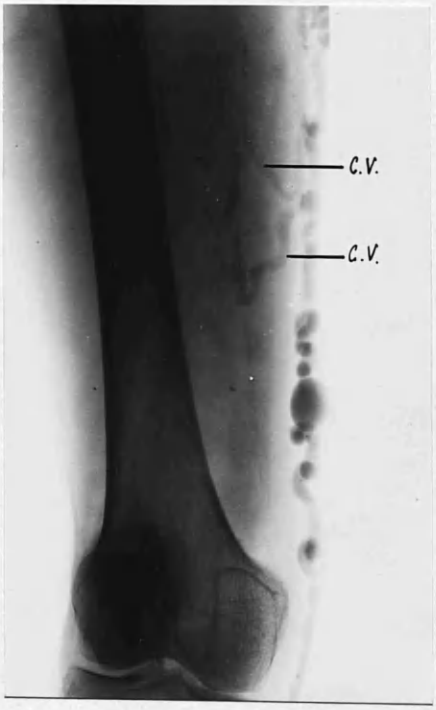
Ill. 83.

Ill. 84.

contraction of the limb, with the result that localised dilatation develops in the superficial vein at its junction with the communicating vein. On the other hand, if the latter is competent, no such dilatation occurs. These localised fusiform dilatations of the superficial veins, at their junction with communicating veins, can be identified quite easily



Ill. 85.



Ill. 86.

in venograms, and serve to differentiate those communicating veins which are incompetent from those which are competent.

At operation, the usual surgical method of determining competency of communicating veins was used (Warwick, 1931). The veins were considered to be incompetent or competent according to whether or not continuous bleeding occurred from them after they had been sectioned at the point of junction with the associated superficial vein. The following illustrations are all of cases confirmed at operation.

Ill. 82, 83 and 84 (also Ill. 76 and 78, also confirmed at operation), demonstrate the localised dilatation of the superficial system which occurs, indicating that the associated communicating vein is incompetent (marked I.C.V.), while Ill. 85, (a duplicate of Ill. 72) shows no

dilatation implying that the communicating vein is competent, (marked C.C.V.).

When there is extensive varicosity of the superficial circulation both at the point of junction with the communicating vein and above and below it, as in Ill. 86, localised dilatation cannot, of course, be identified. But in this series, in the thigh, all such communicating veins have been found to be incompetent at operation, and they should be so regarded until proved otherwise.

Summary of Technique.

The technique employed in these cases was, then, as follows. The patient lay supine on the cassette tunnel. Antero-posterior films were taken by the overhead tube of the couch on which the patient was lying, lateral films by a portable set.

For communicating veins in the thigh, 20 ccs. of Pyelosil was injected into the proximal part of the internal saphenous in a retrograde direction, during the last 5 ccs. of the injection two films, an antero-posterior and a lateral, being taken of the area. In those cases in which the internal saphenous could not be injected in the upper third of the thigh a similar amount of Pyelosil was injected in a proximal direction into the internal saphenous at knee level, a tourniquet having previously been lightly applied around the upper third of the thigh.

For communicating veins on the medial side of the lower leg, 10 to 15 ccs. of Pyelosil was injected in a retrograde direction into the internal saphenous in the region of the knee, antero-posterior and lateral films being taken as the injection was completed. Communicating veins on the lateral side of the lower leg were demonstrated by proximal injection of 10 ccs. of Pyelosil into the external saphenous above the ankle, with a tourniquet lightly applied around the knee immediately below the patella.

Incompetency of the communicating veins was diagnosed as has been described.

The Clinical Material.

Patients in whom there had been a previous attack of deep thrombophlebitis were excluded from this series, but otherwise there was no selection of patients, apart from the obvious essential that the degree of varicosity of the superficial veins was sufficient to require treatment.

A total of 75 cases was investigated.

Of these, 40 were examined for communicating veins in the thigh (Section I), and 35 for communicating veins in the leg below the knee (Section II), and they have been subdivided accordingly.

SECTION I. Communicating Veins in Thigh.

Venographic Findings.

In the 40 cases investigated, 51 communicating veins were identified. The number in each individual case varied between 1 and 4, the average being 1.4. These numbers correspond fairly closely with the results of anatomical dissections - Sherman (1944) on the basis of 101 such dissections, found the average number to be 1.9 the extremes being 1 and 6. The distribution of the communicating veins according to position was as follows; 7 in the upper third of the thigh, 24 in the middle third and 20 in the lower third.

Both competent and incompetent communicating veins were identified in the same patient, but of the total of 51 such veins seen, 37 were considered to be incompetent. These were distributed among 33 patients there being one in 29 patients and two in the remaing 4. The communicating veins considered competent numbered 14.

Comparison of Venographic and Operative Findings.

The method used at operation in determining whether or not a communicating vein was incompetent has already been described, on page 124.

24 of the 37 communicating veins considered to be incompetent were operated on. In each instance a communicating vein was identified in the position indicated

in the films and the operative findings regarding competency were as follows; in 21 instances the communicating vein was considered to be incompetent; in 1 it was considered to be competent, while in the remaining 2 the competency was doubtful.

5 of the 14 communicating veins considered to be competent were also operated on, mainly because they occurred in patients who had also an incompetent communicating vein which was being ligated, and it was little trouble, at the same time, to ligate the competent communicating vein. In these cases also, a vein was found at exactly the site indicated venographically, and in all 5 it was considered to be competent.

Summing up, then, of the 29 cases operated on, a vein was found on each occasion at the site indicated by venography. In 26 of these the venographic opinion regarding competency was correct, in one it was wrong, while in 2 the result was doubtful.

In addition, 3 further cases underwent operation. These were cases in which no communicating vein could be demonstrated by venography, but in which one appeared to be present clinically. In none of these cases was a communicating vein found at operation.

Comparison of Venographic and Clinical Findings.

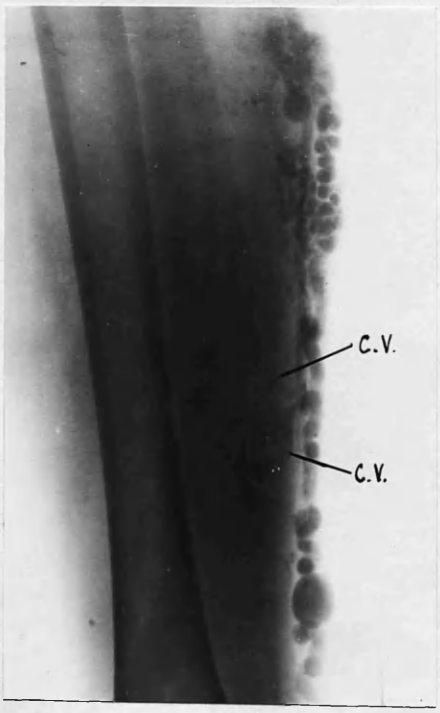
Of the 24 communicating veins considered incompetent venographically and operated on, 13 were identified clinically as being incompetent.

Of the remaining 13 communicating veins considered incompetent venographically, but without operative confirmation, 8 were identified clinically.

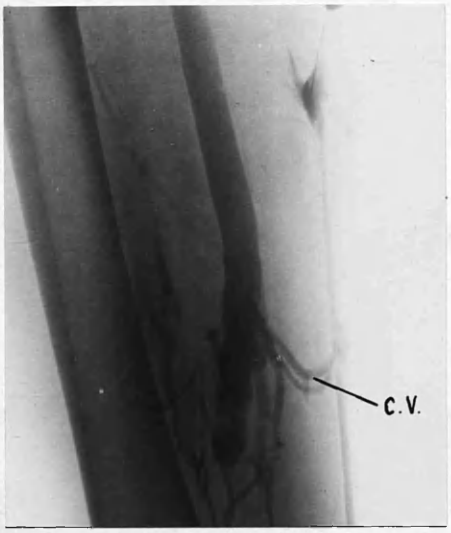
In 5 instances incompetent communicating veins were diagnosed clinically, while none could be identified by venography. Three of these cases were operated on, but no communicating vein was found.

Conclusions. Section I.

Although these figures indicate clearly, as does appear to be correct, that venography is a much more accurate method of identifying communicating veins in the thigh than clinical tests, they do less than justice to the venographic method of examination. For example, in a case such as Ill. 87, where there is very extensive varicosity of the superficial system, although the clinical tests indicated an incompetent communicating vein



Ill. 87.



Ill. 88.

Ill. 89.

they provided little information as to its exact situation. Few surgeons would care routinely to undertake the rather extensive dissection required among these masses of veins, and if they did, they would no doubt, be quite satisfied when they had ligated the first large incompetent communicating vein found. On the other hand, by venography, the position of the incompetent communicating veins was localised accurately before operation, and this, combined with the knowledge that two were present, made the dissection much more straightforward and less time consuming. Even in a much less complicated case, such as Ill. 88, the clinical tests did not locate the communicating vein any more clearly than the middle third of the thigh, whereas by venography, its position was identified accurately before operation. Again, as in Ill. 89 (confirmed at operation) an incompetent communicating vein may divide

into two branches before joining the internal saphenous. This cannot possibly be identified by clinical methods alone, and consequently only one branch may be ligated at operation.

SECTION II. Communicating Veins Below the Knee.

A total of 35 cases was investigated.

As was mentioned previously, page 109, Warwick (1931) has classified the communicating veins of the lower leg into two groups - direct, in association with the internal saphenous, when they pass straight from the superficial to the deep circulation, in the corresponding part of the leg, and indirect, as in the upper part of the external saphenous, when the communication is via a muscular vein to the popliteal. In the 35 cases investigated in this group, it was found that all the communicating veins demonstrated in the upper half of the leg below the knee were of the indirect type, both in association with the internal as well as with the external saphenous, as in Ill. 90 and Ill. 91. These communicating veins appear really to be muscular branches draining into the popliteal and communicating with

Ill. 90.

Ill. 91.

Ill. 92.

the superficial system. They can be identified quite easily as slender trunks, in venograms in normal legs, as in Ill. 92, where one can be seen running from the superficial system through the muscles of the calf to the popliteal vein. When the superficial veins are varicose, however, a considerable increase occurs both in the size and number of these communicating branches. Whether superficial varices produce enlargement and incompetence of the communicating veins, or vice versa, is a matter for individual opinion. At any rate, these indirect communicating veins are much larger and more numerous, and appear to be in every way more important, than those small paired communicating veins which

are normally present. They communicate from the popliteal vein with the superficial system as far distally as the lower borders of the bellies of the gastrocnemius muscle.

The importance of this observation is at once apparent. When, in the rubber tourniquet tests, the tourniquet is applied below the patella, this is done to distinguish between, firstly, incompetence of the direct communicating veins connecting the superficial systems with the posterior tibial and peroneal veins, and, secondly, reflux from the popliteal into the external saphenous and thence to the internal saphenous. Compression by the tourniquet producing a negative result - that is, diminution in size of the varices below the tourniquet - is then taken to indicate the second possibility; whereas, in actual fact, the compression of the tourniquet has also prevented reflux from the popliteal via those indirect communicating veins to the internal saphenous system. The standard treatment, heretofore, after a negative result with this test, has been ligation of the external saphenous vein, since this was considered to be the site of the reflux; while reflux from the popliteal to the internal saphenous has not been dealt with since it has not been appreciated that it occurred. It is not surprising, therefore, that recanalisation after treatment occurs with such frequency in the internal saphenous vein on the medial aspect of the leg.

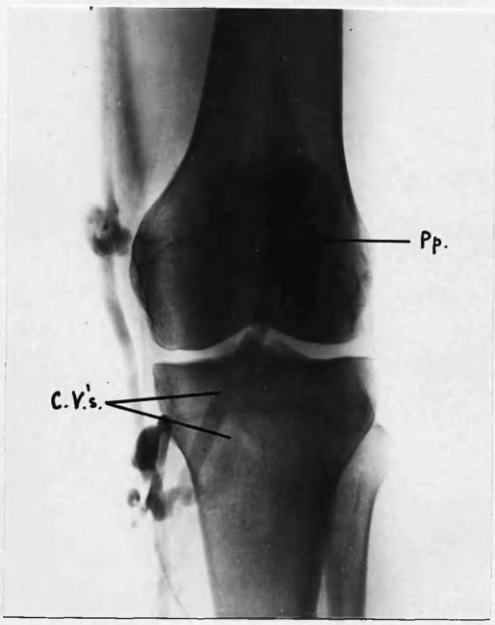
The fact that a channel is available - via these indirect

communicating veins - between the popliteal and the internal saphenous, may also account for the oft-reiterated statement that reflux of blood occurs from the external to the internal saphenous systems, although it is only very rarely, clinically, that any such communication can be identified.

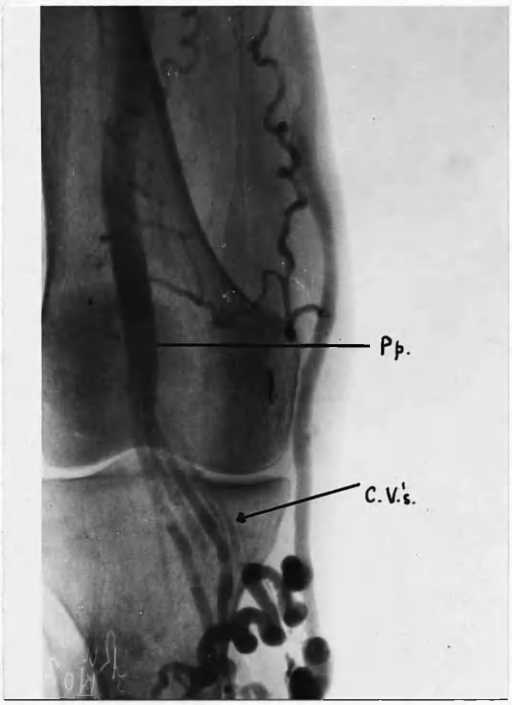
In view of the fact that, as has been explained, the tourniquet test in these cases provides an erroneous result, and since it is generally agreed that it is very difficult to identify the position of incompetent communicating veins in the lower leg by the Two Finger test alone, the venographic results will be compared only with the operative findings and not with the results of the clinical tests.

Venographic Findings.

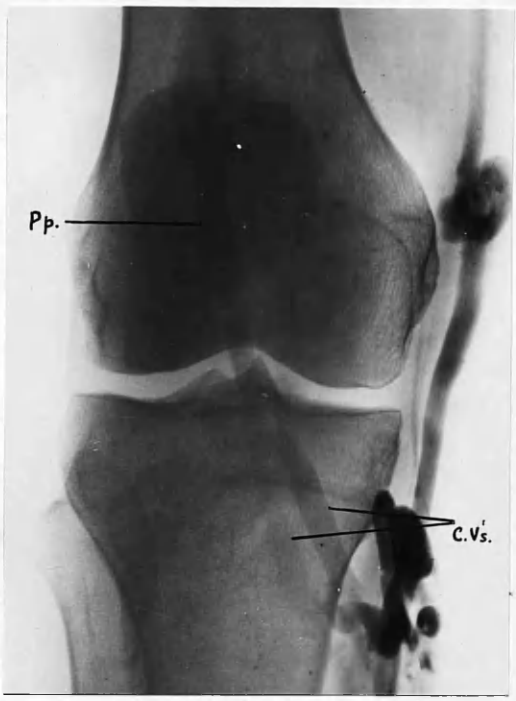
Indirect communicating veins of this type were demonstrated in every one of the 35 cases, by venography. The number, in each individual case, varied from one or two, as in Ill. 93, up to leashes of blood vessels, six or seven in number, as in Ill. 94, usually quite close together. In position, they extended between two finger's breadths, as in



Ill. 93.



Ill. 94.



Ill. 95.

Ill. 96.

Ill. 95, and eight finger's breadths, as in Ill. 96, below the level of the knee joint. All of these communicating veins joined the popliteal vein, as is shown in the illustrations.

In every case, the superficial veins in the leg below the knee were varicose, and, consequently, it was considered that the

associated communicating veins were also incompetent, although the localised fusiform dilatation which is so characteristic in the thigh, could not always be identified.

Comparison of Venographic and Operative Findings.

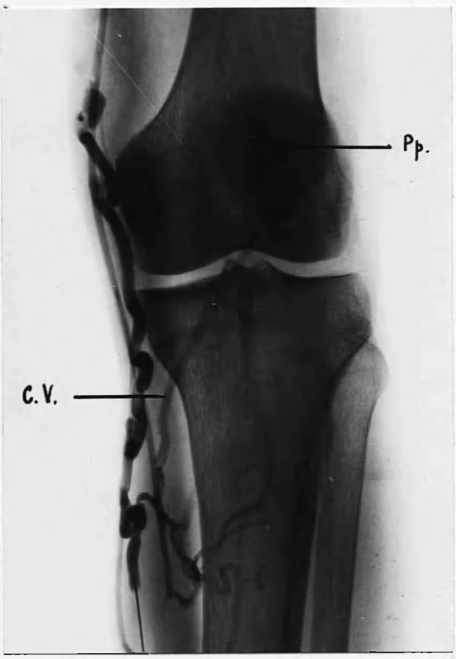
Of the 35 cases investigated venographically, 23 underwent operation for ligation of the communicating veins.

In every case veins were found in the position indicated by venography. Where only one or two communicating veins were present, the number could be checked at operation, and the venographic and operative findings agreed closely; where leashes of blood vessels occurred, there often appeared to be more at operation than were visible on the venogram, although, as indicated on the films, they usually entered the superficial veins in fairly close proximity to each other. In these cases the varicose superficial loop was usually exsected, the communicatihg veins being tied off in groups.

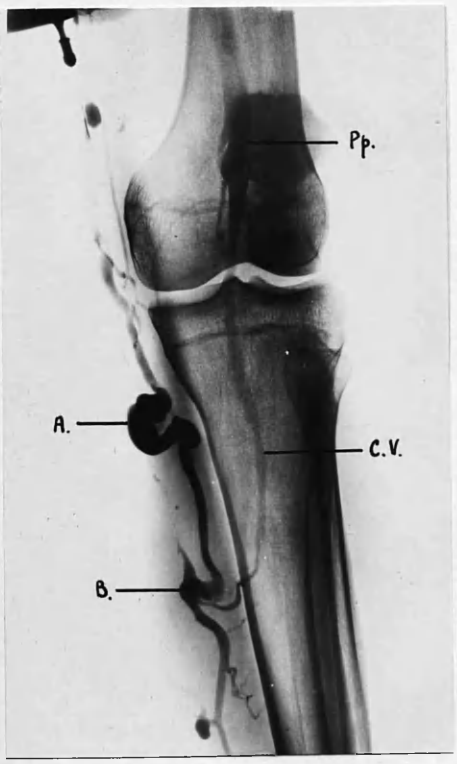
It will be remembered that all cases were considered to be incompetent venographically. The operative findings indicated that in 19 cases the communicating veins were incompetent, while in 4 they were considered to be competent.

Conclusions. Section II.

It would appear then, that venography is as accurate in locating the position of communicating veins below the knee as it is in the thigh, but that it is not quite so accurate in determining whether or not the veins are competent.



Ill. 97.



Ill. 98.

The illustrations in this section so far, have all been of communicating veins which were found to be incompetent at operation. Ill. 97, however, is of one of the cases in which, at operation, the communicating vein was considered to be competent. If this is compared with Ill. 90, a proved incompetent, it will be seen that it is almost impossible to distinguish between the two regarding competency of the communicating veins. It must be concluded, therefore, that in certain instances it is not possible to say, with any accuracy, whether or not a communicating vein below the knee is or is not competent.

On the other hand, where localised fusiform dilatation of the superficial system can be identified at its point of junction with the communicating vein, as in Ill. 98, and in several of the other

illustrations (93, 95, 96 and 84), it is possible to be quite certain that the associated communicating vein is incompetent. Ill. 98, is of a case in which both varicose loops on the internal saphenous (marked A & B) were exposed at operation. As indicated in the venogram, no communicating vein was found at A, while a large incompetent communicating vein was present at B.

CONCLUSIONS. PART IV.

(1). Using the techniques which have been described, in venography a method is available of localising the position of the communicating veins in the leg with the greatest accuracy.

(2). Judged from the operative findings, venography provides a very accurate method of determining the competency of communicating veins im the thigh, and a reasonably accurate method of determining the competency of communicating veins in the lower leg.

(3). Writers on this subject are almost unanimously of the opinion that, to minimise recurrences after surgical treatment, incompetent communicating veins should be ligated at their point of junction with the superficial system. The difficulty, heretofore, has been to identify accurately the position of those communicating veins which were incompetent. By the use of venography, long incisions and tedious dissections may be avoided, surgical treatment made more effective, and the incidence of recurrences due to incompetent communicating veins very much reduced.

PART V. RECURRENCE OF VARICOSE VEINS AFTER TREATMENT. Page.

RECURRENCE OF VARICOSE VEINS AFTER TREATMENT.

In considering recurrences of varicose veins after treatment, it is as well to remember that statistics in this field lose much of their value, since writers frequently do not make it clear either whether recanalisation has occurred in the veins previously treated, or whether recurrence is due to enlargement of fresh varices or to enlargement of varices which previously had been considered too small to merit attention. In addition, variations in the surgical technique employed serve further to emphasize descrepancies in the final figures of recurrences, which vary between 35% (Fergusson, 1935) and 7% (Lowenburg, 1937).

Moore and Knapp (1942), however, reviewing different operative procedures on the basis of 121 cases, concluded that the best results were among those in which high ligation had been performed, and this operation is now generally regarded as being the treatment of choice when the internal saphenous is incompetent. Without going into details of operative surgery, the operation comprises double ligation with excision, of a segment of the internal saphenous vein at the sapheno-femoral junction, with double ligation and excision of those branches of the saphenous which are normally present in this area, namely, the superficial circumflex iliac

vein, the superficial external pudendal vein, the superficial epigastric vein and the internal and external superficial femoral veins.

With regard to recurrences after this procedure, Stalker & Heyerdale (1940) and Glasser (1943), have given detailed descriptions of the very considerable anatomical variations which occur frequently in the veins in this region, and these authors, although they quote no figures, are of the opinion that recurrences after high ligation are very largely due to errors in surgical technique, the most common being failure to ligate the internal and external superficial femoral veins. Glasser remarks that "Lack of knowledge of anatomy (at the fossa ovalis) is probably the greatest single cause of poor results", and Dickson Wright (1940b) and Edwards (1934), have also emphasized the importance of careful surgery in this region, in the prevention of recurrences. Faxon & Barrow (1938), however, following up 365 high ligations, on the average 2.9 years after operation, consider that of the 75 cases regarded as failures, 35 were due to recanalisation of the superficial veins by incompetent communicating branches, and Sherman (1944) and Lesser & Danelius (1944), both regard incompetent communicating veins in the thigh as being a most important cause of recurrence.

It would appear then, that, on the basis of these authors findings, the presence of varicose veins in the

thigh and leg after the operation of high ligation may be due to any one of the following causes.

(1). Failure to ligate the internal saphenous, some other vein, usually the internal or external superficial femoral, having been ligated instead.

(2). Failure to ligate the internal saphenous, with, in addition, an incompetent communicating vein in the thigh.

(3). An incompetent communicating vein in the thigh alone, the internal saphenous having been ligated correctly.

(4). Faulty ligation of the internal saphenous; by this it is meant that, although the saphenous has been ligated, an error in technique has occurred - ligation at too low a level, failure to tie off all the branches etc. - so that recanalisation has occurred.

(5). Faulty ligation of the internal saphenous and, in addition, an incompetent communicating vein in the thigh.

It can, of course, be objected that the first two causes mentioned are not really recurrences since the initial treatment was a complete failure; but to the clinician, seeing such a case for the first time, the patient presents with patent incompetent varicose veins, the history of an operation, and a scar in the groin. Not until an accurate diagnosis has been made can any individual case be classified accurately, and as the venographic investigations to be described, like those in previous sections,

are entirely concerned with diagnosis, and not with comparisons of, or errors in, surgical techniques, the five causes listed can be considered to cover all possible means of 'recurrence' in patients in whom varices are present in the thigh as well as in the lower leg after surgical operations in the groin.

The venographic investigations which follow were carried out to try to determine whether or not venography could be of assistance to the clinician in evaluating these cases more accurately.

The Writer's Investigations.

The patients on whom this investigation was carried out were among those attending the Varicose Vein Clinic between August, 1947, and December, 1948, complaining of the reappearance of varicose veins after treatment. The routine of examination was similar to that described in previous sections. The patients were first seen at the clinic, where they were examined and the findings recorded; thereafter they were referred to the X-ray Department for venography.

The Clinical Material.

The following types of case were excluded from this series. (1). Those in whom there was no evidence of recurrence in the thigh, the recanalised veins being confined to the region distal to the knee. (2). Those cases which

had been treated only by injections of sclerosing solutions. Howard et al. (1931) found a 98% recurrence rate in such patients and it is now a matter of general agreement that incompetent veins thrombosed by this method do recanalise, and that surgical intervention is required. (3). Those cases in which any surgical operation other than high ligation has been performed. Again, there is general agreement (Edwards, 1934, Wright, 1940b,), that ligations of the internal saphenous distal to the sapheno-femoral junction, are followed by the development of a collateral anastomosis which rapidly leads to recanalisation, and that, consequently, the treatment of these cases is by adequate high ligation. Since the diagnosis can be made easily by observing the position of the operation scar, and the treatment is standardised, obviously no advantage was to be gained by subjecting this type of case to venography.

The patients included in this series, then, were those giving a history of having had an operation for varicose veins and in whom, on examination, firstly, an operation scar was found in the groin in the region of the fossa ovalis, and, secondly, extensive varices were present both in the thigh and below the knee.

A total of 33 such patients was investigated.

The average age of these patients was 40 years, the

extremes being 23 years and 59 years. If those cases are excluded in whom it was found that the varices now present were due to the fact that at the original operation the internal saphenous had not been ligated, the average time between the previous operation and the patient reporting for further treatment was 3 years 7 months, the extremes being 3 months and 5 years 8 months. These figures, of course, do not represent a true index of the time taken for the veins to recanalise as many of the patients had patent veins for a considerable period before coming again for treatment. In nine instances the patients had attended clinics for injections of sclerosing solutions after the original operation. The degree of varicosity in these patients was just as marked as in those in whom no such treatment had been given. As many of these patients had received their initial treatment at other Hospitals throughout the country, records were not available, and so it was not possible to determine the incidence of retrograde injection of sclerosing solutions at operation.

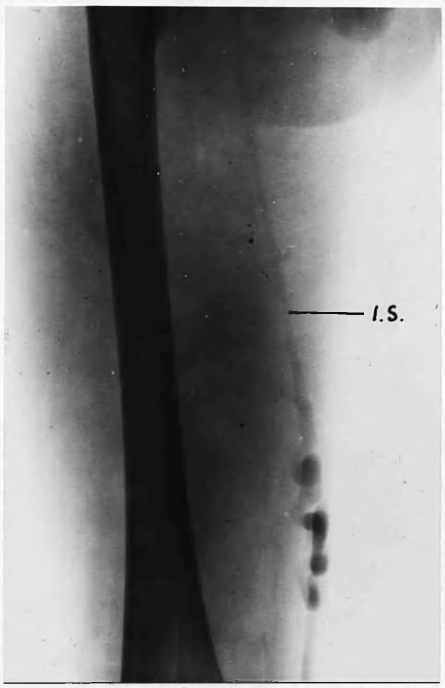
Clinical Examination.

In cases of this type, obviously the clinical examination has to be adapted to meet the needs of each individual case, and it is not therefore practicable to go into details. But in general, after taking the history and verifying that incompetent veins were present in the thigh

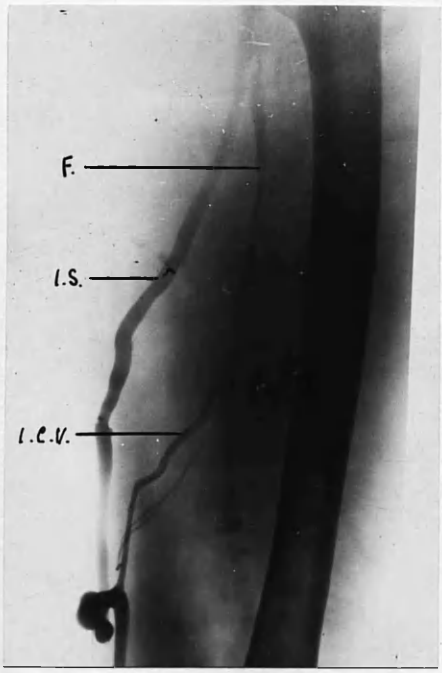
and lower leg, the examination was directed towards the following points. (1). The position of the operation scar in the groin. If this was situated either too low, or too far medially or laterally, the possibility either of non-ligation, or faulty ligation, of the internal saphenous vein was considered. (2). Palpation of the internal saphenous in the groin. When this can be done, of course, recurrence must almost certainly have developed from this region. When the patient is fat, however, or when the veins are small and deeply embedded in the tissues, or when there are large numbers of varices present, it may be difficult to identify the upper end of the internal saphenous, especially when there is a scar in the area. (3). The presence of varicose medial and lateral superficial femoral veins. When these are present and can be identified as such by being traced up to the fossa ovalis, it is almost certain that recurrence has developed from this region. (4). Incompetent communicating veins in the thigh. The methods used in identifying these have already been described fully in Part IV.

Venographic Technique.

As described in the other Parts, the patient lay supine on the cassette tunnel, antero-posterior films being taken by the overhead tube of the couch on which the patient was lying, laterals by a portable set.



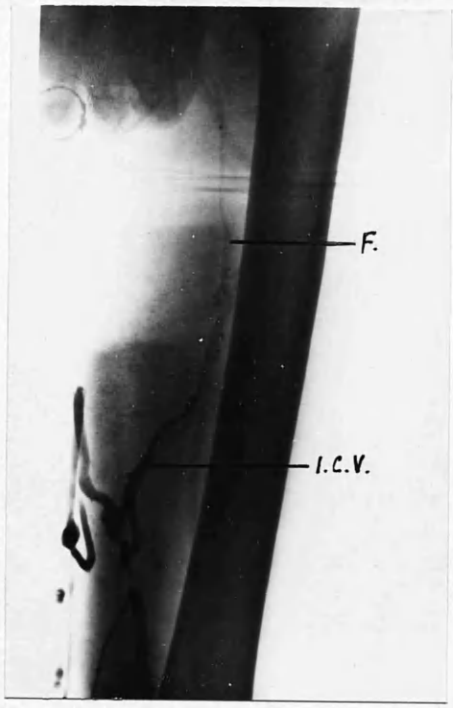
Ill. 99.



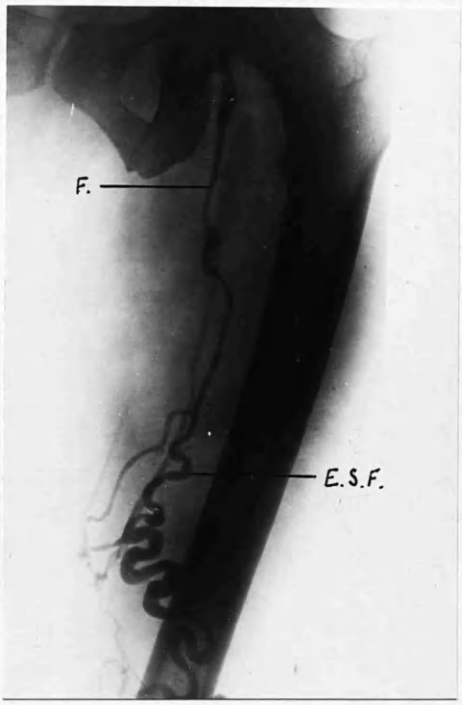
Ill. 100.

Like the clinical examination, the venographic technique must be varied to a certain extent to suit individual cases, but this is not difficult and is really a matter of commonsense.

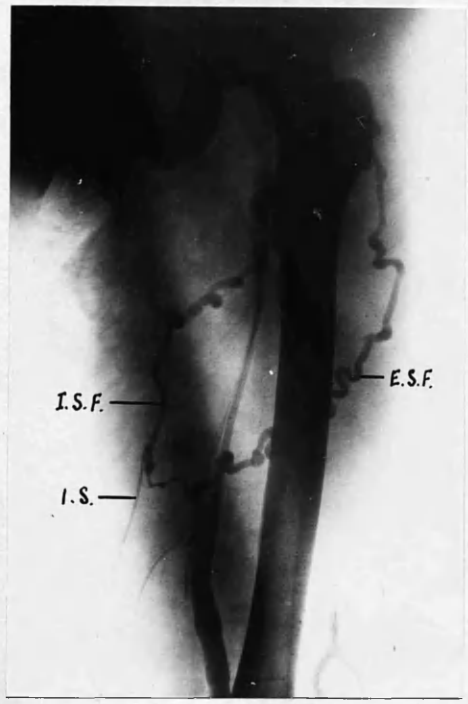
In general it is necessary to inject the patient twice, 20ccs. of Pyelosil being used on each occasion. The first injection is made into the main saphenous trunk in the region of the knee and the films are exposed. Occasionally these films will demonstrate a patent saphenous vein to the sapheno-femoral junction, and, in addition, an incompetent communicating vein in the thigh. In most cases, however, either a patent trunk will be seen to the groin or all the dye will have run into the deep circulation from the superficial via a communicating vein. In the former instance one of the techniques described in



Ill. 101.

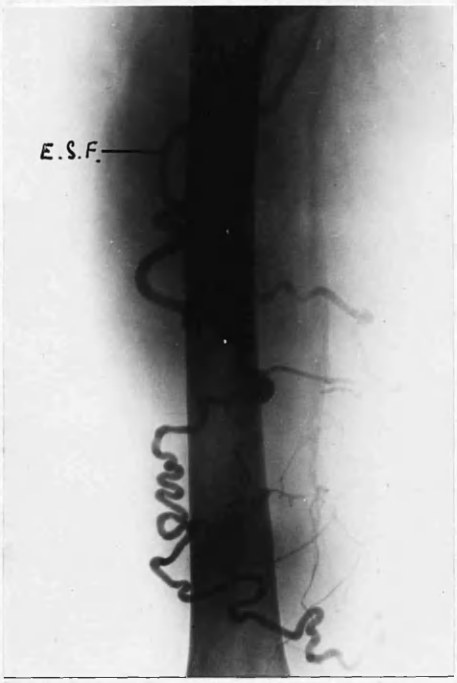


Ill. 102.

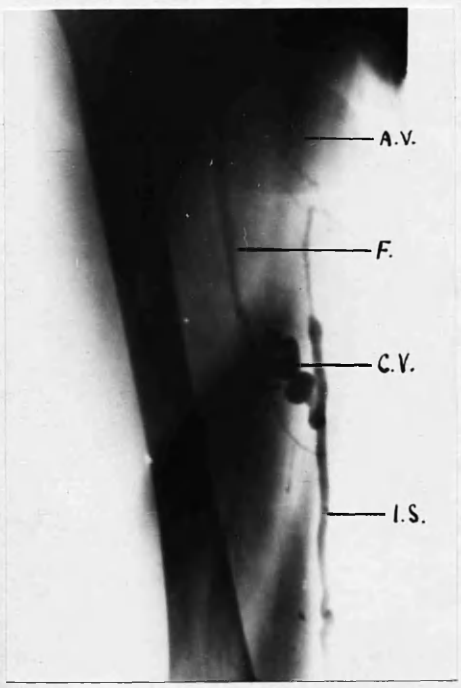


Ill. 103.

Part IV, for identifying communicating veins should be employed; in the latter it is necessary to reinject the saphenous proximal to the point of junction with the communicating vein to demonstrate whether or not it is patent to the groin, since, as was pointed out in Part II,(Page 37) all the dye may run out of the superficial system into the deep via a



Ill. 104.



Ill. 105.

communicating vein, although the superficial system, proximal to that point, is quite patent.

Using the combination of these techniques suitable for each individual case, all the methods of recurrence described on page 143 can be identified. The venographic findihgs in the accompanying illustrations were all confirmed at operation.

Ill. 99, is an example of the first cause mentioned, failure to ligate the internal saphenous. Ill. 100, is of a case in which an incompetent communicating vein (marked I.C.V.) is present in addition to a patent internal saphenous. Ill. 101, is an example of the third cause listed, recanalisation of the superficial system due to an incompetent communicating vein in the thigh. Examples of the fourth cause mentioned, inadequate ligation of

the internal saphenous are shown in the three illustrations 102, 103, 104. In the first of these, Ill. 102, recurrence has developed through the external superficial femoral vein which connected with the main saphenous trunk above the knee producing complete recanalisation in the leg. Ill. 103, is an example of recurrence through both the internal and external superficial femoral veins which had united to produce complete recanalisation of the internal saphenous, while Ill. 104, is another example of recanalisation through the external superficial femoral vein. Lastly, Ill. 105, demonstrates the final possibility mentioned, inadequate ligation of the internal saphenous and in addition, an incompetent communicating vein in the thigh. In this film the anastomotic vessels (marked A. V.) can be seen bridging the gap between the point of ligation and the internal saphenous distally.

Using these techniques, then, the different methods of recurrence can be identified quite easily.

Comparison of Clinical and Venographic Findings.

Of the 33 cases investigated by venography, 25 underwent operation.

The venographic findings were confirmed as being correct in every one of the 25 cases on which operation was performed.

In contrasting the clinical and venographic findihgs, in an effort to assess whether or not it is worth while performing venograms on cases of recurrence, it would be

neither fair to the clinician nor of any practical value to him, to compare the results on the basis of the causes of recurrence listed on page 143. To the clinician, it is only of academic interest to distinguish, firstly, between non-ligation and faulty ligation of the internal saphenous at the original operation (causes 1 and 4, page 143), and secondly, between non-ligation and faulty ligation of the internal saphenous in the presence, in addition, of an incompetent communicating vein in the thigh (causes 2 and 5, page 143).

From the purely practical point of view of what further operations are required, the clinician, faced with any individual case of recurrence, wants an answer to the following three points. (1). Is the recurrence from the groin, necessitating high ligation. (2). Is the recurrence from an incompetent communicating vein in the thigh, necessitating its ligation. (3). Are both operations required.

Accordingly, the venographic results, which can be regarded in the 25 cases which underwent operation, as being synonymous with the operative findings, have been subdivided into three groups, as follows.

Group A.

Those cases in whom the superficial veins were patent to the groin (causes 1 and 4, page 143). Total number, 9.

Group B.

Those cases in whom recurrence was due to an incompetent

communicating vein in the thigh (cause 3, page 143). Total number, 6.

Group C.

Those cases in whom the superficial veins were patent to the groin and in whom, in addition, an incompetent communicating vein was present in the thigh (causes 2 and 5, page 143). Total number, 10.

Group A.

Of the 9 cases in this group in which the venographic findings indicated patency to the groin, the clinical results

Ill. 106.

Ill.107.

were in agreement in 6 cases and in disagreement in 3, each of these cases being diagnosed as recurrence due to an incompetent communicating vein in the thigh alone.

Ill. 106, is of the first of these cases. The varix,

marked A, was considered to be the point of junction of the superficial system with an incompetent communicating vein, whereas, on the film it can be seen that the superficial veins are patent to the groin.

Ill. 107, is of the second case. Although the diagnosis of recurrence via the external superficial femoral vein appears simple on the film, there were large numbers of other varices, not visible on the film, present on the medial aspect of the patients thigh and it was considered that recurrence had developed in this area through an incompetent communicating vein.

The third case was grossly obese, and although she had a varicose ulcer and incompetent veins in the leg and lower thigh, it was not possible to identify the saphenous trunk in the groin.

As a matter of interest, of the 9 cases in this group, the venographic findings indicated that in 4 cases the internal saphenous had not been ligated at the original operation, while in the remaining 5, ligation had been faulty.

Group B.

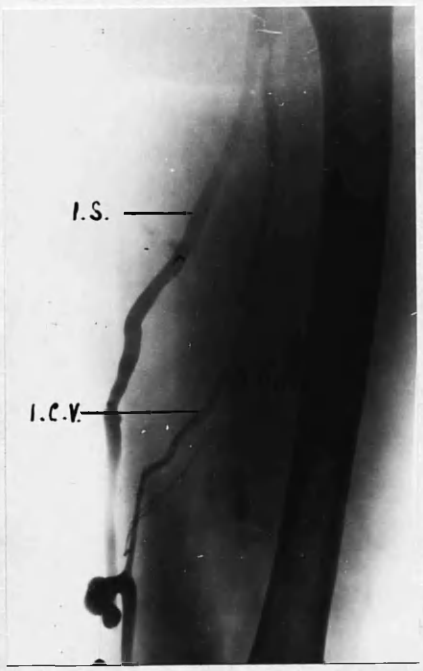
Of the 6 cases in this group, in which the venographic findings indicated recanalisation due to an incompetent communicating vein in the thigh, the clinical results were in agreement in every case. The only advantage in performing venograms in these cases appears to be, as was indicated in

Part IV, that the position of the incompetent communicating veins can be located much more accurately, than by the clinical test.

In view of Homans remark, quoted on page 110, to the effect that the communicating veins in the thigh are of little importance, it is of interest to observe that in 6 of these 25 cases, or nearly 25%, recurrence was due to incompetence of a communicating vein in the thigh.

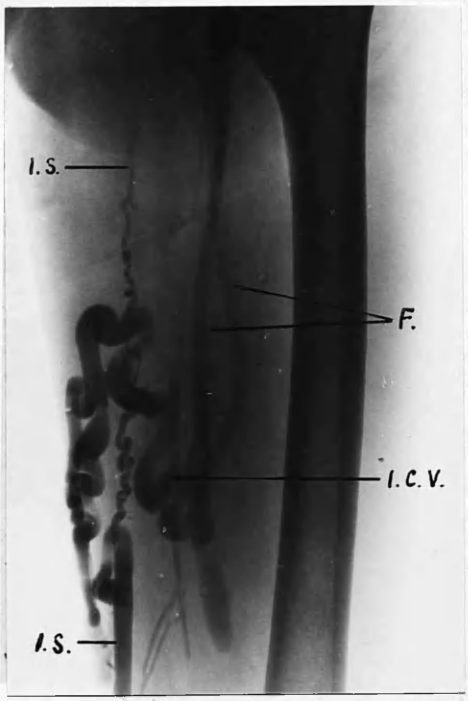
Group C.

Of the 10 cases in this group, in which the venographic findings indicated patency to the groin, and in addition, an incompetent communicating vein in the thigh, the clinical findings were in agreement in 5. Of the remaining 5 cases, 4 were considered to be due to recanalisation from the groin alone, while the remaining case was thought to be due to an incompetent communicating vein in the thigh alone.



Ill. 108.

Ill. 108 (a duplicate of Ill. 100), is of one of the four cases thought to be due to recanalisation from the groin alone. In the illustration it can be seen



Ill. 109.

that, in addition, there is a large incompetent communicating vein in the thigh. In this case, in view of the length and oblique position of the communicating vein, it is easy to understand how a tourniquet applied around the thigh in this region would compress the communicating vein as well as the internal saphenous, and so produce a false negative result (see page 115).

Ill. 109, is of the last case, thought clinically to be due to an incompetent communicating vein in the thigh alone. In the illustration it can be seen clearly that the internal saphenous has recanalised, and is patent to the groin.

Again, it is of interest to observe, that of the 10 cases in this group, the venographic findings indicated that in 3 cases the internal saphenous had not been ligated, while in the remaining 7, ligation had been faulty.

Summary. Of the 25 cases operated on, then, the venographic findings were correct in every case, while the clinical results were in error in 8 instances.

Of the 8 cases not operated on, the venographic and clinical findings were in agreement in 6 instances. In the remaining 2 cases, an incompetent communicating vein in the thigh was missed by clinical tests.

CONCLUSIONS. PART V.

(1). On the basis of the findings which have been described, it would appear that venography may be of considerable assistance in clarifying the diagnosis, and so influencing subsequent treatment, when varicose veins have recurred after operation.

(2). It is particularly valuable in those cases in whom, for any reason, the superficial veins cannot be identified in the groin, and there is, consequently, doubt as to whether a further operation is required in this region.

(3). As was pointed out in Part IV, venography provides an efficient method of determining the presence of incompetent communicating veins, and is considerably more accurate than the results of clinical examination in identifying their location.

GENERAL SUMMARY.

In Part I, the history of venography was reviewed, the scope of the Writer's investigations indicated, and some general observations on technique discussed.

In Part II, a description was given of the findings in 134 venograms performed on normal legs using different techniques, particular attention being paid to absence of filling and incomplete filling of the deep veins. With regard to the former, it was found that while certain techniques demonstrated patency of the deep circulation from the ankle to the groin in every instance, no technique could be relied on to fill all the deep veins; with regard to the latter, four different ways in which this could occur were described, and it was pointed out that the appearances so produced were indistinguishable from those hitherto ascribed to acute deep thrombophlebitis. It was concluded that, while venography is capable of demonstrating patency of the deep circulation of the leg, it must be extremely unreliable in the diagnosis or exclusion of acute deep thrombophlebitis.

In Part III, an account was given of the elaboration in venographic technique required to demonstrate the deep circulation of the leg when the superficial veins are varicose and the ankle oedematous, and, with particular reference to

the deep circulation, the results of venograms performed on 36 cases of varicose ulceration, and 26 cases of post-phlebitic ulceration, were described. It was found that the deep circulation was patent from the ankle to the groin in every instance, and that in 11 cases of post-phlebitic ulceration the normal deep veins had been replaced by tortuous leashes of incompetent blood vessels. The clinical and venographic findings were correlated, and it was concluded that, since the superficial varices are not compensatory, a history of deep thrombophlebitis in the leg concerned should not be regarded as a contraindication to radical obliteration of varicose veins.

In addition, the results were described of retrograde injection of an opaque medium into the femoral vein in 23 normal legs. It was found that, in 16 instances, extensive retrograde flow occurred, and the conclusion was reached that this finding should not be regarded as indicating congenital incompetence of the valves of the deep veins.

In Part IV, techniques for the demonstration of the communicating veins in the lower limb were described, and the appearances of competent and incompetent communicating veins illustrated. The results of venographic examinations performed on 40 patients for the identification of communicating veins in the thigh, and on 35 patients for communicating veins below the knee, were compared with the

results of clinical tests, and with the operative findings. It was concluded that venography provides a very accurate method, both for identifying the exact position of communicating veins, and for determining whether or not they are incompetent, although the venographic opinion regarding competency is less reliable for communicating veins below the knee than for those in the thigh.

In Part V, a description was given of venographic and clinical investigations on 33 patients suffering from recurrence of varicose veins after the operation of high ligation of the internal saphenous vein. The venographic techniques used in demonstrating the different methods of recurrence were discussed, and the clinical and venographic results were compared with the operative findings. It was concluded that, in this type of case, venography may be of considerable assistance in clarifying the diagnosis, and so influencing subsequent treatment.

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