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A CLINICAL STUDY ON SERIAL RETROGRADE VENOGRAPHY OF THE LOWER EXTREMITY WITH VARICOSE VEINS*

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ABSTRACT

Venography furnishes a map of the otherwise invisible deep veins of the extremities, discloses pathological changes, localizes the communicating veins, and tests the function of veins and valves.

This clinical study, was carried out to evaluate the serial retrograde venography of the lower extremities with varicose veins, using the serial long film changer with a tilt. Forty-three extremities with varicose veins of twenty-six patients were examined with both ascending and retrograde venographies, and the visualization of the veins, their valves and communicating veins were discussed.

Good contrast filling of the veins was obtained mainly in the part of the leg by ascending venography, but the superficial femoral vein was opacified only in a half of the cases studied. In retrograde venography, the contrast medium drifted downward, filling the superficial femoral and popliteal veins, and entered the more distal leg veins in about one half of the cases. The venous valves in the deep thigh veins were visualized in more than 40% the retrograde venography, but less frequently by ascending venography. In retrograde venography, the visualization of the communicating veins in the thigh was about 50%, but that in the leg about 25%.

It is concluded that retrograde venography is a safe and convenient method to study the hemodynamics of varicose veins in the lower extremities.

INTRODUCTION

Recently, many experimental and clinical studies on the arterial system have been carried out in peripheral vascular diseases. Consequently, remarkable improvement has been seen concerning pathologic physiology, diagnosis, and therapy of peripheral arterial diseases.

Although, diseases of the peripheral venous system are, in general, scarcely

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accompanied with severe clinical symptoms, as compared with arterial diseases, the haemodynamics of the venous system are more complex than those of the arterial system, and further methods of operative reconstruction have yet to established. Also, numerous problems in the diagnosis and therapy of venous disorders remain to be clarified.

The auther has been interested in developing a diagnostic roentgenologic method that will give additional information concerning the venous system of the lower extremity. To be of more value than previously reported methods, it must permit visualization of the venous system under conditions as natural as possible. To achieve this end, the patient should be in the upright position and the extremity should be unencumbered by tourniquets or bandages. With these conditions in mind, the author developed a method of retrograde venography by placing a Teflon needle percutaneously in the common femoral vein in the groin with a serial long film changer.

Serial retrograde and ascending venographies were performed in 43 extremities with varicose veins and a careful record of each case has been obtained for comparison of the results of retrograde and ascending venograms. At the same time, experimental work on the regurgitation of contrast medium was made *in vitro*, simulating the venous vessels of the human erect position.

It was first demonstrated by Trendelenburg[1] (1891) that the flow of blood in varicose veins could be reversed by a sudden change in posture.

The first venograms obtained in a living human subject were published by Berberich *et al.*[2] (1923), who injected 10 to 20% strontium bromide solution in a dose of 5 to 10 ml into the vein of the arm. McPheeters *et al.*[3] (1929) injected 1 ml of Lipijodol into the varices of a leg in their investigation on the influence of inspiration, Valsalva maneuver, and movements of the foot upon the blood flow. The methods described by Sgalitzer *et al.*[4] (1931), should perhaps be included in "Varicography", because the contrast medium injected into dilated superficial veins in the calf often remained at the site for a long time so that only the superficial veins were visualized.

Direct venography for the purpose of demonstrating obstructive lesions in veins was first done by Barker *et al.*[5] (1936). The study was primarily anatomic and was directed toward the demonstration of the state of patency of major venous channels. It was employed principally in the study of thrombo-embolic disorders. In 1940, Bauer[6] reported venographically examined cases of fresh thrombosis, as an exceptional finding, and described the appearance of a floating thrombosis in deep veins. However, he examined his cases with the leg in the horizontal position. This technique does not permit a satisfactory contrast filling of the deep main venous trunks and the muscular veins of the calf. Greitz[7] described in 1955 that a satisfactory study of the anatomy of these veins by venography can be made only with a vertical position of the extremity. Lindblom[8] described in 1941 that when venography was carried out with the extremity in the horizontal position, the contrast medium filled only the lower portion of the lumen of the veins, often as a thin streak, which gave a misconception of the real anatomy. According to him, this was due to sedimentation of the contrast fluid.

The introduction of the concept of retrograde venography by Luke[9] in 1941 marked the beginning of efforts to evaluate venous function radiologically as well as anatomically. His technique was designed to investigate the competency of femoral valves, preventing distal regurgitation of injected radiopaque medium by temporal occlusion of the femoral vein proximal to the site of injection. Bauer[10], in 1948, described a technique of retrograde venography by injection into the proximal end of the greater saphenous vein. The vein was cannulated in the groin surgically and was ligated distally. He regarded retrograde flow of the contrast medium with the patient erect as abnormal, regardless of the presence or absence of symptoms, and advocated ligation of the popliteal vein as the preferable method of surgical management. Sylwan[11], in 1951, using percutaneous femoral injection also concluded the retrograde flow to be an indication of a diseased or abnormal deep venous system. In 1950, Felder[12] presented a venographic technique with the patient placed at 50 degrees from the horizontal. In this fashion, he evaluated the functional ability of the venous system as well as its anatomic or pathologic condition. Scott *et al.*[13] (1951) reported experiences with the injection of a contrast medium into a foot vein with tourniquets about the ankle and the lower extremity, and presented a modification with the patient at 75 degrees from the horizontal.

Radioactive isotopes have been used in the investigation of human venous flow. Wright[14] (1952) injected $sodium^{24}$ to measure the velocity of blood flow in normal veins in relation to posture, pregnancy and the post-operative state. The flow rate in the upright position diminished to about a half of that found in the supine position. Cotton *et al.*[15] (1959) injected $sodium^{24}$ to measure the velocity of blood flow in the legs. A hypodermic needle was inserted into the long saphenous vein in the thigh near the groin with the patient standing; the patient was then tilted to the horizontal position. The tracer injection was given and immediately the table was tilted vertically. Records of these experiments showed that the sudden change of posture produced a retrograde flow of tracer. In 15 of the 20 limbs the isotope travelled as far as the knee and in 8 limbs as far as the foot. The retrograde flow was of short duration.

Schumacker *et al.*[16] (1954) described a functional venography. They injected the dye percutaneously directly into the popliteal vein with the patient tilted 60 degrees from the horizonral position and took X-rays before and after the patient had raised himself 10 times on his toes. There was a high incidence of regurgitation of contrast medium down the femoral vein following groin injections and down the deep veins of the leg after popliteal injections.

This was true both in the extremities of control subjects and in those with venous disorders. No one is allowed to regard regurgitation in the deep venous system in quiet dependency as pathologic or as an indication for operative interruption of the femoral or popliteal vein.

Halliday[17] (1968) reported that intravenous injection at the ankle without a tourniquet outlined all the superficial veins as well as the deep veins, whereas intraosseous injections, even of large volumes, rarely outlined the long saphenous vein, and far more faintly the varices related to it.

Clinical tests[18][19] have been evolved to determine the following items: the competency of the valves of the long or short saphenous veins: the competence of the valve of the communicating veins; and the patency of the deep venous systems. The tests may be enumerated as follows: the Brodie-Trendelenburg test, the Ochsner-Machorner test, and the Perthes's test. Although selection of patients for high saphenous ligation is made only after the performance of one or more of these clinical tests, the incidence of postoperative recurrence of varicose veins remains unexpectedly high.

The failure of high ligation has been attributed by Sherman[20] (1944) to incompetence of communicating veins not revealed by the usual tourniquet examinations. He has demonstrated the incompetence at operation in cases where tourniquet tests were negative. Therefore, the development of a more accurate method of detecting incompetent communicating veins should improve the results of operation for varicosity. Massell[21] (1948) performed the venography by the technique in which three tourniquets were placed, just above malleoli, a few centimeters above the femoral condylus, and as high as possible in the thigh respectively. All three tourniquets were tight enough to obstruct the blood in the superficial veins but not in the deep veins. Another selective venography to demonstrate pathologic communicating veins between the deep and superficial systems was described by Arnordi[22] (1961).

Hershey[23], in 1967, reported that slow injection and proper use of tourniquets avoided flooding of the contrast medium into the superficial veins. The flooding could confuse the interpretation of venograms which reveal pathological changes, localize the communicating veins, and test the function of veins and valves.

The long film cassette changer might be made manual[24][25][26][27][28] or automatic[29]. They were used mainly for arteriography of the lower extremities, but could not be used for venography in tilted positions. The problem in obtaining serial full length venographs of the lower extremity has been solved by Bonte[30] in 1953. He constructed a long hexagonal drum which held six cassettes, each being approximately 5 1/2 inches wide by 39 inches long. The drum was rotated by a hand crank at one end permitting exposures at three second intervals. The entire apparatus could be turned upright for venography of the leg.

DeWeese[31] and Rogoff[32] reported a 14 by 36 inches spring cocking long film cassette changer with tilting table. In patients with venous stasis associated with either varicose veins or the postphlebitic state, there might be much dilution and pooling of contrast medium in the foot and calf. Therefore, they reported a second study by percutaneous injection into the common femoral vein in order to obtain crucial details about the upper part of the vein.

EXPERIMENTAL STUDY

Methods

A mock test was carried out *in vitro* to investigate the retrograde flow of contrast medium in the venous channels in the erect position. Simulating the human femoral vein of the lower extremity, a glass tube, 100 cm long and 0.5 cm in inner diameter, was fixed at certain angles between 30 and 90 degrees to the horizontal level, in which saline solution was irrigated upward. Eight per cent of saline was used because of its specific gravity being similar to that of human blood (specific gravity 1.058). At the top of the tube a Teflon needle was cannulated retrogradely and through which contrast medium was injected. The fluid pressure at the point of the needle was about 40 cm H_2O, equal to the summation of the normal human femoral venous pressure 9.8 to 12.8 cm H_2O, and the length to the groin from the phlebostatic level in the erect position, about 30 cm[33,34]. The flow velocity was controlled by a three-way stopcock, either at 2.1 ± 0.5 cm/sec, the blood flow rate in the normal femoral vein at the erect position, or at 0.8 ± 0.3 cm/sec, in patients with varicose veins[14,15] (Fig. 1).

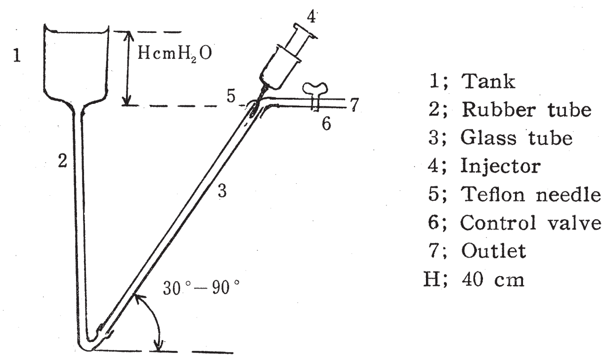


FIG. 1. Experimental arrangement for studying the NaCl-solution contrast system flowing *in vitro*.

Results

1. One ml of 76% Urografin®, sodium and meglumine diatrizoate, injected into the tilted glass tube at angles of 30 to 60 degrees descended against the

constant saline flow, at a rate of 0.8 cm/sec, to reach the bottom after 25 to 35 secnds. However, the contrast medium injected into the tube in the erect position was so much diluted by turbulence so that it did not reach the bottom in many cases (Fig. 2).

2. The descent time of the contrast medium in the tilted tube at angles of 45 to 60 degrees was 35 to 45 seconds, and that at 30 degrees was over 70 seconds (Fig. 3).

3. The same procedure was carried out in the glass tube, tilted 60 degrees with the saline flow rate of 0.8 cm/sec using three different concentrations of the contrast medium: 76%, with a specific gravity of 1.42 g/ml; 60%, 1.33 g/ml; and 54%, 1.20 g/ml. The retrograde flowing velocity increased with the rise in specific gravity of the contrast medium (Fig. 4).

4. Radiographs of the floating contrast medium in the glass tube were taken. Visualization was excellent with the heavier contrast medium and when tubes tilted a few degrees from the horizontal plane were used (Fig. 5).

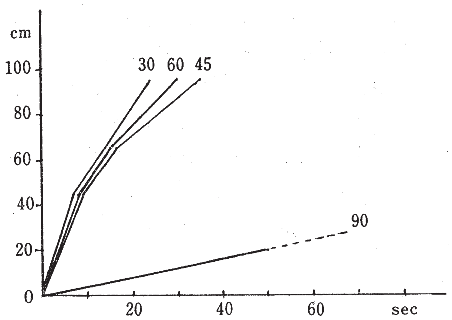


FIG. 2.
velocity of saline solution 0.8 cm/sec
Urografin 76% 1.42 g/ml
angle of glass tube 30 degrees, 45, 60, and 90.

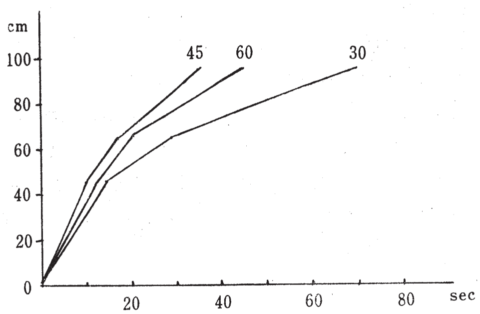


FIG. 3.
velocity of saline solution 2.1 cm/sec
Urografin 76% 1.42 g/ml
angle of glass tube 30 degrees, 45, and 60.

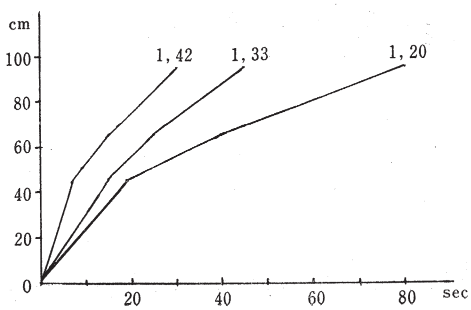
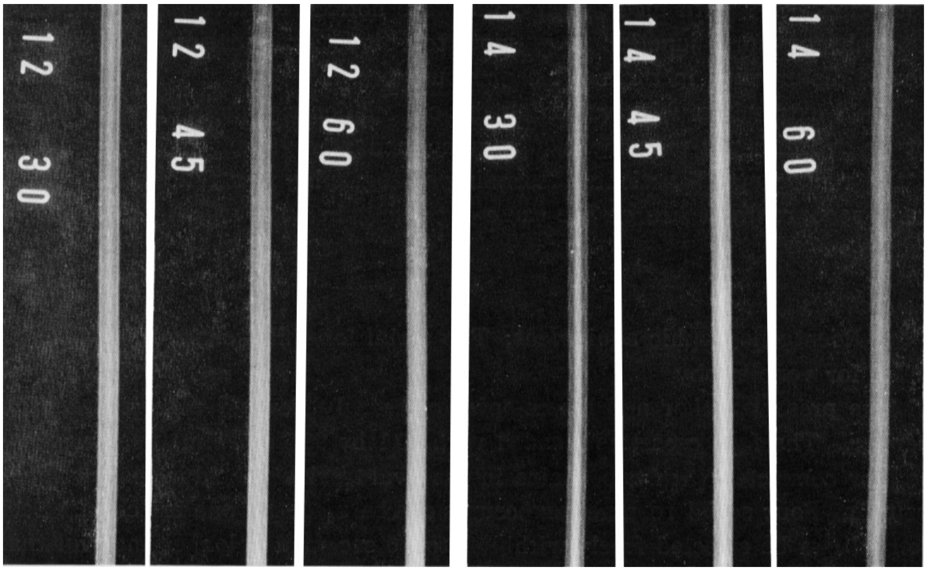


FIG. 4.
velocity of saline solution 0.8 cm/sec
Urografin 76% 1.42 g/ml
60 1.33
54 1.20
angle of glass tube 60 degrees



a b c d e f

FIG. 5. Experimental radiographs

a; 12 30 shows Urografin of S.G. 1.20 g/ml and 30° inclination to the horizontal plane. b; 1.20 g/ml, 45°. c; 1.20 g/ml, 60°. d; S.G. 1.42 g/ml, 30°. e; 1.42 g/ml, 45°. f; 1.42 g/ml, 60°.

Conclusion

From the above findings, the following conclusions may be drawn.

1. Heavier contrast mediums show velocity of descent and better visualization.

2. When the tilt angle of the glass tube is between 30 to 60 degrees, the contrast mediums flow always in retrogradation in the same way.

3. With the saline flow rate like the normal femoral venous flow, the contrast medium descent in the glass tube tilted 30 degrees, is significantly slower than in the tubes tilted 45 to 60 degrees.

4. Therefore, excellent visualization of the retrograde flow of the contrast medium should be obtained in the glass tubes tilted at angles of 45 to 60 degrees from the horizontal plane.

CLINICAL STUDY

Materials

Forty-three extremities of 26 patients, 12 men and 14 women, were subjected to study. The ages of the patients ranged between 20 and 60 years, and most of them were in the fourth decade. Seven patients had mild and relatively superficial varicose veins, 18 with eczema and pigmentation, 9 with induration and 9 with ulcer. All cases were noticed to have incompetence of the saphenofemoral junction by previous tourniquet examination, and 2 patients showed disturbunce in the short saphenous vein.

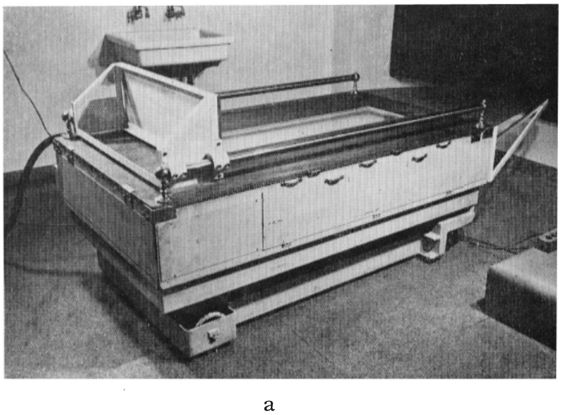
In 12 extremities with varicose veins of 9 patients, venography was carried out by two different techniques, ascending and retrograde. In 31 extremities of the remaining 17 patients, ascending venography was followed by retrograde venography, twice on the same leg using heavier and lighter contrast mediums.

Methods

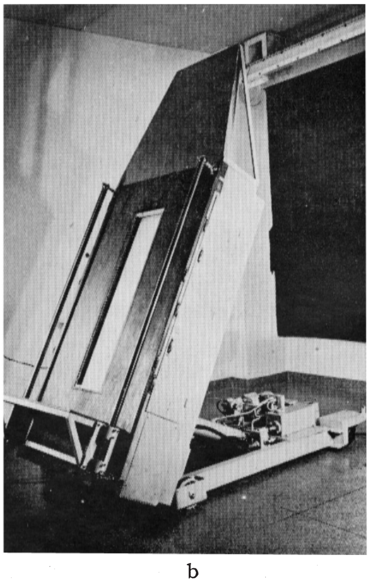
1. Roentgenographic equipment; The serial long film changer with a tilt for venography

The present author and his co-operators newly deviced a serial long film changer. The four cassettes (loaded with 20.1 by 90.5 cm film) are driven by a motor connected with two chains in the oval track and held in the horizontal position. Four serial roentgen exposures can be made by one injection. Each interval can be selected freely within 2 to 30 sec, and a longer interval than these can be obtained manually if necessary. The film changer is connected to a common X-ray unit and an injector. The selection of automatic or manual operation is optional. Moreover, this table can be tilted to any opposed angle of 0 to 60 degrees from the horizontal plane. This changer can be easily moved by only one person.

The average technical factors are 50 kilovolts peak and 300 miliamperes for 0.1 second with a compensated intensifying screen 'US'. The forcus-film



a



b

FIG. 6. Outside views of long film changer for venography.
a; Horizontal position of film changer. Step and handrails are seen and in window at center of top of the changer, long film cassette is seen,
b; Inclined at 60°.

distance is 180 cm. A wedge filter has been constructed for insertion at the tube window in order to equalize roentgenographic density from thigh to calf (Fig. 6).

2. Ascending venography

Sensitivity test is performed by the venous injection of 1 ml of 60% Urografin. The patient is reassured and coached in the details of the procedure. Premedication is done subcutaneously with 0.5 mg of atropin sulfate 30 minutes before the procedure. The patient is placed on the table of the serial long film changer in the horizontal position. The rubber tourniquets were placed round the calf and just above the malleoli and are tight enough to constrict the superficial veins but not the deep veins.

The percutaneous venous puncture should be carried out as distally as possible, preferably on the dorsum of the foot or the internal malleoli with a 19 gauge needle. The film changer is tilted to 45 to 60 degrees with regard to the patient's clinical state. Forty ml of 60% Urografin is injected slowly with minimal pressure in 60 seconds. After the injection, the first film is taken antero-posteriorly (Fig. 7-a). The second radiography is then taken laterally (Fig. 7-b). The time interval between the first and second rediographs is 30 seconds. Within about 60 seconds after the second radiography, the rubber

a

b

c

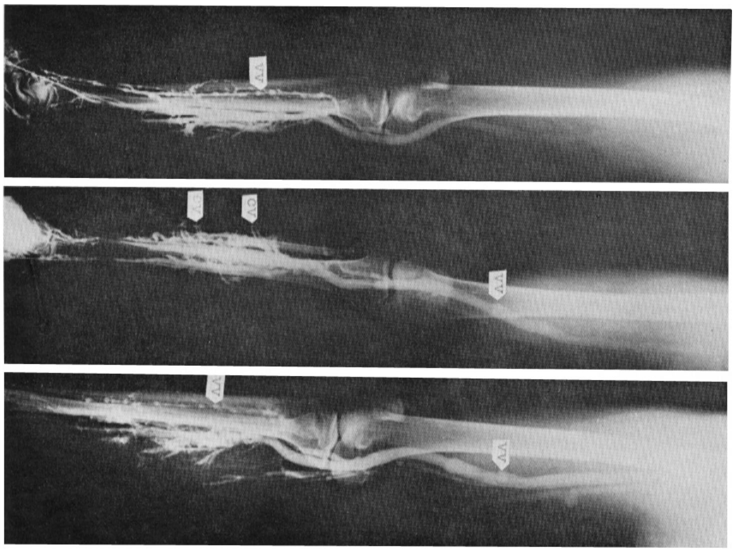


FIG. 7. Three ascending venographs Y.M. (right)

Numerous valvular sinuses seen in the thigh and leg. Many incompetent communicating veins seen in the leg. After exercise (c), Urografin has travelled down into the long saphenous vein from its proximal junction, and good amount of dye seen in the leg. (vv) shows venous valves, and (cv) the communicating veins.

tourniquets are removed, the patient is requested to move the foot 10 times energetically to contract the soleus muscle, and a third film is taken (Fig. 7-c).

3. Retrograde venography

Premedication is the same as in ascending venography. The patient is placed horizontally on the serial film changer. All elastic wrappings are removed from the legs. A 19 gauge needle 8 cm long made with Teflon is used. The needle is preferably inserted percutaneously and retrogradely under local anesthesia in the inguinal fold immediatly medial to the femoral artery whose pulsations are best felt with the leg rotated outwards. Before being connected to the tube and syringe the needle is introduced directly into the femoral vein. When the tip meets the fascia, the latter is penetrated by a gentle thrust and, as a rule, the needle will then enter the vein. A plastic tude, about 30 cm long, is then connected to the needle and normal saline is injected. The suction will show whether the needle is still in proper position. The film changer is tilted from 45 to 60 degrees. Forty ml of 76% Urografin is injected slowly in about 60 seconds without exerting pressure to disorder the venous pressure.

The first film is obtained at the end of the injection (Fig. 8-a, 9-a). The patient then takes a shallow breath (during which valves of the veins are transiently opened, if any) and again strains. Then after the 30 second lateral the film is taken (Fig. 8-b, 9-b). Within about 60 seconds after the second radiograph, the patient is requested to move the foot 10 times energetically

a

b

c

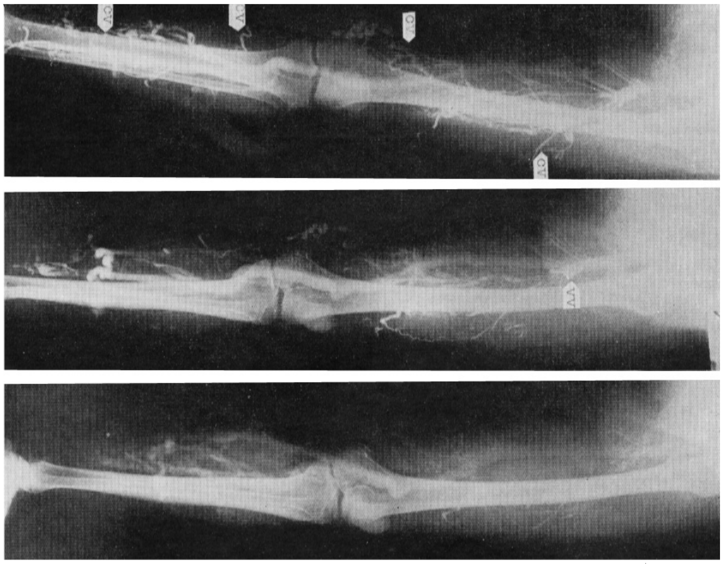


FIG. 8. Three retrograde venographs C.N. (left)

The needle was introduced into the deep femoral vein. Contrast solution has travelled straight down to the ankle level. From thigh to leg, deep venous valves are scarcely seen and numerous incompetent commuuicators are visible.

and a third film is taken (Fig. 8–c, 9–c).

In the initial examination of 12 extremities, only contrast medium of heavier specific gravity, namely 76% Urografin with specific gravity 1.42 g/ml, was used, but in the later examinations of 31 extremities, venography was performed two times on the same extremity using contrast medium of the heavier specific gravity and a lighter one, namely, 54% Urografin of specific gravity 1.20 g/ml. The patient was then returned to the horizontal position and normal saline solution was rapidly flushed through the needle (Fig. 10, 11).

a

b

c

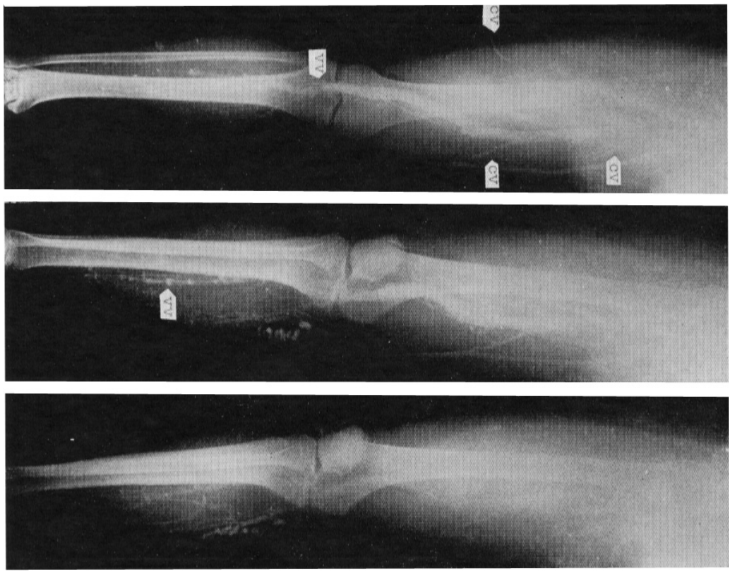


FIG. 9. Three retrograde venographs K.K. (right)
Marked regurgitation seen in deep veins and long saphenous vein. Communicators visible in thigh and leg. In the leg, numerous regularly shaped valvular sinuses are shown (b).

Results

Careful examination of the various venograms was made, with attention paid to the ascending and retrograde venographies, and the effects of movement of the foot on the venous system were evaluated.

1. Visualization of the veins

Visualization of veins was graded as excellent, good and poor. Excellent visualization signified that the contrast was clear and the main veins were not overlapped or not complicated and their details could be demonstrated, good visualization, when the contrast was not so poor, and poor visualization when numerous superficial varicose veins were filled and the deep veins appeared confused or no visualization obtained. Veins of the extremity were classified

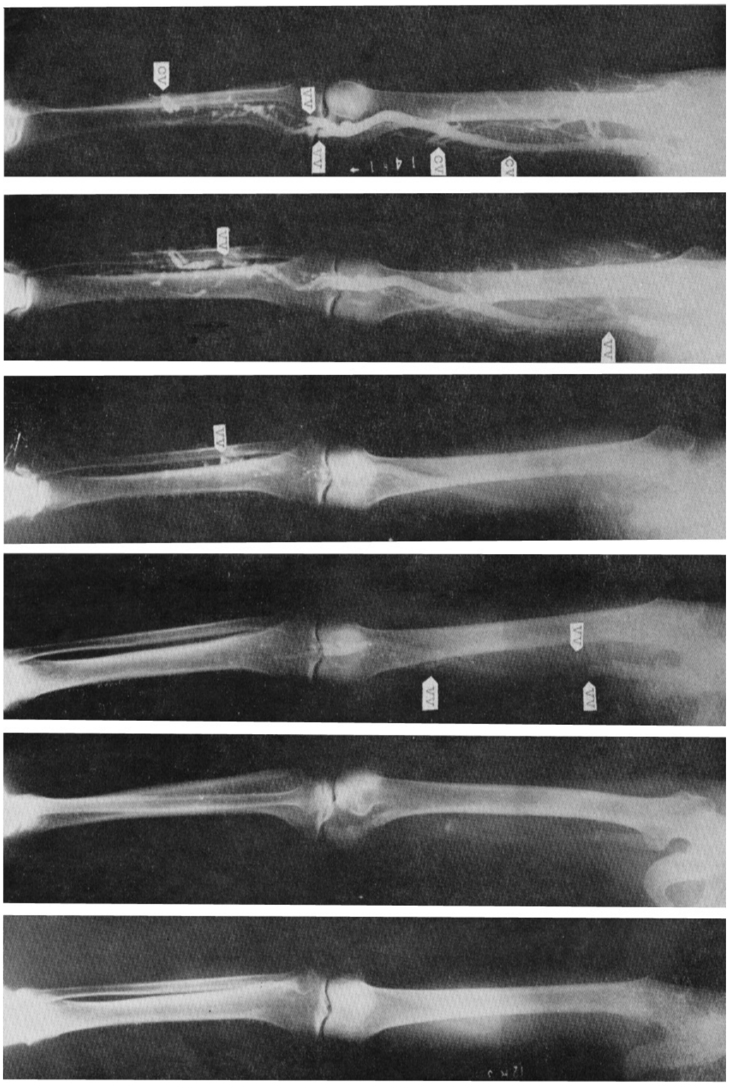


FIG. 10. Six films showing comparison of retrograde venography with Urografin of heavier and lighter specific gravities S.Y. (right).

Figs. a, b and c, first, second and third exposures, using 76% Urografin (1.42 g/ml). Figs. d, e and f when 54% Urografin (1.20 g/ml), was used the same as above. In former (a, b and c), Urografin flows through incompetent femoral valves to midleg. In latter (d, e and f), dye flows down to just below the knee.

as shown in Fig. 12.

1-1. Routine ascending venograms after injection

Good contrast filling of the veins in the leg was obtained mainly by ascending venography. Popliteal veins were opacified in 30 of 43 extremities a

b

c

d

e

f

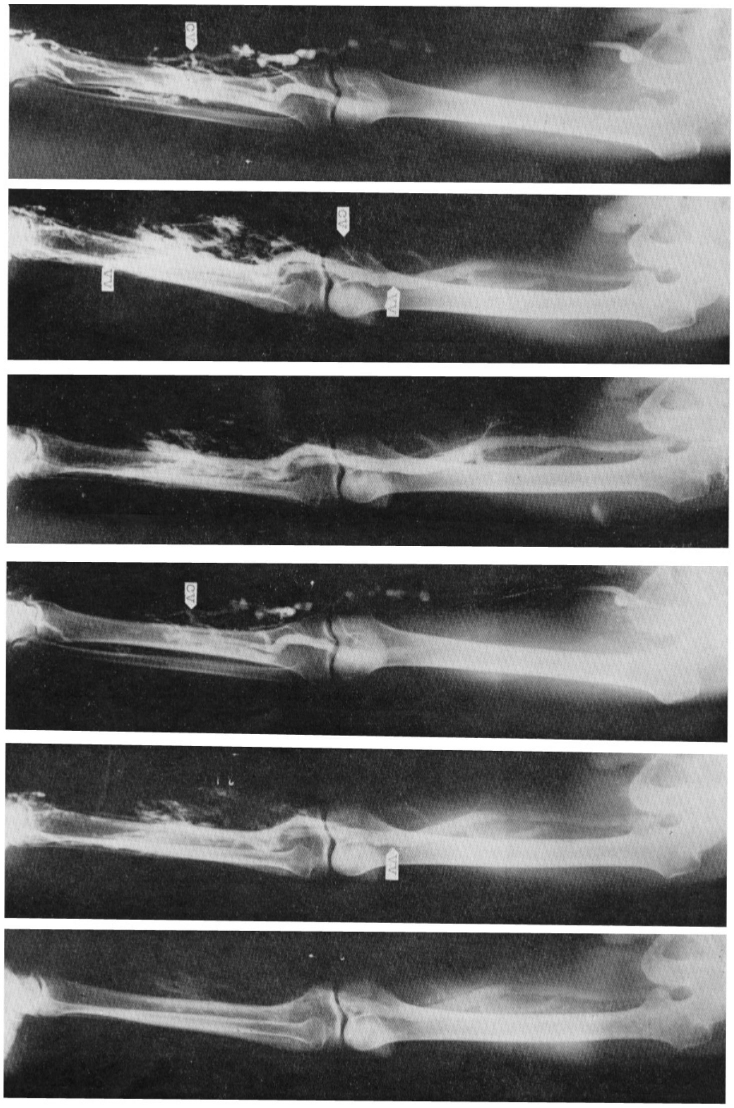


FIG. 11. Six films showing comparison of retrograde venography with Urografin of heavier and lighter specific gravities S.Y. (left)

Figs. a, b and c when heavier Urografin, and d, e and f when lighter Urografin were used. The needle is placed in the long saphenous vein. Varix in the proximal end of the long saphenous vein clearly visualized, through not seen in ascending venography. Urografin travelled straight down the long saphenous vein to the ankle level (a and d), passed into the deep veins through many incompetent communicators (b and e), and drifted upward through the irregularly dilated deep veins.

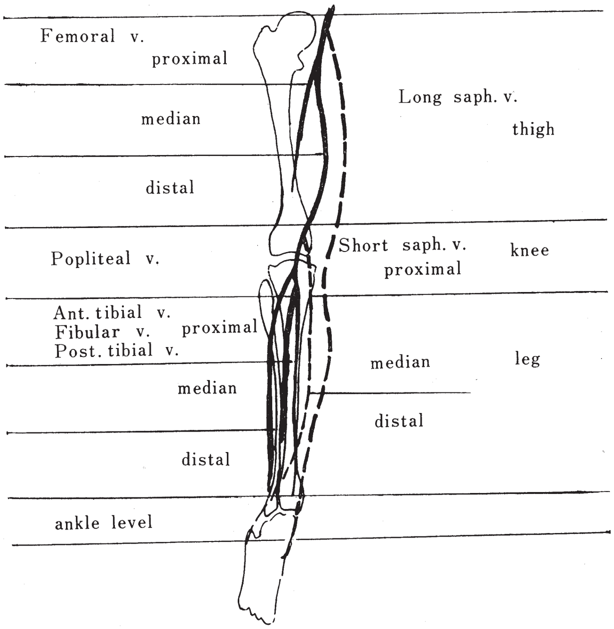


FIG. 12. Divided veins of the extremity.

studied, and superficial and common femoral veins were opacified in only a half of the cases (Table 1). Pathological change of superficial femoral veins was seen in 2 cases of thombosis, in 6 cases of relative dilatation and tortuosity.

1-2. Retrograde venograms after injection

In retrograde venography by means of percutaneous puncture at the groin, the needle was inserted into the common and superficial femoral veins in 22 cases, into the large saphenous vein in 15 cases, and into the deep femoral vein in 6 cases.

When injection was made at the groin, the contrast medium drifted downward filling the superficial femoral and popliteal veins. In one half of the cases, the contrast medium entered the more distal veins of the legs and the short saphenous veins (Table 1).

Varicose veins at the upper portion of the long saphenous vein which were scarcely opacified by ascending venography could be visualized by retrograde venography (Fig. 10). In two instances where the femoral vein was not visualized, the patients had femoral thrombosis, namely secondary varicose veins.

1-3. Comparison of visualization in the retrograde venography with Urografin of different specific gravities

Retrograde venography were carried out in 31 extremities with varicose veins (17 patients), two times in each extremity using Urografin of heavier

TABLE 1. Visualization of the Veins after Injection (in 43 cases)

		Ascending venography				Retrograde venography			
		Excellent	Good	Total	%	Excellent	Good	Total	%
Femoral v.	proximal	7	10	17		33	8	41	95
	median	10	10	20	46	29	12	41	
	distal	16	15	31	70	29	7	36	84
Popliteal v.		21	12	33	76	24	9	33	76
Ant. tibial v.	proximal	27	4	31		14	12	26	60
	medisn	30	2	32	74	12	6	18	
	distal	24	3	27		3	6	9	
Fibular	proximal	24	3	27		14	4	16	35
	median	26	3	29	67	9	4	13	
	distal	22	1	23		4	2	6	
Post. tibial v.	proximal	26	2	28		12	7	19	44
	median	33	0	33	76	6	7	13	
	distal	33	0	33		4	4	8	
Deep veins of ankle level		27	2	29	67	0	2	2	0.5
Long saph. v.	thigh	3	2	5		12	10	22	
	knee	5	2	11		15	9	24	55
	leg	28	6	34	79	10	6	16	
Short saph. v.	proximal	12	3	15		7	16	23	53
	median	13	0	13	34	6	15	21	
	distal	4	2	6		3	6	9	

and lighter specific gravity.

With 76% Urografin, the visualization rate of the superficial femoral vein in the upper half of the thigh was 93% while with 54% Urografin, the rate of the same vein fell to 61%, while in the superficial femoral vein in the lower half of the thigh and the popliteal vein the ratio was 51% to 45%.

In the deep veins of the leg, below the popliteal vein, opacification became less, especially in the lower half of the leg. Sixty per cent of the long saphenous veins in the thigh were filled with Urografin, while about 50% of those in the leg were filled. Urografin flowed down mixing and decreasing the concentration in the distal portion of the leg due to absence of long saphenous valves (Table 2).

1–4. Serial retrograde venography

Serial retrograde venography was performed with injection of 40 ml of 76% Urografin, within 45 seconds, into the common femoral vein in the groin. Four serial roentgenograms were taken at intervals of 12 seconds after the initiation of injection. In advanced cases with varicose veins, regurgitation of contrast medium was found more rapidly and distally in the deep veins and clearer films in contrast were obtained (Fig. 13).

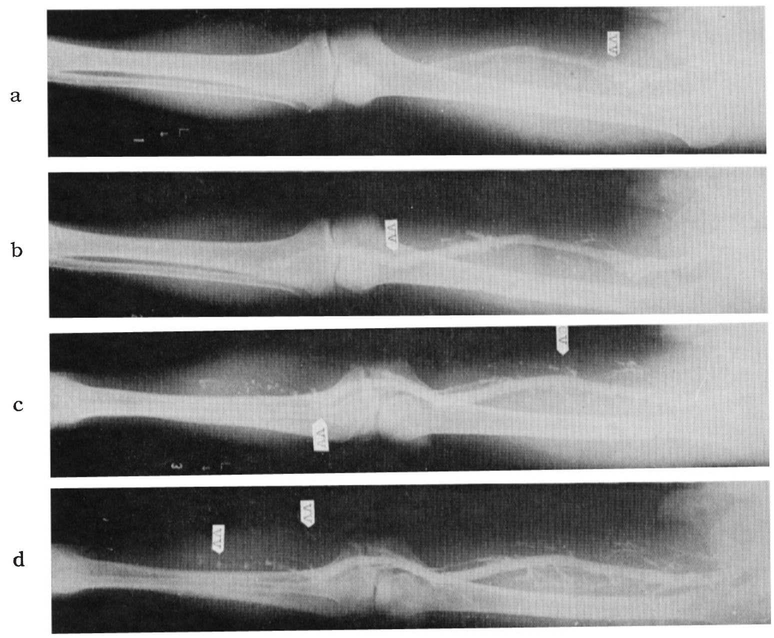


FIG. 13. Four serial retrograde venographs taken at relatively short intervals M.N. (left)

Four films taken at interval of 12 seconds from beginning of the injection. Initial film (a) shows that retrograde flow is marked toward the competent (supposedly) upper valve of the superficial femoral vein. The second film (b) shows marked regurgitation to popliteal vein. In other films, there is seen a flow down gradually to the deep leg veins and to opacify the clearly shaped valvular sinuses.

1–5. Ascending venograms after exercise of foot

After exercis, contrast medium retaining in dilated veins of the leg tended to drift upward and deep veins of the thigh were visualized, if venous function remained in them. But the visualizations were less in number and density than in retrograde venograms. After exercise the long saphenous veins were more evident than before exercise, as the contrast medium regurgitated from the junction with the common femoral vein (Table 3).

1–6. Retrograde venograms after exercise of the foot

As the regurgitation of Urografin was slight, the contrast medium almost disappeared from the leg after exercise of the foot. But functional evaluation was possible (Table 3).

1–7. Emptying rate

The decrease in opacification (emptying) of the deep veins was graded as poor, good and excellent. Poor emptying signified that there was little or no change in opacification of the deep veins following exercise, good emptying when only small portions of the veins and valvular cusps remained opacified,

TABLE 2. Comparison of Visualization in the Retrograde Venography with Different Specific Gravity of Urografin (after injection, in 31 cases)

		Heavier (76% 1.42 g/ml)				Lighter (54% 1.20 g/ml)			
		Excellent	Good	Total	%	Excellent	Good	Total	%
Femoral v.	proximal	24	5	29	93	24	5	29	93
	median	23	6	29		13	6	19	
	distal	21	3	24	77	8	8	16	51
Popliteal v.		20	3	23	77	6	8	14	45
Ant. tibial v.	prorimal	10	6	16	51	3	4	7	22
	median	8	4	12		3	2	5	
	distal	2	2	4		2	0	2	
Fibular	proximal	11	3	14	45	3	4	7	22
	median	8	4	12		1	2	3	
	distal	2	2	4		0	2	2	
Post. tibial v.	proximal	11	4	15	48	4	4	8	25
	median	5	4	9		3	3	6	
	distal	4	2	6		0	2	2	
Deep veins of ankle level		0	2	2		0	0	0	
Long saph. v.	thigh	10	9	19	61	8	10	18	58
	knee	12	9	21		6	9	15	
	leg	7	10	17		4	8	12	
Short saph. v.	proximal	7	7	14	45	2	9	11	35
	median	6	6	12		3	8	11	
	distal	3	2	5		0	2	2	

and excellent emptying when the valve only retained Urografin.

In ascending venography, emptying of the deep leg veins was good or excellent in about 60% of cases, but superficial femoral veins were conversely filled with the upward flow.

In retrograde venography, excellent emptying was seen in the deep veins of the thigh and leg. This suggests that the function of deep venous return was not so interrupted, though many cases showed poor emptying in the thigh in ascending venography (Table 4).

2. Visualization of venous valves

Visualization of venous valves was graded as excellent and almost good. The marked sedimentation of Urografin in the valvular sinuses, a possible sign of valvular competency, is shown as excellent, and almost good when swelling of the valvular sinuses only was recognized and insufficiency of the valves was suspected (Tables 5, 6).

2-1. In ascending venography, the venous valves were visualized in one half of the cases, although visualization of the deep veins was excellent in the leg, and poor in the thigh.

TABLB 3. Visulization of the Veins after Exercise

		Ascending venography				Retrograde venography			
		Excellent	Good	Total	%	Excellent	Good	Total	%
Femoral v.	proximal	13	19	32		4	16	20	
	median	15	15	30	70	6	15	21	
	distal	18	15	33	76	6	15	21	49
Popliteal v.		18	12	30	70	4	13	17	40
Ant. tibial v.	proximal	7	16	23	54	0	6	6	18
	median	6	13	19		0	3	3	
	distal	6	12	18		0	0	0	
Fibular	proximal	7	12	19		1	6	7	16
	median	10	13	23	54	3	3	6	
	distal	10	10	20		3	0	3	
Post. tibial v.	proximal	7	22	29		3	6	9	
	median	10	21	31	70	2	4	6	26
	distal	7	13	20		1	3	4	
Deep veins of ankie level		3	6	9	2	0	0	0	0
Long saph. v.	thigh	3	16	19		7	10	17	40
	knee	4	19	22	54	3	10	13	
	leg	3	18	22		3	7	10	
Short saph. v.	proximal	6	16	22	54	4	14	18	
	median	6	15	21		6	13	19	44
	distal	4	7	11		1	4	5	

2–2. In retrograde venography, venous valves in the thigh were adequately visualized in more than 40% of cases, and those in the leg were similarly visualized in ascending venography.

3. Width of veins and size of their venous valves

The widths of deep veins were measured at their origin before and after exercise, but no apparent difference was found.

The widths of veins just above their valves and the size of the venous valves were measured and plotted in Fig. 13. Excellent valves were marked with circles, and almost good valves with crosses.

In the thigh and knee, it was found that valves suspected as insufficient were seen generally in dilated veins and were greater in size than excellent valves. But the size of the valves was not completely correlated with retrograde flow.

There was no relation between the size of venous valves and retrograde flow in the anterior and posterior tibial veins and fibular veins. In the extremities, the size of venous valves was almost in proportion to the width of veins.

4. Visualization of communicating veins

Anatomically, communicating veins have been noted to be distributed in

TABLE 4. Emptying of Veins (in 43 cases)

		Ascending venography			Retrograde venogrpahy		
		Excellent	Good	Poor	Excellent	Good	Poor
Femoral v.	proximal	11	19	13	23	16	4
	median	13	15	15	22	15	6
	distal	10	15	18	22	15	6
Popliteal v.		18	12	18	24	13	4
Ant. tibial v.	proximal	23	16	7	37	6	0
	median	24	13	6	40	3	0
	distal	25	12	6	43	0	0
Fibular	proximal	24	12	7	36	6	1
	median	20	13	10	37	3	3
	distal	23	10	10	39	1	3
Post. tibial v.	proximal	14	22	7	33	7	3
	median	12	21	10	37	4	2
	distal	23	13	7	39	3	1
Deep veins of ankle level		34	6	3	0	0	0
Long saph. v.	thigh	24	16	3	26	10	7
	knee	21	18	4	30	10	3
	leg	21	19	3	23	7	3
Short saph. v.	proximal	21	16	6	25	14	4
	median	22	15	6	24	13	6
	distal	32	7	4	38	4	1

considerable abundance in the extremity, but it was nearly impossible for all of them to be opacified. Communicating veins were frequently doubled especially on the lateral aspect of the leg, and one of them was usually about 1.0 to 0.5 cm thicker than the other. They ran predominantly in a horizontal direction. The communicating veins tended to be dilated, irregular, valveless and increased in number in patients with varicose veins.

In ascending venography, as deep veins were overlapped by superficial varicose veins, accurate demonstration of the communicating veins was impossible in many cases. The visualization rate was 70% in the leg, and less in the thigh.

In retrograde venography, the visualization rate of communicating veins was about 50% in the thigh but 25% in the leg (Table 7).

DISCUSSION

Venography furnishes a map of the otherwise invisible deep veins of the extremities, discloses pathological changes, localizes the communicating veins, and can test the function of veins and valves.

Radiographic interpretation has been made easier by producing a more

TABLE 5. Visualization of the Venous Valves after Injection

		Ascending venography				Retrograde venography			
		Excellent	Good	Totsl	%	Excellent	Good	Total	%
Femoral v.	proximal	3	0	3		18	1	19	44
	median	2	6	8	18	12	4	16	37
	distal	3	1	4		7	3	10	
Popliteal v.		3	4	7		10	3	13	
Ant. tibial v.	proximal	13	9	22	51	19	0	19	44
	median	10	3	13		7	1	8	
	distal	7	4	11		0	1	1	
Fibular	proximal	10	9	19	44	10	1	11	25
	median	6	6	12		6	3	9	
	distal	1	3	4		2	2	4	
Post. tibial v.	proximal	12	4	16	37	12	3	15	34
	median	4	6	10		4	0	4	
	distal	9	9	18		6	3	9	
Deep veins of ankle level		3	3	6		3	0	3	
Long saph. v.	thigh	0	0	0		0	0	0	
	knee	1	1	2		0	0	0	
	leg	1	1	2		0	0	0	
Short saph. v.	proximal	3	1	4		12	1	13	
	median	3	4	7		6	0	6	
	distal	0	0	0		3	0	3	

distinct contrast shadow. This obvious improvement can probably be attributed to the increase in amount of contrast medium in the vein and to many roentgen exposures at various stages. However, this is accompanied by numerous side effects. Many authors have stated venographic studies by various techniques to solve this problem.

Early investigators, using short films, were able to visualize only short segments of the leg. The use of long films and exercise to propel the contrast medium cephalad made it possible to study the veins of the entire lower extremity by means of serial examinations.

Ascending Venography

Lindblom[8] stated that, when venography was carried out with the extremity horizontal, the contrast medium filled only the lower portion of the lumen of the veins, often as a thin streak, and gave a misconception of the real anatomy. Later, ascending venography was performed with the position of 45 degrees[8][35] or 30 degrees[36] from the horizontal plane.

DeWeese *et al.*[37][38] reported that the use of a large amount of contrast medium at a semi-erect position improved the clarity of the films, and propelled the contrast medium cephalad.

TABLE 6. Visualization of the Venous Valves after Eexercise

		Ascending venography			Retrograde venography		
		Excellent	Good	Total	Excellent	Good	Total
Femoral v.	proximal	5	3	8	13	1	14
	median	4	3	7	6	3	9
	distal	3	4	7	0	1	1
Popliteal v.		3	3	6	1	0	1
Ant. tibial v.	proximal	6	4	10	0	0	0
	median	0	2	2	0	0	0
	distal	4	1	5	0	0	0
Fibular	proximal	1	4	5	1	1	2
	median	1	2	3	0	0	0
	distal	2	1	3	1	3	4
Post. tibial v.	proximal	4	3	7	0	0	0
	median	3	1	4	0	0	0
	distal	4	1	5	0	1	1
Deep veins of ankle level		2	0	2	0	0	0
Long saph. v.	thigh	0	0	0	1	1	2
	knee	1	0	1	0	0	0
	leg	0	0	0	0	0	0
Short saph. v.	proximal	4	0	4	4	1	5
	median	4	1	5	4	0	4
	distal	0	0	0	0	0	0

TABLE 7. Visualization of the Communicating Veins

		After injection			After exercise		
		Ascending	Retrograde		Ascending	Retrograde	
			76%	54%		76%	54%
Thigh	proximal	0	12	6	0	0	0
	median	4	20	10	4	13	5
	distal	9	20	8	9	5	0
Knee level		0	14	4	4	0	0
Leg	proximal	27	14	0	8	0	0
	median	30	9	3	2	2	0
	distal	20	0	0	2	0	0

Felder *et al.*[12] reported that the visualization of the superficial femoral vein was improved from 80.9% to 85% and that of the popliteal from 83 to 92%, as the angle of the tilted table was changed from 45 degrees (in 1950) to 65 degrees (in 1955) and the quantity of contrast medium was increased. Many modifications have been carried out in the tilt of patients at 60 to 75 degrees from the horizontal[38][39].

Greitz[7] examined 27 patients with ascending venography and noticed that

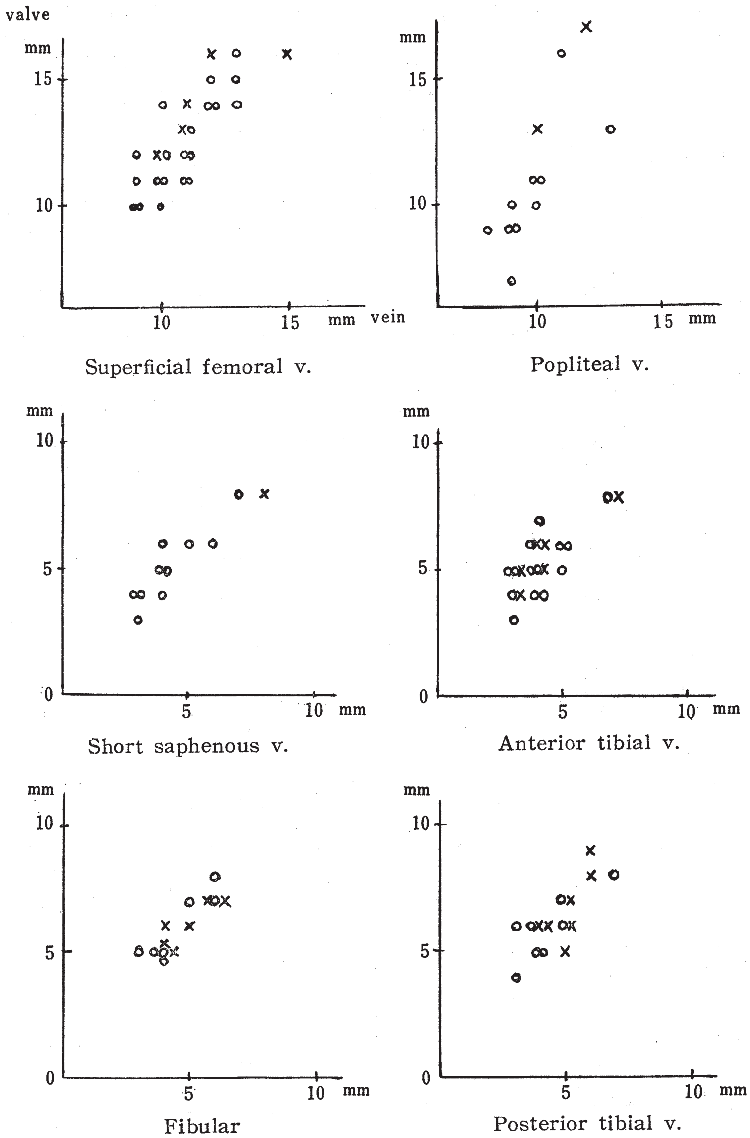


FIG. 13. The width of the veins versus their valves
○ competent valves
× incompetent valves

the relationship between the thickness of the layer of contrast medium and serum varied, as the tilt of patients changed. To give a clearer picture of this condition he carried out an experiment *in vitro*. According to him, contrast medium followed the superior wall of a tube for several inches, and in an absolutely vertical tube with the blood stream directed upwards a laminal flow, which would appear as a layer formation, may be obtained. After repeating clinical experience based on his experimental findings, he concluded that the table tilt at 65 degrees was suitable, patients then being in a comfortable position.

In the present clinical study, ascending venography was carried out in patients tilted at 45 to 60 degrees from the horizontal plane according to Greitz's examination[7]. Consequently, the popliteal veins and deep lower leg veins were visualized in about 75% but the superficial femoral veins were opacified in about 70%, and the long saphenous veins were more evident than before exercise due to regurgitation from its proximal junction.

Therefore, the present author improved the method of percutaneous injection into the common femoral vein[7] in order to obtain crucial details of the upper part of this vein.

Retrograde Venography

Retrograde venography of the lower extremity was first introduced by McPheeters *et al.*[3], who injected Lipiodol into the varicose saphenous vein, and observed its spread by fluoroscopy, taking X-ray films at various stages.

Luke[9,40] also reported on retrograde venography. A small catheter was introduced through the saphenous stump, the patient was placed upright on the tilted table, Diodrast injection was carried out through the catheter, and 3 pictures were taken in rapid succesion. Satisfactory pictures were obtained in 18 of the 28 studied, and revealed valvular incompetence with varying degrees of deep vein deformity, and saphenous varices. Starkloff *et al.*[41] developed a similar method with a catheter. They reported that delay in emptying and retrograde flow of the contrast medium in the upright position were findings of great significance.

Sylwan[11] described retrograde venography in which the patient was placed on the tilted table at an angle of 65 degrees from the horizontal plane and the femoral vein was punctured directed toward the knee, immediately below the inguinal ligament.

Schumacker *et al.*[16], injecting the contrast medium percutaneously directly into the femoral vein with the patient tilted 60 degrees from the horizontal position, obtained opacification of the common femoral vein only to the first or second valve station. Further, they undertook popliteal venography with percutaneous injection in the popliteal space. This type of popliteal venography clearly outlined the femoral and popliteal veins. Significant regurgitation was observed in 7 of 10 studied in the femoral vein, and varices of the leg were opacified diffusely. A varying amount of regurgitation into the deep veins of the leg likely occured.

The present experimental study showed that the relationship between the opacification of the glass tube and the quantity of the regurgitation of contrast medium depended upon the angle from the horizontal plane, and a clearer contrast was obtained at angles from 45 to 60 degrees from the horizontal plane. Immediately after retrograde injection, the layer formation of the heavier contrast medium was seen, but soon after the contrast medium became mixed with the solution and moved with it. Since clear difference of visualization as seen *in vitro* could not be found in clinical venograms, it is not necessary to fix the angle of the X-ray table according to the condition of the patient examined.

The present clinical study showed that the radiopaque medium drifted downwards the distal portion of the leg veins in one half of the cases, and especially, 2 of 6 cases with incompetent thigh deep veins examined showed regurgitation to the ankle level. Good filling of veins in the presence of venous insufficiency is due probably to the relatively heavier specific gravity of the dye used and to the slow distal blood flow of the blood stream.

By using 76% Urografin of higher specific gravity (1.42 g/ml), 93% of the superficial femoral veins were shown up, and about one half of cases of the deep leg veins were demonstrated without overlapping by numerous venous networks. Fifty to 60% of the long saphenous veins were opacified through the entire extremity. Visualization of the communicators was possible in about 50% in the leg by ascending venography, and almost the same in the thigh by retrograde venography.

By using 54% Urografin of lighter specific gravity (1.20 g/ml), visualization of the lower half of the deep thigh veins was decreased to 50 to 60%. Proximal femoral venography may be expected to give more information as a valuable supplement to other methods of determining the cases of chronic venous insufficiency of the lower extremity. It is a simple procedure, and the results thus far obtained have been helpfull and informative in the selection of cases for deep vein imcompetency.

Serial retrograde venography of relatively short interval was performed with 40 ml of 76% Urografin. The regurgitation in the superficial femoral vein was seen in the initial phase of 12 seconds, but becoming mixed with venous blood below the knee level, the velocity of retrograde flow to the deep leg veins was decreased, and three deep veins in the leg were opacified gradually downward during the next 36 seconds (Fig. 13).

Contrast Medium in Ascending Venography

Percutaneous venipuncture into one of the superficial veins of the dorsum of the foot or ankle has been carried out by numerous authors[7][21][31][38][39].

Felder *et al.*[12] described the ascending venography with rubber tourniquets. The first 20 ml of Diodrast was injected into a small vein of the dorsum of the foot as rapidly as possible, followed by a second 20 ml, and intravenous infusion of 100 ml of 5% dextrose at a rapid rate. This made a total of 40 ml of Diodrast injected into each, or 80 ml in all. The films were exposed 90 seconds after the completion of the injection, after two stereo exposures of the legs, and one exposure of the thighs. Comparison of percentages of visualization between two studies, 1. using 40 ml of contrast medium (in 1952) and 2. using 80 ml in the postphlebitic limb (in 1954)[42], showed that the communicating veins of the leg and thigh were visualized about 11% in the former and over 80% in the latter using a new technique. The superficial femoral vein was visualized in 80%, and the popliteal vein in 92% of the studies. He reported some reactions in 84 of the cases studied; namely, acute thrombophlebitis in 1.2%, nausea when the patients were lowered to the horizontal position, and syncope in 1.2% towards the end of the study.

Sanders[36] reported that 45 ml of 60% Conray was slowly injected and three exposures were made over one and a half minutes after the injection. In his report, he used the up and down exercise of the toes to enhance filling of femoral and iliac veins but not to test the emptying of the deep veins.

Bauer *et al.*[43] stressed that the method of exposing a vein was not only unsuitable due to the risk of ulceration developing in the devitalized tissue, but also to be unnecessary. It is always possible to perform percutaneous injection at least in all cases suffering from chronic venous insufficiency. It is not generally agreed that the puncture should be carried out as distally as possible, preferably on the dorsum of the foot.

In the present study, percutaneous venous puncture into the superficial veins on the dorsum of the foot or the distal end of the long saphenous vein in the medial malleolus was carried out. Sixty seconds after percutaneous injection of 40 ml of Urografin, the first film was taken. A second exposure was made 30 sec. after the first exposure. Making a bi-plane exposure, demonstration of the deep leg veins became possible with moreover communicators and short saphenous veins also shown up. A third film taken about 60 sec. after the second showed the emptying of the deep leg veins, the filling of the deep thigh veins, and the regurgitation of the long saphenous veins from its proximal junction.

The filling rate of the femoral vein was enhanced by exercise from 50 to 70% before exercise to 76% after exercise, but the popliteal vein remained at 76%, without showing any influence of the exercise.

Contrast Medium in Retrograde Venography

Sylwan[11] reported that 40 ml of Umbradil was injected in two parts, 20 ml very slowly in more than one minute and a further 20 ml as quickly as possible. Films of the thigh, knee and calf were taken at each phase in the sagittal and lateral planes.

The contrast medium at times runs down the long saphenous vein to outline the subcutaneous veins of the calf. The superficial femoral vein is filled rapidly with dense contrast medium which pass up veins from below via the communicating vessels from the superficial veins. Pathological changes in the deep veins of the thigh may be shown by means of retrograde venography. This is not possible by other methods of investigation.

In retrograde venography of the present study, the percutaneous venipuncture was performed in the horizontal plane so as to free a patient from anxiety and discomfort during the treatment. The Teflon needle in the vein was well fixed to the skin with a tape to prevent the injury of punctured veins. The veins punctured percutaneously in the groin were the common femoral vein, superficial femoral vein, deep femoral vein and long saphenous vein. Wherever veins were punctured, injection was carried out slowly with minimal pressure without influencing the physiological venous pressure by abnormal pressure. The results were nevertheless usually almost the same.

The present study demonstrated, in high speed serial retrograde venography with Elma-Schönander film changer of Gidlund type (at the interval of 2 to 5 sec) that Urografin injected into the long saphenous vein drifted downward along the vein wall and passed through the gap of valvular cusps. It is supposed that normal vein valves may vary greatly in their function, allowing blood to flow in a retrograde direction in many cases, and if there is a slowly ascending blood flow in the femoral vein, it keeps the valves slightly open, and allows the descending contrast medium to travel down between them (Fig. 14).

Comparative retrograde venography was taken using Urografin of heavier and lighter specific gravities. In cases of clinically mild varices, it was found frequently that Urografin of heavier specific gravity drifted downward in the deep veins of the leg, but regurgitation of Urografin of lighter specific gravity was less (Fig. 10). In severer cases, Urografin drifted downward in the same manner regardless of specific gravity (Fig. 11).

According to Halliday[17], large amounts of Urografin were administrated to patients who underwent bilateral venography from the ankles to the inferior vena cava (240 ml Urografin 30% plus 60 ml 60% plus 40 ml 76%). This dose was exceeded in 2 patients and produced a mild pyrexia, sensation of heat in the extremities, and pronounced flushing of the face. No systematic reactions occurred. The use of large quantities of the contrast medium improves the clarity of the films. The tendency to faint during the examination is a common phenomenon. It may be countered by premedication in the same manner as before surgery.

The dose of Urografin in the present study was 80 ml of a 60% solution in ascending venography or 40 ml of 76% plus 40 ml of 54% in retrograde venography per day. No accident occurred as a result of this precedure. Nausea and discomfort were seen in about 20% of the cases. These disap-

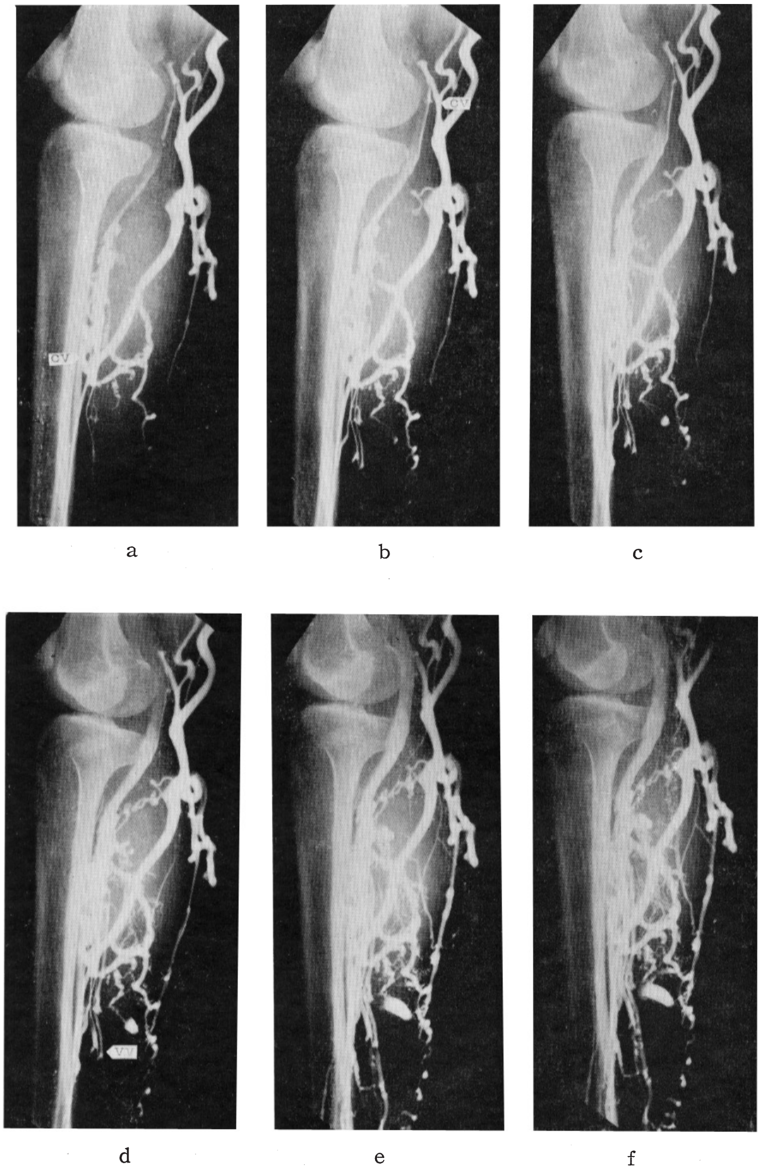


FIG. 14. Six high speed serial retrograde venographs Y.M. (left).

a, b, c ··· and g taken 8, 12, 22, 27, 32, and 42 secs. after injection, respectively. a and b) Urografin seen to flow into the deep leg and popliteal veins through two communicating veins. Upper vein has marked valve, c and d) below relatively competent valves of the post tibial vein, layer formation is seen. The flow down into the long saphenous, deep and superficial varicose veins are seen. e and f) Regurgitation continues through the deep venous valve, in spite of these veins showing watertight function. Venous return scarcely shown in the popliteal vein.

peared soon after return of the patient to the horizontal position and venous infusion of saline solution.

Valves

Initially, the regurgitation was considered as an evidence of incompetent valves and the incompetence of valves in the deep circulation might be associated with symptoms of venous stasis, just as is found in varicose veins. The injected radiopaque solution is heavier than blood and conceivably pass down between the valves even if blood does not.

Luke[44] could not find any symptoms or signs to indicate deep venous incompetence and reported rather that retrograde flow was permitted in different degrees because valvular efficiency varies tremendously from person to person, and that some retrograde flow should be considered a normal phenomenon, and that physiologically these valves are not the watertight system previously supposed.

The present study showed that excellent and almost good visualization of venous valves can result in about 40% of the deep thigh vein in retrograde venography, and in about 45 to 50% of the deep leg veins in both ascending and retrograde venographies. But the long asaphenous valves were scarcely visible, since the valves themselves disappeared before the examination. Observation of regurgitation by Urografin of heavier specific gravity and of a lighter one showed that Uregrafin flowed down more distally in severer cases regardless of specific gravity. The function of the deep venous valves was parallel with the clinical symptoms of varicose veins.

Communicating Veins

Massell *et at.*[21] performed ascending venography with three tourniquets placed just above the malleoli, a few centimeters above the femoral condylus, and as high as possible on the thigh respectively. All these tourniquets were adjusted to hinder but not completely obstruct the flow of blood through the deep veins. Incompetence was not often encountered in the veins which connect the superficial and deep venous systems in the thigh. On the other hand, superficial veins which were filled from incompetent communicators above or below might overlap the deep vein system and simulate communicating veins. Incompetent communicating veins would be visible by roentgenray, only when there was good filling of the deep veins with which they were connected. Slow injection and proper use of tourniquets avoided flooding of the superficial veins, which could confuse interpretation[23].

DeWeese[31] described that if only a few communicators and collaterals were visualized in the presence of normal deep thigh veins, they tended to empty after exercise. But in the presence of abnormal thigh veins, they were more likely to fill or increase in number after exercise. Communicators in extremities with varices were demonstrated in about 70%, but they were seen in only one case of 13 normal extremities.

The regurgitation of communicating veins from the deep veins, namely opacification, should not depend on their anatomy and physiology. Hence, visualized communicating veins show the probable presence of hemodynamical disturbance or incompetence, whether dilatation and tortuosity are seen or not (Table 8).

TABLE 8. Classification of the Communicating Veins

	Diameter (mm)	Ascending venography			Retrograde venography		
		Good	Incompetent	Total	Good	Incompetent	Total
Thigh	1						
	2	2	1	3	10	3	13
	3	1	2	3	6	1	7
	4				2	2	4
	5					1	1
Knee	1				1		1
	2				4	1	5
Leg	1	1		1		4	
	2	2	4	26	2	3	4
	3	5	20	25	1	2	5
	4		3	3		1	3
	5		7	7		1	1
	6		1	1			1

The author performed ascending venography with the tourniquets placed round the calf. However, flooding to the superficial veins could not be avoided as was expected.

The present clinical study showed that in ascending venography about 70% of visualization was obtained in the deep veins in the thigh and leg. The deep veins in the leg, which were obscure due to opacification of numerous superficial varicose veins, were decided to be non-visualized. The visualization of the communicators was obtained in a few cases in the thigh and in 70% in the leg.

On the other hand, in retrograde venography, this flooding was scarcely seen, and detailed record of the function of the deep veins was taken, as well as their clear pattern and structure. Though the visualization in the lower leg was less than 60%, diagnostic informations can be taken from opacified deep veins, if they could be filled. Communicators were seen in 50% in the thigh and 25% in the leg.

Thus, two methods are necessary to diagnose the incompetent communicators in lower extremities with varicose veins.

Emptying

Schumacker *et al.*[16] reported on retrograde venography, where exposure of the first film was made immediately after the injection, and the patient was urged to exercise vigorously by raising himself on his toe 10 times, and the second exposure was made approximately one minute after the first exposure. Significant regurgitation was observed in 7 of 10 studied, in the thigh and midleg. In all of the cases, after the exercise, the superficial and deep femoral veins were completely emptied, through often small amounts of medium could be seen hanging in valve cusp areas and occasionally small branches were still faintly opacified. The distended varices, following the exercise, were more diffusely but less densely opacified due partially to the dilution of the injected solution and partially to the proximal passage of a significant portion of it in the deep circulation.

The present author performed ascending venography mainly at a tilt of 60 degrees. The patient was made to exercise by moving his foot 10 times energetically for the purpose of enhancing the filling of the femoral veins but not for emptying. After the exercise, about 60% of the deep veins in the leg tended to empty, but the superficial femoral veins appeared to fill and increase their number. Though the present author tried to keep contrast medium away from the superficial veins with tourniquets, many portions of the superficial veins were opacified through incompetent communicating veins. Since there may be much dilution and pooling of contrast medium in the foot and calf, in patients with severer venous stasis associated with varicose veins, the deep veins of cases, severe and mild, can not be emptied completely by the same exercise. The present author must admit that straining and foot exercise were practised incompletely because of fainting or nausea in about 20% of the cases studied.

Though poor in ascending venography, it is found that the emptying of the deep leg veins is excellent in retrograde venography. Hence, if some deep veins are previously supposed to be incompetent by ascending venography, it will be found by retrograde venography that the function of venous return is maintained, though regurgitation is seen.

Serial Film Changer

DeWeese *at al.*[31] reported ascending venography by serial long film technique. The first exposure was made on a 14 by 36 inches size film, and at the end of the injection a second long roentgenogram was taken with the body at 60 degrees from the horizontal plane. Spring cocking cassettes with intensifying screens were mounted under the top of a tilting table. Cassette-changing in the tray was easy in serial venography performed in the semierect position, as there is no great pressure of speed as in serial arteriography[32].

Wagner[45], in intra osseous venography, employed a serial film changer which accomodated four 12 by 48 inches cassettes in a drum. Examination was performed in the supine position, and if opacification is inadequate, a tilting table was made available, from the horizontal to 15 to 30 degrees semi-upright positions. They[30)31)45)] constructed and used the 4 to 6 long film changer for venography, but in Japan these types of film changer have not yet been used.

In the present study, the serial long film changer was deviced for venography of the lower extremity. The roentgen exposure is made at intervals of 2 to 30 sec. automatically. This unit was convenient; as the patient may experience no discomfort during percutaneous venipuncture and the procedures conducted smoothly; when the leaning patient experiences discomfort, nausea or syncopal attack during the injection, the changer may be quickly lowered to the horizontal plane; the work can be carried out with a feeling of confidence; the use of long films made it possible to study the hemodynamics of the entire lower extremity with varicose veins.

SUMMARY

In order to study the hemodynamics of varicose veins in the lower extremities, serial retrograde venography was carried out using a newly devised equipment. Advantages of the technique and the favorable results are summarized as follows:

1. Using a serial long film changer, it is possible make to four serial full length venography with adequate angles and intervals. Position exchange during the procedure can be made so smoothly that patient experience no discomfort.

2. In retrograde venography regurgitation of the contrast medium, to below the bifurcation of the deep lower leg vein occurs, though not too much, and the deep thigh and leg veins are well visualized, though the deep thigh veins are poorly opacified in ascending venography.

3. By retrograde venography, the deep venous valves, communicating veins and valvular function of the deep veins were demonstrated to be near the physiological state.

4. By performing serial retrograde venography at relatively short intervals, regurgitation of the deep vein can be demonstrated more clearly, and may show other clinical findings which have not been made hitherto by usual functional test and venography. Further progress in the study of the physiology of venous valves can be expected.

5. Retrograde venography is a safe and convenient method of studying the hemodynamics of the varicose veins in the lower extremities.

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