

THE POST-THROMBOTIC ULCERATION OF THE LOWER EXTREMITY: ITS ETIOLOGY AND SURGICAL TREATMENT*

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INTRODUCTION

CHRONIC ULCERATION OF the lower extremity following deep venous thrombosis is a condition that undoubtedly has plagued the human race since man assumed the erect position. There have been various recent estimates of its incidence in different countries. Roholm, according to Bauer,¹ in 1942, estimated that there were between 5000 and 15,000 patients with ulcers of the legs in Denmark in 1937. Wright,²¹ in 1931, estimated that there were 250,000 in the British Isles. No figures are available for the United States, but the incidence is probably comparable, and a conservative estimate is that there are between 300,000 and 400,000 cases in this country. The man hours of work lost to industry because of this disease are incalculable, as is the amount of suffering of those afflicted. The actual amount of money spent on treatment and alleged cures, by all the patients, in addition to the wages lost, must be in the astronomical figures. It is not infrequent to see patients who have spent from \$2000.00 to \$5000.00 for treatment, with no permanent improvement except for temporary healing, and in many cases the ulcerations have even become larger following some forms of treatment that have been used.

The results of therapy in general, from the viewpoint of a cure, have not improved greatly during the past two and one half

centuries. This is due, chiefly it is believed, to a failure to understand the basic pathological physiology of the condition, and in part because the care of the patients in most clinics is delegated to the youngest and least experienced members. Even today, it is much the same as in 1801, when Home¹⁰ wrote: "It has been unpropitious to the improvement of the treatment of ulcers on the leg, that they have been universally admitted to be the most unmanageable cases which become the object of surgery; that they are cases in which the most eminent surgeons are too often known to fail in performing a cure; and therefore, bring no imputation of want of skill on those practitioners who happen to prove unsuccessful. This has led the younger part of the profession in the army to be too diffident of their own ability; to despair of success where so many have failed, and to follow a beaten track, in which so little advance has been made, that ulcers on the leg are not unjustly considered as the opprobrium of surgery."

The medical and surgical literature is replete with numerous methods of alleged cures, but the multiplicity suggests the ineffectiveness of the majority. Reliable statistics, furthermore, on a sufficient number of patients treated by any one method over a period long enough to assay its value, are notably absent from the numerous reports. It is of extreme significance that a post-thrombotic ulceration of the lower extremity is a chronic disease, so that the cura-

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tive value of any form of therapy can be determined only on the results obtained after a sufficient period of time has elapsed since the therapy was instituted. The ineffectiveness of producing a cure by the more common surgical methods of treatment is demonstrated by the following statistics* on a group of 131 patients treated at the Massachusetts General Hospital after two to five year follow-up periods.

(1) A split-thickness skin graft to the ulcer was performed in five cases, with recurrence of the ulceration in all five, or 100 per cent recurrence. (2) Excision of the ulcer and the abnormal skin and tissue around it, including the deep fascia beneath it, down to normal muscles and tendons, then covering the raw surface immediately with a split-thickness skin graft, as advocated by Homans,⁹ was performed on 13 extremities; only three, or 23 per cent, were healed, and ten, or 77 per cent, recurred. (3) Ligation and division of the long saphenous vein, for an unaccountable reason, gave slightly better results, since in this group ten, or 50 per cent, were healed and the same number unhealed. (4) Lumbar sympathectomy, an operation which is not performed in our clinic at the present time for the postthrombotic syndrome, with or without ulceration, because of the development of serious postsympathectomy complications in some of the cases, was performed in eight patients, four, or 50 per cent, were healed, and a similar number were unhealed. (5) Ligation and division of the communicating veins of the lower leg,¹³ but without removing the superficial veins or interrupting the deep venous system, as described in this article, was performed on 49 extremities; in this group 27, or 55 per cent, were healed and 22, or 45 per cent, were unhealed. From these statistics it is obvious that none of the meth-

ods, even the latter with a healed rate of only 55 per cent, gave good enough results to warrant continuing their practice. (6) In 1948, another method was recommended from our clinic¹⁴ consisting of interruption of the superficial femoral vein and ligation and stripping of the long and short saphenous veins. This procedure was performed on 36 extremities, and at the end of three years there was a recurrence of ulcerations in approximately 60 per cent of the cases. (7) Popliteal vein interruption, as advocated by Bauer,² has not proven in our hands to yield any better results than these other methods. Because of the poor results, all these procedures have been abandoned in our clinic for the treatment of the postthrombotic syndrome with ulceration.

The purpose of this paper is to review briefly the anatomy of the venous systems of the lower extremity, to discuss some aspects of the pathological physiology of the post thrombotic type of ulceration, and to correlate these data with a more radical method of surgical treatment than has been previously recommended, which includes interruption of the deep venous system in the thigh, and the veins of the communicating system in the lower leg, in conjunction with a radical removal of the superficial system of veins and partial removal of the deep fascia of the lower leg.

ANATOMY

The veins of the lower extremity consist of three systems, the superficial, the deep, and the communicating veins. The superficial system is made up of the long, or internal, and the short, or the external saphenous veins and their numerous tributaries. There are many osculations between these two veins, especially in the lower leg below the knee. In the normal extremity all of these vessels contain bicuspid valves that permit the blood to flow only cephalad. The veins of the deep venous system in the normal lower extremity are the main chan-

* These were collected with the assistance of Dr. Philip J. Morrison, now Chief Surgeon, Veterans Administration, Wilkes-Barre, Penna.

nels through which blood returns to the large veins in the trunk. They consist of the common femoral, superficial femoral, deep femoral and popliteal veins in the thigh; and below the knee the posterior tibial, the anterior tibial and the peroneal veins. These vessels, like the superficial veins, contain segmentally arranged bicuspid valves that permit blood to flow only toward the heart. The communicating veins in the thigh connecting the femoral and the long saphenous vein are relatively few in number, but many occur in the lower leg joining the deep and the superficial systems. All of these communicating veins contain bicuspid valves which permit blood in the normal extremity to flow only from the superficial veins to the deep ones. They have been described in a previous report published in 1938 by the author,¹² and more recently Sherman¹⁹ has elaborated upon the ones in the thigh. The valves of these vessels, especially those just above the medial malleolus on the inner side of the lower leg, the most common site of chronic ulcerations, become incompetent in the post thrombotic state. This, it is believed, occurs because the communicating veins in this location receive so little support from the tendons through which they pass, that they become dilated and incompetent from the increased venous pressure which occurs in the post thrombotic extremity. The superficial system of veins for the most part lie beneath the skin in the subcutaneous tissues, from which they receive little external support. As a result they likewise become dilated and their valves incompetent in this condition. It is important to remember that these three systems of veins, with their bicuspid valves, the muscles and the fascial covering of the lower extremity, constitute what has been termed "the venous heart," which, when normal, actually pumps the blood back toward the heart during muscular activity.

Any discussion regarding the etiology of the post thrombotic ulceration should in-

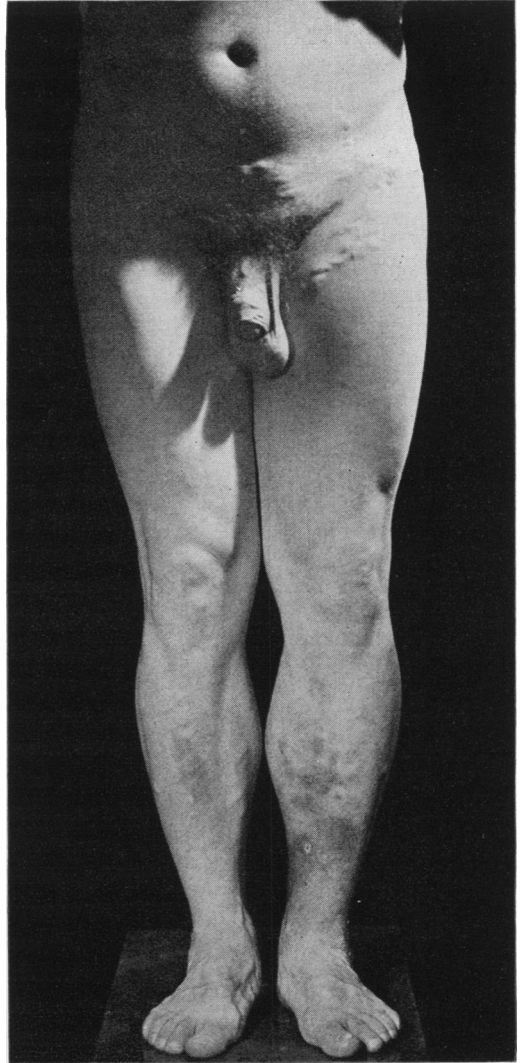


FIG. 1. A photograph of the extremities of a man 32 years of age, demonstrating the thrombotic sequelae, four years following a deep venous thrombosis of the left lower extremity, secondary to an operation for acute appendicitis. These are (1) edema, (2) pigmentation, (3) varicose veins, (4) stasis cellulitis, or the brawny induration of the subcutaneous tissues seen usually on the inner side of the lower leg, (5) stasis dermatitis and (6) chronic ulceration. Note the varicose veins in the upper left thigh and lower abdomen, which develop following canalization of the deep venous system, and in the majority of patients do not represent collateral venous channels for the return of blood from the extremity.

clude the lymphatics of the lower extremity, since they, as well as the veins, are damaged by the preexisting thrombotic

state. This is demonstrated by the fact that the most common thrombotic sequela in our patients was lymphedema of the limb, as it was found in 100 per cent of the extremities.¹⁴ Chronic lymphedema is one of the least well understood pathological conditions that involves the lower extremities, but it is believed that in the post thrombotic syndrome, it probably results from lymphatic obstruction due to scarring and fibrosis, which develops in the perivascular tissues of the femoral blood vessels, and secondarily involves the lymphatic vessels that lie in such close proximity to them. The role of lymphedema in the etiology of the post thrombotic ulcer of the lower extremity has never been satisfactorily explained. It would appear that it alone is not the sole cause, because chronic ulcerations are rarely seen in the presence of elephantiasis of the lower extremity without venous pathology. Undoubtedly it plays a role, however, because in this type of ulceration, edema of the subcutaneous tissues is universally present, and if not controlled by a proper elastic support, the permanent healing of the ulceration is difficult to maintain.

PATHOLOGIC PHYSIOLOGY

There is a widespread belief among the medical profession that the thrombotic sequelae, including chronic ulceration, occur because the deep venous system remains occluded indefinitely, and furthermore, that the varicosities of the long saphenous system which develop especially in the upper part of the thigh and may extend on to the lower abdomen (Fig. 1), represent collateral venous channels through which the blood must necessarily leave the limb. A better understanding of the pathologic physiology of the post-thrombotic syndrome, however, throws a great deal of doubt on this theory. Instead it is now believed that the thrombotic sequelae develop because of canalization of the deep venous system, with a resulting

derangement of the normal venous physiology in the lower extremity. A number of attempts^{4, 7} have been made in the past to determine if there are abnormalities in the venous blood and the lymph which might explain the etiology of the post-thrombotic changes in the limb, but none has contributed to the solution of the problem.

Another theory held by some of the earlier writers was that the ulcerations were secondary to ischemia of the integument, due to constriction of capillary bed from the extensive scar tissue underneath and around the ulceration. This theory now seems untenable because of the good results obtained without removing this scar tissue by the method to be described. It is now believed that quite to the contrary, the ulcerations result from too much blood under too great a pressure. This opinion is substantiated by the following facts: (1) The scar tissue is not removed by the method described here; (2) instead, the surgical procedure is directed against the venous systems of the lower extremity; and (3) a higher percentage of healed ulcers has been obtained by this method with better cosmetic results than by any other method.

VENOUS PRESSURES

A study of the venous pressures (1) in the lower extremity with normal veins, (2) in one with simple varicose veins and (3) in another with the post thrombotic syndrome, gives very valuable information in regard to the pathological state arising from venous disorders of the lower extremity. They have been reported by several authorities,^{3, 6, 8, 17, 20} and there is general agreement as regards the actual pressure values.

A. *The Normal Extremity.* The venous pressure in the normal lower extremity with competent venous valves, while standing in the erect position, in all three venous systems is equal approximately to the pressure exerted by a column of blood extend-

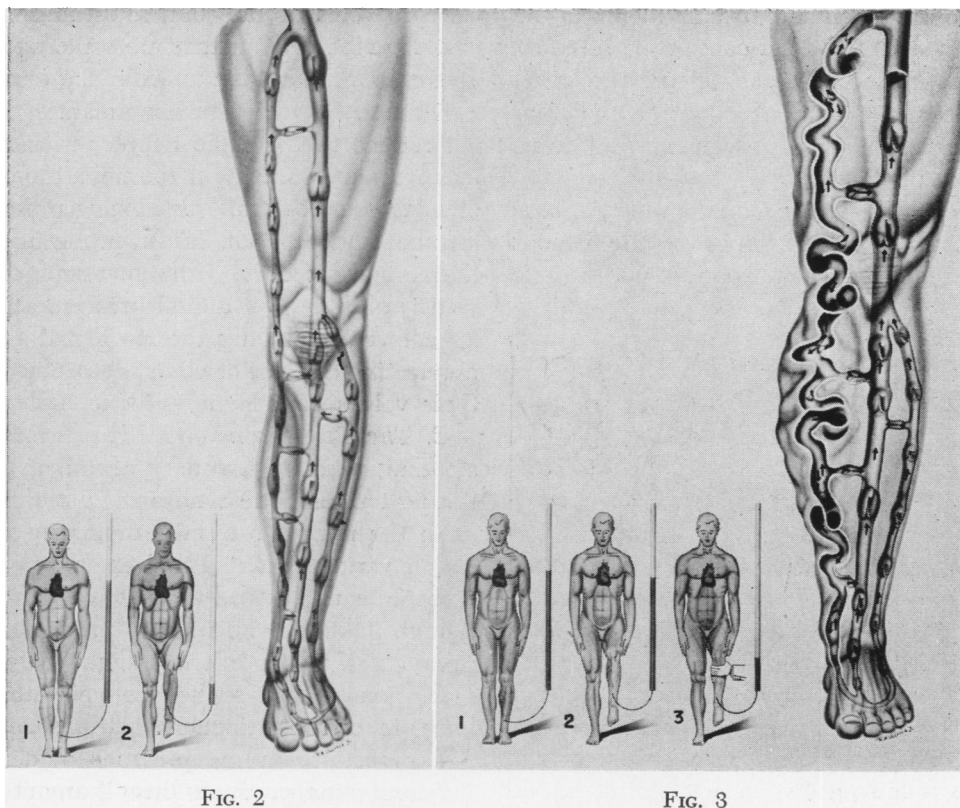


FIG. 2

FIG. 3

FIG. 2. An artist's drawing to show the normal venous pattern in the lower extremity, consisting of the superficial, deep and communicating systems of veins. These vessels all contain bicuspid valves which permit blood to flow only toward the heart in the former two, and from the superficial to the deep systems in the latter one, as indicated by the direction of the arrows. These veins, with their valves, the muscles of the lower extremity and the fascial sheaths surrounding them, constitute what is known as the "venous heart" of the lower extremity. *Inset 1.* demonstrates the standing venous pressure in the lower leg by cannulating the long saphenous vein. *Inset 2.* demonstrates the marked fall in the venous pressure during walking, indicating a normal functioning "venous heart."

FIG. 3. An artist's drawing to show the venous pattern in the lower extremity in a patient with simple varicose veins of the long saphenous system, which allows blood to flow in either direction in it. The external saphenous, deep and communicating veins are all normal. *Inset 1.* demonstrates the standing venous pressure is the same as in the normal extremity. *Inset 2.* demonstrates only a slight reduction in the venous pressure on walking because of the incompetent valves of the saphenous system so that a state of ambulatory venous hypertension exists in the long saphenous system. *Inset 3.* demonstrates a marked reduction in the venous pressure during walking when the trunk of the long saphenous vein is occluded by digital pressure. These observations indicate normal deep and communicating systems of veins, with an incompetent long saphenous system.

ing from the level of the right auricle to the point on the lower extremity where the venous system has been cannulated. The standing venous pressure at the ankle approaches that of the arterial system, that is, in the neighborhood of 100 to 120 mm. of Hg., indicating the great pressure to which

the walls of these veins are exposed, even in the normal individual. A remarkable reduction in the standing venous pressure can be demonstrated during walking, due to the pumping action of the "venous heart" in the normal lower extremity (Fig. 2). Under these conditions, the pressure will

tend to approach zero, usually being in the vicinity of 30 to 40 per cent of the standing venous pressure. The actual pressure level will depend to a great extent on the competency of the venous valves in all three systems of veins.

B. The Extremity with Simple Varicose Veins. If similar readings of the venous pressure are taken in a patient with simple

varicose veins of the long saphenous system, it will be found that the standing venous pressure is the same as in the normal individual, but the walking pressure does not reduce to the same degree; in fact it may remain essentially the same in the case of severe varicosities. The walking pressure can be made to fall, however, similar to the normal response, if the long saphenous vein is occluded by digital pressure at the knee level, providing the deep and communicating systems of veins are patent and their valves competent (Fig. 3).

C. The Post-thrombotic Extremity. The standing venous pressure in a patient with the post thrombotic syndrome is the same as in the normal extremity or in one with simple varicose veins. The pressure remains essentially unchanged during walking, although there may be a slight diminution in some cases, and in others a slight increase. Occlusion of the saphenous vein at the knee, in contradistinction to the effect of this procedure in the presence of simple varicose veins, produces little if any reduction in the pressure, which indicates that the valves of the communicating and deep systems of veins are incompetent, thus reducing the efficiency of the "venous heart." It is possible, therefore, in the presence of simple varicose veins, and in the post-thrombotic syndrome, to speak of a state of *ambulatory venous hypertension* which is most marked in the latter (Fig. 4).

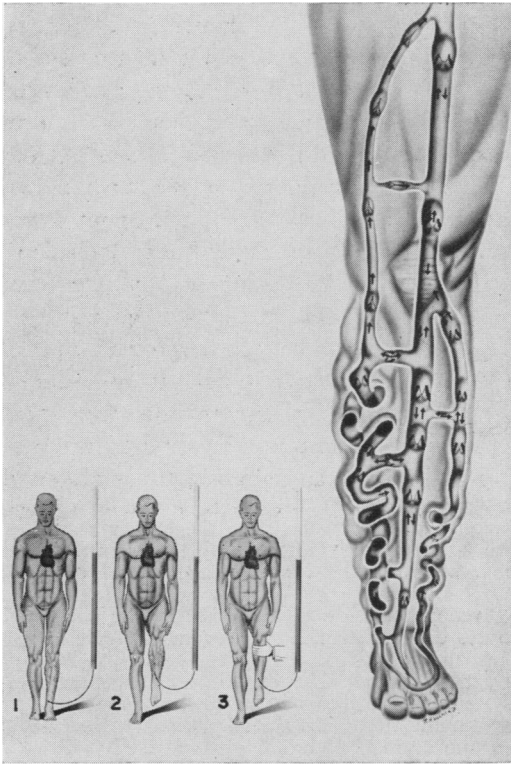


FIG. 4. An artist's drawing to show the venous pattern in the post-thrombotic lower extremity, and to demonstrate the loss of function of the "venous heart" in this condition. Note that the deep venous system has canalized, and all the veins of the superficial deep and communicating systems are incompetent except the long saphenous trunk in the thigh, as indicated by the direction of the arrows. *Inset 1.* demonstrates that the standing venous pressure is the same as in the normal extremity and the one with simple varicose veins. *Inset 2 and 3.* demonstrate that on walking with or without occlusion of the saphenous vein there is no change in the venous pressure, so that in the post-thrombotic extremity a state of ambulatory venous hypertension exists in all the venous systems of the lower extremity, the result of incompetence of the venous valves in all of them, which, it is believed, explains the etiology of the thrombotic sequelae.

ETIOLOGY OF THE THROMBOTIC SEQUELAE

The sequelae of deep venous thrombosis which characterizes the post-thrombotic state consist of the following in the order of their frequency: edema, pain, pigmentation, varicose veins, stasis dermatitis, stasis cellulitis and chronic ulceration (Fig. 1). It is believed that they arise because of the ambulatory venous hypertension which develops as the result of canalization of the deep veins, with the resulting incompetence of the valves in the deep, communicating

and superficial veins of the lower extremity, and not because of occlusion of the deep venous system as is so commonly believed. Canalization of the deep veins occurs, probably within a relatively short period following thrombosis of them, because in over 400 femoral vein interruptions performed for the post-thrombotic syndrome, some within a year of the thrombotic process, all were found to be patent. The following sequence of events, it is thought, occurs after the deep venous system becomes canalized. First, the increased venous pressure resulting from the destruction of the valves of the deep veins is transmitted to the communicating system of veins, which, because of the lack of adequate support to their walls, especially on the inner side of the lower leg above the ankle, become dilated, and as a result, their valves become incompetent. The increased venous pressure is then transmitted to the superficial veins, and they in turn become dilated and incompetent, especially in the lower leg, since they have no supporting structures to prevent their dilatation. It is usually after all three systems of veins have become incompetent and dilated that the thrombotic sequelae involving the skin and subcutaneous tissues develop. As further evidence that it is not occlusion of the deep venous system which causes the thrombotic sequelae, it has been observed that permanent interruption of the deep system of veins at the level of the superficial femoral vein apparently does not lead to these chronic changes in the leg. At the Massachusetts General Hospital during the past 12 years the femoral veins in over 5000 limbs have been interrupted by ligation and division without the development of the sequelae, except in a few patients with pre-existing varicose veins. This absence of venous interruption sequelae has been especially true in the patients that were done for the prophylaxis of thromboembolic disease without signs of deep venous throm-

bosis at the time of femoral vein interruptions.

The post-thrombotic ulcer as a rule does not appear for a year or more following the original deep thrombosis. However, in some cases ulcerations have been seen within a year of the original thrombosis, but in each, the femoral vein has been found canalized at operation. As the state of ambulatory venous hypertension persists, varicosities of the communicating and superficial veins develop which undoubtedly play an important role as an etiological factor in the ulcerations. The fact that obliteration of the large subcutaneous veins by elastic adhesive bandages, paste boots, elastic bandages or the inflatable balloon type of stocking devised by Scott,¹⁸ will result in healing the vast majority of post-thrombotic ulcerations, is believed to be additional evidence that this derangement of the venous anatomy and physiology play an important role in the chronic skin and subcutaneous changes. It is important to understand that these methods of bandaging, in addition to keeping the superficial veins empty of blood, at the same time reestablish, in part at least, the normal action of the venous heart of the lower extremity, which it is believed undoubtedly explains the beneficial results obtained for the most part by these measures.

TREATMENT

The goal of any therapeutic procedure should be a complete cure of the condition for which the treatment is instituted, but for many diseased conditions it is not always possible to attain. However, in many, a great deal can be accomplished toward this goal. This is true of the post-thrombotic syndrome with or without ulceration, since it is impossible completely to restore the extremity to the normal condition which existed before the deep venous thrombosis occurred, because of the irreversible changes produced in the venous valves of

the deep venous system by the thrombotic process. Nevertheless it has been found possible to cure the chronic ulcerations and the stasis dermatitis in many of the extremities, and at the same time to ameliorate the other thrombotic sequelae.

Preoperative. It is necessary to have the ulcerations completely epithelialized and the areas of chronic dermatitis cleared up before the surgical procedure to be described is performed, in order to reduce to a minimum the danger of postoperative infection. This can be accomplished by either of two methods: (1) Complete bed rest with elevation of the extremity above the heart level, and the application of warm saline dressings to the ulcer three to four times each day. This method has the drawback that it is expensive because of the high cost of hospitalization, plus the fact that the individual can no longer perform his or her work and so earn a wage. It should be resorted to, therefore, only for huge, painful ulcerations. (2) An ambulatory method of healing the ulceration has been developed, which is much less expensive and permits the patient to continue at work. The purpose of this type of treatment is to obliterate all of the superficial veins of the lower leg by means of a large spongy dressing held in place with a very firm bandage. It is essential that this be applied so that it is absolutely fixed to the skin in order that it will not move about; if it moves, the ulceration will become more painful and will increase in size. The method that has been evolved is as follows: The skin of the entire leg, except for the ulcer, is painted with an alcoholic solution of resin to make the bandage and dressing adhere to the skin. A generous gauze dressing, with unmedicated vaseline, is applied directly to the ulcer. This relieves the pain in part, by preventing adherence of the gauze to the ulcer, and it also permits absorption of discharge from the ulcer into the dressing. This bland type of dressing

is recommended because the medicated ointments have little if any healing value, and if used routinely, allergic reactions will be encountered in some patients which are distressing both to the patient and the doctor. A topical agent which will heal these ulcerations is still being sought for, but as yet none has been found.

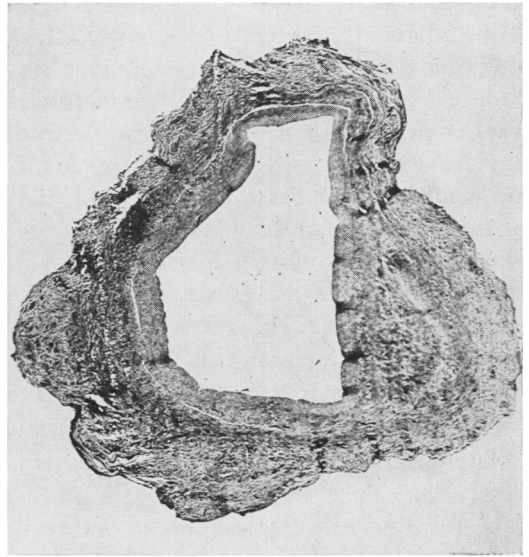


FIG. 5. An enlargement of a microphotograph of a canalized post-thrombotic superficial femoral vein, removed 11 years after the deep venous thrombosis. Note the marked thickening and fibrosis of the vein wall and the patent lumen which leaves it a rigid tube and without functioning valves.

The following statement made by Home¹⁰ in 1801, a century and a half ago, is believed to still hold true today: "From these observations, it must appear obvious that there is no probability that any one medicine can ever be discovered which, whether internally administered or locally applied, shall have powers adapted to the cure of all ulcers on the legs; and it would appear, the idea that such a medicine may exist has retarded very considerably the advancement of our knowledge and the treatment of ulcers by inducing surgeons to make use of the same applications to ulcers very different in their kind."

The lower leg is next bandaged with five to six layers of plain gauze bandage from the toes to just below the knee, using one complete roll of 4-inch width. This gauze bandage adheres to the skin because of the resin compound previously applied to it, thus preventing the dressing from slipping about on the skin, a point of utmost importance in the ambulatory treatment of these ulcerations. A thick layer of cellucotton is placed directly over the ulcer area and encircling the ankle just above the malleoli. An additional roll of the same material is placed over any large veins which may be seen leading into the ulcer area, and is incorporated into the gauze bandage to aid in obliteration of them. Finally a 4-inch wide, 60-inches long elastic adhesive bandage is wrapped over the gauze bandage, starting just above the ankle, then coming distalward, covering the heel and foot down to the toes, then returning back up the ankle and the leg to the knee and back down again to the ankle, thus covering the lower leg, ankle and foot with two layers of elastic adhesive bandage. The entire five feet of this elastic adhesive bandage is used, paying particular attention to obtain extra pressure over the cellucotton padding. It is best applied by wrapping the leg from the inside out, as it gives more adequate pressure over the ulcers on the inner side of the ankle and the veins feeding into them.

The purpose of this form of treatment is to apply a very firm elastic type of compression so that the superficial veins around and beneath the ulcer are completely obliterated. The bandaging, furthermore, when performed in the above manner, reestablishes the function of the venous heart, in part at least, since it prevents the pooling of blood in the subcutaneous venous reservoirs, and thereby favors the movement of it toward the heart during muscular activity. Ambulation is encouraged for this reason after the application of this type of

dressing. The first bandage is removed after one week; the next one in ten days to two weeks, depending upon the amount of drainage, and then it is changed every two weeks until the ulcer is epithelialized. Most ulcerations, unless they are very large, will heal usually within six to eight weeks. In most instances it is desirable to continue this type of treatment from two to four weeks after the ulceration has healed, in order that the tissues return more nearly to their normal state, and further to permit the body to destroy the bacteria which may be lying dormant in the tissues of these chronically infected areas.

Technic of Operative Procedure. The following surgical method of treatment of the thrombotic ulceration has a four-fold purpose: (1) to remove all the enlarged superficial veins, especially in the lower leg, namely the long and short saphenous veins and their tributaries; (2) to sever the communications between the deep and superficial systems of veins by dividing and ligating the communicating veins, especially those on the inner and posterior sides of the lower leg; (3) to interrupt the canalized and valveless venous system in the thigh (Fig. 5) and so prevent the reflux of blood through it from the larger proximal venous reservoirs, and also to shunt the blood through other venous channels that may still have functioning venous valves; and (4) to attempt restoration of the lymphatic drainage from the superficial tissues and the skin into those of the deeper muscular structures, by resection of the deep fascia of the lower leg, a procedure similar to that prescribed by Kondoleon¹¹ for chronic lymphedema.

An extensive surgical dissection, both in the groin and in the lower leg, is necessary to accomplish these aims. It is essential, therefore, that all ulcerations be healed and epithelialized, and the areas of dermatitis cleared up before surgery is performed. If the ulceration is too large to heal by the

ambulatory method described above, the patient is admitted to the hospital for saline dressings to the ulcer until it is cleaned up and healed, or if it is too large to heal under this treatment, a split-thickness skin graft is placed over the granulating area. In some instances of long standing chronic ulceration it may be necessary to excise the ulcer, as first described by Homans,⁹ with its base, including the deep fascia down to normal muscle, tendon and periosteum, covering the raw surface immediately with a split-thickness skin graft. This latter method, as a rule, even if the ulcer is cured, leaves such an ugly depression in the leg that it is used only as a last resort, especially in women. After the grafted area is well healed, the patient is discharged home with a firmly applied elastic adhesive bandage, as described above in the ambulatory treatment. This is changed at two-week intervals, and usually within four to six weeks the patient is readmitted for the definitive surgical procedure to be described below.

The first step is to expose the long saphenous and superficial femoral veins in the groin, using a vertical incision to facilitate exposure of the latter vein. The saphenofemoral junction is sought, and also that of the superficial femoral and *profunda femoris* veins. The dissection to expose the latter should start distalward on the superficial femoral vein and work proximalward until the *profunda femoris* branch is encountered. The common femoral vein should not be isolated and then traced distalward to its bifurcation because the dissection necessary to isolate one of these post-thrombotic veins may traumatize its walls, with resulting thrombosis and pulmonary embolism. Before interrupting the superficial femoral and saphenous veins, venous pressures with a saline manometer are taken in the former before and after temporary occlusion of them, as previously described.¹⁴ The superficial femoral vein is occluded first, and then it and the long saphenous together, in order to determine how much interference

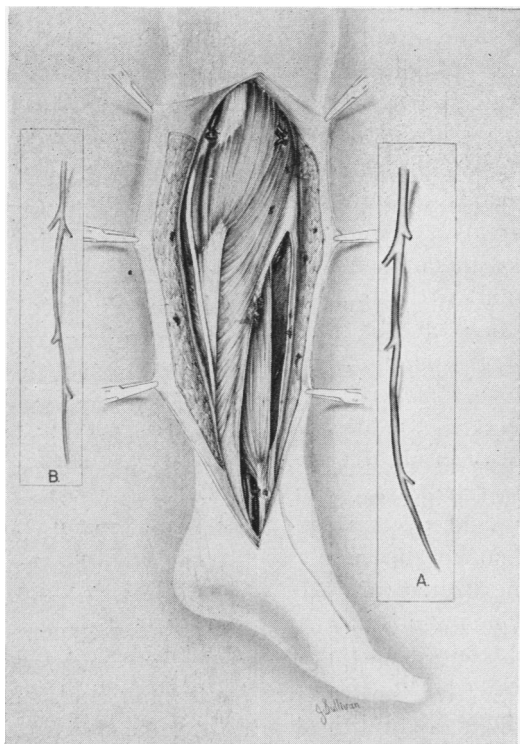


FIG. 6. An artist's drawing to show the ligation and division of the communicating veins on the inner and posterior aspects of the lower leg, the excision of the internal and external saphenous veins and a portion of the deep fascia. A longitudinal incision is made about 2 cm. posterior to the tibia from the level of the tibial tubercle to just below and posterior to the internal malleolus. The communicating veins between the posterior tibial and the superficial veins are ligated and divided and the internal (A) and the external (B) saphenous veins resected after excising some of the deep fascia to expose them. The distal end of each is also stripped down on to the foot by an intraluminal stripper. Care is taken to leave a 1 cm. rim of deep fascia on the edges of the incision to use for suturing in closing the incision. Interruption of the superficial femoral vein at its junction with the *profunda femoris* and the internal saphenous vein at the saphenofemoral junction, and the stripping of the latter to the upper end of the longitudinal incision are done to complete the recommended operative procedure. (Courtesy of Minnesota Medicine, 32: 38, 1949.)

to the venous return from the extremity, interruption of one or both of these vessels will produce. If the pressure rises over twice the initial value after interrupting the superficial femoral vein, it is considered unwise to interrupt this vessel. As a rule, however, the pressure seldom increases

more than a few centimeters of saline, and in some instances it has even fallen slightly.

The superficial femoral artery and vein are very intimately adherent to each other, the result of the periphlebitic fibrotic process, which develops at the time of the acute venous thrombosis and subsequent to it. Great care must be taken for this reason not to damage the artery, because if it is injured, thrombosis may develop and gangrene of the extremity result. Relatively blunt tipped, but sharp, scissors are used to dissect the artery and vein apart. The dissection is facilitated by retracting the vein away from the artery. The latter should never be grasped by an instrument or retracted by a piece of rubber tubing or a ligature, because of possible fracture of the arterial wall with a resulting thrombosis, which almost invariably results in gangrene of the extremity. Inadvertent damage to the vein is not as serious, because it is planned to interrupt this vessel after it has been isolated. The interruption of the superficial femoral vein should be by ligation and division. The ligature on the proximal end of it must be in close approximation to the profunda femoris branch, so that there is no cul de sac of the superficial femoral vein in which blood might stagnate to produce a thrombus, which could propagate into the common femoral vein with resulting pulmonary embolism. Ligation of the saphenous vein, for the same reason, is performed flush with the femoral vein.

The common femoral vein should never be interrupted in this surgical procedure because if it and the long saphenous both are, there remain too few adequate venous channels for the blood to leave the limb. The importance of the preservation of the profunda femoris and the common femoral veins cannot be overemphasized, when the interruption of the long saphenous vein and the deep venous system are to be performed. The level of the latter interruption under these circumstances must always be distal to the profunda femoris branch.

After completing the interruption of the long saphenous and superficial femoral veins, the next step is to ligate and divide the communicating veins on the inner and posterior aspects of the lower leg, through a long vertical incision (Fig. 6). As originally described in 1938,¹² all the communicating veins in the lower leg were interrupted when dealing with the post-thrombotic type of ulcer, using three longitudinal incisions. In recent years, however, it has been found that the anterolateral and posterolateral incisions are not necessary in the vast majority of cases because most of the post-thrombotic ulcerations occur on the inner side of the lower leg. Furthermore, if the more recent technic (described here) is followed, only the incision on the inner side of the leg is necessary to interrupt all except some of the communicating veins on the anterolateral side of the leg. The incision commences just distal to the level of the tibial tubercle and extends distalward about 2 cm. posterior to the inner edge of the tibia, extending halfway between the internal malleolus and the inner tuberosity of the *os calcis*, where it curves slightly forward to extend just beyond the internal malleolus. The incision is carried through the deep fascia along its entire extent. After making the incision, towels are sutured to the edges of it to prevent contamination of the operative field from the skin. The posterior tibial communicating veins are found directly under the incision, arranged in a longitudinal pattern. Usually beneath areas of stasis dermatitis, stasis cellulitis, pigmentation, or chronic ulceration, one or several large incompetent communicating veins will be found. In most instances the larger of these veins lie just above the internal malleolus in the lower third of the leg where the majority of the post-thrombotic ulcers occur, since it is here they pass through the tendons of the flexor muscles, and as a result are unsupported by the muscles as are those more proximal in the leg. Not infrequently, however, some

very large communicating veins may be found coming out along the posterior edge of the tibia in the upper and middle thirds of the leg, so that it is important in all cases to use the long incision, described

greatly of the numbness, since they are so grateful to be relieved of their chronic ulceration and dermatitis. The distal end of the saphenous vein is then stripped downward to the base of the great toe, using an



FIG. 7. A. A photograph to show a \$3624.00 postthrombotic ulcer, which had persisted for seven years despite three surgical procedures and attempts to cure it by conservative measures.

B. The same extremity three years after interruption of superficial femoral vein and the communicating veins in the lower leg; with removal of the internal and external saphenous veins and the deep fascia on the inner and posterior aspects of the lower leg. Note the well healed scar of the longitudinal incision and the absence of any ulceration.

above, to permit adequate exposure in the proximal part of the lower leg. These vessels are exposed by incising the attachment of the deep fascia to the posterior edge of the tibia, which at the same time exposes the main trunk of the long saphenous vein. This vessel is excised from the upper end of the incision down to just above the internal malleolus. The saphenous nerve is usually seen, but no particular attempt is made to preserve it. Although its removal results in some anesthesia of the skin over the anterior part of the lower leg, the majority of the patients do not complain

intraluminal stripper. The anterior skin flap must not be retracted away from the internal malleolus to excise this portion of the saphenous vein, because if this is done, the skin usually will slough, necessitating excision and the application of a split-thickness skin graft. It is essential, however, to remove the distal portion of the saphenous vein, especially if there are skin changes below and posterior to the internal malleolus. This can be accomplished satisfactorily by the stripping procedure. The long saphenous vein in the thigh is also stripped from the upper end of the long

incision in the lower leg to the groin, by means of an intraluminal stripper.

The dissection is then carried between the deep fascia and the muscles posteriorly, by retracting forward the gastrocnemius and soleus muscles. As a rule a number of communicating veins will be encountered passing through the deep fascia. These are ligated and divided. The dissection is carried far enough lateralward to expose the short saphenous vein and the sural nerve. They both lie beneath, but exterior, to the deep fascia, so it is necessary to incise this structure to expose them. The nerve is carefully preserved, whereas the vein is excised, carrying the resection as far proximalward as possible, and distalward to where it begins to pass to the outer side of the ankle. The distal portion is then stripped with an intraluminal stripper to beyond the external malleolus. A triangular portion of the deep fascia with the apex at the ankle and the base in the proximal lower leg is then excised from the posterior skin flap. Care is taken to leave a rim of fascia, about one centimeter in width, on the anterior and posterior edges of the incision. These are utilized in the closure of the incision by suturing them together. This step is a very important one because it will prevent undue tension on the skin sutures, which, if it occurs, may result in necrosis and sloughing, with the formation of new ulcers.

The advantages of removing a large portion of the deep fascia are three-fold: (1) It allows closure of the incision without tension because the deep fascia encompasses the muscles so tightly and is so inelastic that great difficulty will be encountered if it is not partially excised; (2) after its removal, a number of large subcutaneous veins, tributaries of the saphenous system which otherwise would be missed, are visualized and so can be removed along with the short saphenous vein; (3) its removal possibly favors lymph drainage from the subcutaneous tissues into the muscle lymphatics. It is noteworthy that

the absence of the fascia in no way interferes with the appearance or the shape of the extremity, such as one might anticipate from herniation of the muscles through the area in which it has been removed. A small one centimeter incision is made for drainage purposes in the center of the upper portion of the posterior skin flap, near the mid-line of the leg.

Hemostasis is secured by using No. 000 plain catgut ligatures, and in addition, the diathermy to control the smaller bleeding vessels. The long incision is closed in layers, using interrupted sutures of No. 00 chromic catgut to the deep fascia. The sutures and ligatures used for hemostasis and closing the subcutaneous portion of the lower leg incision should always be catgut and never of nonabsorbable material, such as cotton or silk. This is because the longitudinal incision does not always heal completely by primary union, so that if the latter type are used, it will often be necessary to remove them before healing is complete. The skin is approximated with interrupted sutures of 36-gauge stainless steel wire. This material is used because it causes less reaction and it may be left in place longer without danger of infection, which might lead to necrosis and ulceration. A large gauze dressing is applied and held in place with an elastic gauze bandage. The ankle is immobilized with a plaster cast extending from the toes to the knee. The groin incision is closed in layers, carefully approximating the deep fascial layers as well as the skin. Penicillin, 100,000 units, and 0.25 Gm. of streptomycin are given intramuscularly before the operation, and every six hours after the operation for three to five days, and then discontinued if the temperature is normal.

Postoperative. The extremity is elevated slightly for five days by placing four to six-inch blocks under the foot of the bed, in order to reduce postoperative edema and thereby prevent tension on the suture line with resulting necrosis of the skin. The

plaster cast is removed after one week and the incision in the lower leg is inspected. Any sutures that seem too tight are removed and the remainder are left in place for approximately another week. Postural exercises are commenced if the incision is clean and healing *per primam*, using a cycle of three minutes of elevation, two minutes of dependency, and five minutes resting in the horizontal position. These are performed for one hour, three times daily for approximately a week or two. The purpose of them is to stimulate the vascular tone of the capillaries in the lower leg and the foot.

Ambulation is begun on the ninth or tenth postoperative day, with firm elastic bandage support extending from the toes to the knee. The patient is discharged from the hospital usually on the 14th to the 16th postoperative day with a compression bandage of elastic adhesive, over a gauze bandage similar to the type used to heal the ulceration prior to the operation. This is changed usually in ten days to two weeks, when another one is applied. At the end of about one month, if healing has taken place *per primam*, the patient is fitted with a heavy-weight, two-way stretch, knee length elastic stocking with a heel. The instructions are that the patient must wear it all day every day, as long as the extremity swells, which in a number of cases may be for an indefinite period. In many cases the elastic stocking eventually is only used during a part of the day, and in some cases it is possible to discard it. The importance of adequate elastic support to the limb following the operation cannot be overemphasized, because lymphedema is the most difficult of the thrombotic sequelae to cure, and as a rule, following this extensive surgical procedure it increases temporarily and may persist indefinitely, unless the above steps are taken to control it.

Additional postoperative treatment consists of injections of a sclerosing solution

into any varicose veins which may persist. As a rule, very small amounts are injected, since in most instances the circulation of the blood through these veins is so retarded that marked reactions may develop if large amounts are used. As time goes on there is frequently a marked scaling of the skin in the old ulcer and pigmented areas, and occasionally new areas of dermatitis may develop. The rubbing of these each night with a hydrated vaseline or cocoa butter is recommended, which controls this complication in most instances.

CASE REPORT

L. P., a female patient, age 42 years, was first seen on November 4, 1949, complaining of an ulcer of the left lower leg of 7 years' duration. A deep venous thrombosis of the left lower extremity had developed after a Cesarean section in 1936. This was treated conservatively by 3 months of bed rest. The ulcer first appeared in 1942, and the following operative procedures and treatments were utilized unsuccessfully in other clinics, in an attempt to cure it.

A. *Previous Treatment.* 1. On October, 1943, a high ligation of the left internal saphenous vein was performed. The ulcer healed for several months.

2. October, 1944, the ulcer recurred, then healed after several months with ointments and elastic support.

3. October, 1945, the ulcer recurred and healed again with ointment and elastic support.

4. October, 1946, the ulcer recurred.

5. December, 1947, a lumbar sympathectomy was performed and the ulcer remained healed a few months.

6. October, 1948, the ulcer recurred. Penicillin ointment was used, which was unsuccessful in healing the ulcer and produced a generalized skin dermatitis.

7. March, 1949, lumbar paravertebral procaine injections were used in an attempt to relieve pain, then reexploration of left groin and multiple superficial vein interruptions in the left thigh and lower leg were performed.

8. April, 1949, the ulcer recurred. Because of severe pain, she had to use demarol for relief at night.

B. *Steps in the Radical Treatment with Healing of the Ulcer.* 1. November 4, 1949. The patient was first seen (Fig. 7A). Elastic adhesive compres-

sion bandages with a vaseline dressing to the ulcer were applied on the following dates: November 4, 15 and 25; December 9 and 20, 1949; January 4 and 17, and February 3, 1950. The ulcer was healed and the patient admitted to the hospital February 17, 1950.

2. February 20, 1950, the left superficial femoral vein and the communicating veins in the lower leg were interrupted, the internal and external saphenous veins were resected and the deep fascia removed as described above. The patient was discharged on the twelfth postoperative day, with an elastic adhesive bandage applied over a gauze dressing and bandage. This was changed at two-week intervals because the incision had not completely healed.

3. June 1, 1950, the patient was fitted with a heavy weight, 2-way stretch type of elastic stocking with a heel in it.

4. March 1, 1953, the ulcer remains healed approximately 3 years since the radical operative procedures (Fig. 3B). She still wears an elastic stocking because the leg swells if she does not support it.

Comment. This case is typical of many unfortunate individuals suffering from the post-thrombotic type of ulceration of the lower leg, who are subjected to inadequate surgical treatment. In addition to undergoing a great deal of suffering and incapacitation because of the recurrent ulcerations, she also had been hospitalized on three occasions for surgical procedures that were ineffective in healing the ulcer, and furthermore, she had spent over \$3634.00, a small fortune, on this extremity when she was first seen on November 4, 1949, with the ulcer still open. Since the more radical surgical procedure described above (Fig. 7 A) was performed, and with the support of an elastic stocking, the ulcer has remained healed for over three years, and in addition she is free of pain and can lead a normal existence (Fig. 7 B).

In summary, although it is impossible to speak of a cure of the post-thrombotic syndrome, it can be stated that by utilizing the above-described preoperative treatment, the operative procedure and the postoperative follow-up care, the majority of post-

thrombotic ulcerations can be cured. In addition, the other thrombotic sequelae are improved, that is, the pain in the extremity is greatly relieved, the pigmentation fades, the stasis dermatitis clears, the stasis cellulitis disappears, or is greatly improved, and the varicose veins are removed for the most part, so that the extremity is restored to a more normal condition, enabling the patient to return to a normal existence, except for the necessity of having to wear an elastic stocking in most cases, for the control of the lymphedema.

CONCLUSIONS

1. The post-thrombotic syndrome with ulceration of the lower extremity develops, it is believed, because of a state of ambulatory venous hypertension in the lower extremities following canalization of the deep venous system, the result of impairment of the normal "venous heart" of the lower extremity, due to the destruction of the venous valves of the deep venous system, and the secondary development of incompetent valves in the veins of the communicating and superficial venous systems.

2. The operative procedure consisting of the radical removal of the superficial system of veins, ligation and division of the communicating veins on the inner and posterior aspects of the lower leg, interruption of the deep venous system of the thigh by ligation and division of the superficial femoral vein, and removal of a portion of the deep fascia of the lower leg, has given excellent results in the treatment of the post-thrombotic syndrome with chronic ulceration, when combined with adequate elastic support to the lower leg.

3. The ulcerations must be healed and the areas of dermatitis must be cleared up before performing this type of operative procedure. This is accomplished in the majority of patients by reestablishing, in part at least, the function of the "venous heart"

of the lower extremity, by utilizing tight elastic compression bandages.

4. A careful follow-up regimen is necessary for the best results in these patients, since one is dealing with a chronic disease, which by operation alone is only partially relieved and not completely cured.

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DISCUSSION.—DR. WILLIAM W. HEROY (Huntington, Long Island, New York): I would first like to thank the Association for the privilege of the floor, and then would hasten to commend this paper as being a very excellent contribution. Finally, I would like to present, very briefly, our experience with this subject at Bellevue Hospital, on the Columbia Division, with this particular problem.

I think the etiology is pretty well agreed on, as pointed out by Dr. Linton. I think that perhaps we have approached it a little bit differently. Having the same problem, we started in 1946 to do what we called our fasciotomy. Just to exemplify the type of patient and the over-all results, I would like to take time out to show you three slides.

(Slide) This is typical of any one of our cases. This patient had been in and out of the OPD for