TABLE IX.
SUMMARY

	No.	Percentage
Total patients	229	
Dead	41	17.9
Living	188	82.1
Sputum negative	144*	76.6
Able to work	127	67.6

(* 9 of these were negative before operation)

NOTE: About two-thirds of the operations covered by this study were done by Dr. R. H. Macdonald, of Saskatoon. It was my privilege to be associated with him from the beginning. His experience and counsel have been available as Consultant in Thoracic Surgery since January, 1937, and are gratefully acknowledged.

I am indebted also to Dr. R. G. Ferguson, Director of Medical Services, to Dr. H. C. Boughton, Superintendent Saskatoon Sanatorium, and to Dr. G. H. Hames, for their continued interest and valued assistance.

RÉSUMÉ

De 1927 à 1940, 312 malades ont eu des thoracoplasties. Les résultats rapportés sont basés sur les malades opérés depuis au moins deux ans. On ne fit pas l'apicolyse. Les phrénicectomies n'ont été pratiquées que plusieurs mois après les thoracoplasties. Dans la majorité des cas, les principales indications de la thoracoplastie sont la cavitation et le crachat bacillifère. Les principales contreindications sont la présence de lésions trachéo-bronchiques étendues, l'atteinte récente ou progressive du poumon opposé et la dégénérescence du myocarde. On attend moins longtemps qu'autrefois avant de pratiquer la thoracoplastie et l'intégrité du poumon opposé est moins rigoureusement exigée. Le pneumothorax aura été tenté avant de songer à la chirurgie. On ne défend pas l'exercice modéré avant la thoracoplastie afin d'améliorer le tonus vasculaire et la capacité vitale. Notre mortalité fut de 17.9 pour cent, les morts précoces comprises. Les morts plus tardives, imputables à la tuberculose figurent pour 14.4 pour cent du total. Les complications post-opératoires furent l'infection de la plaie dans 10.4 pour cent des cas, la dissémination de la tuberculose au même poumon 10 fois, et au poumon opposé 12 fois, enfin l'otite moyenne tuberculeuse. Quatre-vingts-six pour cent des malades furent congédiés avant un an. Les crachats de 59 pour cent du total des opérés cessèrent d'être bacillifères. Depuis la sortie du Sanatorium, 62.3 pour cent des malades travaillent. JEAN SAUCIER

OBLITERATIVE VASCULAR DISEASE: TREATMENT BY SYMPATHECTOMY

BY R. I. HARRIS

Toronto

TWO types of obliterative vascular disease commonly present themselves as clinical problems, and in both lumbar sympathectomy can be a valuable form of treatment. The two types are thromboangiitis obliterans (Buerger's disease) and peripheral arteriosclerosis.

Buerger's disease is the more important both because it is more common and also because it occurs in young men in the prime of life. Unknown factors initiate a pathological process which manifests itself chiefly in vessels of moderate size in the extremities, more often in the lower extremity. The involved vessels undergo a series of changes, the first of which is a subacute inflammation involving all coats of the artery and spreading to the adjacent vein. During the acute phase the lumen of the artery is occluded by thrombus. The acute phase subsides and is followed by a reparative phase in which the thrombus is organized and often recanalized. Finally, the reparative tissue matures into scar. The disease progresses from segment to segment of the artery in a discontinuous manner, sometimes slowly, sometimes rapidly, sometimes involving large sections of the artery, sometimes small sections. The effect is to produce a diminished blood flow to the extremity which intermittently becomes worse.

The clinical picture usually is clear. The disease occurs chiefly, perhaps exclusively, in young males, and involves their legs four times more frequently than their arms. The symptoms are all due to diminished blood supply to the extremities. The earliest symptoms are *cold feet and tired feet.* Later *intermittent claudication* becomes a conspicuous feature. This sign occurs when the blood supply is diminished to a point when it is adequate for the muscles while they are at rest but inadequate while they are working. The waste products of the metabolism of muscle activity accumulate in the muscle because the flow of blood is inadequate to remove them. Where they have accumulated in sufficient concentration muscle function is impaired and the patient experiences pain and muscle cramp. A short rest enables the circulation to wash out the metabolites and permits the muscles to function again until a further accumulation of metabolites occurs. The patient, therefore, presents a very distinctive syndrome. After a certain period of muscular work, he becomes disabled by pain and cramps in the muscles. The pain becomes so severe that he must stop: a comparatively short rest restores the situation and he can again undertake the amount of muscular effort necessary to cause the

accumulation of metabolites. Since the lower extremities are the common site of Buerger's disease, intermittent claudication is most often induced by walking. At a given stage in the disease, claudication is induced by a constant amount of work. The patient's story, therefore, is "after walking a certain distance, the pain in my legs is so severe that I have to stop. After I rest a few minutes, I can again walk the same distance and this is repeated as long as I walk." The symptoms come on rapidly with rapid walking and slowly with slow walking.

As the disease progresses *colour changes* occur in the foot. The dependent foot is rosy purple, indicating capillaries filled with blood circulating sluggishly. If the foot is elevated it blanches rapidly to a marble whiteness, indicating that the capillaries empty more rapidly by gravity than they can be filled from the partially obstructed arterioles. The colour changes are of some value in the diagnosis of the disease since they indicate in a dramatic and easily recognized form a circulatory disturbance which demands investigation.

The pathological changes sometimes involve the superficial veins (15 per cent of cases) and when this occurs it presents a pathognomonic and easily recognized manifestation of the disease, *migrating thrombophlebitis.* It attacks chiefly the radicles of the long saphenous vein on the dorsum of the foot and the lower half of this vein itself. The involved segments exist as tender red streaks in the skin which slowly spread along the course of the vein, often skipping a segment.

As the disease progresses on its intermittent course, *diminution or absence of pulsation* in the dorsalis pedis and posterior tibial arteries becomes evident.

In the advanced stage when the flow of blood is barely sufficient to maintain vitality of the part, a new type of pain appears, situated in the foot and constantly present. It is aptly called *rest pain.* Since it is worse at night it causes much loss of sleep and rapidly undermines the morale of the patient. It is this persistent and intolerable pain which warns of impending gangrene and drives the patient to welcome amputation.

When the impairment of circulation has reached any considerable degree of severity *trophic changes* appear. The skin becomes thin and pigmented, the nails furrowed and dry. An important manifestation is poor response to injury. Trivial abrasions, which in a normal foot would be of no consequence, in the presence of a feeble circulation can initiate a disastrous chain of events. Small wounds fail to heal and become portals through which infection enters. Infection is poorly combated and may precipitate gangrene.

Gangrene is the ultimate manifestation of this progressive arterial disease.

VASOSPASM IN BUERGER'S DISEASE

Though the essential pathological feature in Buerger's disease is an organic occlusion of vessels and mechanical interference with blood flow, in many cases there is superimposed an element of *vasospasm* which is of great importance. One might think that the presence of serious obliterative vascular disease would initiate a protective reflex which would ensure the maximum flow to the extremity by the dilatation of all arterioles. Such, however, is not the case. Indeed, Leriche believes that the presence of thrombosis initiates reflex vasospasm rather than dilatation. It certainly happens often that a patient with Buerger's disease has organic occlusion of the arteries of moderate size plus spastic occlusion of the arterioles of the collateral vessels. If tobacco plays any part in Buerger's disease, it probably is in this connection. I am not convinced that tobacco has anything to do with the initiation of the organic disease in the vessels (thromboangiitis obliterans). But tobacco does cause vasospasm and by so closing the collateral channels it may easily become a secondary factor of considerable importance. Nearly every case of Buerger's disease is accompanied by some degree of vasospasm, sometimes much and sometimes little, and this fact is of great importance in the planning of treatment.

PERIPHERAL ARTERIOSCLEROSIS

When the characteristic arteriosclerosis of advancing years attacks the vessels of the limbs it can result in obliteration of the lumen of vessels with resulting diminution of blood flow. The pathology is entirely different from that of Buerger's disease, though the result and hence the clinical picture is similar. In this disease, the primary change is the familiar degeneration of the media, Mönckeberg's sclerosis. Its presence in vessels of moderate size and the accompanying medial thickening cause narrowing or obliteration of the lumen. When thrombosis

occurs there is a sudden diminution in the blood flow with consequent sudden increase in the severity of symptoms. Whereas Buerger's disease is an inflammatory lesion of blood vessels, peripheral arteriosclerosis is a degenerative disease affecting only the artery.

Though the pathology of arteriosclerosis is so profoundly different from that of Buerger's disease, the clinical manifestations naturally are similar, since both are manifestations of diminished blood supply to the extremities. Cold, tired feet, intermittent claudication, colour changes and trophic changes, passing on to rest pain and gangrene, mark the progress of arteriosclerosis just as they do Buerger's disease. There are, however, some important differences. Arteriosclerosis is a disease of old age and it affects females as well as males. Moreover, it is but part of a generalized disease and other manifestations are often present, such as cerebral arteriosclerosis, renal disease, or cardiac disease.

TREATMENT

This paper is concerned chiefly with the value of sympathectomy in the treatment of obliterative vascular disease. But since it should not be used indiscriminately in every stage, and in every case, something must be said of other and more conservative forms of treatment and of selection of cases.

In the earlier stages of these obliterative vascular diseases, simple conservative measures can do much to alleviate symptoms. Modified habits of life which will permit less standing and walking should be attempted. It is extremely important in this country that the feet should be kept warm and dry by woollen socks and boots which are not tight. Many cases of frostbite are not simple frostbite but are the effect of cold upon feet which have inadequate circulation. This factor should always be remembered in every case of frostbite. Care should be taken to avoid minor injuries to the toes and feet. An open wound enormously complicates the problems to be faced and often precipitates disaster, *e.g.*, gangrene. Hence ingrown toenails, injuries incurred while paring the nails, scratches from nails in the boots, abrasions, etc., should be vigilantly guarded against. It is in this stage that tobacco should be prohibited. There is reasonable evidence that it induces vasospasm and by this means diminishes further the already inadequate blood supply. Alcohol has a beneficial effect because of the vasodilatation it produces. A glass of whisky in the evening relaxes vasospasm and results in temporary increase in blood flow.

My experience with Pavaex therapy has not been entirely satisfactory. Some cases have been benefited, some have not been benefited; some I thought were actually made worse. The instrument seems ideally suited to develop a collateral circulation in a limb suffering from impaired blood supply. That it does not always do so in Buerger's disease and peripheral arteriosclerosis I believe to be due to vasospasm in the peripheral arterioles. These are not passive tubes to be opened wider by mechanical force. On the contrary, they are living and elastic structures. Pavaex therapy may temporarily increase the flow through them against the resistance of vasospasm, but when the machine is stopped vasospasm again takes control.

Though conservative measures are sometimes of great merit and should be employed in all early cases, most cases slowly progress to the point where increasing impairment of circulation causes serious interference with function and activities; intermittent claudication is constant, severe and easily induced; rest pain is present, and trophic changes or impending gangrene make their appearance. When this stage has been reached, lumbar sympathectomy should be considered.

The success of lumbar sympathectomy in Buerger's disease and peripheral arteriosclerosis is dependent upon the existence of a degree of vasospasm superimposed upon the obliterative vascular disease and capable of being abolished by the operation. The amount of vasospasm which co-exists with obliterative vascular disease varies from case to case; in some it is a conspicuous feature, in others it is nearly or completely absent. Preoperative tests to determine the degree of vasospasm are of some value, though even when these tests show little or no vasospasm to be present some benefit often is obtained by sympathectomy. Two tests are in common use, the Landis test and spinal anæsthesia. In my experience spinal anæsthesia is the more informative. The Landis test is dependent upon reflex dilatation of peripheral vessels when the hands are dipped in hot water. Spinal anæsthesia paralyses the outflow of sympathetic fibres. It more closely reproduces the effect which will be produced by lumbar sympathectomy. Its effect

often is to demonstrate some degree of vasospasm when the Landis test shows none. Both tests depend upon measurements of skin temperature under controlled conditions. A rise in skin temperature indicating increase in blood flow resulting from release of vasospasm.

If pre-operative tests show that the skin temperature of the foot rises 3° C. a good result from lumbar sympathectomy can be predicted. There are, however, many cases in which the rise of skin temperature under test is less than this or even non-existent. The question at once arises as to whether such cases should be submitted to sympathectomy. It has been my experience that some even of these cases often receive such benefit from sympathectomy as to justify its use. Even if the rest pain only is relieved, the result is well worth while, since amputation is avoided or is postponed for years. My present practice is to use lumbar sympathectomy for all severe cases irrespective of the pre-operative tests. If the pre-operative test indicates a considerable degree of vasospasm to be present, the decision is easy since valuable improvement can be promised by sympathectomy. If the pre-operative test indicates little or no vasospasm, the decision is difficult since the only alternative to sympathectomy is amputation. Experience has proved that some improvement can be obtained in many cases when the pre-operative tests give no promise of it. Under these circumstances it seems wise to perform lumbar sympathectomy first and reserve amputation until all other measures have failed.

If sympathectomy is to be used, it should be performed *before* gangrene and open trophic lesions have developed. The task of combating infection and separating off gangrenous tissues add greatly to the demands upon the circulation. The improvement gained by sympathectomy might be great enough to deal with the enhanced problem of gangrene and infection. Often the patient's pain does not disappear until all open lesions have healed.

In every severe case of Buerger's disease, sympathectomy should be given serious consideration and most cases, in my opinion, at some stage should be given the benefit of this operation. Such patients are young adult males in the prime of life and every attempt to restore them to self-supporting existence is justifiable. The situation is different in peripheral arteriosclerosis. The victims of this disease are advanced in years. For the most part they are past the wage-earning period. Moreover, their vascular disease is such as to make possible the existence of serious vascular lesions in other organs, notably brain, heart and kidney. Cases of peripheral arteriosclerosis to be treated by sympathectomy must be selected with care. Only those without organic disease, without serious vascular disease elsewhere, and whose life cannot be slowed down to a tempo within the boundaries of the circulatory sufficiency are suitable cases.

RESULTS OF LUMBAR SYMPATHECTOMY IN OBLITERATIVE VASCULAR DISEASE

During the past ten years, "A" Division of the Department of Surgery, Toronto General Hospital, has performed sympathectomy 39 times for vascular disease (Table I). Two of these cases were Raynaud's disease, 1 was an obscure vascular lesion in a young female, 13 were cases of peripheral arteriosclerosis and 23 were cases of Buerger's disease.

TABLE I.

SYMPATHECTOMY FOR VASCULAR DISEASE
SURGICAL DIVISION "A" — TORONTO GENERAL HOSPITAL
1929 TO 1939

	Good	*Fair*	*Poor*	*Total*
Buerger's disease	13	7	3	23
Arteriosclerosis	5	1	7 (3D)	13
Raynaud's disease	1	..	1 (1D)	2
Other conditions	1	..	..	1
	20	8	11	39

We have been able to follow all of these cases carefully and can now assess the value of sympathectomy. Table I classifies the results as good, fair and poor. Good results mean striking relief of pain and intermittent claudication, increased ability to work and all of this sustained to the present. Fair results mean only slight or moderate improvement in circulation or more improvement which was not sustained or relapse with gangrene after a period of relief. Poor results mean little or no improvement obtained by sympathectomy. On this basis it will be seen that in Buerger's disease a very satisfactory percentage of good results was obtained (63 per cent) as well as 30 per cent of fair results. The results in arteriosclerosis are not so striking. Neverthe-

less, 40 per cent of good results were obtained. When one considers that most of these cases were thus spared amputation it is a result of some importance.

It is perhaps justifiable to illustrate the results by relating the histories of two cases, one of Buerger's disease and one of peripheral arteriosclerosis. In diseases such as these, for which we have no cure in the strict sense of the word, we must rely upon measures which give relief and a few brilliant results are justification for advocating the use of a surgical procedure even though by the very nature of the disease it cannot always be successful.

A CASE OF BUERGER'S DISEASE SUCCESSFULLY TREATED BY SYMPATHECTOMY

J.J., age forty-one, first seen in April, 1932, complaining of pain in the feet and calves. These symptoms had commenced five years previously with aching pain in and abnormal coldness of the right foot. The left foot was similarly involved later though when first seen this was the more painful extremity. Severe intermittent claudication occurred after walking two blocks. He had many attacks of migrating thrombophlebitis. Rest pain was present in the left foot on admission. He was nearly completely incapacitated by pain and had lost more than 50 per cent of time from his work in the year prior to admission.

Examination on admission showed cold feet with marked postural colour changes. Some lesions of migrating thrombophlebitis were present. There was no pulsation in the pedal arteries of either foot. Spinal anæsthesia caused a rise of skin temperature of 4° C. in the left foot and 6.5° C. in the right foot, indicating an accompanying vasospasm of considerable degree.

As the left foot was the source of much the more severe symptoms, a left lumbar sympathectomy was performed on May 7, 1932. This was followed at once by increased warmth and improved colour in the left foot and complete disappearance of the rest pain. He returned to work in a few weeks and continued at this until July, 1933, when he returned of his own accord to have his right side operated upon. During the interval he had worked particularly long hours as mate on a lake freighter, his duties at certain times necessitating his remaining on the bridge for twenty hours at a stretch. A right lumbar sympathectomy was performed on July 13, 1933. Since then he has been continuously at work.

A CASE OF PERIPHERAL ARTERIOSCLEROSIS SUCCESSFULLY TREATED BY SYMPATHECTOMY

J.T., age sixty-three, for a year had been incapacitated by cold painful feet, intermittent claudication, rest pain and finally by the onset of gangrene in his right great toe. Postural colour changes were marked. No pulse could be felt in the pedal arteries of either foot. Pre-operative tests gave a rise in skin temperature of 4° C. He refused operation and left hospital. A month later he returned, driven by the intolerable rest pain to a willingness to submit to anything. The gangrene of the great toe had extended to the metatarso-phalangeal joint. Right lumbar sympathectomy was performed in April, 1930, and the gangrenous great toe disarticulated at the metatarsophalangeal joint. Operation was followed immediately by complete disappearance of the rest pain. The wound of the toe slowly healed. The skin temperature of the right foot was appreciably higher than that of the left and remained so. He remained free from discomfort and led a life of moderate activity for five years before he died of coronary thrombosis.

CONCLUSIONS

1. The two obliterative vascular diseases commonly met with are Buerger's disease and peripheral arteriosclerosis.

2. Though the pathological changes are profoundly different in the two diseases, the result in each case is an intermittently progressive slowing of the circulation which manifests itself by a distinctive clinical picture.

3. Many cases of either disease have an associated degree of vasospasm which contributes materially to the diminished blood flow. The degree of this vasospasm can be measured by pre-operative tests such as spinal anæsthesia and Landis test.

4. In all severe cases of Buerger's disease and in selected cases of severe peripheral arteriosclerosis the operation of sympathectomy should be given serious consideration. If the pre-operative tests result in a rise in skin temperature of 3° C. or more, a beneficial result from operation can be assured. Even a lower rise in skin temperature does not entirely preclude the possibility of improvement sufficiently great to justify the procedure.

It is not beside the mark to remind you that the prosperity of industry depends not merely upon the improvement of manufacturing processes, not merely upon the ennobling of the individual character, but upon a third condition, namely, a clear understanding of the conditions of social life on the part of both the capitalist and the operative and their agreement upon common principles of social action. They must learn that social phenomena are as much the expression of natural laws as any others; that no social arrangements can be permanent unless they harmonize with the requirements of social statics and dynamics; and that, in the nature of things there is an arbiter whose decisions execute themselves.—Science and Culture, T. H. Huxley.