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The Surgery of the Sympathetic Nervous System

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The value attributed to operations on the sympathetic nervous system has waxed and waned from the time when Leriche first described periarterial sympathectomy. This type of sympathectomy is now practically never employed and indications for sympathectomy in general have varied, but we believe that we now have a clear understanding of the place of this operation in therapy, and our knowledge of the physiology of the sympathetic system is based on surer grounds than in past years.

The sympathetic nervous system constricts the arterioles and stimulates the sudoriferous glands. For these reasons its ablation leads to dilatation of the arterioles, unless these are irreparably blocked or their walls hardened by disease, and to the abolition of sweating. Thus sympathectomy is now performed for peripheral vascular disease where dilatation of the peripheral vessels is still possible, for hyperhidrosis, and very occasionally for essential hypertension where denervation of a large part of the peripheral vascular system leads to such considerable dilatation as to diminish materially the peripheral vascular resistance, and so the blood pressure which depends upon this. Although the operation of periarterial sympathectomy was first introduced by Leriche, it was subsequently found that the effect of such a procedure was very limited in its extent because the sympathetic fibres joined the somatic nervous system at an early stage and were distributed to the tissues innervated along with the somatic supply. Consequently surgical attack was concentrated on the sympathetic nervous system before it joined the somatic system and led to the elaboration of the various operations designed to remove parts of the ganglionated sympathetic trunk or occasionally the grey or white *rami communicantes*.

The essential anatomy of the sympathetic nervous system is that the nerve fibres originate in cells of the lateral horn of the grey matter within the spinal cord. The fibres emerging with those from the anterior horn leave the spinal cord with the anterior nerve roots. The vast majority of these fibres which are medullated and therefore called white *rami communicantes* now leave the somatic nervous system and run to the ganglionated sympathetic trunk,

entering at first the ganglion opposite the issuing nerve root. Synaptic junctions may be made in this ganglion, or the white *rami* may run up or down to other ganglia where synaptic junctions are made. The fresh nerve fibres, now non-medullated and therefore called grey *rami communicantes*, leave the ganglionated trunk and join their respective somatic nerves to be distributed to the tissues. The ganglionated trunk therefore presents the most readily accessible part of the sympathetic nervous system for ablation without in any way disturbing the other nerves proceeding to the parts to be denervated.

For many years it has been observed, and is an undoubted fact, that the results of most sympathectomy operations, brilliant or satisfactory as they may be at first, tend in the course of years to become less so, and sometimes after an interval the disease recurs or progresses just as if no operation had been performed. Indeed, physiological tests show that a great deal of sympathetic supply has reappeared in the part. Various explanations have been proffered for this phenomenon: that the nerves have regenerated, or that by depriving the nerve endings of their sympathetic control they have been rendered more sensitive to circulating adrenalin. Neither of these explanations is really satisfactory. It is inconceivable that the regenerating fibres could bridge gaps of several inches and satisfactorily find their appropriate end-organs, nor has there been any well-substantiated evidence that regeneration of this sort occurs in the sympathetic nervous system. With regard to abnormal sensitivity to adrenalin, this can be demonstrated in the cat, but it has been found that in the human being the effect is minimal and quite insufficient to account for the recurrence of phenomena associated with sympathetic innervation. The answer to this problem almost certainly resides in the anatomy of the sympathetic nervous system. We have stated that "the vast majority of" the white *rami communicantes* leave the anterior nerve root to run to the ganglionated trunk and thereby achieve complete separation at this stage in their journey from the somatic nervous system, but unfortunately not all fibres do so in every case, and it is largely due to the work of Skoog (1947) that we now realise that some of these white *rami communicantes* never reach the ganglionated sympathetic trunk, but form synaptic junctions with their respective grey *rami* just outside the anterior nerve root, and in some cases it may be even within the substance of this root. These fibres are of course unaffected by surgical attack upon the ganglionated

trunk and it is probably such residual fibres, unimportant at first, which by gradually taking over the functions of the ablated part of the system lead to a slow recrudescence of symptoms over the years (Fig. 1).

UPPER LIMB

Apart from somewhat rare manifestations of peripheral vascular disease, sympathectomy on the upper limb is performed for Raynaud's phenomenon and to a less extent for hyperhidro-

winter months. It tends to be progressive over a period of years, and gangrenous changes may appear in the tips of the fingers, minor cracks in the skin fail to heal and lead, not infrequently, to a chronic osteitis of the terminal digits with discharge of sequestra. Secondary changes may occur, such as loss of substance of the finger pulps giving rise to typical "taper fingers"; fibrosis, leading to scleroderma, may cause immobility of the fingers and the development of a waxy claw-like hand; and finally, deposits of calcium may appear in the subcutaneous tissues

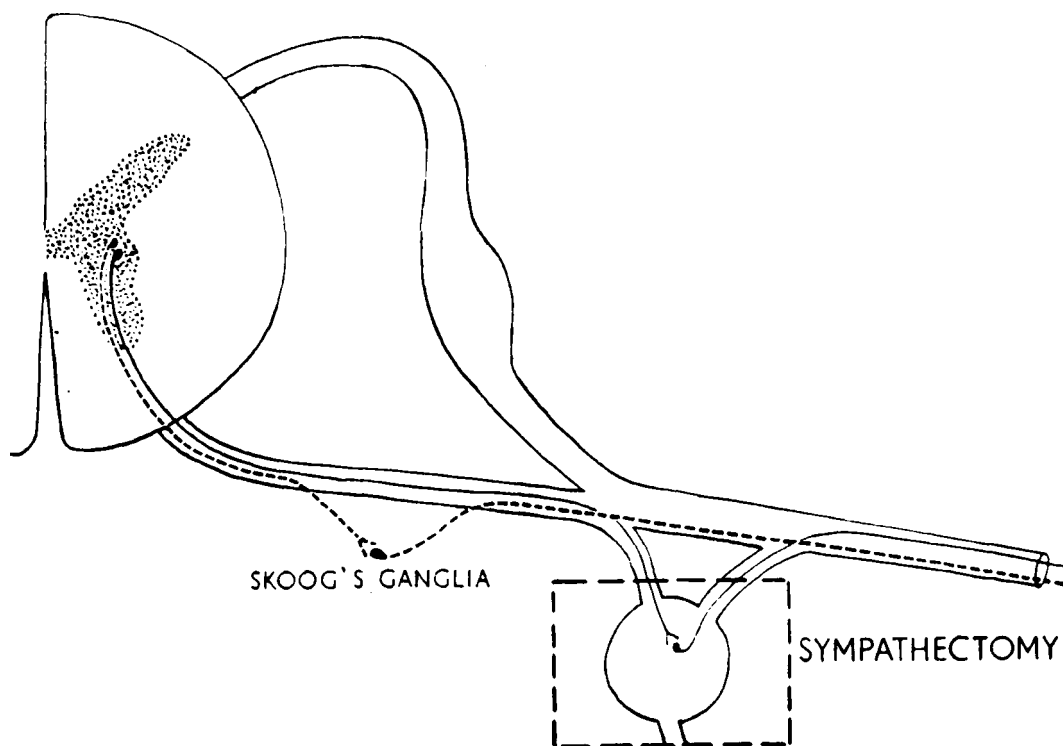


Fig. 1

sis. Raynaud's phenomenon, which it is thought may be linked with more than one pathological process, is characterised by spasm of the digital vessels, giving rise classically to blanching of the digits followed by suffusion with poorly oxygenated blood, which gradually changes from a cyanotic hue to bright red as the attack subsides. The last stages of the spasmodic episode may be very painful. The spasms are induced by cold and usually can be brought on by plunging the hand into a basin of cold water, so that the disease is at its worst during the

of the fingers and hand. Some mild cases of Raynaud's phenomenon yield to medical treatment, and in such mild cases this should always be tried first. Common-sense measures should be adopted, such as avoiding the cold, wearing warm mittens about the house and thick gloves out-of-doors in cold weather, whilst most authorities enjoin complete abstinence from smoking. Priscol has some reputation as a vaso-dilator and may be prescribed in doses of 25 mg. twice a day. A proportion of these cases fail to respond to these measures, and progress despite

such care. Provided the patient is fit for it, a sympathectomy should then be performed.

Various preliminary tests have been devised to see if the sympathectomy is likely to be effective, and these tests will be discussed more fully below, but it is unlikely that they will prove of much value in the upper limb, and a decision to perform a sympathectomy should be made on clinical grounds. There is no need to give the patient a Horner's syndrome, and virtually complete denervation of the sympathetic supply to the upper limb can be performed without disturbing the supply to the head and neck.

The effect of sympathectomy in this disease varies. Occasionally the results are brilliant, but more often the severity of the symptoms is abated, sore places on the fingers heal, and the patient is freed from pain and disability for a variable period. For reasons stated above, this operation cannot be guaranteed to be permanent, and more often than not four or five winters later, with the onset of cold weather, the symptoms tend to recur. Nevertheless, the operation is sufficiently trivial, the danger to the patient so negligible, and the chances of considerable alleviation so great, that such a procedure is well worth while performing.

The same arguments apply to other rare forms of peripheral vascular disease in the upper limb, but in the disease hyperhidrosis, when the symptoms are at all severe, sympathectomy is the only method of treatment and is in these cases brilliantly successful and permanent.

Many people have sweaty palms which are an embarrassment to them in their work and their social life. This sweatiness can be controlled to some extent by common-sense measures, but there are those whose hands sweat so profusely that their work is interfered with and they are unwilling to mix in society because of the acute embarrassment of meeting other people and having to shake hands with them. Occasionally the sweat will simply drip off the hands so that the patient is acutely conscious of the disability the whole time and is continually soaking a succession of pocket handkerchiefs in an endeavour to control his disability. For such a patient sympathectomy is obligatory. Following the operation the hands become completely dry and remain so apparently permanently. One must assume that this exception to the rule in sympathetic surgery, that recurrence is almost bound to occur sooner or later, is due to the fact that in the three or four years when the sympathectomy is absolutely operative the sudoriferous glands atrophy, so that on return of some sympathetic function the glands are not

in a position to respond, and the effect is maintained.

The sympathetic supply to the upper limb arises in the lateral horn of the grey matter of the upper thoracic segments of the spinal cord. Issuing with the anterior roots from T.2 to about T.8, the white *rami* run to the sympathetic chain and, streaming upwards, most of them have their synaptic junctions in the stellate ganglion, from which ganglion the grey *rami* issue to join the somatic nerves of the upper limb. If this were all, a simple section of the chain immediately below the stellate ganglion would serve completely to denervate the upper limb without interfering with those fibres coming from T.1 to the stellate ganglion, practically all of which are distributed to the head and neck. Unfortunately, a few of the white *rami* destined for the arm have their synaptic junctions in T.2 and to a less extent in T.3, from which ganglia grey *rami communicantes* issue to join the somatic supply to the arm independently and without passing through the stellate, so that a simple section of the trunk below the stellate ganglion would fail to cut these connections (Fig. 2). The aim, therefore, is to ablate T.2 and T.3, or, alternatively, to cut the white *rami communicantes* going to T.2 and T.3, together with section of the cord below T.3.

The operation to denervate the upper limb of its sympathetic supply can be performed in three ways. The anterior supraclavicular approach, which was the original operation, gives excellent access to the stellate ganglion, but as it is not necessary to remove this ganglion, and in fact better to leave it if a Horner's syndrome is to be avoided, other methods were devised to approach more directly the second and third thoracic ganglia, ablation of which is all that is necessary. The advantages of the anterior approach are that two sides can be performed at the same sitting; that previous pulmonary disease, if quiescent, is no contra-indication to the operation; and that if there is any doubt as to the diagnosis between Raynaud's phenomenon and the costo-clavicular syndrome, this matter can be investigated at the time of the operation and the requisite procedure adopted should it turn out to be the latter.

The posterior approach, which involves the resection of a length of the third rib in the region of the angle, has the advantage over the anterior approach in that it comes down directly on the second and third thoracic ganglia and these can be identified with precision. It is, however, a difficult operation to perform, the sympathetic trunk being met with at some con-

siderable depth, and it is apt to leave an unsightly puckered scar in a part normally exposed by evening dresses.

The third method is a lateral, trans-pleural approach through the second interspace. This approach is certainly the easiest to perform, is accurate, leaves an invisible scar, and is attended by practically no complications. The disadvantages are that it cannot be performed on both

LOWER LIMB

Sympathectomy on the lower limb is also performed mainly for peripheral vascular disease. The precise pathological nature of this disease is more variable in the lower than in the upper limbs. In the lower limb the consequences of arteriosclerosis and thrombo-angiitis obliterans are more common than Raynaud's disease, although the last does occasionally occur here. Nowadays, however, it is appreciated that the

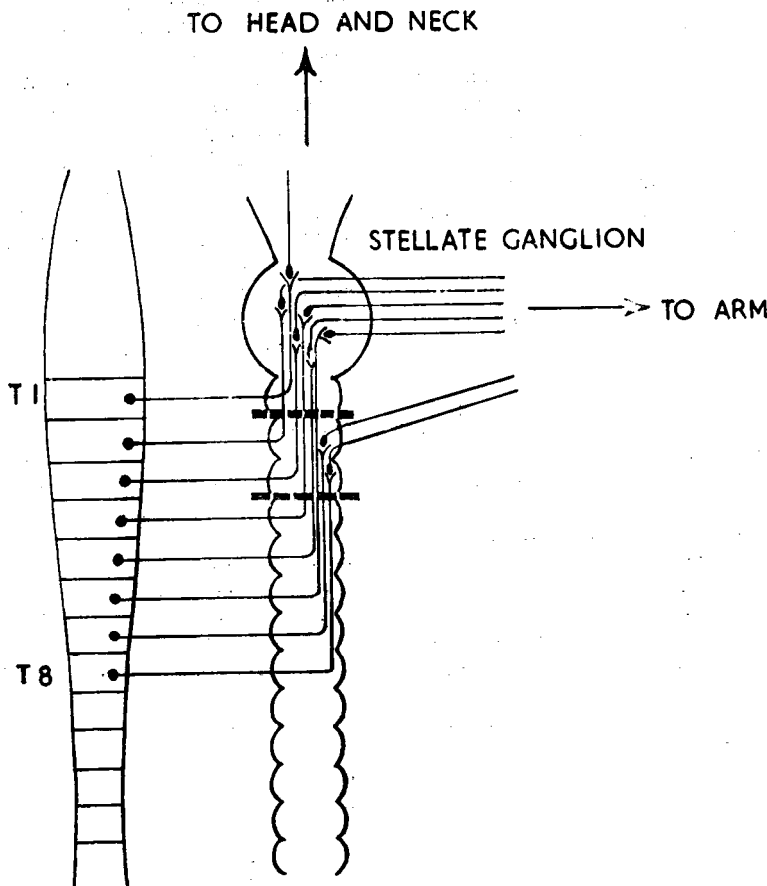


Fig. 2

sides at the same sitting; if there is any doubt about the diagnosis, the cost-clavicular syndrome cannot be investigated at the time of the operation and corrected; and it is unsuitable where there has been a history of phthisis or other reason to suspect adhesions in this part of the pleural cavity.

distinction between these different pathological states is very difficult to make clinically and, in fact, little theoretical purpose is served by attempting to do so, and the diagnosis of "peripheral vascular disease" is therefore far more commonly employed in clinical practice. Proportionately, arteriosclerosis is by far the

commonest of these affections, and it has only recently been appreciated that the changes characteristic of this state may occur at a relatively early age, so that symptoms of arterial deprivation in a lower limb over the age of forty are most likely to be due to this. In addition, it is occasionally necessary to perform sympathectomy on the lower limb for hyperhidrosis, and the operation performed for this purpose is equally successful as in the upper limb.

The symptoms of peripheral vascular disease in the lower limb differ in some respects from those met with in the hand and arm. Perhaps the commonest symptom is the so-called intermittent claudication due to disturbance of the blood supply to the muscles of the leg, particularly those of the calf, and leading to cramp-like pain if these muscles have been subjected to exercise for a variable period. Changes in the integument of the feet are common and the skin often becomes cold, yet livid in colour, the nails are brittle, and hair disappears from the lower leg and the dorsum of the foot. Accompanying these changes there is often "rest pain" at night in bed when the warmth of the bed-clothes increases the metabolic requirements of the part. Finally, gangrene of one or more toes, or even of half the foot, may supervene, and this final stage is often precipitated by a thrombosis of the affected vessels, completely occluding them, or even by an embolus of atheromatous tissue, discarded higher up in the arterial tree, lodging in and plugging a distal vessel.

Argument ranges to and fro in regard to the place of sympathectomy in dealing with these phenomena. It is generally agreed that sympathectomy is disappointing in relieving intermittent claudication. The reason for this is that the sympathetic supply to the vessels of the skin is richer than the sympathetic supply to the vessels of the muscle. Consequently a sympathectomy will have a more profound effect on the skin than on the muscle and indeed will secure a redistribution of blood favourable to the skin in comparison with the muscle, so that were it not for the fact that the total blood-supply to the two types of tissue taken together is considerably increased, sympathectomy might even make claudication worse. This, however, virtually never happens in practice and one can say that intermittent claudication is relieved in about a quarter of the cases, improved to a slight extent in a further quarter, and is unaffected in half. The milder the claudication the more likely is it to be helped by sympathectomy. It is as well that this is so because we would regard

intermittent claudication as a danger signal, implying that the whole of the blood-supply to the limb is in jeopardy and that gangrene is a serious danger. Consequently, sympathectomy is indicated in claudication not so much to relieve this symptom, but as a protection against consequences which are extremely likely to ensue.

It is difficult to get precise figures of the incidence of gangrene of a limb following intermittent claudication with and without sympathectomy, but it is not improbable that without sympathectomy the chances of gangrene eventually supervening are approximately sixty per cent. With sympathectomy the chances are probably under thirty per cent. The reason why sympathectomy is so effective in protecting the patient against these serious consequences is to some extent due to the fact that patients with the symptoms of intermittent claudication do not have a normal expectancy of life, and if the limbs can be safeguarded for a period of about ten years, which sympathectomy can usually be relied upon to do, this is unfortunately all that is necessary in most cases.

For "rest pain" a sympathectomy is very valuable and will usually abolish the pain as well as protecting the part from subsequent gangrene.

When, however, gangrene has already supervened it is arguable if sympathectomy is of much value except to improve the chances of a below-knee amputation surviving. In young patients who can learn to use an artificial limb, and where accordingly a below-knee amputation would be of inestimable value, it is probably worth while doing a lumbar sympathectomy as a preliminary to such a below-knee amputation with an enhanced probability that this amputation will be satisfactory.

For twenty years or more the decision as to whether or not to perform sympathectomy of the lower limb has depended very largely on the result of preliminary tests. These tests depended upon paralysing the sympathetic by means of spinal anaesthesia, paravertebral block, raising the internal environmental temperature by means of vaccines, or by heating one limb. The effect was then recorded by means of skin temperature readings or plethysmograph and oscillometry studies, and innumerable methods of carrying out these procedures have been devised with the greatest ingenuity. When all is said and done, it is doubtful if any of these tests are of much value in practice, and many centres dealing extensively with peripheral vascular disease have abandoned their use, relying on clinical observa-

tion to decide if operation is likely to be helpful. Of all the tests probably arteriography is the only one which is of value, and its practical application is somewhat restricted. From the patient's point of view the only value of arteriography is to decide if the blockage in the arterial tree is sufficiently localised to merit the trial of resecting the blocked portion of the artery and replacing this segment by means of an arterial graft.

For this operation to be contemplated, various conditions must be satisfied. The patient must be young enough and fit enough to stand a prolonged and tedious operation, the disease must certainly be unilateral, and the general condition of the peripheral vascular system must be relatively good. Technically this operation is for the most part employed only when the blockage is within the femoral artery, that is, when there is unilateral disease with a palpable femoral pulse and an absent popliteal one. Consequently the above criteria may be taken as the indications for arteriography. In all other cases it is doubtful if preliminary tests are worth while. The operation of lumbar sympathectomy is a trivial one and the preliminary tests so uncertain that one might coin the aphorism that "the best way of telling if a sympathectomy is going to work is to perform a sympathectomy."

In choosing cases for this operation the age of the patient is important and it is not usually warrantable to perform sympathectomy on patients over the age of sixty, although some clinics, particularly in America, pay no regard to this age limit. General considerations of fitness for an operation of any sort obviously apply with particular force in patients whose whole cardio-vascular system is suspect, and a common-sense attitude to suitability for an operation is the best that can be enjoined.

The sympathetic outflow to the lower limb arises from the lower thoracic and upper two or three lumbar, the white *rami communicantes* pass through the lower thoracic chain to the lumbar chain, and here those fibres destined to supply the upper part of the limb have their synaptic junctions, grey *rami* emerging to join the lumbar plexus to be distributed to the thigh and region around the knee. Those fibres, however, destined for the foot and toes, which are those requiring ablation in these circumstances, pass through the upper part of the lumbar plexus and have synaptic junctions in the fourth lumbar ganglion and the sacral ganglia, their grey *rami* then running with the sciatic nerve to be distributed to the distal part of the limb.

Opinions vary to some extent as to what it is necessary to do in performing a lumbar sympathectomy, but all are agreed that the second and third lumbar ganglia must be removed, some would include the fourth, others would go up to the first. In general, the more lumbar ganglia that are extirpated the more certain is the effect, although it must be borne in mind that the ablation of both first lumbar ganglia may lead to sterility.

The operation, which can be performed on both sides at the same sitting, consists in an extraperitoneal approach to the lumbar chain. The precise details of this approach vary from surgeon to surgeon and there is not much to choose between them.

HYPERTENSION

The operation of sympathectomy is performed for certain rare complaints such as causalgia, erythrocyanosis, and so on, with variable effect, and it is not intended to discuss these rather more unusual occasions when sympathectomy might be considered. A word, however, must be said about the operation of sympathectomy in relation to essential hypertension. This disease is so common that its management comes within the purview of almost every doctor. For most patients there is little that is necessary to be done other than to advise them to organise their lives with the fundamental rules in mind, "don't worry, don't hurry and don't stoop." If they do not know that they have a high blood pressure it would be generally ill-advised to tell them so, but should they know it, the doctor is usually justified in playing down the consequences of so common a condition. In addition, symptoms can be relieved by the prescription of simple analgesics and the regular administration of phenobarbitone in small doses, should this be desirable.

A few cases, however, have such high blood pressures that their lives must be in constant jeopardy, or the symptoms are so severe and quite uncontrollable by the ordinary means that they interfere with their work or enjoyment. Others are faced with loss of vision, and this group will require something more definite in the way of treatment than the general management which, as has been said, is all that is necessary for the vast majority. In addition to periods of bed rest and a far more restricted programme of activity, specific drugs are available. At the time of writing the most popular are the hexamethonium group. By the prescription of such drugs the blood pressure, if susceptible to treatment at all, can often be

lowered, and it is nearly true to say that hexamethonium can effect in a very simple way everything that can be effected in a much more complicated and painful way by operation.

Thus it will be seen that operation can play only a very small part in the treatment of a very few cases of essential hypertension. Nevertheless, in the following types of patient thoracolumbar sympathectomy should be seriously considered:—

- (1) Those patients who cannot take the hexamethonium group of drugs because of sensitivity.
- (2) Those patients in whom hexamethonium has no effect upon the blood pressure.
- (3) Those patients whose mode of life is such that they cannot be under that constant medical supervision which the prescription of the hexamethonium group of drugs ordains.
- (4) Those patients of a worrying and anxious nature in whom the continual administration of drugs by injection constitutes a constant reminder of their disorder and exacerbates their anxiety to the detriment of their blood pressures.

In these patients the operation of thoracolumbar sympathectomy holds out a prospect of alleviation when none other exists. The operation itself is a severe and painful one and is performed first of all on one side and then, after two or three weeks, on the other. The purpose of the operation is to dilate a considerable portion of the arteriolar bed in order to lessen the peripheral vascular resistance of a considerable portion of the whole tree, and also to denervate the suprarenal glands so that those sudden

exacerbations of blood pressure consequent on emotional stimulus to these glands do not occur. The best all round operation for this purpose is that devised by Smithwick (1940), and consists in the removal of the sympathetic chain from T.8 to L.2 inclusive, together with all three splanchnic nerves. The effects of the operation are to produce an immediate, and generally considerable, drop in both systolic and diastolic blood pressures with relief of symptoms and, if it has been impaired, improvement in vision. Unfortunately, for the reasons stated above, these effects are not permanent. The blood pressure generally starts to rise again after a year or two, and after three or four years is usually back at its pre-operative level. Fortunately the symptoms do not usually recur to the same extent and the patient, who pre-operatively may have been suffering from crippling early morning headaches in the occipital region, is completely free from these for five or six years, or even permanently, although the blood pressures have returned to their pre-operative levels. In other cases the headaches may return, but are nearly always far less in severity, and the patients themselves are usually well satisfied with the results of the operation and feel that the tribulations which they have been forced to undergo have been worth while.

It will be seen, therefore, that this operation must be prescribed with the greatest circumspection, but if this is done it still has a limited but valuable place in the treatment of essential hypertension.

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