foot, followed by a sensation of blood welling up between his toes. Percussion of a medially placed neuroma caused a temporary sensation of the nail being lifted off the phantom great toe. He generally felt he could move the phantom toes, but after treatment by percussion this subjective ability to move the phantom disappeared.

Present Plan of Treatment

The evolution of the best plan of treatment is still a matter for experiment, but the following method will be successful in most cases.

The use of a local analgesic before the first treatment has been discontinued as unnecessary, and instead a sphygmometer cuff is applied to the amputation stump and inflated to over 200 mm. Hg. Within two or three minutes the tender scars and neuromata become less sensitive, and gentle hammering with a wooden mallet or by means of a mechanical vibrator can be started and continued with increasing vigour for about 10 minutes. The blows of the mallet are usually transmitted to the neuroma through a wooden applicator (see below).

If the stump is too short for the sphygmometer cuff, hypalgesia of the neuromata can be obtained by prolonged pressure on them, and indeed the application of pressure is just as effective as hammering in abolishing the stump pain, as shown by the use of a golf-ball in Case 3.

During percussion or pressure on the neuromata a great variety of sensations are referred to the phantom foot or hand. These gradually become less, and the part of the phantom affected becomes numb and painless in 5 to 10 minutes if the strength of percussion is correct.

There are usually at least three neuromata in each stump, which should all be treated in the same way. Bruising of the stump should be avoided if possible, but if a bruise develops the next treatment can be applied to the nerve just above the neuroma.

After treatment the patient should wear his artificial limb for as long as he wishes—the more the stump is exercised the better. Jactitation usually ceases to be troublesome after the first or second treatment.

Treatment at first must be repeated at least twice daily, but before long one treatment a day is usually sufficient, and the patient soon learns to knock away his phantom pain whenever it becomes troublesome. A heavy mallet is required to treat neuromata buried under thigh muscles, but in other instances a light mallet may be adequate.

Repeated pressure is often useful, as in Case 2, while in a few instances the application of a sphygmometer cuff at a pressure of 200 mm. Hg for half an hour rendered the stump comfortable for many hours. This method, however, is probably not suitable for frequent use.

The patients soon learn the optimum period of percussion, and should each be provided with a suitable mallet and a wooden applicator with a smooth metal cap. For the applicator, half the handle of a hammer with a "dome-of-silence" on one end is very suitable if the rough edges of wood are filed smooth. The patients should continue treatment once or twice a day for several weeks; thereafter the duration and severity of treatment required should be ascertained by experiment in each case. Adequate information regarding the necessary duration of treatment is not yet available.

During percussion of the neuromata, but before the onset of general numbness in the stump, many sensations appear in the phantom that are of great physiological interest. Among these are, first, the reappearance of long-since-vanished parts of the phantom, and secondly the reappearance, as in Case 7, of pre-amputation sensations of the type described by Henderson and Smyth (1948).

Finally, it seems probable that some other painful conditions, such as tender scars, are just as easily relieved by this method of treatment.

Summary

The otherwise intractable pains and jactitations which sometimes occur in amputation stumps and phantom limbs may be abolished by repeated percussion of, or pressure on, the stump neuromata.

Repeated treatment by hammering or by a mechanical vibrator has proved to be highly successful in all of seven cases treated.

During treatment many interesting sensations appear in the phantom.

I am specially indebted to Dr. J. Spalding, who has assisted in this study, and to several members of the Ministry of Pensions medical administrative staff, who have encouraged this work and have referred patients for treatment.

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CHEMICAL SYMPATHECTOMY

BY

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The interruption of sympathetic activity in the extremities is not now a new process; it dates back for over 20 years. Reviews of large numbers of cases (Telford, 1944; Haxton, 1947a) have established the value of this treatment for a greater variety of circulatory disorders than is generally appreciated, and much discomfort and suffering can be relieved by its application. In addition to its beneficial effects in arteriosclerosis, thrombo-angiitis obliterans, erythrocyanosis, poliomyelitis, Raynaud's disease, perniosis, and erythromelalgia, sympathectomy has been found to effect a prolonged and apparently permanent cure of hyperidrosis (Adson, Craig, and Brown, 1935; Telford, 1938; White, 1939; Haxton, 1948). But to achieve such benefits one or more open operations of a major character are required, and although the mortality rate is very small in expert hands (Telford, 1944) the treatment entails a good deal of discomfort and a convalescence of several weeks at least.

Patients who are in poor general condition are denied the benefits of sympathectomy, and although there is no fixed age limit comparatively few are treated by this operation after 60. Furthermore, a considerable number of sufferers from vascular disorders are not troubled seriously enough to justify the upset of open sympathectomy, and yet there is no doubt that their lot can be made much easier and their outlook improved by sympathetic interruption. It would seem, therefore, that there is a place for non-operative interruption of sympathetic activity if this can be achieved with little disturbance to the patient and with a lasting effect.

Paravertebral injections of 85% alcohol were introduced by Swetlow (1926) for anginal pain, but he aimed rather to anaesthetize the intercostal nerves than to block the sympathetic chain. The latter procedure was developed successfully by White (1935), who used alcohol to destroy the upper thoracic ganglia. Although a lasting interruption of sympathetic activity can be obtained, the injection of alcohol is followed in a considerable proportion of cases by a prolonged and painful neuritis. Ochsner (1943) states that the incidence of this complication is too high to make alcohol injection a justifiable substitute for open sympathectomy,

and the few cases which I have treated thus have confirmed his conclusion. De Takats and his co-workers (1946), too, have abandoned the paravertebral injection of alcohol because of the unpleasant complications.

Phenol in aqueous solution has been used to destroy periarterial and presacral sympathetic nerves (Doppler, 1926; Binet, 1933) mainly in gynaecological cases. Doppler decided to use 6% phenol after a trial of many substances, including acids, bases, alcohols, and ethers, and Binet reports experiments which demonstrated that painting with 6% phenol interrupts the conductivity in the cervical sympathetic chain of rabbits. There was, however, a considerable return of conduction within an hour. Mandl (1947) injected 0.2 ml. of 6% phenol into the cervical ganglion of cats and noted that the Horner syndrome persisted for 14 days. Degenerative changes were present in the ganglion for up to 45 days after the injection. He states that this solution causes no damage to other tissues—a conclusion reached also by Binet (1933). This evidence suggests that aqueous phenol should be a useful agent for paravertebral injection of the sympathetic chain in cases in which an interruption of activity longer than that provided by procaine is required. So far as can be determined, however, it has not been thus used by previous workers.

I have used such injections in the treatment of vascular disorders since March, 1947, and altogether some 220 cases have received one or more paravertebral injections of aqueous phenol. This experience has shown the treatment to be of undoubted value and worthy of addition to the surgeon's armamentarium. Only lower-limb cases will be considered here, as the application of the procedure to vascular disorders of the upper limb is still considered to be in the experimental stage and no conclusions may be drawn.

Method

The method has undergone several alterations in the light of investigations on the cadaver and by radiography after the injection of a diodone-procaine mixture (Haxton, 1947b). Now two 12-cm. needles are inserted through skin weals 7 cm. from the midline and opposite the second and third lumbar vertebrae. These points are more lateral than is advised by American writers (Labat, 1922; White, 1935; Ochsner, 1943), but trial in the necropsy room shows that unless the needles are inserted with considerable obliquity they cannot be made to pass near the sympathetic chain. The needle must establish contact with the side of the vertebral body, and by manipulation it is persuaded to slide tangential to the bone for a further distance of 1 to 2 cm. The point may be felt to pierce the psoas fascia, and when it is in the correct plane a tentative injection of procaine should flow easily; in fact, a drop of fluid on the end of the needle is often sucked in. This indicates, rather surprisingly, that the intra-abdominal pressure is commonly sub-atmospheric.

A careful watch must at all times be kept for the welling of blood or cerebrospinal fluid from the needle. When the needle is correctly positioned a preliminary injection of 2 ml. of 4% procaine is made. As a rule the patient notices a feeling of warmth in the limb before this is detected by the observer, but the sole of the foot should begin to warm up within a few minutes of the injection unless there is severe organic arterial obstruction. Provided there are no symptoms of numbness or paralysis the injection is completed with aqueous phenol. It is important, however, that the whole technique of inserting the needles with accuracy should be mastered by careful practice in many cases before any injections of phenol are undertaken, because failure to place the needle point correctly may cause serious complications.

I believe that a more lasting effect is secured with 10% phenol in water than with a 6% solution, but at the former strength the solution and syringes must be kept warm or precipitation will occur. A total of 10 to 12 ml. is used as a rule, and this is well within the toxic dose, as Binet (1933) often injected 50 ml. of 6% phenol without untoward effects. No evidence of toxic reaction has appeared in this series. The patient remains in the lateral position for 15 minutes to prevent spread of the injection, and can then get up and go home if ambulant.

Results

When the needles have been accurately placed, warming of the corresponding foot has occurred within five minutes except in cases of severe arterial obliteration and when the feet have been very cold at the start. In more than 90% of cases a warm and dry foot has been obtained, and in 60% the effect has been a lasting one, the foot remaining warm and dry for months. In some cases in which the effect has not persisted the injection has been repeated and a good and lasting result obtained. The longest follow-up is now nearly two years, and the signs of sympathetic denervation remain. In two cases in which subsequent sympathectomy by open operation has been carried out there has been evidence neither of further improvement in the blood flow in the foot nor of greater symptomatic relief. Successful injection therefore results in a sympathetic interruption which is lasting and complete enough for practical purposes.

In the two cases in which sympathectomy was performed after phenol injection of the lumbar chain the interval in one was two days and in the other seven days. In both there was oedema of the tissues surrounding the chain—more pronounced in the earlier case—and some opacity of the sheath over the psoas muscle. The sympathetic chains looked swollen and their rami were easily broken. Histological examination of the chains revealed that the majority of the ganglion cells had lost their nuclei and were degenerating. A small piece taken from the anterior surface of the psoas major muscle showed some degeneration of the superficial fibres. A third patient, operated on five months after a phenol injection, had a fair amount of fibrosis in the vicinity of the sympathetic chain, and this made sympathectomy rather more difficult than usual. These observations show that phenol destroys the ganglion cells of the sympathetic chain and thereby produces the same effect as sympathectomy by open operation, and, further, that it causes little damage to surrounding structures.

Complications have been few, consisting for the most part of some irritation of the genito-femoral nerve. This develops in about 10% of cases and is manifest by hyperaesthesia in the groin, not often severe enough to cause great discomfort and lasting as a rule about three weeks. Only once has any more serious complication developed, and that was in an early case: an obese woman who developed signs of a low spinal analgesia lasting three hours and a weakness of the quadriceps on the injected side lasting three months. The needle was here incorrectly placed and the injection must have entered an intervertebral foramen. There should be no risk of such a complication if a 12-cm. needle is used and is inserted for its full length in obese patients.

A variety of conditions have been treated by "chemical sympathectomy," with the following results.

Hyperidrosis

One severe case affecting the feet was injected in October, 1947, with an immediate and dramatic cure which has remained complete. This demonstrates well the efficacy of phenol in producing a lasting interruption of sympathetic activity.

Erythrocyanosis and Perniosis

Six cases of cold blue legs with painful nodules of fat necrosis and, in some, chronic ulceration were treated with lasting benefit in all but one. Similar relief has been provided in two cases of severe chilblains.

Arteriosclerosis

Twenty-three patients have been treated for intermittent claudication, and the majority of these have stated that they benefited, some considerably. A few have had no benefit, but injection is always worth a trial, since there is a good chance that it will help the patient and the risk of harm is negligible.

The main field for sympathetic interruption is in the severer degrees of organic arterial occlusion due to arteriosclerosis with thrombosis in the arteries or, in younger men, occasionally to thrombo-angiitis obliterans. Severe ischaemia is indicated by pronounced colour changes between dependent and elevated positions of the leg and also by pain in the foot, which is worse in bed, and which, by interfering with sleep, rapidly exhausts the patient. This unhappy state can be greatly changed for the better by sympathectomy; much symptomatic relief is provided, and the risks of gangrene are reduced (Telford, 1944; Telford and Simmons, 1946). Chemical interruption by phenol injection has now been used in 65 such cases. It has given profound and lasting relief from rest pain in half of these and considerable relief in nearly all the remainder (Table I).

TABLE I.—Results of Chemical Sympathectomy with Phenol in 86 Cases of Arteriosclerosis of the Lower Limbs

	Relieved	Improved	Unchanged	Total
Pain	32	27	6	65
Claudication	2	21	13	36
Gangrene of toe	13	6	4	23
Ulceration	18	7	4	29

Pain due to inflammation in the neighbourhood of a gangrenous or infected part is not, however, relieved by this treatment or by sympathectomy. Phenol injections have greatly improved the precarious circulation in the foot, and in several cases with gangrene of one toe healing has been achieved with loss only of the affected digit. Patches of gangrene on the heel and chronic ulcers on the outside of the leg have likewise healed, with preservation of the limb. Patients have been very grateful for the relief afforded, and I have no doubt that the method merits a high place in the treatment of arteriosclerotic ischaemia in patients too old or otherwise unsuitable for open sympathectomy, and in those in whom the impairment of the blood flow is not advanced enough to justify the disturbance of an open operation.

Some of the arteriosclerotic cases have been complicated by diabetes mellitus and yet they have had good results. One woman with gangrene of both middle toes, with severe rest pain and intermittent claudication at 30 yards (27.4 metres), had one side injected, with resulting complete relief of pain in the ipsilateral foot and rapid healing of the gangrenous area. The patch on the other foot continued to spread and cause pain until that side was injected, after which rapid healing occurred. She was seen 18 months later and was symptom-free, with warm, dry, well-nourished feet and no claudication.

Venous Insufficiency

Fifty-eight cases of old white leg and similar deep-vein thrombosis have been treated by phenol injection with benefit to the patient in all but a few instances (Table II). After injection

TABLE II.—Results in 58 Cases of Chronic Venous Insufficiency of the Lower Limbs

	Relieved	Improved	Unchanged	Total
Ulcer	19	26	3	48
Swelling	6	16	28	50
Pain	24	19	3	46

tion patients have reported that there is less aching and tiredness in the leg, and the warm foot is often much appreciated. In some the swelling has been reduced, but this is by no means a constant sequel. The explanation of this improvement lies

partly in the removal of venous spasm, with a resulting fall in venous pressure, and partly in the improved nutrition of the capillary walls, with reduced transudation into the tissues.

When chronic ulceration has been present, often for many years, the injection has been followed by increased vascularity of the ulcer base, and healing has occurred in 40% of cases, although the patients remained ambulant and wore only tulle-gras and "viscopaste" dressings, well supported by crêpe bandages. In some cases supportive treatment alone had been tried for many weeks without effect. Any patient in whom a chronic ulcer of the leg due to venous insufficiency is associated with a cold and damp foot (evidence of sympathetic over-activity) now has a chemical sympathectomy as part of the treatment.

Conclusions

Sympathetic interruption by the injection of aqueous phenol has much to recommend it. Compared with open operation it is a relatively minor ordeal for the patient, necessitating no rest in bed (most cases have been treated as out-patients). Sufferers from vascular disorders will much more readily submit to this than to the major operation of open sympathectomy, and the treatment can be employed in cases in which operation is considered unjustifiable because of the age and general condition of the patient or because the chances of improvement are insufficient—e.g., in claudication and chronic ulceration of the leg.

The injection results in destruction of the ganglion cells, with a consequent interruption of sympathetic activity which can persist for two years at least. It is likely that some sympathetic activity will return in most cases, as indeed happens after open operation (Haxton, 1947b); but the method has the merit, denied to operation, that it can be easily and rapidly repeated if necessary. Complications are slight as a rule, and apparently much less troublesome than those following alcohol injections.

It must be strongly emphasized, however, that this method should be employed only by those who have had much experience with paravertebral injection of the sympathetic chain with local analgesics, since injection of phenol into the theca or a blood vessel would probably have serious consequences. In competent hands the method is a safe one, but the untried and untrained operator could easily cause disaster.

The sum total of suffering saved by this simple treatment has been very large, and patients have been extremely grateful for the relief provided, particularly since their pain and disablement have often been of long duration and many other treatments have been tried without benefit.

Summary

Six or ten per cent. phenol in aqueous solution has been used for paravertebral injection of the lumbar sympathetic chain in 200 cases. It destroys the ganglion cells and produces a lasting sympathetic interruption. Favourable results have been obtained in a variety of circulatory disorders, and complications have been few.

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