sore throats. In 1943 he had been accepted as a first-class life by an insurance company, the blood pressure then being 130/90 mm. Hg. In June, 1948, he was admitted to Westminster Hospital for tonsillectomy, and on pre-operative examination was found to have a blood pressure of 230/150 mm. Hg with pulsus alternans. There was no other cardiovascular abnormality, except that the fundi revealed exudates, haemorrhages, and vascular changes. The blood urea, however, was 120 mg. per 100 ml., and the urea clearance 26% of normal. Whilst in hospital he was free from symptoms and sympathectomy was not performed, on account of his poor renal function. He died from uraemia three months later.

Summary and Conclusions

Twenty-four cases of severe hypertension which have undergone lumbo-dorsal sympathectomy are presented. Their pre-operative state is described, and the results of operation are discussed. The following conclusions are reached: (1) the chances of permanently lowering the blood pressure are slight; (2) retinopathy, when present, may improve considerably; (3) there is not enough evidence to indicate clearly the effect in hypertensive heart disease—some patients may appear to improve temporarily, but this is unlikely with severe disease; (4) operation causes striking symptomatic relief, with notable gain in weight; and (5) in primary malignant hypertension the malignant phase may disappear.

In a properly selected case the relief is greater than that which can be obtained by medical treatment alone. Such cases are not numerous. The operation should be limited to severe and rapidly progressive cases with severe symptoms referable to their hypertensive state which comply with the following conditions: age less than 50 years, the renal function should be good, there should be no evidence of coronary or cerebral artery disease, and there should be no severe heart disease or heart failure.

Operation in early and mild cases is not advisable.

We are indebted to Sir Arnold Stott, Sir Adolphe Abrahams, Dr. W. E. Lloyd, Dr. S. P. Meadows, Dr. C. J. Gavey, Dr. F. D. Hart, and Dr. J. L. Lovibond, under whose care these patients were admitted, for permission to use their case records. We are particularly grateful to Sir Arnold Stott and Dr. C. J. Gavey for their continuous assistance and advice, and to Mr. E. F. King for his ophthalmic reports on these patients. We also wish to record our gratitude to Mr. C. E. Drew and Miss Joan Smith for help with the records and follow-up; to Dr. Peter Hansell for reproducing the chest films and electrocardiograms; and to Miss F. E. Stevens for clerical assistance.

REFERENCES

- Bassett, R. C. (1948). *Med. clin. N. Amer.*, **32**, 187.
 Blodgett, J. B., and Cutler, E. C. (1947). *Medical Annual*, p. 131. Bristol and London.
 Bourne, G., et al. (1948). *Proc. R. Soc. Med.*, **41**, 728.
 Moore, R. Foster (1916-17). *Quart. J. Med.*, **10**, 29.
 Wagener, H. P., and Keith, N. M. (1939). *Medicine, Baltimore*, **18**, 317.

Dr. F. M. Foote, executive director of the United States Society for the Prevention of Blindness, said in his address to the society's conference in New York: "Among the most serious eye problems that we must tackle is glaucoma. We are all deeply disturbed to know that at least 25,000 Americans are blind from glaucoma and approximately 150,000 more have lost the sight of one eye from this disease. We know that untold numbers of men and women over 35 years of age are working this morning in offices, in industry, in their own homes, unaware that they have early glaucoma—unaware that, unless they are fortunate enough to be among those discovered early, they will lose their eyesight so slowly, so gradually, that a large part of their useful vision will be gone before obvious symptoms bring them to the attention of a competent eye specialist. . . . The best estimates available on eye injuries in industry indicate that each year 100 workers are blinded and an additional 1,000 lose the sight of one eye. It should be possible, 40 years from now, to show that 90% of this unnecessary eye-loss has been prevented. If a man has defective eyesight, as in the case with 40% to 50% of industrial workers, he will find that safety glasses actually help him to do his job better if the hardened lenses are ground to include the correction he needs. Industry is in a position, therefore, not only to prevent accidental loss of sight, but also to help in preventing the loss of a skilled employee because of a visual handicap due to disease."

PAINFUL AMPUTATION STUMPS AND PHANTOM LIMBS*

TREATMENT BY REPEATED PERCUSSION TO THE STUMP NEUROMATA

BY

W. RITCHIE RUSSELL, M.D., F.R.C.P., F.R.C.P.Ed.

(From the Department of Neurology, Radcliffe Infirmary, Oxford)

Current surgical practice concerned with amputations involves many measures which are designed to protect the stump neuromata from trauma or irritation. At the operation the nerves are often divided as short as possible, while most modern prostheses aim at avoiding pressure on nerves. In spite of these precautions pain in the amputation stump or phantom limb remains common (Sliossberg, 1948), and is often associated with spasmodic twitchings of the stump. The latter may become so violent that the term "epilepsy of the stump" is sometimes used; Weir Mitchell (1872) employed the term "chorea" to describe them.

The medical treatment of these cases has been disappointing, and the difficulties encountered in getting relief by surgical measures is evident from the current neurosurgical practice of treating some of these cases by excising areas of the brain.

The following case records, however, indicate that treatment at the periphery may, after all, prove successful by a very simple procedure. This possibility was considered for three chief reasons. First, in the normal limb nerve endings in the skin are rendered insensitive by occupations which involve repeated minor trauma or prolonged firm pressure on the skin. Secondly, conduction of a mixed nerve is easily interrupted by repeated pressure, without the production of any spontaneous pain. Thirdly, the regenerating nerve fibres in an amputation stump are likely to be no less vulnerable to minor trauma or pressure than are normal nerves and nerve endings. It seemed obvious, therefore, that the effect of maintaining tender neuromata in a chronically concussed state merited investigation.

The first method tried was to deaden the neuromata with procaine and to percuss them for 10 to 15 minutes with a piece of wood.

Case 1

In 1937 a man aged 25 lost portions of four fingers of the left hand in a machine accident. He made a good recovery, and remained fit for work as a carpenter until February, 1942, when the palm of the left hand began to sweat excessively. One year later, while serving in the South African Army, he began to experience sharp stabbing pains in the phantom fingers and dorsum of the hand. On Feb. 28, 1944, the stellate ganglion was excised. The pain was relieved for two weeks, but then returned with great severity.

On examination in Cairo, four weeks after operation, Horner's syndrome was present on the left and the injured hand did not sweat. The ends of the amputation stumps were very tender, especially over some palpable neuromata. There was no sensory loss. On April 2 the digital nerves of the index-finger stump were injected with procaine, and then for about 15 minutes the end of the stump was hammered quite vigorously with a light piece of wood (a wooden test-tube container). This treatment was very successful, and the other tender stumps and scars were similarly treated. Thereafter it was found that if the patient two or three times daily tapped the tips of the amputation stump on a table for several minutes at a time, or if he applied prolonged pressure by handling tools firmly, he could keep all spontaneous pain and stump tenderness in abeyance.

*A preliminary report.

On April 26 he was using his hand freely without pain, and after designing and constructing a small wooden hammer, which he gave us for the treatment of similar conditions, he was discharged to duty on April 29.

Circumstances precluded the further study of such cases at that time. In recent months, however, six consecutive cases of intractable pain in amputation stumps and phantom limbs have been treated with such uniform success that this preliminary report seems desirable.

Case 2

A private aged 25 was injured by a circular saw in December, 1947. Both thumb and index finger of the right hand were severely damaged and partly amputated. After several plastic operations further amputations were carried out and tender neuromata were excised in January, 1949. The wounds healed, but the neuromata grew again quickly and caused great pain on attempts to use the hand.

On March 5, 1949, the neuromata were injected with procaine and percussed lightly for about 10 minutes. The patient was then given vigorous gripping exercises in order to cause pressure on the neuromata. Thereafter he continued to hammer the neuromata whenever the sensitivity returned. He found, however, that squeezing a piece of wood with his hand was most effective, and even on waking in the morning, when some sensitivity had returned, a few vigorous squeezes of a cricket-bail abolished the sensitivity.

Case 3

A soldier aged 24 was wounded in Italy in June, 1944. There were injuries to the right frontal region of the brain, the left eye, and the left shoulder. The left upper limb was amputated through the shoulder-joint.

When admitted to hospital in February, 1949, various aspects of his case were investigated, but only the state of the amputation stump need be considered here. There was considerable pain in the phantom arm, which consisted of the forearm, hand, and fingers in a position of flexion. There was a large stump neuroma, measuring nearly 2 in. (5 cm.) in diameter, which when pressed upon caused pain in either the radial or the ulnar half of the phantom hand.

Treatment by percussion to this neuroma first aggravated the phantom-limb pain, but after treatment for about five minutes the pain disappeared, and with it the phantom sensation for half the hand also vanished for at least an hour. A slight change in the position of the hammering deadened that half of the hand which was unaffected by the first treatment.

The neuroma in this case was difficult for the patient to reach himself, and it was found that the application of local pressure was more convenient. A golf-ball was bandaged to lie over the neuroma at the shoulder, and the patient, by leaning his weight on the ball for half an hour, succeeded in making the neuroma insensitive for some hours.

Case 4

A man now aged 47 was wounded in 1917 at the age of 16. He lost his right foot and had a below-knee amputation performed. The stump caused a lot of trouble, and several operations and re-amputations were carried out. Finally in 1920 a mid-thigh amputation was done. Severe pain in the stump and phantom foot continued, and six further operations were carried out between 1929 and 1942 to excise neuromata and spurs on the stump. In 1946 pain was again severe, and in August, 1946, the sciatic nerve was divided in the buttock and the distal part of the nerve removed. After this he was almost free of pain for a year; but again the pain recurred, and during the past three years it has been very troublesome and has become steadily more frequent and severe. The pain was severe during the day and kept him awake at night. He was taking both codeine and phenobarbitone tablets regularly. He could wear his artificial leg all day, but after walking for half a mile shooting pains and involuntary jerking of the stump forced him to stop. The pains were felt chiefly in the phantom foot, especially on its lateral aspect.

The patient was admitted to hospital on March 29, 1949, with a view to surgical division of the spino-thalamic tract. It was decided, however, first to try the effect of percussion treatment.

The amputation stump appeared healthy, but there were several tender spots which on pressure caused pain in the phantom.

Treatment was begun on April 2. Progress was good, and after three weeks he was discharged home. By this time pain in the phantom was infrequent, and could be quickly abolished by percussion. For periods of several hours the phantom disappeared entirely. The jumping of the stump also ceased. He had required no drugs, and had slept eight to nine hours every night for two weeks. A mechanical vibrator* was specially effective in his case, and for some hours after treatment there was neither pain nor awareness of the phantom.

When seen two weeks after returning home he reported that one or two short periods of hammering administered daily by his wife sufficed to keep the pain in abeyance.

Case 5

This patient, now aged 54, was wounded in 1918 in the right thigh. Chronic infection followed, and violent jerks of the wounded leg—it would jump right out of bed—led to high mid-thigh amputation in 1947. Pain in the phantom, however, became continuous from the day of the amputation. A tight pain in the lateral three toes of the phantom was particularly unpleasant. He could wear his prosthesis for only an hour at a time. The stump was healthy, but there were medial, lateral, and posterior tender spots which on pressure caused pain in the phantom.

Treatment was started on April 7, 1949, and proved to be very successful. Percussion with a mallet and applicator was specially effective, and the patient learnt to abolish all phantom pain by this method.

On discharge home on May 13 he was able to wear his prosthesis all day; he slept well without drugs, and the pain and jactitation of the stump were controlled by self-administered treatment for about 15 minutes daily. When seen a week after returning home the amount of hammering required to allay pain had become even less.

Case 6

This patient, now aged 59, was hit in the right knee by a shell fragment in 1918. Chronic infection followed, and a mid-thigh amputation was carried out in 1929. He remained free of all pain until November, 1948, when the stump began to jactitate in association with a "kicking" pain in the phantom leg. He found that a bandage applied to the stump so tightly that it ulcerated the skin was effective in arresting the jactitation of the stump.

Treatment was begun on April 22, 1949, and was very successful. It was soon possible for him to wear his prosthesis all day without either pain or jactitation. After treatment had been continued for a month he found that hammering for about 10 minutes twice daily was sufficient to keep the phantom-limb pain in abeyance.

Case 7

A man now aged 37 was wounded in the left foot on Oct. 24, 1942, and had a mid-leg amputation. He has been conscious of a phantom foot ever since, and the sensation of his great toe nail being twisted off was most unpleasant. There was also some jactitation of the stump at night.

The stump was healthy, but there were three very sensitive neuromata. Treatment was started on April 28, 1949. The sphygmometer cuff quickly rendered the neuromata insensitive for the first treatment, and the patient learnt to abolish both phantom and its pain by percussing the neuromata with a wooden mallet and applicator. If he treated the stump in the evening he could depend on having a comfortable night. He was discharged home on April 13, and a week later the amount of treatment necessary was even less.

When he was first treated percussion for 10 minutes abolished the phantom for about half an hour, but after two weeks one treatment of less duration abolished the phantom completely for four hours, while discomfort was avoided by one short period (five minutes) of treatment daily.

During percussion of the posterior neuroma this patient gave a vivid account of the temporary aggravation of the phantom sensations. These included reopening of the old wound of his

* The "Stanco" vibrator, as supplied by Stanley Cox, Ltd., 11, Gerrard Street, London, W.1.

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.

REFERENCES

- Henderson, W. R., and Smyth, G. E. (1948). *J. Neurol. Neurosurg. Psychiat.*, **11**, 88.
 Mitchell, S. Weir (1872). *Injuries of Nerves and Their Consequences*. Lippincott, Philadelphia.
 Sliossberg, A. (1948). *Les Algies des Amputés*. Masson, Paris.

CHEMICAL SYMPATHECTOMY

BY

H. A. HAXTON, M.D., Ch.M., B.Sc., F.R.C.S.

Consultant Surgeon, Crumpsall Hospital, Manchester

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,