The greatest single obstacle is the shortage of nursing staff.

We have made proposals for a recruiting campaign, the principle feature of which is the attraction of trained nurses to the tuberculosis service.

All steps should be taken to make active modern treatment available to the patient in his home.

Much more energetic steps should be taken to provide preventoria.

As part of a "crisis expansion" local authorities should adopt a bold and imaginative policy in the allocation of houses.

Money spent freely but wisely for these purposes will prove to be a sound national investment.

A vigorous, sustained, and well-planned campaign of public education regarding tuberculosis should be undertaken.

We have made recommendations for the central co-ordination and direction of these operations.

A much greater sense of the urgency of the situation is required on the part of all—the general public, the administrators, the nurses, and the doctors. What has hitherto been a desultory and intermittent campaign must be transformed into nothing less than a national crusade.

The subcommittee wish to record their keen appreciation of the tireless work and indispensable assistance given by their secretary, Dr. E. R. C. Walker, and the clerk to the subcommittee, Miss S. V. Williamson, and to express their indebtedness to the British Medical Association for the facilities afforded.

APPENDIX

Beds Required for Optimum Service

Region	Population	Present Beds (Autumn, 1949)		Requirements Based on Physicians' Estimates	2½ × 1938 Pulmonary Tuberculosis Deaths (Hosp. Surveyors, 1945)	2½ × 1946-8 Average Annual Pulmonary Tuberculosis Deaths	2½ × 1946-8 Average Annual Pulmonary Tuberculosis Deaths
		Staffed	Unstaffed				
Northern ..	195,000	228	3	355	232	285	314
North-eastern ..	506,000	428	21	516	380	415	457
Eastern ..	419,000	401	53	600	472	540	594
South-eastern ..	1,135,000	948	126	1,580	1,140	1,365	1,487
Western ..	2,914,000	3,513	301	4,554	4,227	5,690	6,259
Total for Scotland	5,169,000	5,518	504	7,605	6,451	8,295	9,111

TREATMENT OF PAINFUL AMPUTATION STUMPS

BY

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AND

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Last year one of us (Russell, 1949) described a method of treating painful amputation stumps and phantom limbs by repeated percussion to the stump neuromata. This form of treatment was developed on the theory that conduction in a mixed nerve is easily interrupted by repeated pressure without causing pain, and that the regenerating nerve fibres which form neuromata in an amputation stump might well be even more vulnerable to minor trauma than are normal nerves and nerve endings. It was considered likely, therefore, that if painful neuromata are repeatedly hammered their nerve fibres will gradually degenerate and be replaced by fibrous tissue. It was hoped that this process would be followed by relief of spontaneous pain, and in the report mentioned above seven consecutive cases were described, all of which responded remarkably well to this form of treatment. These seven patients have recently been followed up, and the progress report of all of them has been very satisfactory. Most have been able to discontinue treatment to a large extent, but some still give the stump an occasional hammering if the pain shows a tendency to recur. These patients have therefore either lost all tendency for the pain to recur, or, if they have slight twinges, these can be removed by a short period of treatment. This is most encouraging, for the evidence available indicates that with the passage of time there is no tendency for the pains to become resistant to the treatment—rather the reverse.

Further Cases

The purpose of this paper is to give the results achieved in further cases, and to include more details of the methods used.

We have had under consideration 37 further cases, but a number of these had disabilities which rendered them unsuited to percussion treatment. For example, in three cases the amputation followed extensive nerve lesions of the limb concerned; one case had a cold, diffusely tender stump which was relieved by sympathetic nerve block as advised by Leriche (1939); one case had sciatica, one had osteoarthritis of the spine, two had faulty prostheses, one was a major hysteric, and one refused to co-operate.

There were, however, 33 cases, including the seven published in 1949, which seemed to suffer from pain in the stump or phantom limb of such a nature that treatment by percussion was at least worth a trial. The main features of these cases are given in Table I.

Percussion treatment has been adopted elsewhere, and a number of cases which have proved resistant to this and to other forms of treatment have been referred to us. These cases fall into the second half of Table I, and owing to this selection of cases the results shown in that half of the table are not so good as in the earlier cases.

From the table it will be seen that there were 26 cases of lower-limb amputations (22 above the knee) and eight

TABLE I.—Chief Features of the Main Group of Cases

Case No.	Age	Site of Present Amputation	Date of 1st Amputation	Chief Operations	Interval from 1st Amputation to Onset of Pain	Pain		"Jactitations" of Stump		Temperature of Stump to Touch	Palpable Neuromata	Pain on Pressure on Neuromata or Tender Areas in Stump. Referred to:		Results		
						Phantom	Stump	With Pain	Without Pain			Phantom	Stump	1 Week	1-3 Months	Over 3 Months
1	25	L. finger	1937	1944, symp.	6 years	Lanc.	Tend.				Yes	Yes	Yes	Exc.	Exc.	Exc. 5 years
2	25	R. thumb, 2 fingers	1947	1948-9, st. (4)	At once	Ach.	Tend.				"	"	"	"	"	Exc., 12 m.
3	24	L. shoulder disart.	1944			"	No				"	Yes	"	"	"	Exc., 12 m.
4	47	R. A/K	1917	1917, B/K amp.; 1920, A/K amp.; 1929-42, neur. (6); 1946, n.s. (sci.)	11 years	Lanc., rig.	"	Yes		Normal	"	"	No	I.S.Q.	"	Exc., 11 m.
5	54	R. A/K	1947		At once	Rig.	Ach.	"	Yes	"	No	"	"	Imp.	Good, 2 m.	Imp., 10 m.
6	59	R. A/K	1934		14 years	Lanc., rig.	No	"		"	"	"	"	Exc.	Exc.	Exc., 4 m.
7	37	L. B/K	1943		2-3 weeks	Ach., rig., comp.	"	"		"	Yes	"	"	Exc.	"	Exc., 9 m.
8	38	R. A/E (L. A/K)*	1944	1944, A/E (and A/K) amp.; 1947 neur.; 1948, symp.	4-5 days	Ting., rig.	"	No	No	Warmer than normal	"	"	"	I.S.Q.	Imp.	Imp., 7 m.
9	50	L. A/K	1926	1926, disart. at knee; A/K amp.	4 years	Lanc.	"	Yes	"	Normal	No	"	"	"	"	Good, 7 m.
10	53	L. A/K	1915	1915, A/K amp.; 1937-49, neur. (several)	22 "	Ach.	Lanc.	"		"	Yes	"	"	Good	Exc.	Exc., 8 m.
11	52	R. A/K	1917	1917, A/K amp.; 1918, st.; 1946, st.; 1947, n.s. (sci.)	27 "	No ph.	"	"	No	Cold	No	No	Yes	I.S.Q.	Good	Imp., 7 m.
12	53	L. A/K	1929	1929, A/K amp.; 1931, st.	1½ "	Tick.	"	No	"	Normal	"	"	"	"	Exc.	Exc., 6 m.
13	55	R. A/K	1917	1917, Syme's amp., st.; 1918, A/K amp.	At once	Comp., lanc.	No	Yes		"	Yes	Yes	No	"	Imp.	I.S.Q.
14	42	L. B/K	1948		7 months	Burn.	"	"	Yes	Cold	No	"	"	Imp.	Exc.	Good, 6 m.
15	60	R. hip disart.	1921		27 years	Burn., lanc. comp.	"	"		Normal	Yes	"	"	Exc.	Exc.	Exc., 8 m.
16	49	L. A/E	1941	1941, B/E amp.; 1942, A/E amp.; 1943, n.s. (br. pl.), neur.; 1944, mes. tract.	At once	Ting., rig.	Tend.	Yes		"	"	"	Yes	I.S.Q.	I.S.Q.	
17	65	L. A/K	1916	1916, A/K amp.; 1945, st. (2)	25 years	Ach.	No			"	No	No	"	"	"	
18	50	R. A/K	1918	1918, A/K amp.; 1919, st.; 1948, sp. an.	2 weeks	"	"	Yes		Cold at tip	Yes	Yes	No	Exc.	Exc.	
19	58	R. B/K	1948		3 "	Rig., lanc.	Tend.	"		Normal	No	"	Yes	I.S.Q.	Imp.	Good, 4 m.
20	60	L. A/K	1915	1915, A/K amp.; 1916, st.; 1922, neur.; 1933, neur.; 1937, st.	1½ years	No	Lanc.	"	Yes	Cold before pain	"	No	"	I.S.Q.	I.S.Q., 1 m.	Imp., 4 m.
21	70	R. A/K	1918	1918, B/K amp.; 1919, st. (2); 1920, A/K amp.	31 "	Ach.	No	No	No	Cold at tip	"	Yes	No	Imp.	I.S.Q., 3 m.	
22	58	L. A/K	1916	1916, A/K amp.; st.	3 "	No ph.	Ach.	Yes	Yes†	Normal	"	Yes	"	"	Good, 3 m.	
23	36	L. A/K	1942	1942, A/K amp.; 1944, st.	3 "	Burn.	No	"	"†	"	"	Yes	No	I.S.Q.	I.S.Q.	
24	58	L. A/K	1919	1919, B/K amp.; 1923, st.; 1924, A/K amp.; 1926, n.s. (sci.); 1931, neur.; 1934, neur.; 1943, n.s. (sci.)	2 "	"	Ach.	No	No	"	Yes	"	Yes	Imp.	Good, 2 m.	
25	64	L. A/K	1918		At once	Lanc.	No	Yes	Yes	"	No	"	No	I.S.Q.	I.S.Q., 2 m. (see text)	
26	65	L. A/E	1916	1916, 3rd fing. amp.; 1925, 4th and 5th fing. amp.; 1926, symp.; 1930, A/E amp.; 1942, neur.; 1950, see text	26 years	No	Burn.	"	No	Cold	No	"	Yes	I.S.Q.	I.S.Q., 2 m.	
27	63	R. A/K	1917	1917, A/K amp.; 1922, st.; 1931, n.s. (sci.)	At once	Burn., lanc.	No	"	"	Normal	No	No	No	"	Good, 2 m.	
28	53	L. A/K	1917	1917, A/K amp.; 1929, st.	"	No	Lanc.	"	"	"	"	"	Yes	I.S.Q., 7 w.	I.S.Q., 7 w.	
29	26	L. B/K	1944	1944, Syme's amp., B/K amp.	2 months	Ach.	Tend.	"	"	"	"	Yes	"	Imp.	Good	
30	51	L. A/K	1918	1918, A/K amp., st.; 1921, neur.	At once	Ach., lanc.	No	"	Yes	"	Yes	"	No	Exc.	Exc.	
31	70	R. A/E	1918		3 years	No	Lanc.	"	"	"	"	"	"	I.S.Q.	I.S.Q.	I.S.Q., 8 m.
32	45	R. A/E	1948	1948 (before amp.) symp.; A/E amp.; 1949, st. (3)		No ph.	Burn., ting.	"	Yes	Warmer than normal	"	"	Yes	"	Imp.	Imp., 6 m.
33	48	R. A/K	1944		At once	Lanc.	No	"	No	Normal	No	Yes	No	Imp., 2 m.	Good, 3½ m.	

Cases 1-7 are those described in a preliminary report (Russell, 1949).

* This man had a double amputation. He complained of pain only in the upper-limb phantom.

† Jactitations occurred at times when these patients were asleep.

Abbreviations:

Amputations: A/K, above knee; B/K, below knee; A/E, above elbow; B/E, below elbow; Disart., disarticulation.

Operations: Amp., amputation; neur., neuromectomy; mes. tract., mesencephalic tractotomy; n.s. (br. pl.), nerve section (brachial plexus); n.s. (sci.), nerve section (sciatic nerve); sp. an., spinal anaesthetic; st., other stump operations.

Pain: Ach., aching; burn., burning; comp., complex; lanc., lancinating; rig., rigidity; tend., tender; tick., tickling; ting., tingling; no ph., no phantom limb on first attendance.

Definitions:

Excellent (exc.): Having no pain or able to dispel occasional attacks of pain for certain by percussion.

Good: Much less pain but not completely amenable to percussion.

Improved (imp.): Having less pain.

Unchanged (I.S.Q.): No apparent benefit from percussion treatment.

upper-limb amputations (six above the elbow). One man (Case 8) had had both an arm and a leg amputated, but complained of pain in the phantom arm only. A surprising finding in many cases was the long interval between the original amputation and the onset of pain. This interval was over one year in 16 cases and over five years in nine. Nineteen of the patients were wounded in the first world war, and eight in the second world war. In all cases amputation had been undertaken because of the direct or indirect results of trauma.

The Stump and Phantom Pains

The sensation of a phantom limb appears after nearly all amputations, as has been maintained by Weir Mitchell (1872), Leriche (1939), and Henderson and Smyth (1948). Not only had all our cases experienced phantom-limb sensations, but in all except three (Cases 11, 22, 32) these sensations were still present, generally in association with phantom-limb pains. The persistence of phantom sensations was therefore a marked feature in this group of cases. This contrasts with the experience of Henderson and Smyth (1948), who studied the "normal" phantom sensations in some 300 men with amputations in a prisoner-of-war camp. About 98% of their cases experienced the sensation of a phantom limb after amputation, but after six to twelve months the phantom sensations were only rarely felt, while they had for the most part disappeared after two to three years. Only about 6% of these 300 complained of pain during the period of observation.

The pains of which the patients complained were clearly often of very great severity. They were referred to the phantom limb in 17 cases, to the stump in seven, and to both phantom and stump in nine cases (Table I).

The patients' descriptions of the pain are very varied, but a distinction should be made between the pains which are almost always present in some degree and the pain which occurs in bouts. The latter consists of severe lancinating or stabbing pain recurring several times a minute and lasting for several hours or even days. In severe cases the patient is very miserable during a bout, and the pain is reminiscent of severe trigeminal neuralgia. During an attack the patient is reluctant to allow the stump to be touched, and is careful to prevent even a draught from playing on it, while the stump jumps or jactitates with each jab of pain.

Case 25.—A man aged 64 was wounded in the left leg and thigh in September, 1918, and two days later the limb was amputated just above the upper wound at the level of the mid-thigh. Before amputation he had severe pain in the left hip, upper thigh, and in the foot, but the areas in which he had been wounded felt numb. Since amputation he has been liable to attacks of stabbing pain. It is felt in the phantom limb, mainly in the ankle, especially the lateral side, and each stab is accompanied by a jactitation of the stump. Attacks at first lasted only two hours and recurred every two to three weeks, but in the past two years the pain has grown steadily worse, and attacks last 12 to 24 hours and recur every two to seven days. During an attack he is quite incapacitated. The first follow-up report on this case was not satisfactory, and further observation will be required.

In addition, however, to these "nerve" pains, many patients describe a painful set rigidity of the toes or fingers which can be particularly unpleasant. Other types of pain often accompany this rigidity, as in the following case.

Case 19.—A man aged 58 had a railway goods truck pass over his right leg in July, 1948, and a few hours afterwards the leg was amputated below the knee. Three weeks later he began to feel pain in the phantom limb. It was of four types. The fourth and fifth toes were constantly hyperflexed and painfully rigid; the big toe felt rigid and constricted "as though

it were protruding through a hole in his sock but more uncomfortable"; tight cramp-like sensations were felt in the phantom calf muscles; and lastly there were occasional pains shooting into the lateral side and ball of foot, the big toe, and the fourth and fifth toes. This man had an extremely tender stump and gradually improved with percussion treatment.

One may wonder why this feeling of rigidity is so painful. Livingston (1943) describes how he asked a patient "why the sense of tenseness in the [phantom] hand was so frequently emphasized among his complaints. He asked me to clench my fingers over my thumb, flex my wrist, and raise the arm into a hammerlock position and hold it there. At the end of five minutes I was perspiring freely, my hand and arm felt unbearably cramped, and I quit. 'But you can take your hand down,' he said."

Complex sensations may also be described, as in the following case:

Case 7.—A man aged 37 was wounded in the sole of the left foot in October, 1942, and in January, 1943, the leg was amputated below the left knee. Two or three weeks after amputation he began to feel an aching pain in the lateral side of the ankle and to have the sensation both of the presence of the wound in the sole of his foot and of the nail of his big toe being twisted off. When he percussed neuromata in the stump he felt at first a temporary aggravation of the phantom sensations. These included the opening of the wound in the foot and a sensation of blood running between the fourth and fifth toes. He says that he does not remember experiencing this sensation before amputation. Percussion on one spot at first intensified the feeling that the nail of his big toe was being torn off, and then caused the toenail sensation to disappear. The patient responded very quickly to percussion, and nine months later wrote that he was able to play strenuous table tennis. Occasionally when he was taking less exercise he began to get a slight recurrence of pain, but he could at once drive it away with percussion.

Examination of the Stump

The amputation stumps varied greatly, but on the whole the spontaneous pains seemed to depend on factors showing no connexion with the general state of the stump tissues other than nerves.

Most of the cases with frequent or continual pain had tender neuromata or hyperaesthetic scars which on pressure caused pain that was often referred to the phantom and caused jactitation. This tenderness on pressure with pain radiating to the phantom appeared to be due to neuromata of large or small size which were the "touch" spots for the pain. We have come to regard this type of reaction as an indication that treatment by percussion is likely to be successful.

Details of Treatment by Repeated Percussion

Treatment by percussion depends on the view that if the thousands of nerve fibres in a neuroma are repeatedly subjected to trauma they degenerate, cease to be tender, and lose their capacity for causing spontaneous pain.

Every effort is therefore made to find and locate as accurately as possible all tender neuromata. They can generally be felt as nodules a few millimetres to a few centimetres in diameter which on pressure give paraesthesiae referred to the phantom or, less commonly, cause local pain. In some cases the neuromata are so covered by muscle that their presence can be presumed only if a well-localized area can be found where pressure or hammering elicits paraesthesiae in the phantom or marked local pain.

If the neuromata are very tender a sphygmomanometer cuff is applied to the proximal part of the stump and inflated sufficiently to occlude the arterial blood supply.

FIG. 1.—Mallet and applicator in use.

After some minutes the anaesthesia makes the neuromata less sensitive* and they can be percussed. This is usually done with a mallet and an applicator consisting of a wooden shaft about 15 cm. long with a metal "dome of silence" on one end to provide a smooth contact that will not damage the skin and a crutch

rubber on the other to deaden the sound of tapping (Fig. 1). The applicator is held firmly on the neuroma and hammered with the mallet as hard and as rapidly as is possible without causing the patient undue discomfort. If the patient has sensations referred to the phantom or stump these confirm that the applicator is well placed on the neuroma.

After percussion has been performed for several minutes the cuff is removed and percussion is continued for 20 minutes. After the first treatment the cuff is generally not necessary, and the percussion is repeated three or four times daily.

An electrical vibrator is sometimes preferred to the mallet. It gives percussion over a wider area, but is less powerful and is sometimes more apt to bruise the skin than is the mallet and applicator. Whichever form of treatment is used the patient is taught to apply it himself. Electrical vibrators† are especially useful in upper-limb amputations which the patient cannot himself treat with a mallet and for dealing with lower-limb neuromata which the patient can-

FIG. 2.—Stanco vibrator on stand.

not reach. A stand to hold the vibrator firmly in any desired position is an advantage for treatment in hospital (Fig. 2), as prolonged handling of a vibrator causes numbness of the physiotherapist's hands.

*This method of local anaesthesia was in use in the fourteenth century (de Mondeville, 1320).

†The "Stanco" vibrator is manufactured by Stanley Cox, Ltd., 11, Gerrard Street, London, W.1.

‡The vibrator stand and the percussor were designed by Dr. E. J. Schuster, and manufactured by Mr. H. G. East, instrument maker, Oxford

A more powerful percussor‡ (Fig. 3) with a remote drive has been found useful for treating deeply placed neuromata. Only smooth metal or vulcanite applicators should be used with mechanical vibrators: other materials, such as rubber, are apt to damage the skin by friction.

The response of a favourable case is illustrated by the following report:

Case 15.—A man aged 60 was wounded in the thigh in June, 1918. The wound healed quickly, and for six months he walked well, but was then found to have a tuberculous infection of the upper part of the femur. The head and neck were excised, and shortly afterwards, in 1921, the right lower limb was disarticulated at the hip. He had no pain until November, 1948, when he began to feel an intermittent burning sensation in the toes and lateral side of the phantom foot, accompanied by the sensation of jerky and powerful plantar flexion at the ankle.

FIG. 3.—Electric percussor with flexible drive.

At other times, especially at night, the phantom limb felt fixed in flexion and he could not get to sleep until he had straightened it.

He had a well-marked sciatic neuroma. When this was percussed he felt a variety of sensations in the phantom leg, mainly a feeling of fixity or tension, but even after a single treatment of 15 minutes he volunteered that his leg was now at rest and within four days he had a longer night's sleep than for four months. Nine months later he was never bothered with pain and he only rarely needed to use the mallet. He was able to withstand the jolts of his local bus and the changes of weather, either of which had formerly brought on pain.

In other instances, however, the benefit of treatment becomes apparent more slowly.

Case 12.—A man aged 53. At the age of 3 years he had an illness which left him with a weak left leg, and in adult life the leg was 2 in. (5 cm.) shorter than the right. In October, 1929, he was involved in a road accident and suffered injuries to his head and left leg. He was unconscious for 13 days, but has had no permanent disability from the head injury. The left leg was amputated at the level of the mid-thigh 14 days after the accident. Eighteen months later he developed a sinus and a sequestrum was removed. After this operation he began for the first time to feel spontaneous pain, which was intermittent with periods of complete freedom. At first he had attacks of pain lasting 18 hours and recurring every month, but in the last six years the attacks had been occurring every 10 days. During an attack he felt in the stump a "drawing" or lacerating pain lasting two to three seconds and recurring three times a minute; and in the phantom a very disagreeable sensation in the toes and sole as though they were being strongly tickled. There was no neuroma palpable in the stump, but he was taught to percuss some tender areas. He obtained no relief for a month, but continued the percussion three times a day, and thereafter the pain became less frequent and could be dispelled by percussion. After six months he was applying percussion for 10 minutes once a day, and wrote: "The

phantom makes an attempt to come about once every three weeks now, but it is too feeble to trouble me in any way, and I can usefully knock it away in 10 minutes of hammering."

Results of Treatment

The results⁹ of treatment carried out as described above are usually highly gratifying. In many cases the first treatment gives relief which is so obvious that the patient quickly becomes an enthusiastic exponent of the method. In others the results are at first less apparent, and, as the patient often at first looks askance at the treatment, considerable time and effort have to be expended in persuading him to continue. Here the advantages of treating the patients in a centre where there is a tradition of cures are obvious.

Though few cases have been under treatment for more than a year the effect of it seems to be better as time passes; in most cases the patient can gradually reduce the number of treatments after some weeks, and in some instances even stop treatment.

For instance, Case 7, nine months after his first attendance, writes: "I do very little hammering these days. Only when it is raining hard or I am very tired or shaky do I need to 'tap,' and then it is to a phantom that seems 'half-hearted' and nothing compared with the feelings of discomfort I had before having treatment."

Case 1 was treated over five years ago in Cairo, and this patient writes from South Africa to say that he has had no further pain in his finger stumps except when on holiday and not using his hands much, when the pain sometimes returns. There is thus no evidence that these pains become resistant to treatment by percussion; indeed, the reverse seems more probable.

In Table II an attempt is made to classify the results of treatment in the 33 cases comprising the main group. Nine of these cases have been entered as deriving no benefit from

TABLE II.—Results of Treatment in 33 Cases (Definitions as in Table I)

	Total	Excellent	Good	Improved	Unchanged
No. of cases	33	11	8	5	9
Mean duration of follow-up (months)*		6	4	7	—
Range (months)		1-11	2-8	4-10	—

* Case 1 (follow-up over 5 years) is excluded.

treatment by percussion. It should, however, be added that there was only one failure among the first 15 cases treated, while in the last 18 there were eight failures. This worsening of recent results is due partly to cases of especial difficulty being referred, and partly to the treatment of some of the later cases being inadequately supervised. One "failure" (Case 26) subsequently obtained complete relief after an operation; this case is described later. It therefore seems that the proportion of failures in this series is higher than it would be in a less selected group. One occasional difficulty in dealing with pensioners depends on their having a vested interest in maintaining a high percentage of disability. There were, however, very few cases in which we felt that this factor seriously interfered with treatment.

Discussion

Although the theoretical prospect of converting a tender neuroma into a painless knot of fibrous tissue by repeated trauma seemed likely enough, the success of our attempts to do this in practice exceeded expectations. It was hard to believe that the well-known effects of pressure or trauma on nerve endings had not previously been fully exploited.

Gordon and Carleton (1923) described a somewhat similar method in a paper entitled "Hysterical Pain," and considered, on the basis of a theory of thalamic function, that the patients must experience pain to improve. Our experience suggests, however, that good results may be obtained whether the treatment is painless or painful, and that the changes observed indicate that the important part of the treatment depends on the physical changes caused at the periphery, in the neuromata and tender scars. Further, it seems clear that, whatever psychological factors there may be, the severe pain usually depends on afferent impulses which originate in the neuromata.

One highly gratifying feature of the treatment is that the patients are often enabled to discontinue drugs they have taken for years, and are again able to sleep without being repeatedly awakened by pain.

The chief complaint of Case 15 was that the pain used to keep him awake at night. There was improvement in this respect within a few days of beginning percussion, and eight months later he wrote: "I have rarely had to use the tapping, and when I have it has only been of very short duration, between three and five minutes. I feel really well and full of energy, and I can safely say when I go to bed that I am going to sleep, and I do sleep well. I really think that nerve is afraid of the mallet."

Dr. John Scarff, of the Neurological Institute, New York, has kindly sent particulars of a patient, a professional man, who after a mid-thigh amputation for embolism 10 years ago had suffered continuous pain. He became dependent on codeine in increasing amounts to enable him to work, until he was taking 20 gr. (1.3 g.) hypodermically each 24 hours. Finally he became exhausted and was obliged to enter hospital. After being treated with prolonged thio-pentone he began to hammer the stump neuromata. This brought relief, and two months later he was not only free of pain but had taken no narcotic of any kind since starting the treatment.

The possibility of treating other painful conditions by similar methods has been little explored, except in the case of tender scars, in which excellent results may be expected. Fibrositic nodules are also sometimes quickly rendered painless by a mechanical vibrator.

One point with regard to amputation operations should be mentioned—namely, that our experience suggests that at operation the nerves should not be cut short but left long in an exposed situation. It is often the well-hidden and protected nerves which cause most pain.

In Case 26 we felt obliged to advise disarticulation of a short stump at the shoulder to make it possible to crush the neuroma, which were very high in the axilla, and to leave the nerves as long as possible so they could be easily percussed. He was a man of 65 when he first attended. He had had a minor injury to the middle finger of his left hand in 1915, but the wound did not heal, and a year later the finger was amputated. The hand and forearm were swollen and remained so, and the other fingers became flexed into the palm. The fourth and fifth fingers were amputated in 1925, he had a cervical sympathectomy in 1926, and in 1930 the arm was amputated above the elbow. He had the sensation of a phantom limb after amputation, but it was not painful, and in the last two years he has rarely felt it at all. In 1936 he began to feel a constant burning pain in the whole stump and an aching pain in the left shoulder radiating down the left side of the chest into the left flank. The pain had been relieved for six months, in 1942 by excision of neuromata, but the pain had recurred. It was unfortunately impossible adequately to percuss the neuromata, many of which were at or above the apex of the axilla.

At operation the neuromata were not excised but crushed with clamps and left in an easily accessible position over the

chest wall. His pain was relieved immediately by this operation, and, should it recur, treatment by percussion is now much more likely to be successful, as the neuromata are easily reached.

In conclusion it should be emphasized that treatment by percussion has not on any occasion in our experience done harm. In some cases benefit has been apparent almost from the first treatment, but in others considerable perseverance has been required to get the desired relief.

Summary

The treatment of painful amputation stumps by repeated percussion to the neuromata has proved successful in most cases.

Of 33 cases considered suitable for percussion treatment, 19 reported good or excellent results and 5 were improved. There was only one failure in the first 15 cases treated, but in the last 18 cases, some of which were especially difficult, there have been eight apparent failures.

Methods of applying the treatment are described. The neuromata are located as accurately as possible. If they are very tender the arterial supply to the stump is occluded by a sphygmomanometer cuff, as anoxaemia renders them less sensitive. Percussion is done with a mallet and an applicator about 15 cm. long. After several minutes the cuff is removed and percussion continued for 20 minutes. An electrical vibrator may be used in place of the mallet, and is of particular value in treating areas beyond the patient's reach. Cases with cold and diffusely tender stumps should be treated by sympathetic block or section rather than percussion.

Illustrative case histories are given.

We are specially indebted to Dr. E. J. H. Schuster for designing and constructing apparatus, also to several members of the Ministry of Pensions staff for their encouragement with this study, and to Miss Ruth Hurst for her assistance with the treatment of many of these cases at Headington Hill Hall Rehabilitation Centre, Oxford.

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Another highly successful year's working was announced at the annual general meeting on June 6 of the Medical Sickness, Annuity, and Life Assurance Society, Ltd. The chairman, Mr. R. J. McNeill Love, said that when he last addressed the members he had reported on improvements in the policies and policy conditions, and he was now pleased to say that these had produced most satisfactory results. It had been hoped that the new life assurance business might pass the £1,000,000 mark for the first time, and it was gratifying to find that the amount actually achieved was £1,420,734. The figures for the current year indicated that this progress had been fully maintained. A subsidiary company, Medical Sickness Finance Corporation, Ltd., appeared for the first time in the accounts. By the end of last year it had assisted members of the medical and dental professions in the purchase of cars and equipment to the extent of about £100,000. The directors were convinced that this would be a satisfactory investment, especially when there was an increase in the number of cars for the home market. The increase in life assurances effected during the year amounted to £649,614. Claims had increased by £14,646, but were well within the amount expected. The amount paid in sickness benefit was £77,448. The funds of the Society stood at £4,371,026, an increase of practically £330,000.

P.T.A.P.

DETERMINATION OF THE ESSENTIAL Lf DOSAGE

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P.T.A.P. is an integrated diphtheria prophylactic prepared by the adsorption of highly purified toxoid on to pure aluminium phosphate—each prepared separately. Because of this it is possible not only to duplicate accurately any given composition but also to alter, at will, the amounts of both, as well as their ratios. In this we have a means of answering a number of important questions in diphtheria prophylaxis which previously could not be reliably investigated at all.

Of the several questions that required an accurate answer three have now received attention: (a) How much mineral carrier is required to produce the maximal anti-toxin response? (b) What is the route of choice for inoculation? (c) What is the essential or optimum quantity of toxoid necessary?

An account of work done to determine the correct dosage of aluminium phosphate carrier for young children has already been described (Bousfield, 1947a, 1947b; Holt and Bousfield, 1949). This amount was found to be not less than 5 mg. of $AlPO_4$, determined by observing the Schick conversion rate following a single injection. The conversion rate obtained, using 5 or 7.5 mg. of $AlPO_4$, was of the order of 97%; and this was found to persist for at least 15 months in 95% of the children examined. These figures bear interesting comparison with those of Faragó (1935), who, by using a 1-ml. dose of large-precipitate A.P.T., obtained an overall S.C.R. of 93.5% (4,297 cases) following one inoculation, and furthermore reported no significant decline in the S.C.R. after one year.

We have found the route of choice to be intramuscular, in that the relative effectiveness of the intramuscular route to the subcutaneous is 2.6—that is, in order to obtain the same results, 2.6 times as much $AlPO_4$ carrier must be used by the subcutaneous route as by the intramuscular.

Included in these same reports were the results of preliminary attempts to determine the essential toxoid dosage. No statistically significant differences were obtained when the $AlPO_4$ carrier was maintained constant at 7.5 mg. injected, and the amount of toxoid varied from 30 to 5 Lf per dose; the S.C.R.s were determined three months after a single intramuscular inoculation (Holt and Bousfield, 1949, Tables III and IV).

As the solution of this question is one of no small importance or interest the experiment has now been extended. For purposes of accurate comparison it is not a reliable procedure to compare uncritically one set of clinical results with another made at a different time or place. Because of this it is a minimum precaution always to arrange that new materials should overlap, in terms of the variable under investigation, with former preparations used in previous experiments.

It is of some importance also to describe the exact procedure used in making the Schick tests. Schick control was invariably used in all work carried out since