the hospital environment played a rôle in the production of carriers, it is difficult to decide. The former seems to me the more rational solution.

As it was realized that the technic was faulty, the next series was thus investigated: Swabs were planted directly on blood agar plates,⁷ and after twenty-four hours' incubation the microscopic morphology of typical hemolytic colonies was studied. This series covered 140 officers, about 75 per cent. of whom were included in the first investigation. The same process was repeated twice at three to four week intervals. The migratory life of the army officer prevented the completion of observation in all the group. This incompleteness tended to lower the percentage, which I believe would have been even more striking had the work been performed on a stationary body.

Of 140 officers of whom cultures were taken, 83 per cent. were positive on at least one examination; 25 per cent. showed *Streptococcus hemolyticus* in appreciable numbers on three or more trials, and only 17 per cent. were consistently negative. These figures indicate that the transient streptococcus carrier is very common and that the persistent carrier—I believe had my investigation been carried out over a longer period the term chronic carrier would have been appropriate—is also common.

When these facts are considered in the light of the scarcity of primary streptococcus disease at this hospital and the absence during their entire residence at that post of such infection among the Medical Corps officers, the importance of the streptococcus carrier, as an etiologic factor in the origin and spread of that infection, becomes parallel to that of the pneumococcus carrier. Another analogy to that organism lies in the recent work on streptococcus grouping, which will probably separate these organisms into parasitic and saprophytic groups similar to those of the pneumococcus.

It is my opinion that in the case of the streptococcus, healthy and diseased carriers bear the same relation to the health of the community as exists with the other organisms just discussed.

CONCLUSIONS

1. Acute respiratory disease is at present the greatest menace to the youth of our country.
2. It is more serious in the army than in civil life.
3. The transient healthy carrier is more common than should be expected from the incidence of the specific disease.
4. This transient quality is shown by the disappearance of the organism without treatment.
5. The chronic healthy carrier is rare, except in the case of the "saprophytic pneumococcus" of Cole, in which many of the organisms may be nonpathogenic, and with *Streptococcus hemolyticus*, in which a similar condition may well exist.
6. The potent factors in the spread of these diseases rest in this small group of chronic healthy carriers and the diseased carrier.
7. The latter, during the prodromal stages of disease and convalescence, is of by far the greatest importance.
8. They respond to attempts at disinfection even less satisfactorily than do the chronic healthy carriers.

520 Commonwealth Avenue.

7. To meat infusion agar is added 10 per cent. sterile defibrinated human blood, and the mixture plated.

ELECTRICAL STIMULATION OF PERIPHERAL NERVES EXPOSED AT OPERATION

SURGICAL VALUE

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The occurrence during the war of large numbers of nerve lesions of traumatic origin has stimulated the investigation of nerve function by various methods, among which that of electrical stimulation is of recognized importance. Operations for the correction of these lesions have furnished the opportunity for the direct stimulation of exposed nerve trunks, pathologic and normal, by which means extremely important information may be gained. This paper is based on such observations in a series of seventy-three cases in which operation was performed in the service of Lieut.-Col. C. H. Frazier at U. S. Army General Hospital No. 11, Cape May, N. J., and U. S. Army General Hospital No. 41, Fox Hills, N. Y., and aims at presenting general conclusions and such other data as may be of interest to the surgeon. The case reports, with more detailed anatomic and theoretical consideration, will be embodied in another paper.

TECHNIC

As soon as nerves are freed at operation, those of the leg are oriented at a point distal to the lesion by a black silk thread passed through the sheath on their posterior aspect, and proximal to the lesion by a white thread similarly placed. The arm nerves are oriented in the same way on the anterior aspect. This permits proper orientation for stimulation, suture and pathologic examination.

The stimulating electrode (Fig. 1) used was bipolar and was devised by one of us (W. M. K.) following the principle of the French investigator, Henri Meige. It is rather simple. Two strands of No. 2 copper wire about 2 yards long are strung with small glass beads for insulation. The two strings of beads are placed in a glass tube, 8 inches long, whose edges are well rounded, and are held in position by nonvulcanized rubber. Another modification of the electrode is as follows: At a point, about 1½ inches from the handle end of the tube, a slight indenture is made by drawing the tube out a bit. The beaded wires are drawn toward the stimulating end and a rubber band is placed over them at the indenture, thus holding them in place. The beaded wires are then allowed to trail off in their original direction (Fig. 1). The stimulating ends of the electrode are twisted back on themselves, thus making a loop. This avoids trauma to the nerves. This electrode may be readily sterilized. The battery used was the Harvard inductorium, No. 20, made by the Harvard Inductorium Company, Boston (Fig. 2). The freed nerve is held by a glass rod with a curved end which permits it to rest as in a cradle. The strength of the current is best taken as that which will produce a minimal contraction in a neighboring muscle. This rarely fails to cause stimulation of the nerve. The stimulation should always be applied both below and above the lesion. Normal nerves require much less current than abnormal. The stimulating is done with

the electrodes placed longitudinally on the nerve—this to avoid diffusion as much as possible. The sequence is: posterior side, internal, anterior, external. The surgeon while stimulating calls out the aspect of the nerve he is working on, in order to avoid confusion. The muscles stimulated are observed by another man. In stimulating the arm nerves it is better to use the terms radial and ulnar than internal and external. It has been found valuable to have nerve maps in the

in estimating the degree of nerve injury and in facilitating operative procedure. It enables him easily and quickly to identify normal nerves, often a difficult matter otherwise, especially when the normal anatomic relations are disturbed by pathologic conditions. Again, direct electrical stimulation is the most dependable means of determining conductivity in motor nerves which have been injured but not interrupted, as in the case of compression.

Fig. 1.—Stimulating electrode.

Fig. 2.—Battery.

operating room for reference. The findings are directly recorded on circular charts.

VALUE OF THE METHOD TO THE SURGEON

The surgical aspects of this subject are of considerable importance, not only because of the increased accuracy of diagnosis and of surgical manipulation which a better knowledge of topography insures, but also because direct electrical stimulation of nerves exposed at operation is of material aid to the surgeon

ELECTRIC PHENOMENA

We are all familiar with the paradoxical phenomenon of Erb, most frequently found in compression palsy of the musculospiral nerve from the use of crutches. In this condition the nerve conducts impulses when it is stimulated through the skin below the area of compression, but this area acts as an area of decrement, and its muscles cannot be made to react when the nerve is stimulated through the skin above the point of compression. We have found that in some cases the nerve

NUMBER OF REACTIONS IN NERVES AND MUSCLES IN FIFTY-SIX OPERATIVE CASES

	Case Numbers	Nerve	Muscles and Sensations	Total
I. Brachial plexus.....	5, 41	5		
1. Pectoralis major.....			1	1
II. Median nerve:				
(a) Inner head.....	31	1		
(b) Outer head.....	11, 31	2		
(c) Trunk.....	2, 3, 9, 13, 16, 17, 19, 26, 27, 30, 36, 43, 44, 45, 50, 53, 57, 69	18		
1. Pronator radii teres.....			14	
2. Flexor carpi radialis.....			12	
3. Palmaris longus.....			3	
4. Flexors of the fingers.....			11	
5. Flexor longus pollicis.....			7	
6. Pronator quadratus.....			2	
7. Abductor pollicis.....			2	
8. Opponens pollicis.....			1	
9. Lumbricales.....			1	
10. Sensory.....			1	
III. Ulnar nerve.....	3, 8, 11, 13, 16, 18, 27, 28, 42, 43, 45, 49, 50, 60, 66	16		54
1. Flexor carpi ulnaris.....			11	
2. Flexor profundus digitorum.....			10	
3. Adductor pollicis.....			5	
4. Interossei.....			5	
5. Hypothenars.....			4	
6. Sensory.....			1	
IV. Circumflex nerve.....	39	1		36
1. Deltoid.....			2	
V. Musculospiral nerve.....	15, 22, 31, 33	4		2
1. Triceps.....			4	
2. Supinator longus.....			2	
3. Extensor carpi radialis.....			2	
4. Extensors of the fingers.....			1	
VI. Sciatic nerve:				
(a) Internal popliteal division.....	12, 20, 23, 24, 63, 64	6		
1. Hamstrings.....			4	
2. Gastrocnemius.....			3	
3. Tibialis posterior.....			2	
4. Flexor longus digitorum.....			2	
5. Flexor longus hallucis.....			2	
6. Intrinsic.....			0	
(b) External popliteal division.....	14, 21, 59	3		13
1. Peronei.....			3	
2. Tibialis anterior.....			2	
3. Extensor digitorum.....			1	
4. Extensor hallucis.....			1	
VII. Internal popliteal nerve.....	1, 6, 7, 10, 40, 51, 52, 54, 56, 58, 63, 64, 68	13		
1. Hamstrings.....			2	
2. Gastrocnemius and soleus.....			9	
3. Tibialis posterior.....			10	
4. Flexor longus digitorum.....			5	
5. Flexor longus hallucis.....			4	
6. Intrinsic.....			2	
VIII. External popliteal nerve.....	10, 14, 38, 46	4		32
1. Peronei.....			4	
2. Tibialis anterior.....			1	
3. Extensor digitorum.....			1	
4. Extensor hallucis.....			1	
Total.....		73		161

and its muscles are quite unresponsive to electrical stimulation at all points through the skin, while direct stimulation of the nerve trunk at operation causes muscle reaction. We have also observed all of the conditions of Erb's reaction elicited by direct stimulation of the exposed nerve.

3. A phenomenon of difference between percutaneous and direct stimulation.

The explanation of the last mentioned phenomenon appears to be simple. The direct stimulation of an exposed nerve is stronger and less diffused, and suffices to overcome the decrement in conduction produced by

Fig. 3.—Heads of the median nerve: A, external (6 and 7); pronator radii teres; B, internal (8 and 1): 1, flexor carpi radialis; 2, flexion of the fingers; 3, flexion of the thumb; 4, abductor pollicis.

Fig. 4.—Median nerve, midarm level: 1, pronator radii teres; 2, flexor carpi radialis; 3, palmaris longus; 4, flexores digitorum; 5, flexor pollicis; 6, pronator quadratus.

Fig. 5.—Median nerve, midforearm level: 1, sensory; 2, opponens pollicis; 3, abductor pollicis; 4, lumbricales.

Fig. 6.—Ulnar nerve: 1, flexor carpi ulnaris; 2, flexor profundus digitorum; 3, hypothenars; 4, interossei; 5, adductor pollicis; 6, sensory.

Fig. 7.—Musculospiral nerve: 1, triceps; 2, supinator longus; 3, extensor carpi radialis.

Fig. 8.—Sciatic nerve: 1, hamstrings; 2, gastrocnemius and soleus; 3, flexor longus hallucis; 4, flexor longus digitorum; 5, tibialis posterior; 6, peronei; 7, tibialis anticus; 8, extensors of the toes.

Fig. 9.—Internal popliteal nerve: 1, hamstrings; 2, gastrocnemius; 3, tibialis posterior; 4, flexor longus digitorum; 5, flexor longus hallucis; 6, intrinsics; 7, flexor brevis hallucis.

Fig. 10.—External popliteal nerves: 1, peronei; 2, tibialis anticus; 3, extensors of the toes.

Summarizing the phenomena due to areas of decrement which we observed, we have:

1. Erb's indirect, or percutaneous, paradoxical phenomenon.

2. A direct paradoxical phenomenon, from stimulation of the nerve trunk.

the lesion, while stimulation through the skin does not.

The surgical importance of these reactions is obvious. Where conductivity can be demonstrated, nerves or portions of nerves can be conserved which might otherwise be considered as completely interrupted and consequently subjected to unnecessary operative resection

and suture. Finally, the free ends of nerves that have been completely interrupted can be identified in the recent stage of injury, that is, until secondary degeneration develops. In cases in which it is of interest to cut the fibers to some muscles, let us say the gastrocnemius and soleus group, as in Little's disease, or when a trans-

It serves as an indispensable guide to operative manipulations.

It is a means by which we may add to our all too scanty knowledge of peripheral nerve anatomy.

Fig. 11.—Levels of stimulation of the main arm nerves and their branches.

plantation is desired, say of the triceps fibers into the circumflex nerve, it is essential to use electrodes.

RESULTS OF STIMULATION IN SEVENTY-THREE CASES

The results obtained have been combined for each nerve and are represented on the accompanying charts (Figs. 3, 4, 5, 6, 7, 8, 9 and 10). The black areas represent the responsive area on the circumference of the nerve, namely, the area in which faradization caused muscle contraction. The arrow in Figure 4 indicates that the fibers to the pronator radii teres muscle cross from the external aspect to the internal aspect of the median nerve on its anterior surface, the extent of the crossing being several inches in the midarm portion of the nerve. The absence of a black line to represent the position of the fibers for the tibialis posticus in Figure 9, and the location of the numbers throughout the circumference, indicate that we were unable to localize definitely the fibers to this muscle, but found them on all aspects of the nerve in different cases. This was the only exception to the rule that the fibers to a given muscle pursued a straight course from the plexus to the point of branching. The charts of the circumferential position of various bundles represent the results of stimulation at various levels (Figs. 11 and 12).

Fig. 12.—Levels of stimulation of the sciatic nerve and its branches.

CONCLUSION

Electrical stimulation at operation gives important information to the surgeon as to the location of nerves and their degree of abnormality due to injury.

RESTORATION OF LOSS OF BONE

INCLUDING AN ANALYSIS OF THE FIRST HUNDRED CASES OF FRACTURE TREATED BY BONE GRAFT AT U. S. ARMY GENERAL HOSPITAL NO. 3, COLONIA, N. J.*

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In the task of restoring loss of bone substance and function in the wide variety of traumatism resulting from the war, the plastic surgeon is confronted with a correspondingly varied array of mechanical problems. The recognition of the underlying biologic and physiologic significance of tissue growth and metabolism is a fundamental requirement in the successful treatment

Fig. 1.—Requisite apposition of bone layers of graft with respective parts of host bone. The graft is of sufficient length to extend well beyond the eburnated area of the host fragments, coming into generous contact with the healthy vascular marrow substance. The cross-section at E shows the eburnated plug of bone where, as a rule in pseudarthrosis, it closes the marrow cavity in the fractured ends. Here the gutter has been deepened sufficiently to receive the full amount of marrow of the graft, which is demonstrated (lower drawing and cross-section at D) in extensive contact with the marrow of the host fragments. The arrows on the marrow in the host fragments indicate the direction of blood supply to the graft from its principal normal source, namely, the marrow substance of the host. By the insertion of the inlay, with its full amount of marrow, a continuous marrow bridge is formed, extending from the healthy marrow of both host fragments through the gutter in the eburnated ends. This marrow bridge plays a most important rôle as conductor of blood vessels and osteogenic cells from one host fragment to the other. The cross-sections at D and E show also the cabinet-maker fit of the inlay graft with the host fragments, which not only affords mechanical fixation of parts, but also favors the stimulus to bone growth from frictional irritation, emphasized by Roux.

of these cases. The surgical repair of bone, and more particularly the use of the bone graft in cases of pseudarthrosis with or without bone loss, is based not only on the ultimate establishment of adequate fixation of the bone fragments, but also on the attainment of a proper environment for the nourishment of the graft. This entails the exact coaptation of parts of the graft to respective parts of the host bone; in other words, the adequate and extensive contact of all four corresponding bone layers, namely, periosteum, cortex, endosteum and marrow.

* Read before the Congress of the Italian Orthopedic Association, Bologna, Oct. 18, 1919.