

NERVE-BRIDGING.

REPORT OF ONE SUCCESSFUL CASE.*

ALFRED S. TAYLOR, M.D.

Visiting Surgeon, Randall's Island Hospital; Assistant Instructor
in Operative Surgery, College of Physicians and Surgeons.
NEW YORK CITY.

The literature of the surgery of the peripheral nerves is fairly voluminous, but, instead of being indexed under any one caption in the *Index Medicus*, it is scattered through the various subheadings of surgery. This renders it difficult to cover the ground completely.

In the case reports, of which the literature largely consists, the results are usually stated in such general terms as to be of little value for a study aiming to evolve the best technic for the treatment of the different types of cases. This difficulty is not hard to understand if it be remembered that the results from nerve surgery are late in appearing (1 to 2 years), and that it is almost impossible to keep track of the patients and maintain their interest sufficiently to permit of frequent systematic examinations for record. For these very reasons the post-operative record of the case reported in this paper con-

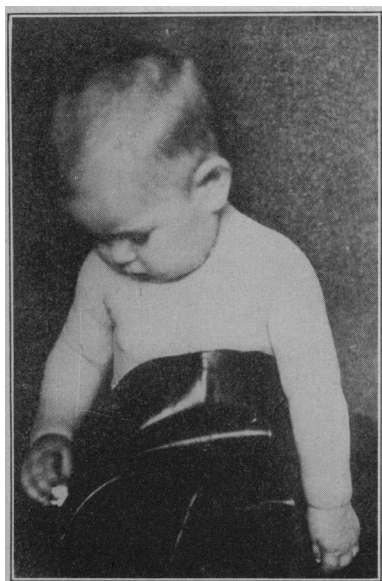


Fig. 1.—Before operation. Total paralysis of left upper extremity.

sists almost entirely of photographs. No electrical tests were possible.

To put the technic of nerve-anastomosis and nerve-bridging on a sound basis much experimental work must be done to determine the relative values (with regard to the return of motor power, co-ordination and normal trophic conditions), of lateral implantation as compared to end-to-end anastomosis. The bridging of gaps between the ends of divided nerves, which can not be approximated is a modified type of end-to-end anastomosis.

To help the nerve ends to grow together various expedients have been used. These may be classified as:

(a) Neuroplasty, where one or both of the nerve-ends are so split and turned over as to meet and bridge the gap.

(b) Grafting or nerve-transplantation, where a section of nerve from the same or another individual, or even from one of the lower animals, is made to fill in

the gap by suturing its ends to those of the divided nerve.

(c) Tubulization, where a tube is used to connect the two nerve ends to prevent the ingrowth of connective tissue during the development of the new nerve tissue which is to form the permanent bridge. Various kinds of tubes have been used, decalcified bone, formalinized gelatin, arteries (fresh or formalinized) from different animals, magnesium, etc.

(d) *Suture à distance*, where a catgut suture is passed from one nerve end to the other several times, forming a framework between the two. With this is often combined one of the tubulization methods.

(e) Resection of bone, where enough bone is removed to permit direct end-to-end suture of the nerve. This method does not involve true nerve-bridging, but must be included as a method of dealing with nerve defects.

(f) Lateral implantation of both proximal and distal stumps of the damaged nerve into a neighboring motor nerve. There is some evidence to show that fibers from the proximal stump grow down along the nerve into which it is implanted and thus help to bridge the gap.

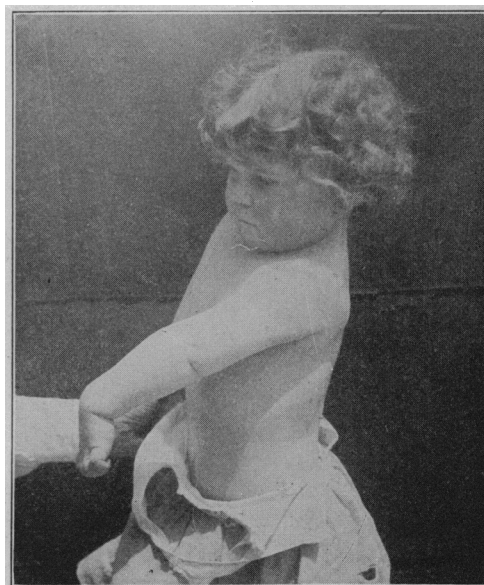


Fig. 2.—Eleven and a half months after operation, showing anterior elevation of extremity. Fingers contracted from neglect of after-treatment.

It is well established that materials interposed between the nerve ends act only as guides which degenerate and are absorbed as the new nerve grows. In neuroplasty, then, the flaps secured from the nerve ends are changed to mere bridges which degenerate and are absorbed. The larger the flaps have to be, the more damage is done to the very structures on which dependence is placed for filling in the gap, and the more regeneration is necessary to replace the nerve tissue thus lost.

In nerve transplantation much time and trouble must be expended to obtain a graft of the right size, in aseptic condition, just at the time it is needed.

In 1904, Powers¹ collected 22 cases of transplantation. "Satisfactory" results were reported in 22 per cent. of the cases, but Powers questions their authenticity because of the absence of detail in the reports.

Douglas-Crawford² adds one case in which he reports

* Read before the Surgical Section of the New York Academy of Medicine, Dec. 6, 1907.

1. Transactions Amer. Surg. Assoc., 1904.

2. Liverpool Med. Chir. Jour., 1906, vol. xxvi, p. 200.

"nearly complete success" after four months, in bridging a three-inch interval in the musculo-spiral nerve by means of the spinal cord of a rabbit. This would represent a very unusually rapid regeneration of nerve, entirely aside from the transplantation.

Marion³ states that neuroplasty and nerve transplantation have been abandoned because they are very delicate, tedious operations, and their results are inferior to those obtained by *suture à distance*. Tubulization also involves much trouble in preparation of the tubes, which must be of many sizes. Some authors state that these foreign bodies cause increased connective tissue growth, which interferes with nerve union. Foramitti⁴ in numerous experiments with fresh and formalized calves' arteries found no such reaction. Only one case of the use of this method in the human being is recorded and that resulted in complete failure.¹

In contrast to these three troublesome procedures *suture à distance* has many advantages. It does the minimum of damage to the nerve ends, is simple, is applicable in any situation, holds the nerve ends as close together as possible without undue tension, introduces an

less. There is some power in the serratus magnus, contraction of which (with trapezius) throws the extremity slightly forward. The soft tissues are flabby, and the extremity is cold. The muscles show reaction of degeneration. A large indurated mass can be felt on the left side of the neck at the site of the brachial plexus.

Operation.—June 8, 1905. Ether anesthesia. The plexus was exposed. The deep cervical fascia was much thickened and adherent to the entire front of the brachial plexus, which was a dense mass of cicatricial tissue, with the nerve roots running into its upper end and the nerve trunks coming from it below the clavicle. The nerve roots of the entire plexus were divided above the cicatricial mass (nearly at the intervertebral foramina). The plexus was dissected out *en masse* and removed by dividing the nerve trunks at their exit from its distal end beneath the clavicle.

The severed nerve ends could not be approximated closer than 2 cm. to the nerve roots, so loops of chromicized catgut (No. 1, 40 days) were passed between the two. Around the whole series of loops Cargile membrane was wrapped to form a single large canal. The wound was closed without drainage, and the neck and shoulder were fixed and held in close proximity for six weeks. The reaction was good. The wound healed by primary union.

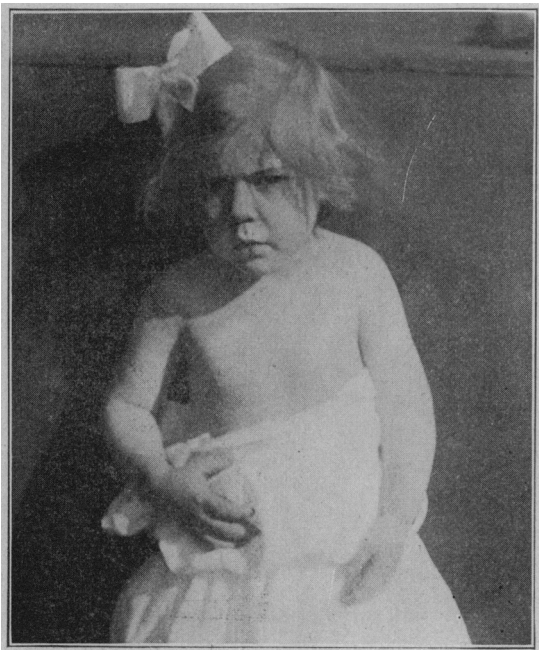


Fig. 3. Two years four and a half months after operation, showing natural position of left upper extremity. Contracture of fingers has disappeared.

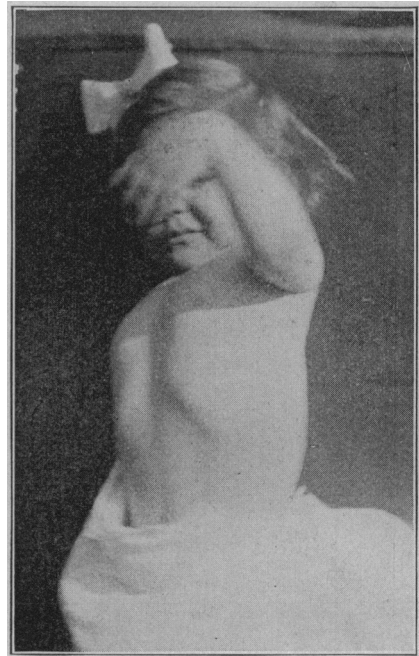


Fig. 4.—Shows power to elevate the extremity.

absorbable foreign body which causes the minimum of disturbance to the tissues and acts as a framework along which the nerve fibers grow to each other. Its results in practice are superior to those of the other methods.³

In the following case the *suture à distance* method was used. The patient was Case 9 of the series of "Brachial Birth Palsy" cases operated on and reported in conjunction with Drs. L. Pierce Clark and Thomas P. Prout:⁵

Ruth F., aged 1 year, the second child, was large, and was delivered with instruments. Soon after birth, it was noticed that the left upper extremity was motionless. There has been no return of motion (Fig. 1). In other respects she has been very well.

Physical Examination.—She is a large, well-nourished child, normal except for the left upper extremity which hangs life-

After her return home she was presented for examination only at long and irregular intervals. At the end of three months the muscles were more flabby than ever, the shoulder was a flail joint and there was no sign of returning power. December 4, 1905 (six months), the mother first noticed that the terminal segments of the thumb and first three fingers were swollen, red, glossy and ulcerated on the tips. They were not sensitive and were not infected. The mother reported that after six weeks more, sensation gradually returned, and the finger condition then improved. While this trophic disturbance of the fingers was present, there was slight but distinct activity in the pectoralis major, triceps and serratus magnus muscles.

May 21, 1906 (11½ months), the movements in the above mentioned muscles were stronger. There also appeared some power in the deltoid muscle, both for anterior elevation of the arm and slightly for abduction. There was slight power of flexion at the wrist (Fig. 2). When lying supine she could raise the extremity to the vertical position without much effort. The shoulder-joint had lost its flail character. The tissues of the extremity were firmer, warmer and of a more natural

3. *Chir. du Systeme Nerveus*, Paris, 1906, vol. vi.
4. *Archiv. f. klin. Chir.*, 1904, vol. xxiii, p. 643.
5. *Amer. Jour. Med. Sciences*, October, 1905.

color. There was distinct flexion contracture of the fingers. The massage ordered had not been given.

October 27, 1907 (28½ months), the flexion contracture of the fingers had entirely gone. The tips of the thumb, index and middle fingers were still somewhat red and shiny. The extremity was growing well, and had a good color and warmth. Sensation was about normal (Fig. 3). For the last six months she had used the extremity freely, handling playthings, helping to feed herself, etc. Power had returned in varying degree to all the muscles, least in the flexors of the fingers and extensors of the radial carpus. The mother states that both the power and range of motion increase as time goes on, and that most of the improvement has occurred in the last six months (Figs. 4 and 5). The hand is beginning to develop power, but this is not indicated in the pictures.

This case represents the successful bridging of a 2 cm. gap in each of the roots of the brachial plexus by means of the *suture à distance*, combined with a modified tubulization due to the use of the Cargile membrane. The case was a most favorable one because of the very excellent general condition and the age of the child. It is well known that nerves grow and regenerate far more vigorously during infancy than at any later period.

Nerve tissue bridges a gap at the rate of ¼ mm. per day.⁶ While cases of successful bridging have been reported where the interval was so great as 7.5 cm.,² as a rule failure will follow an attempt to bridge more than 4 cm. interval.⁶ When a gap larger than 4 cm. exists recourse may be had to one of two procedures: (a) Implantation of both ends of the damaged nerve into a neighboring motor trunk (proximal end as well as distal end, because there is some growth of fibers from the proximal end, along the nerve trunk into which it is implanted). (b) Resection of sufficient bone to allow the nerve ends to be apposed directly by suture. This method is indicated where the paralyzed nerve has a large and important muscle-field.

In cases similar to the one reported, including cases of traumatic rupture of the brachial plexus in adults, where reasonable approximation of the nerve ends can not be obtained, it is my personal opinion that the clavicle should be divided near its middle and the fragments allowed to override so as to permit of close approximation or direct apposition of the nerve ends. Certainly, an extremity with returned muscle-power, even at the expense of great deformity of the clavicle and shoulder, is much to be preferred to one which is permanently paralyzed. After nerve regeneration has occurred, and voluntary motion is returning (1 to 2 years), the clavicle may be restored as far as possible to good position by open operation with partial resection if necessary.

In dealing with the surgery of nerves one thing can not be emphasized sufficiently, namely, that from the time of paralysis the tissues of the affected region must be kept in as good condition as possible by means of massage, electricity, passive motion, etc., in order to prevent fibrous degeneration of muscle, contracture of muscles and ligaments, resulting in deformity, and the irregular forms of the bony joint-surfaces due to growth in abnormal positions. Obviously, the same means must be used after operation until regeneration has occurred.

Authentic cases of nerve regeneration with return of motor power have been reported where the paralysis has continued for five, ten, fifteen and even twenty-nine years before operation. While nerve power may return after indefinite periods of paralysis, it is easy to understand how the results of operation, both as to promptness

and completeness, may be interfered with or entirely nullified by changes in the structures other than nerves, due to neglect of the above mentioned precautions.

Since moderate delay under proper conditions does not prejudice the return of nerve function in those debatable cases where the gap to be bridged is so large as to necessitate a choice between *suture à distance*, lateral implantation, and resection of bone, the *suture à distance* may be tried. If after a reasonable time, there is no return of power, either of the remaining methods may be tried, according to the indications previously outlined.

SUMMARY.⁷

1. The literature of nerve surgery is not well indexed; case reports give results in very general terms, often because of the difficulty of tracing cases and making systematic examinations over the long periods of time necessary.

2. Much experimental work is still necessary to determine the best technic for the solution of the various problems in nerve surgery.

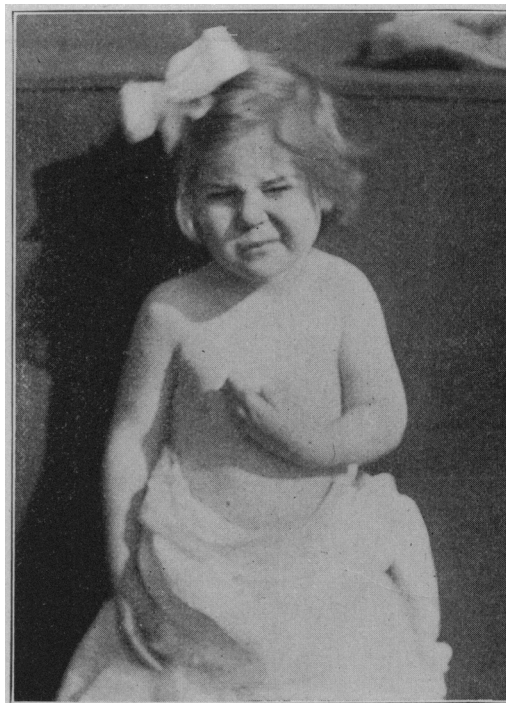


Fig. 5.—Shows flexion at elbow, combined with supination of forearm and hand.

3. Nerve defects can be bridged. Judging from the material at hand, *suture à distance* offers the simplest and most successful method.

4. The younger the patient and the better the general condition, the more hopeful is the result.

5. Results come only a long time after operation, and depend for completeness on massage, passive motion, electricity, etc.

6. Probabilities are against the bridging of gaps greater than 4 cm., although a few cases are reported.

7. For defects larger than 4 cm., resection of bone or lateral implantation of nerve ends may be used. Good

7. The following references may also be consulted in connection with this subject: Spitzzy (H): Amer. Jour. of Orthop. Surg., vol. II, Aug. 26; Wien. klin. Wochschr., 1905, xviii, p. 57; Zeitschr. f. Orthop. Chir., 1905, xiv, p. 672; Zeitschr. f. Orthop. Chir., 1904, xiii, p. 326. Von Aufferberg (F): Arch. f. klin. Chir., 1907, lxxxii, p. 615. Taylor (A. S.): and Prout (T. P.): THE JOURNAL, Jan. 12, 1907. Rau (N.): Liverpool Med. Chir. Jour., 1903, xxiii p. 277.

6. Ehrmann: L'étude de la suture de nerfs à distance, Paris, 1896.

muscle power with bone deformity in an extremity is much to be preferred to complete or serious paralysis.

NOTE.—After this paper was written Hashimoto and Tokuyoka (*Archiv. f. klin. Chir.*, lxxxiv, 2, 354) reported 50 cases of nerve repair with use of Foramitti's formalized calves' arteries. These persist two months or more and do not cause tissue irritation. No successful case of bridging by their use was reported.

Clinical Notes

CASE OF MIXED CELLED SARCOMA.

FREDERICK S. BARON, M.D.
ZANESVILLE, OHIO.

Patient.—Ambrose G., American born, of German parentage, age 19, white, an ironworker.

Family History.—Father living, fine physique and health, aged 45. Mother died at 30 from diabetes. (?) No brothers or

period the patient attempted to work, but could only put in part time, due to the vertigo, the loss of power in the lower limbs, and the disturbance in co-ordination, until finally he became unfitted for work.

Physical Examination.—He was admitted to the Good Samaritan Hospital, May 2, 1906. Pulse, temperature and respiration were normal. At the time of admission, the tumor-like masses had increased in size and in number. They varied in size from an English walnut to the size of an orange. These small growths followed along the direct lymph chains, and were situated quite superficially under the skin and subcutaneous tissue. In color they were deep mahogany, and glistened, due to the stretching of the skin covering. They had a great vascular supply, but at no time did they break down. The patellar reflexes were exaggerated. The pupils were normal. His gait was cautious, and of a rolling character. The urine showed nothing abnormal. The blood was not examined.

Microscopic Examination.—A section of one of the tumors from the anterior part of the chest wall showed many cells containing large round vesicular nuclei, also spindle cells, with



Fig. 1.—Head of patient with mixed celled sarcoma.

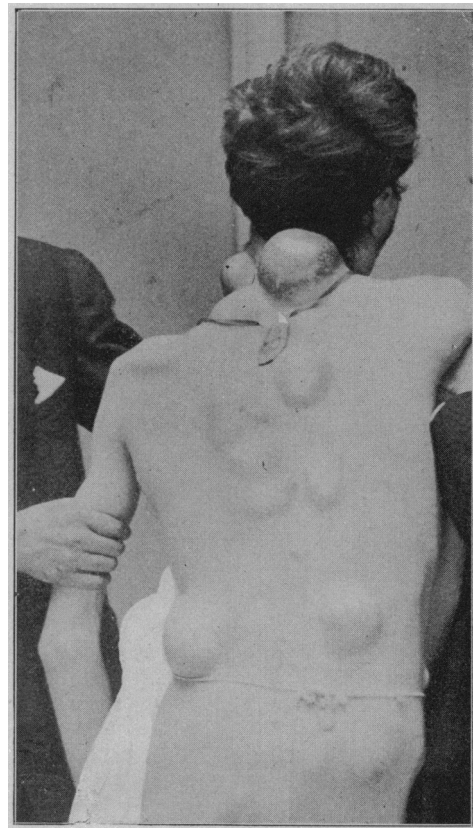


Fig. 2.—View of back of patient with mixed celled sarcoma.

sisters; no aunts or uncles afflicted with tuberculosis or cancer.

Personal History.—Never ill, except with diseases of childhood. On Nov. 22, 1904, a small wine colored nevis was removed from the right temporal region at the margin of the temporal hair line, under local anesthesia. The wound healed fairly well, but would seep a watery secretion when irritated by cutting or combing the hair. General health excellent, a strong, well-knit, muscular man, height 5 feet 9 inches, weight 148.

History of Disease.—On March 4, 1906, the patient came under my observation complaining of weakness in the legs and a feeling of uncertainty while at work, which he said was progressive. At times he would fall over while at work. During this interval, a small tumor-like mass made its appearance just below, or about at the temporo-maxillary joint on the right side, and a little later another appeared just below the middle third of the clavicle, on the same side. During this

vesicular nuclei, and small round cells. The intercellular tissue, instead of being wavy, was straight.

Diagnosis.—Mixed celled sarcoma.

Course of Disease.—From the time of admission to the hospital to the time of death, which occurred July 25, 1906, there was a constant increase in the size of the growths, and in their number. The tumor masses in the omental chain of glands could be seen distinctly through the abdominal wall, and were very numerous. Emaciation became extreme, pressure pain from the presence of the masses in the abdomen, and behind the eye, which from the intraorbital pressure was bulged out beyond the plane of the supraorbital arch, was severe. Post-mortem was refused.

The photographs were taken two days before death, and serve to give a fair illustration of the size and the extensive distribution of the growths over the body.

For the very excellent photographs I am greatly indebted to Dr. H. R. Geyer.