

A NEW METHOD OF PERIPHERAL NERVE ANASTOMOSIS; REUNION OF A SEVERED NERVE BY TUBULATION WITH AN ARTERIAL TUBE FIXED AND PRESERVED IN 70% ALCOHOL

by

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The routine technique of nerve anastomosis is to suture the epineurium of the two ends of the severed nerve with fine silk. This method has some drawbacks. For example, when the nerve to be united is of small caliber, or when the suture has to be done under great tension, this method of suture is technically impossible or quite insecure, thus the suture passing through the nerve parenchyma is inevitable. If the nerve parenchyma has been involved into the suture, especially when the nerve to be united is fine, the thread used for suture may exert a mechanical stimulation as a foreign body with the result of fibrosis or formation of neuroma at the site of the anastomosis and, in addition, regenerated nerve fibers tend to proceed toward irregular directions other than into the peripheral stump of the severed nerve. Thus the regeneration of the nerve which is enough to ensure the perfect recovery of the lost function can not be established.

The key points to ensure the success of the nerve union are as follows ;

- 1) To adapt closely the cut surface of the proximal nerve stump, which is the source of regenerating fibers, to the cut surface of the distal stump, which provides the channel into which the fibers are to be routed;

- 2) To remove as much as possible the obstacles intervening between the nerve stumps;

- 3) To prevent a mass of fibers from escaping into the surroundings tissue.

For these purposes, less stimulative suture materials, such as Cut-gut or Tantalum wire, are used instead of silk. However, even with these materials, the operative procedure is likewise difficult and some stimulative effects still remain as far as they are left at the site of the anastomosis.

For the tubulation of the united nerve, decalcified bone tube, fresh arterial- or venous-tube, fascia, gelatine membrane, etc, are used, but they all have more or less shorts.

WEISS performed sutureless reunion in case of the anastomosis of a small nerve, with tubulation using the auto-graft of a fresh arterial- or venous-tube, and reported the satisfactory results both functionally and histologically.

Later SPERRY confirmed from his experiments that WEISS's method of nerve union was quite excellent. However, to take a piece of fresh blood vessel is often

difficult and trouble-some, and when tension between the two nerve ends is considerably great, the adapted nerve ends are separated and escape from the arterial tube.

Also TAKETOMO in our Clinic tried to unite the nerve ends without suture, making the tubulation with an autogenic fascia membrane or venous tube, and reported good clinical results.

According to KIMOTO, the results of repair of an arterial defect using an arterial graft fixed and preserved in 70% alcohol are never inferior to those in case of a fresh arterial autograft. In the course of experimental investigations on the crossed anastomosis of antagonistic peripheral nerve in dogs, I tried to use such an alcohol-fixed arterial tube for the tubulation of the site of the nerve anastomosis, modifying TAKETOMO's method. I believe it is worthwhile to report on this operative technique of the nerve anastomosis, since this technique is quite convenient to practice and, moreover, I could confirm its excellent results in the regeneration of nerve fibers and it seems to promise the wide clinical application.

Preparation of an arterial tube. A piece of artery in proper length and size is taken off from a cadaver, washed in physiological saline solution so that it becomes free of blood and then preserved in 70% alcohol. The procedure to take off an artery needs not be aseptic, because of the sterilisation in alcohol, and the arterial tube may be heterogenic as well as homogenic, since it is denaturated by the fixation. The material may be preserved in the usual room temperature.

The fixed arterial tube is much more convenient than the fresh one, because it can be used at any time.

OPERATIVE TECHNIQUE

The fixed and preserved arterial tube of nearly the same diameter (or slightly narrower) with the nerve to be united is taken out at the time of use, then it is immersed in the physiological saline solution for about 10-15 minutes and softened. Thus the arterial tube regains its elasticity almost the same as in the fresh one.

No. 0 silk thread is used for the suture.

The steps of the operation are illustrated in the accompanying figures: In the middle of the arterial tube of the 1.5-2.0cm length, a minute hole is pierced. (cf. Fig. 1, a)

Ligatures by suture are made separately at both ends of the severed nerve, in order to lead them into the arterial tube. (cf. Fig. 1, b)

One of the leading threads is pulled through the arterial tube and taken out from the hole. Thus, one nerve end attached to this leading thread is passed through the arterial tube, to appear from the middle hole. (cf. Fig. 1, c)

Then, 3-4 interrupted sutures with silk are made between the end of the arterial tube on this side and the epineurium of the nerve, taking care not to involve the nerve parenchyma. (cf. Fig. 1, d)

The same procedure is done at the other end of the nerve. (cf. Fig. 1, e)

Both nerve ends appearing outside the hole of the tube are cut off with a sharp knife, above and below the point of ligation respectively. (cf. Fig. 1, f)

Cutting off these nerve ends should not be too extensive, because, if so, both ends will fall back into the tube owing to their own elasticity and fall to adapt correctly. From my experience, it is most desirable that, after cutting, both nerve ends should lie slightly upon each other outside the hole. (cf. Fig. 1, g)

Then, the arterial tube is extended with two forceps at both ends of it, in order that the nerve ends are adapted to each other correctly in the arterial tube. (cf. Fig. 1, h) (Some additional pressure upon each end of the nerve through the wall of the tube is advisable.)

Finally one suture is made to close the hole. (cf. Fig. 1, i)

As the advantages of the arterial tube, it firstly provides a firm link between the nerve ends and, secondly, prevents the formation of a neuroma and the straying escape of regenerating fibers.

By this technique, crosswise anastomosis of heteronymous nerves in the hind limb was performed in dogs, and 6-12 months later, it was confirmed that the threshold for the electrical stimulation applied to the proximal section of the anastomosed nerve returned to almost the same level as in the preoperative measurement.

At the time of necropsy (even 12 months postoperatively) the arterial tube which had covered the site of the anastomosis looked as a white membrane, but no marked adhesion with the surrounding tissue was observed.

In the histological examination, any neuroma at the site of the anastomosis was not observed, and regenerated nerve fibers were found to have grown down almost parallelly and linially, contrary to the confusional regeneration following the ordinary technique of the nerve anastomosis. (cf. Fig. 2, 3)

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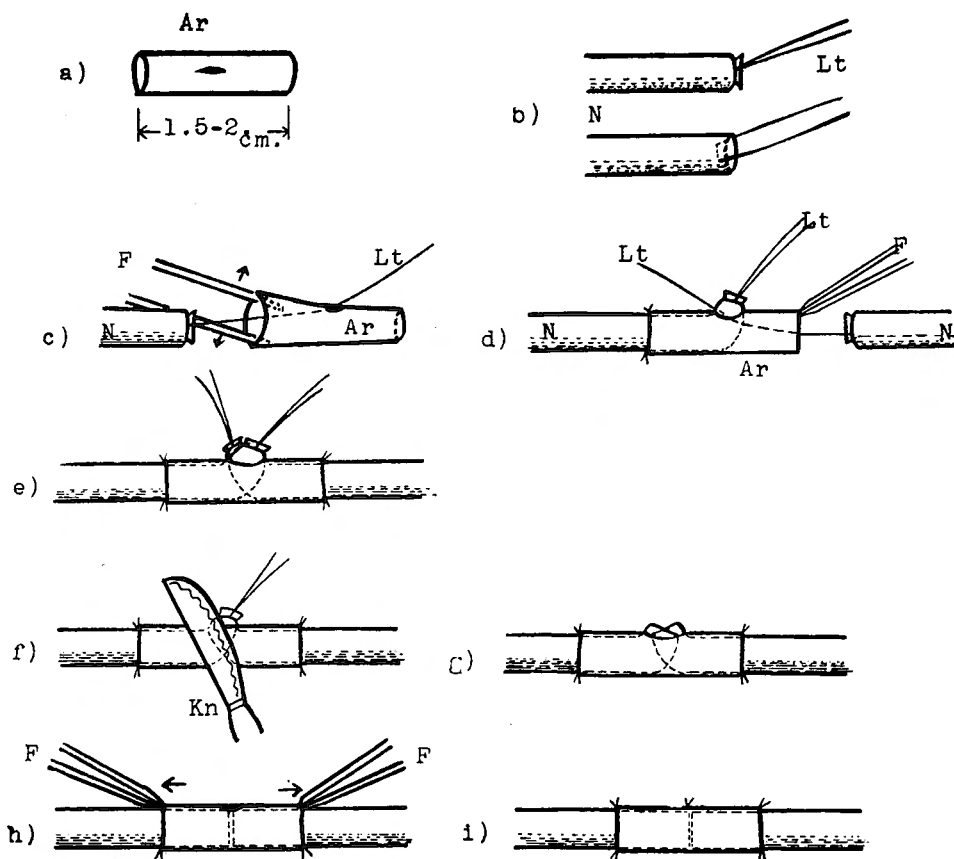


Fig. 1. Diagram illustrating the operative procedure.

- a) Alcohol fixed arterial tube (Ar) with a middle hole.
- b) Leading thread (Lt) set on the end of nerve (N).
- c) Insert forcep (F) into one end of Ar and open it lightly, pull N into the lumen of Ar by Lt.
- d) 3-4 interrupted sutures are made between the end of the tube and the epineurium.
- e) The same procedure is performed at the other end.
- f) Cut off the end of N with a sharp knife (Kn).
- g) After cutting, both nerve ends must lie slightly upon each other!
- h) Pull Ar with two F in the opposite directions, and let the nerve ends adapt to each other correctly in the tube.
- i) Close the middle hole.



Fig. 2. Photomicrograph of the longitudinal section of the united nerve. Proximo-distal direction from left to right. Ehrlich Myelin-sheat stain, $\times 6$.

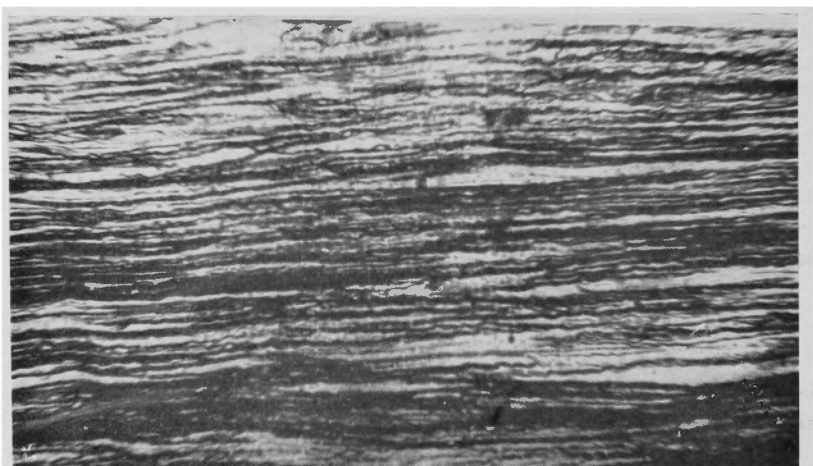


Fig. 3. Photomicrograph of the longitudinal section at the site of union. Regenerating fibers run in straightly parallel course. Weigert-Pal stain, $\times 80$.

和文抄録

神経縫合改良術式

70% Alcohol 中保存動脈管による套管法

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大学院学生 渡 辺 浩 策

従来一般に行われている神経縫合法は、両断端の神経外鞘を細い絹糸にて縫合するものであつて、此術式には多くの欠点、困難を有している。即ち神経実質に糸をかける事なく、神経外鞘のみ縫合する事は、神経が細い場合、両断端間に張力のかゝる場合等には縫合は困難であり、又術後縫合糸の刺激により fibrosis, neuroma等を作り、再生繊維は多数外部に迷走し、完全なる機能恢復の前提である完全なる神経再生は望み得ない。神経縫合の要点は、再生源たる中脳端と受入部たる末梢端の両断面を密接せしめ、その間に再生の障碍の原因となる恐れのあるものを除き、再生繊維の外部への迷走を防ぐ事である。私は末梢神経交叉縫合に関する実験的研究に際し、70% Alcohol 中保存動脈管を用い、神経断端面に全く糸を通ずる事なく套管法を行い、神経再生状況の優秀である事を確認した。

動脈管は予め剖検時に適当なものを採取し、血液を洗つて後70% Alcohol 中に保存するもので Alcohol の

殺菌力の為に採取は無菌操作を必要とせず、又固定により変質する為に同種血管たる事も要しない。保存は室温に放置してよい。

手術は保存動脈管を食塩水にて軟化したものを用いて套管法を行う。即ち神経端に設置した誘導糸の下に、血管端より予めあけられた血管中央の小孔に神経端を引き出し、その側の血管端と神経外鞘との間に、実質を損傷せぬ如く、3~4ヶ所縫合固定する。他側端からも同様に行い、中央孔より露出した両神経端を更めて鋭利に切除する。この時両神経端はやゝ重なる程度が良く、長がすぎても、短かくて血管内に後退する様でもいけなく、血管両端に軽く張力を与えて断端を管内に納め、管内で両神経端を適合せしめる。本法の動脈管は両神経間の副木となると共に再生繊維の外部への迷走を防ぐものである。両断面に全く糸を通じない為に再生繊維はほぼ完全に末梢へ再生し、組織学的にも再生繊維はほぼ平行に、直線的に再生延長する事を確かめた。