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DISSECTION OF PERIPHERAL NERVE SHEATHS WITH AN ULTRASONIC MICROSCALPEL WITHOUT IMPAIRING NERVE CONDUCTION

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In neurophysiological research it is often necessary to dissect nerves without disturbing conduction of nervous impulses. An important step in the operation is incision of the nerve sheaths — the outer (epineural) sheath to isolate a separate nerve branch from the main trunk, and the inner (perineural) sheath to isolate microbundles or single nerve fibers [3]. Usually the sheath is incised in the longitudinal direction under the microscope by means of microscissors or, in the case of a thin branch, with a piece of razor blade [4]. Both methods require many micromovements with the cutting edges and they are accompanied by traction on the nerve along the path of the instrument. During operations on nerves *in vivo* a further difficulty is bleeding from the divided epi- and perineural vessels. These complications may lead to injury to nerve fibers. The writers have developed a method of dissecting the epineurium and perineurium by means of an ultrasonic microscalpel (USM) which is free from the defects described above and have determined the level of impairment of conduction of excitation along the nerve caused by the use of this method.

EXPERIMENTAL METHOD

The USM was made on the basis of the UZKh-201 apparatus for ultrasonic surgery, manufactured commercially, operating on a frequency of 44 kHz [1]. For this purpose, a pointed fragment of safety razor blade 8-10 mm long was soldered to the tip of the vibrator. The amplitude of the longitudinal oscillations of the razor blade was selected to be 2-5 μ.

In five cats anesthetized with chloralose and urethane the saphenous nerve in the hind limb was freed from connective tissue for a length of 5-7 cm from the knee to the hip joint. Folds of skin were formed into a well along the nerve which was filled with mineral oil. In the distal part the nerve was placed on stimulating electrodes, and in the proximal part on recording electrodes. Bipolar (differential) derivation was used to record the composite action potential. The signal was amplified by 10^4 times with a PARC (model 113) amplifier and filtered in the 20 Hz—1 kHz band. A segment of nerve 10 mm long was chosen between the recording and stimulating electrodes, where the epi- and perineurium were incised by means of the USM (Fig. 1A).

EXPERIMENTAL RESULTS

The control composite action potential of the nerve is illustrated in Fig. 1B. Waves of the composite action potential, formed by impulses in Aβ and Aδ fibers, were recorded during stimulation of the nerve with square pulses (amplitude 1.0-1.2 V, duration 0.1 msec). Thin unmyelinated C fibers were stimulated by square pulses (amplitude 10-12 V, duration 1 msec). The amplitudes of the impulses were three times the threshold values for excitation of Aδ

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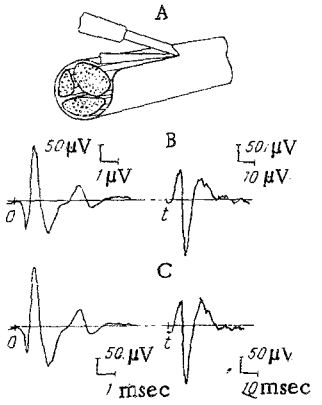

Fig. 1. Dissection of epineurium of cat saphenous nerve by USM. A) Scheme of incision; B) control (before incision of epineurium) composite potential consisting of Aβ, Aδ, and C waves (from left to right). C wave shown after t = 48 msec. Distance between stimulating and recording electrodes 50 mm; C) composite potential of same nerve after incision of epineurium 10 mm long. Temperature of nerve 32°C.

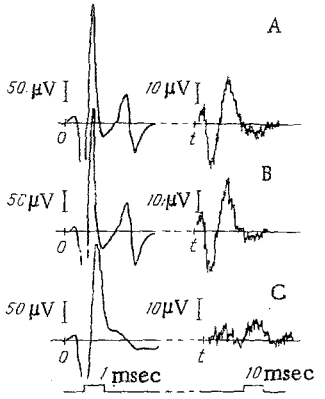

Fig. 2. Incision of perineurium of cat saphenous nerve by USM. A) Control (before incision) composite potential of nerve branch. C wave shown on right, starting from t = 48 msec. Distance between electrodes 47 mm; B) composite potential of nerve branch after incision of perineurium 10 mm long; C) reduction of waves of composite potential after separation of incised region of perineurium with dissecting needles. Temperature of nerve 36°C.

and C fibers, respectively. The nerve sheath was incised under a layer of mineral oil by puncture with the point of the USM, followed by switching on the ultrasonic oscillations and moving the USM along the nerve (Fig. 1A). After dissection of the epineurium, waves of the composite action potential were rerecorded (Fig. 1C).

The identical shape of waves of the composite action potential in Fig. 1, B and C indicates that the USM caused virtually no change in impulse conduction along fibers belonging to the different groups forming the saphenous nerve. The following advantages of dissection of the sheath by USM over the traditional methods were discovered: 1) absence of any marked mechanical tension along the nerve; 2) the hemostatic effect, manifested as thrombosis of the divided epi- and perineural vessels, as a result of which bleeding into the epineurium was negligible or absent altogether; 3) elimination of the need for saw-like movements of the instruments characteristic of work with an ordinary microscalpel during incision of nonhomogeneous areas of the epineurium (blood vessels, for example).

Dissection of the perineurium is necessary for experiments to record impulses in single fibers. The control composite action potential of a single branch of the saphenous nerve, surrounded by a perineural sheath (the epineurium has been removed) is illustrated in Fig. 2A. The trace of the potential after dissection of the perineurium by USM is shown below (Fig. 2B). It will be clear from Fig. 2 that in this case the composite potential was virtually unchanged, evidence of preservation of conduction along Aβ, Aδ, and C fibers of the branch of the saphenous nerve.

The most important advantages of the USM for dissection of the perineurium were those mentioned above under headings 1 and 3. Since there are no sufficiently large vessels in the perineurium difficulties with hemostasis do not arise even during work with an ordinary microscalpel. Incidentally, during movement of the USM along the perineurium, mechnical resistance of the divided tissue is not felt. Care is necessary on insertion of the razor blade deep into the nerve branch, for too deep an incision leads to trauma to the fibers, which is reflected in lowering of the amplitude of all waves of the composite potential. Other procedures causing trauma to the nerve include separation (retraction) of the incised segment of perineurium from the bundle of nerve fibers by means of dissecting needles (Fig. 2C).

While noting advantages of USM over the ordinary microscalpel such as the absence of tension on the nerve, and the unimpeded longitudinal path of the instrument, requiring no "sawing" through nonhomogeneities in the sheaths, its hemostatic effect can be singled out in particular. The point is that in some cases to prevent drying of the nerve, the sheath is incised under a layer of liquid. This makes the arrest of bleeding difficult even when relatively small vessels are divided. The hemostatic action of ultrasound has been observed also in the case of incision of brain tissue [2].

The experiments described above show that "sonication" of the nerve accompanying operation of the USM and generated beneath the sheath by the razor blade source, which is in direct contact with nerve tissue, causes no marked change in conduction of excitation along all groups of nerve fibers of the saphenous nerve, from the thick myelinated Aβ to the unmyelinated C fibers. Incision of the nerve sheath by means of ultrasound may prove useful not only in research, but also in neurosurgery.

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