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Intra-operative Electrophysiological Diagnosis of Spinal Root Avulsion During Surgical Repair of Brachial Plexus Stretch Injuries*

Technical Note

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Summary

Intra-operative direct root-SEPs combined with evoked muscle action potentials (EMAPs) from neck muscles are presented as helpful tools for evaluation of anterior and/or posterior spinal root avulsion from the spinal cord during surgical management of brachial plexus stretch injuries.

Keywords: Brachial plexus stretch injury; root avulsion; intra-operative electrophysiology; direct root SEPs; peripheral nerve surgery.

Introduction

Knowledge of the functional state of cervical roots is essential before surgical brachial plexus repair. Only in cases with functional integrity of the cervical rootlets is direct nerve repair possible. In cases of root avulsion from the spinal cord other surgical strategies are necessary such as neurotisation procedures or/and muscle transfers (in selected cases).

We present an easy to handle intra-operative electrophysiological test to evaluate the functional state of both the anterior and posterior root selectively.

Technical Preconditions

After introduction of general anaesthesia and positioning of the patient, the recording electrodes (subcutaneous stainless steel-electrodes) are placed on the patient. 2 channels are recorded simultaneously (System Viking 2, Nicolet Instruments).

A) The cortical evoked potentials (SEPs) from the contralateral postcentral region are recorded on the first channel. The active electrode (–) is placed at C3' or C4' (according to the 10/20-system). The reference electrode (+) is placed frontally in the midline and behind the hairline.

B) Evoked muscle action potentials (EMAPs) from neck muscles are recorded on the second channel. The recording technique for EMAPs is biopolar with subcutaneous electrodes placed in the neck or in the neck and forehead.

The ground electrode is placed on the contralateral forearm.

Hook-shaped biopolar steel electrodes are used for stimulation of the spinal root (extraforaminally). Square impulses of 0.2 ms duration and supramaximal strength up to 15 mA are delivered with a frequency of 1 Hz (System Viking 2, Nicolet Instruments).

Stimulation and Recording Procedure

Once the spinal roots in question (usually C5–C7) are exposed by a supraclavicular approach up to the

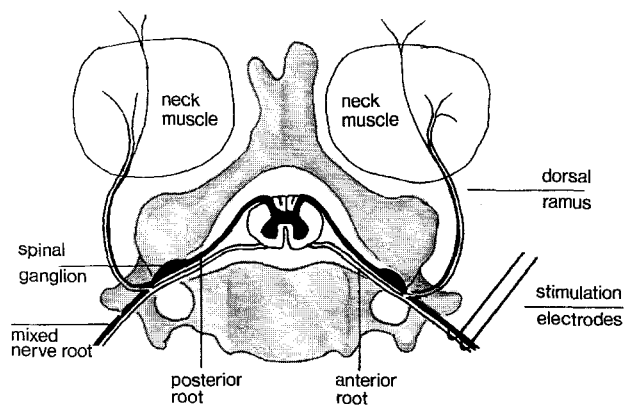

Fig. 1. Cross-section of the cervical spine with stimulation electrodes on the (mixed) spinal nerve root

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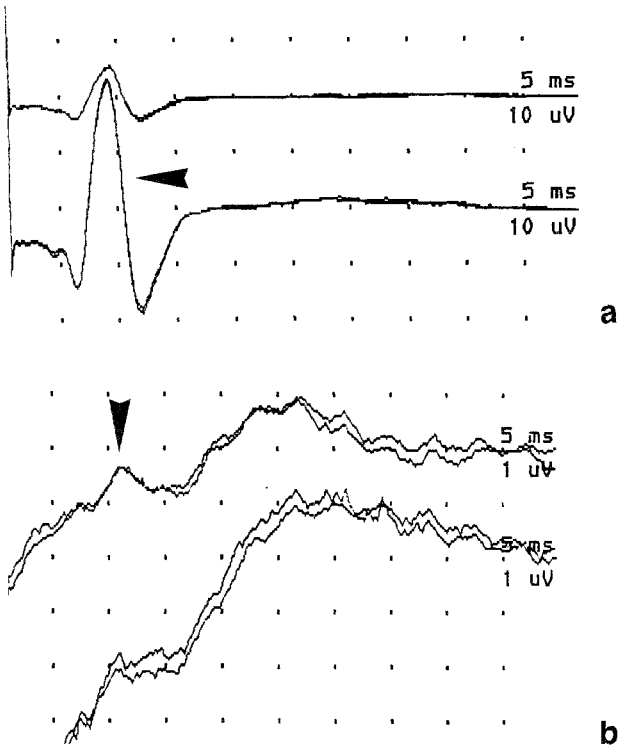

Fig. 2. Stimulation site: C5-root extraforaminally (1.2 mA, 1 Hz). Recording site: upper trace: F3'/F4' – Fz (contralateral postcentral region – forehead); lower trace: C2 – Fz (neck – forehead). (a) Before muscle relaxation: EMAP on lower trace (neck). Note: EMAP also visible on upper trace as far field potential. (b) After muscle relaxation: Cortical SEP on upper trace. Note different latencies of EMAP and SEP and different amplification in a and b (10 uV/div versus 1 uV/div)!

vertebral foramen, anaesthesia is changed from volatile agents to propofol intravenously without muscle relaxation. Then the (mixed) nerve root is stimulated just distally to the vertebral foramen (Fig. 1).

In the case of a functionally intact anterior root the dorsal ramus leaving the (mixed) spinal nerve a short distance above the stimulation site is also stimulated by upward spreading of current and clear polyphasic EMAPs from neck muscles can be recorded on the second trace without averaging (Fig. 2a). Usually the EMAPs are also visible on the first trace with the same latency and shape but lower amplitude (far field potentials!). The muscle potentials have very short latencies (< 10 ms). In the case of anterior root avulsion neck muscles are denervated and EMAPs are absent.

Then *succinylcholine* is given intravenously *for full muscle relaxation.*

Stimulation is repeated and while evoked muscle activity is completely abolished, a cortical SEP can be recorded on the first trace in the case of a functionally intact posterior root showing about the shape of a SEP after upper extremity transcutaneous nerve stimulation (M-shape) with a first negative peak at around 12 ms (Fig. 2b). In the case of complete posterior root avulsion the cortical SEP is absent.

Comments

For many years, we would operatively use evoked cortical responses ECR to evaluate spinal roots. We stopped because if our more peripheral (lateral to the nerve root foramen) nerve action potential (NAP) recordings were flat (absent NAPs) we would resect root until fascicular structure was either seen or not. If seen, then, we would repair, if not, then, we would lead grafts from our other more usable levels or turn to neurotization. If an NAP was of large amplitude and rapid conduction in a distribution where distal loss was complete, then, this represented a preganglionic response and indicated a non-reparable root at least as far as using it for lead-out was concerned. On the other hand, if a smaller NAP with slower conduction was recorded, this indicated a regenerative response and other than external neurolysis, the root was left alone.

Another way to look at dorsal ramus input to paraspinal muscles is to sample their activity by EMG pre-operatively looking for signs of denervation such as fibrillations and denervation potentials. Has this been done by the authors and how does that correlate with the evoked dorsal ramus responses recorded by the authors?

D. Kline

Answer from the Authors

Pre-operative paraspinal EMG was not performed routinely in our series but occasionally. This method is of course helpful since it provides information as to whether root avulsion is present or not. But the problem with pre-operative EMG is, that it is not able to distinguish between different segments concerning root avulsion from spinal cord, which is the most interesting information for the neurosurgeon. A reliable segmental EMG from neck muscles is very difficult to obtain.

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