COMMENTARY

Intra-Operative Electromyographic Monitoring

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ABSTRACT

Intra-operative electromyographic monitoring in spinal surgery monitors nerve root function using stimulus or spontaneous triggering techniques. Its uses and technical aspects are briefly outlined.

Keywords: electromyography, intra-operative monitoring, spinal cord

INTRODUCTION

The intra-operative applications of somatosensory evoked potential (SSEP) and electromyographic (EMG) monitoring have increased significantly over the last 2 decades. A myriad of techniques and applications for monitoring the spinal cord and peripheral nervous system has been developed, evaluated, and used by orthopaedic surgeons and neurosurgeons involved in spinal surgery.

The advent of segmental spinal instrumentation, in particular the use of pedicle screw fixation, introduced yet another set of concerns regarding documenting neurologic integrity intra-operatively. Specific nerve root function is at risk during these procedures. The lower extremity SSEP response receives a contribution from multiple nerve roots in the lumbar spine. Therefore, using this method alone to monitor neural function could result in missing an injury to one specific nerve root. A new monitoring method was therefore needed to provide information concerning the adequacy of nerve root decompression and identification of nerve root involvement. EMG monitoring is one such method being used to provide constant real-time analysis of nerve roots during the entire surgical procedure.

TECHNIQUES

The 2 main techniques of EMG monitoring are spontaneous EMG and triggered EMG. These are the most recent techniques to be added to spinal surgery monitoring protocols. The techniques involve using myotomes in the upper and lower extremities to record neural activity from specific nerve roots which are either at risk or involved in a surgical procedure. Pairs of needle electrodes are placed into muscle groups targeted for recording (Table 1).[1] The active electrode is placed in the belly of the target muscle while the reference electrode is placed subcutaneously above the active needle. Monitoring is in real-time, which means that when a nerve root is stimulated there is an immediate corresponding response from muscles innervated by that root. Stimulation can be attributed to mechanical and electrical sources. Mechanical stimulation refers to many of the surgical variables which directly or indirectly affect nerve roots. Electrical stimulation is usually directed at obtaining a response from the nerve root, known as a compound muscle action potential. These techniques are adaptations of methods used to assess cranial nerve function during various skull base surgeries.[1]

Triggered EMG techniques have proved easy to incorporate into a monitoring protocol and, more importantly, have provided data that are sensitive to bony defects within the pedicle borders. This static, stimulus-dependent technique is, however, not capable of providing information over the course of an entire surgical procedure.[2-4]

Table 1. Spinal root levels of muscle groups used for EMG monitoring.

Spinal Level	Muscle Group
C5	Deltoid, biceps
C6	Biceps, wrist extensors
C7	Triceps, wrist extensors, wrist flexors
C8	Hand intrinsics, finger extensors
L2	Adductors, longus, adductor magnus
L3	Adductors, vastus medialis
L4	Vastus medialis, vastus lateralis
L5	Anterior tibialis, extensor hallucis longus
S1	Medial gastrocnemius, peroneus
S2–S5	Perianal musculature

On the other hand, spontaneous EMG monitoring can be used throughout surgery. This method is fairly straightforward and is not difficult to incorporate.[5,6] Compression or irritation of nerve roots during surgery can be detected with this monitoring. Spontaneous EMG monitoring consists of an ongoing, free run display of activity from an appropriate myotome distribution. Data are monitored using visual and auditory feedback. When a nerve root is activated for whatever reason, there is a resulting neurotonic discharge that is seen and heard on the monitoring equipment (Fig. 1). Multiple recording channels are used to encompass all nerve roots potentially at risk during surgery. Monitoring personnel continuously observe the ongoing activity, informing the surgeon of neural responses as they occur. Not all activity is significant for risk of injury to nerve roots. A certain degree of manipulation and subsequent neural activity is to be expected during surgery. Specific periods of time, such as nerve root retraction during decompression or insertion of pedicle screws, place the involved neural structures at greater risk. Even more importantly, constant monitoring protects the nerve roots from the more insidious, indirect neural pathologies, such as compression from haematoma, that may not be readily apparent to the surgical team.

TECHNICAL CONSIDERATIONS

Most narcotics are compatible with intra-operative monitoring. Drip infusion rather than bolus injection provides steady sedation needed for response consistency. Some degree of muscle relaxant is generally preferred during critical stages of surgery. Careful titration of neuromuscular blockade is needed to perform this type of assessment. Spontaneous and triggered EMG monitoring require a greater degree of muscle activity. Because a response is not always being elicited, it is important that muscles be able to respond to smaller levels of neural excitement. At least 3 or 4 muscle twitches to electrical stimulus are required to ensure adequate reversal of neuromuscular blockade before monitoring is deemed feasible.[1]

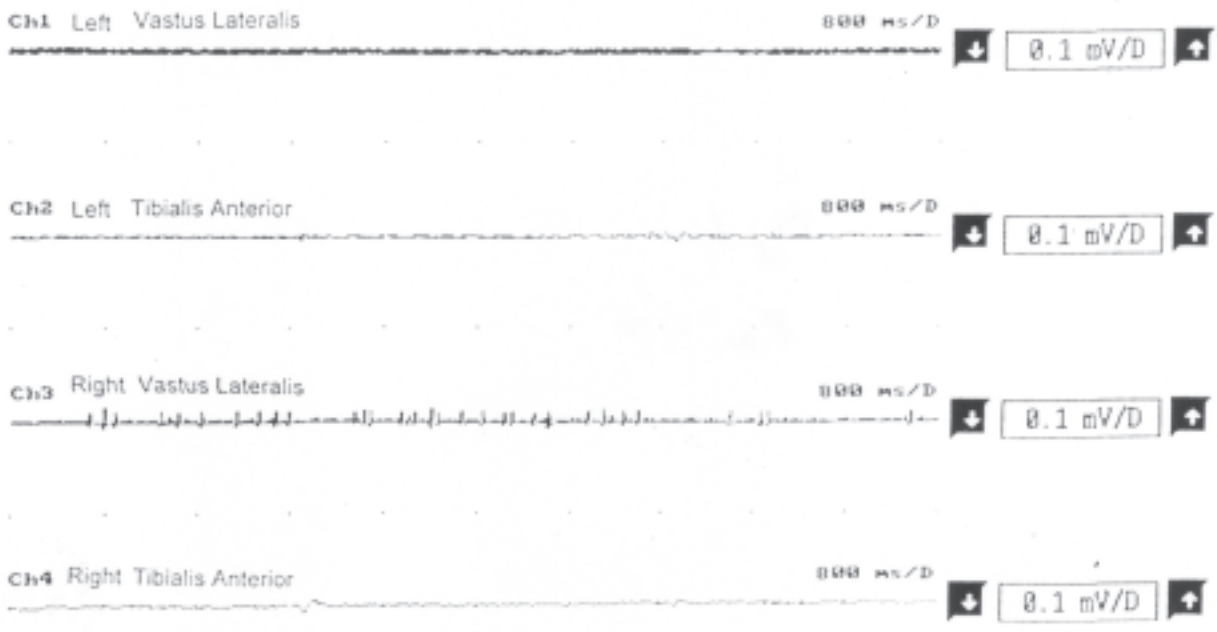

Fig.1. Actual tracings showing neurotonc EMG disarges corresponding to right L4 root irritation during surgery for spinal stenosis. Vertical gain and horizontal sweep speeds are indicated in the tracings.

Some degree of "false alarm" needs to be realised and tolerated by surgeons. These changes can be due to artifacts, subclinical nerve encroachment, and represent early and hopefully reversible neural injury. The EMG techniques in use do not provide any information that is predictive of post-operative improvement in neurologic status. Electrically-triggered EMG testing performed before and after individual nerve root decompression may be able to provide objective data.

PRACTICAL IMPORTANCE

Spinal cord monitoring is now playing a role in the operative treatment of spinal disorders.[7] Its use has grown well beyond the research laboratories and the limited clinical application that was seen many years ago. Intra-operative assessment has become a standard of care in certain spinal surgeries. It is widely used in the surgical correction of scoliosis, degenerative cervical and lumbar spinal conditions. At the Singapore General Hospital, intra-operative spinal cord monitoring has been routinely performed for many years. A dedicated team comprising surgeons, neurologists, anaesthetists, neurotechnicians and support personnel is essential as the work of each group complements those of the others. Intra-operative EMG monitoring, in addition to somatosensory evoked potential, has been a routine practice since 2001, and will continue evolve to meet the growing needs of spinal surgery.

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