Chin Med Sci J
December 2017

Vol. 32, No. 4
P. 260-264

CHINESE
MEDICAL SCIENCES
JOURNAL

REVIEW

Progress in Intraoperative Neurophysiological Monitoring for the Surgical Treatment of Thoracic Spinal Stenosis

Yongsheng Liu, Yu Zhao*

Department of Orthopedics, Peking Union Medical College Hospital,
Chinese Academy of Medical Sciences & Peking Union Medical College,
Beijing 100730, China

Key words: thoracic spinal stenosis; intraoperative neurophysiological monitoring; motor evoked potentials; somatosensory evoked potentials; prognosis

Abstract Thoracic spinal stenosis (TSS) is a group of clinical syndromes caused by thoracic spinal cord compression, which always results in severe clinical complications. The incidence of TSS is relatively low compared with lumbar spinal stenosis, while the incidence of spinal cord injury during thoracic decompression is relatively high. The reported incidence of neurological deficits after thoracic decompression reached 13.9%. Intraoperative neurophysiological monitoring (IONM) can timely provide information regarding the function status of the spinal cord, and help surgeons with appropriate performance during operation. This article illustrates the theoretical basis of applying IONM in thoracic decompression surgery, and elaborates on the relationship between signal changes in IONM and postoperative neurological function recovery of the spinal cord. It also introduces updated information in multimodality IONM, the factors influencing evoked potentials, and remedial measures to improve the prognosis.

Chin Med Sci J 2017; 32(4):260-264. DOI:10.24920/J1001-9294.2017.041

THORACIC spinal stenosis (TSS) is a slowly progressive disease that usually occurs in patients with severe spinal cord compression. Conservative treatment is usually ineffective, and surgical decompression is the only effective treatment to prevent further compression of the spinal cord. The thoracic spine is regarded as a "restricted zone" in spinal surgery, mainly due to the characteristic blood supply and anatomy. Because of the high risk of spinal cord injury in patients with TSS, intraoperative neurophysiological monitoring (IONM) is an important means to ensure patients' safety during the surgery. This technique mainly involves somatosensory evoked potentials (SEPs) and motor evoked potentials (MEPs). It can reflect the functional state of the spinal cord or nervous system in time, and help the subsequent management during operation, so that surgeons could make remedial measures to avoid disastrous consequences. This article provides an overview of progress in applying IONM in patients with TSS.

Received: December 27, 2016.
*Corresponding author Tel: 86-10-69152809, Fax: 86-10-69152809, E-mail: zhaoyupumch@163.com

Theoretical basis of IONM in decompression of TSS

The volume of the thoracic spinal canal is relatively small, and the flavum ligamentum and posterior longitudinal ligament occupy a certain space of spinal canal, leading to a significantly reduced working space for surgical instruments. The pedicles of the thoracic vertebrae are smaller than those of the lumbar vertebrae, and the spinal cord is closer to the inner walls of the pedicles.[1] The spinal cord and nerve roots are prone to be injured during pedicle screw insertion. The reported failure rate of thoracic pedicle screw placement ranges from 3% to 55%.[2] Additionally, the blood supply of the thoracic spinal cord is poor compared with that of the cervical and lumbar segments, making it vulnerable to the impact of ischemic stimulation.[3] Moreover, thoracic decompression surgery is likely to cause ischemia–reperfusion injury,[4,5] and to aggravate spinal cord edema. These factors increase the difficulty and the risk of the surgery. The reported incidence of neurologic deficit reached 13.9%.[6] Therefore, it is essential to apply IONM to monitor functional status during the decompression surgery for patients with TSS.

Relationship between changes in IONM signals and postoperative neurological function

Preoperative baseline waveform of IONM

Factors including age, diabetes mellitus, hypertension, lesion location, and preoperative neurological deficits can influence the success rate of baseline recordings.[7, 8] Ma *et al* [9] classified the preoperative SEP wave pattern into four grades during surgery for patients with TSS. According to the monitoring results, the author believed that, for patients with Grade I preoperative waveform, because of their severe spinal cord dysfunction, intraoperative spinal cord injury did not manifest as waveform alternation，and thus intraoperative monitoring may not be beneficial for these patients.

Lee *et al*[10] reported that it was usually ineffective to apply MEPs to patients with Medical Research Council grade 1 to 2 muscle strength. Wang *et al*[11] reported that for patients with dyskinesia, especially when the muscle strength of lower extremities is grade 1 or less, maximum stimulation still could not produce reliable baseline MEP.

Preoperative monitoring signals represent the functional status of the spinal cord: the inability to obtain preoperative signals indicates severe spinal cord dysfunction. Additionally, the preoperative MEP or SEP amplitudes of TSS patients are usually lower than patients without neurological deficits, which increases the difficulty in monitoring. The ratio of MEP derivation below 50% may indicate paralysis.[12] Therefore, we recommend using IONM to assess the functional status of the spinal cord for patients with preoperative spinal deficits, especially for those with TSS. However, large clinical trials are needed to confirm whether IONM is beneficial to patients whose preoperative monitoring signal cannot be obtained.

Improved or stable signals during the operation

Improvement in the intraoperative signals is characterized by an increase in amplitude and/or latency.[13] Liu *et al*[14] observed the efficacy of intraoperative cortical SEP monitoring in patients with TSS. Twenty-three patients had no abnormal cortical SEP waves intraoperatively and no nervous system complications postoperatively; 12 patients showed improvement in their cortical SEPs during the surgery, and their postoperative symptoms were significantly improved. Matsuyama *et al*[15] recorded compound motor action potentials during the surgery of TSS, and divided the patients into three groups according to their intraoperative signal changes: Group A, no change in potentials; Group B, decreased potentials; and Group C, improved potentials. The recovery rates of Japanese Orthopedic Association (JOA) scores were 50.0%, 48.0%, and 68.3% in Group A, B, and C respectively. The clinical manifestations in Groups A and C were significantly improved compared with the preoperative status. From this viewpoint, the neurological function in the majority of patients after the surgery can be improved, and the prognosis might be better when the intraoperative signals improve or keep stable than when they get worse.

In addition, new neurological deficits or deterioration of the original neurological deficits may appear postoperatively, while the intraoperative signals may not show obvious changes. In this case, a false-negative event occurs.[16] Although the incidence of false-negative intraoperative monitoring in detecting postoperative neurologic deficits during spinal surgery is only 0.36%,[17] the outcome is disastrous for the patients. Therefore, spinal surgeons should be alert to the existence of false-negative tests during thoracic decompression surgery, and endeavor to achieve timely detection and appropriate treatment.

Deteriorated signals and the achievement of the "alarm point" during the operation

The present criterion for an abnormal SEP, namely a 50% decrease in amplitude and/or a 10% increase in latency, has been widely used in the surgical treatment of TSS.[14, 16] In the study by Liu *et al,*[14] the deteriorated signals of two patients that were caused by rupture of internal pedicle wall gradually recovered after re-fixing the pedicle screws,