Scoliosis Research Society
Dedicated to Education, Research, and Treatment of Spinal Deformity

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To: SRS Colleagues

The attached position statement on *Somatosensory Evoked Potential Monitoring of Neurologic Spinal Cord Function During Spinal Surgery,* was developed to assist members in dealing with third party payers. The information expresses the opinion that SEP monitoring is not investigational and is a reasonable option to be used as an integral part of the surgical procedure.

SCOLIOSIS RESEARCH SOCIETY POSITION STATEMENT: SOMATOSENSORY EVOKED POTENTIAL MONITORING OF NEUROLOGIC SPINAL CORD FUNCTION DURING SPINAL SURGERY.

The advent of rigid spinal surgical implants with strong correction forces applied to spinal deformities has significantly increased the risk of neurologic injury including loss of motor function in the lower extremities. As a consequence there exists an urgent need for a method to warn the spine surgeon of impending neurological deficits during surgery, so that changes in the surgical technique can be implemented to restore the normal neurophysiology of the spinal cord. Schmitt's (1981) report from the Scoliosis Research Society Morbidity and Mortality Committee cited an incidence of 0.5% spinal cord injuries during the period 1971 to 1979. MacEwen et al. (1975) survey showed an incidence of 0.72%. More recently, Wilber et al. (1986) reported a 17% incidence of neurologic complications including 13% transient sensory changes and 4 % major spinal cord injuries. Similar statistics have been reported by others (Herring and Wenger, 1982; King 1984). The risk of complications are greatest when patients have kyphosis, congenital scoliosis, pre-existing neurological impairment, or has been in traction preoperatively. The impairment may be from direct stretching of the spinal cord, compression of the cord, trauma during fitting of the orthopedic instrumentation, or interference with blood flow (Nuwer, 1988.) Any procedure that can be used to reduce the rate of post-operative complications following surgery to the spine has tremendous attraction for patients and surgeons alike.

Until the entry of neurophysiological evoked potentials, the only other available method of observing spinal cord function is through the Stagnara Wake-up test (Vauzelle et al., 1973). Wake-up test monitoring techniques have been applied since the mid 1970's, with some problems. The exact moment of neurologic injury remains obscure, and other possible complications exist including accidental extubation, air embolism or fractures of vertebral arches. Occasionally it may be dangerous to intraoperatively wake up patients with certain primary diseases (Mostegl, Bauer and Eichenauer, 1988). Some patients may not be able to cooperate with the wake-up test because of age or mental status. In situations where the wake-up test can be performed it is invaluable.

A number of neurophysiologic spinal cord monitoring techniques have been proposed. They include cortical monitoring of peripheral nerve stimulation known as the somatosensory cortical evoked potential (SCEP), and direct spinal cord stimulation and recording known as the spinal cord evoked potential (SpEP). Since the report by Nash et al. (1977) on routine somatosensory cortical evoked potential (SCEP) monitoring of scoliosis surgery, hundreds of articles on the topic of evoked potential monitoring of spinal cord function during operations of the spine have been reported in the world literature. Recently, techniques for recording motor pathway evoked potentials (MEP) have been developed that include (1) transcranial stimulation, (2) motor cortex stimulation, (3) direct spinal cord stimulation and (4) neurogenic motor evoked potentials (NMEP) (Owen et al., 1988; Lashinger et al., 1988). SCEP measurements used as a test of spinal cord continuity includes some limitations, because the response is conducted through the posterior columns of the spinal cord. While most spinal cord injuries are sufficient to compromise both sensory and motor function, case reports have been reported in which postoperative paraplegia occurred despite preserved intraoperative sensory evoked potentials (Ginsburg et al., 1985; Ben-David et al., 1986). The combined monitoring of sensory evoked potentials and neurogenic motor evoked potentials during spine surgery will decrease the false-negative rates of reporting.

Criteria for evaluating evoked potentials responses during surgical procedures have been investigated during recent years. While early experience was based on empirical observations and there continues to be "grey zones" (Brown and Nash, 1985), there is a developing consensus for evaluating changes in the SCEP that result in surgically related changes in cord function from other variables (Brown and Nash, 1985; Lubicky et al., 1989; Salzman et al., 1988; Roy et al., 1988; Keith and Stambough, 1990). In their series of 52 patients Loder et al. (1991) note that SCEP recordings for patients undergoing spinal surgery for nonidiopathic spinal deformities found no true-positive and no false-negative readings. There were some false-positive findings. They concluded that the predictive accuracy of intraoperative spinal cord monitoring in this patient population is not high, but the sensitivity to potentially harmful surgical events is high. Meyer et al. (1988) reviewed results of 295 surgically treated patients with acute spinal injuries for evidence of postoperative neurological complications. Of those patients, 150 were monitored using SCEP and 145 were unmonitored or administered the wake-up test. Six patients (4%) who were monitored with SCEP experienced intraoperative deterioration of the SCEP; however, only one of the six revealed a new postoperative neurological deficit (0.7%). Of the remaining patients, ten (6.9%) demonstrated new postoperative deficits. These data indicate that the patients monitored with SCEP experienced fewer postoperative complications. The authors concluded that the intraoperative use of SCEP was not able to identify subtle alterations in neurological function; however, due to early warning, SCEP appears capable of preventing profound surgically induced neurological alterations. Shukla et al. (1988) and Friedman and Richards (1988) presented case reports in which SCEP correctly predicted hemi-spinal cord injury during surgical monitoring.

Results of research demonstrating the value of somatosensory evoked potential monitoring of spinal surgery has been published by several authors. A review of these procedures was provided by Nuwer (1988). For example, Dinner et al. (1986) monitored somatosensory evoked potentials and post-operative deficit in 220 patients. They reported that marked changes in SCEP responses indicated a high chance of developing a neurological deficit, and if there was no change the chance of any neurological postoperative deficit was extremely low. Bieber et al. (1988) reported data on two hundred seventy-five consecutive patients who were treated by posterior spinal instrumentation and fusion with intraoperative monitoring using SCEP. Intraoperatively, six patients demonstrated significant changes in evoked potentials during instrumentation of the spine. With immediate removal of the instrumentation evoked potentials returned to baseline. All patients were neurologically normal postoperatively. Brown et al. (1984) reported SCEP results in 300 patients. Three neurologic deficits were documented intraoperatively and confirmed postoperatively. There were four cases in which changes in evoked potentials led to change in the operative procedure, with no subsequent neurologic deficit. Jones et al. (1983) report a series of 138 patients in which three patients were noted to have a reduction of potentials during distraction with improvement following revision of the surgical procedure. These authors concluded that changes in cord function can be reversed when the cause is quickly remedied.

Finally, The Scoliosis Research Society and the European Spinal Deformity Society surveyed their membership regarding the use of intraoperative monitoring of somatosensory evoked potentials in spinal surgery (Dawson et al., 1991). A retrospective analysis of 60,366 heterogeneous surgical cases from the respondent surgeon's memory found 364 cases of postoperative neurologic deficit, 263 of which were identified with SCEP in place (ie true-positive) and 101 that were not detected with SCEP (false-negative cases). In a second part of the survey, analysis of data obtained on 33,000 heterogeneous spine procedures found 248 false-positive, 161 true-positive, and 25 false-negative cases. The authors of the survey concluded that SCEP is "a useful adjunct to the spinal surgeons' armamentarium" and that "the wake-up test should also be considered for cases with increased risk of postoperative neurological deficits."

In conclusion, a substantial body of research has demonstrated that neurophysiologic monitoring can assist in the early detection of complications and possibly prevent post-operative morbidity in patients undergoing operations on the spine. In view of the accumulated research and clinical experience demonstrating the effectiveness of neurophysiologic monitoring, the Scoliosis Research Society concludes that the use of intraoperative spinal cord neurophysiological monitoring during operative procedures including instrumentation is not investigational. The Scoliosis Research Society considers neurophysiological monitoring a viable alternative as well as an adjunct to the use of the wake-up test during spinal surgery.

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