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Intraoperative somatosensory evoked potential monitoring during anterior cervical discectomy and fusion in nonmyelopathic patients—a review of 1,039 cases

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Abstract

BACKGROUND CONTEXT: Intraoperative somatosensory evoked potential (SSEP) monitoring has been shown to reduce the incidence of new postoperative neurological deficits in scoliosis surgery. However, its usefulness during cervical spine surgery remains a subject of debate.
PURPOSE: To determine the utility of intraoperative SSEP monitoring in a specific patient population (those with cervical radiculopathy in the absence of myelopathy) who underwent anterior cervical discectomy and fusion (ACDF) surgery.
STUDY DESIGN: Retrospective review.
PATIENT SAMPLE: A total of 1,039 nonmyelopathic patients who underwent single or multilevel ACDF surgery. The control group (462 patients) did not have intraoperative SSEP monitoring, whereas the monitored group (577 patients) had continuous intraoperative SSEP monitoring performed.
OUTCOME MEASURE: A new postoperative neurological deficit.
METHODS: SSEP tracings were reviewed for all 577 patients in the monitored group and all significant signal changes were noted. Medical records were reviewed for all 1,039 patients to determine if any new neurological deficits developed in the immediate postoperative period.
RESULTS: None of the patients in the control group had any new postoperative neurological deficits. In the monitored group there were six instances of transient SSEP changes (1 due to suspected carotid artery compression; 5 thought to be due to transient hypotension) which resolved with the appropriate intraoperative intervention (repositioning of retractors; raising the arterial blood pressure). Upon waking up from anesthesia, one patient in the monitored group had a new neurological deficit (partial central cord syndrome) despite normal intraoperative SSEP signals.
CONCLUSIONS: ACDF appears to be a safe surgical procedure with a low incidence of iatrogenic neurological injury. Transient SSEP signal changes, which improved with intraoperative interventions, were not associated with new postoperative neurological deficits. An intraoperative neurological deficit is possible despite normal SSEP signals.

Keywords: Cervical spine surgery; ACDF; SSEP; Radiculopathy; Neurophysiological monitoring

Introduction

Intraoperative somatosensory evoked potential (SSEP) monitoring is a frequently used modality for detecting and preventing neurological injury during spine surgery. Its use during scoliosis surgery has dramatically reduced the incidence of new postoperative neurological deficits by

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approximately one-half [1–7]. However, despite the demonstrated usefulness of SSEP monitoring during scoliosis surgery, debate exists concerning its utility for other types of surgical procedures, such as cervical spine surgery [8].

Anterior cervical discectomy and fusion (ACDF) surgery is commonly used to treat cervical radiculopathy. During ACDF, intraoperative SSEPs are often monitored to detect spinal cord injury [9–12]. However, prior literature has provided mixed conclusions as to the utility of SSEP monitoring during anterior cervical surgery. Unfortunately, these previous studies combined data from corpectomy surgeries with discectomy surgeries and do not differentiate between patients with diagnoses of radiculopathy and myelopathy [8,13–16]. Because of the distinct differences between the pathophysiology of radiculopathy and myelopathy, and the differences between the technical aspects of discectomy and corpectomy surgeries, it is difficult to arrive at a firm conclusion regarding the utility of SSEP monitoring without studying these groups separately. Therefore, the goal of this study was to retrospectively review patients with a preoperative diagnosis of cervical radiculopathy in the absence of myelopathy who underwent single or multilevel ACDF either with or without intraoperative SSEP monitoring, and to determine if the use of intraoperative SSEP monitoring resulted in fewer new postoperative neurological deficits as compared with unmonitored cases. To our knowledge, this is the first study of its kind to specifically evaluate the usefulness of intraoperative SSEP monitoring in nonmyelopathic patients undergoing ACDF.

Materials and methods

Study design

This study is a retrospective review of ACDF surgery cases from 1995 to 2004 performed by four different spine surgeons from a single institution (WCW, PG, JDK, WFD). Criteria for inclusion in the study included those patients who had undergone one-, two-, or three-level, instrumented or noninstrumented fusion with either allograft or autograft bone with a preoperative diagnosis of cervical stenosis, radiculopathy, herniated nucleus pulposus, junctional stenosis, or nonunion from prior surgery. Corpectomy or hemicorpectomy surgery, tumor, or a diagnosis of myelopathy were used as exclusion criteria.

Patient population

A total of 1,039 patients were included in the study (Table 1). The control group consisted of 462 cases in which intraoperative SSEP monitoring was not performed. The monitored group consisted of 577 cases where intraoperative SSEP monitoring included cortical and subcortical recordings in response to simultaneous stimulation of the upper (median or ulnar) and lower extremity (tibial or peroneal) nerves.

Table 1
Numerical breakdown of patients by number of cervical spine levels being decompressed and fused in the control and monitored groups

	1-level ACDF	2-level ACDF	3-level ACDF
Control group (n=462)	242	213	7
Monitored group (n=577)	288	231	58
Total (n=1039)	530	444	65

ACDF=anterior cervical discectomy and fusion.

Neurophysiological monitoring

Baseline SSEPs were obtained after induction of anesthesia and before patient positioning in all cases. Continuous upper and lower extremity stimulation was performed simultaneously throughout the surgical procedure. The upper extremity nerve to be stimulated was chosen based on the level at which the decompression was to be performed. At our institution, the average cost of SSEP monitoring is approximately $600 to $800 per case.

Median/ulnar nerve SSEPs

The median or ulnar nerve was stimulated bilaterally in an alternating fashion at the wrist using subdermal needle electrode pairs. Scalp electrodes were P4/Fz and P3/Fz (according to the international 10-20 system), and a cervical electrode was localized at the C7 spinous process and referenced to Fz. Constant voltage stimulators using sufficient intensity to evoke a consistent response produced evoked sensory potentials. Stimulation frequency was 3.43 Hz with duration of 0.2 ms. Bandpass filters were set at 3–300 Hz with a gain of 20k for cortical recordings and 30–1,000 Hz with a gain of 50k for cervical recordings. Averages were computed for 128 trials.

Peroneal/tibial nerve SSEPs

Alternating bilateral tibial nerve stimulation was used unless reproducible responses were unattainable, in which case the peroneal nerve was stimulated. The tibial nerve was stimulated at the ankle using subdermal needle electrode pairs with proximally placed cathodes and the anode placed ~1 cm away. The peroneal nerve was stimulated using pairs of subdermal needles located at the head of the fibula and medially in the popliteal fossa. Recordings were obtained from the scalp and cervical region also using subdermal electrodes. Scalp electrodes were Pz/Fz and P3/P4 (according to the international 10-20 system), and the cervical electrode was localized at the C7 spinous process and referenced to Fz. Evoked sensory potentials were produced by constant voltage stimulators using sufficient intensity to evoke a consistent response. Stimulation frequency was 3.43 Hz with duration of 0.2 ms. Bandpass filters were set at 3–300 Hz with a gain of 20k for cortical recordings and 30–1,000 Hz with a gain of 50k for cervical recordings. Averages were computed for 128 trials.