SPINAL CORD MONITORING DURING OPERATIVE CORRECTION OF NEUROMUSCULAR SCOLIOSIS

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We report our experience of the monitoring of spinal somatosensory evoked potentials in 60 patients with neuromuscular scoliosis. In 15 cases a significant change occurred in the trace when a sublaminar wire was tightened. There were no postoperative neurological deficits attributable to the surgery.

Spinal cord injury is the nightmare of every scoliosis surgeon. In a large series surveyed under the auspices of the Scoliosis Research Society (MacEwen, Bunnell and Sriram 1975) the overall incidence of neurological complications was 0.72%. Segmental spinal instrumentation, often used in neuromuscular scoliosis, carries a particularly high risk of spinal cord injury (Dove 1989).

Attempts to minimise this complication have led to the development of the 'wake-up' test (Vauzelle, Stagnara and Jouvinroux 1973; Hall, Levine and Sudhir 1978), but this is not always practical in patients with neuromuscular scoliosis due to muscle weakness and mental retardation. The electrical activity in the sensory pathways can be monitored continuously during surgery using somatosensory evoked potentials (SEP) and this has proved useful during operations for idiopathic scoliosis (Forbes et al 1991). The reliability of the technique in other types of scoliosis, especially neuromuscular scoliosis, however, has been questioned (LaMont, Wesson and Green 1983; Szalay, Carollo and Roach 1986; Forbes et al 1991). We therefore carried out a retrospective review of our experience of measurement of spinal SEP in neuromuscular scoliosis.

PATIENTS AND METHODS

Since 1984, we have used spinal cord monitoring in all operations for correction of spinal deformity by the posterior approach. A retrospective review was made of the case notes of children with neuromuscular diseases who had corrective surgery for spinal deformity.

The diagnosis, age at surgery, operation performed, complicating factors, the necessity of performing a 'wake-up' test, and the final neurological outcome had all been recorded.

Pre-operatively, every patient was seen by the electrophysiology technician: the common peroneal and posterior tibial nerves were stimulated and the distal motor response noted. The course of the nerve giving the best response was chosen and marked for peroperative stimulation.

When the patient was anaesthetised, a bipolar stimulating electrode and earth electrode (Medelec Ltd, Surrey, England) were applied to each leg. After exposure of the spine, a window was made in the ligamenta flava one or two vertebrae cephalad to the upper extent of the proposed instrumentation. A unipolar recording electrode (SLE Ltd, Croydon, England) was placed in the epidural space, the neutral electrode being a needle which was inserted into the paraspinal muscles. The electrodes were then connected to an electromyography (EMG) machine. Before 1991, we used a Medelec MS 91 and since then a Medelec Neurostar (both Medelec Ltd, Surrey, England).

Both legs were stimulated and the traces, averaged over 128 sweeps, were stored in the machine’s memory and used as controls for the rest of the procedure. The voltage used was usually around 100 V. The exact stimulation guidelines varied from patient to patient, the voltage being slightly higher in boys with Duchenne muscular dystrophy. The pulse duration was always 0.1 ms and the frequency 20 pulses/s.

The current signal was displayed on one channel of the EMG machine and the averaged trace of the previous 128 sweeps on the other. The sweep duration was 50 msec, and the amplifier filters were set at 20 Hz and 2 kHz.

The SEP traces were designated true-positive, false-
positive, true-negative and false-negative, according to the criteria of Szalay et al (1986) which are summarised in Table I. Following Forbes et al (1991), we regarded a loss of amplitude of greater than 50% as significant. Minor changes in latency were ignored.

RESULTS

Adequate documentation was retrieved for 60 patients, 46 males and 14 females. Their average age at surgery was 13.6 years (6 to 20) and their diagnoses are summarised in Figure 1. In 52 patients we performed posterior facet joint fusions with Luque instrumentation from the sacrum or pelvis to the upper thoracic spine. Four patients had posterior spinal fusions with Harrington distraction rods. Three had two-stage operations with preliminary anterior fusion with Dwyer or Zielke instrumentation followed by Harrington or Luque instrumentation posteriorly. In one patient an uninstrumented fusion was performed after loss of the SEP trace during Luque instrumentation.

We obtained an adequate SEP trace in all but two patients. In one, with Friedreich's ataxia, no preoperative motor response could be obtained and peroperative monitoring was not attempted. In the other, with myelomeningocele, no trace could be obtained peroperatively despite a good pre-operative response.

True-negative responses occurred in 43 patients and true-positive responses in 15, invariably associated with the tightening of a sublaminar wire and, in two, accompanied by a sudden fall in blood pressure. In 11 of these patients, the SEP trace returned to its control latency and amplitude after loosening of the wire, which was later tightened uneventfully. In four patients, the SEP trace did not recover. We performed a 'wake-up' test in three of these, and instrumentation proceeded without further mishap. In the other patient a 'wake-up' test could not be performed because of severe mental retardation. The SEP trace did not recover until all the sublaminar wires had been loosened. Instrumentation was therefore abandoned and a fusion was performed without it.

There were no false-positive and no false-negative results. In no case did the postoperative neurological state differ from the pre-operative state. A breakdown of the results by diagnosis is given in Table II.

DISCUSSION

Spinal cord monitoring has proved reliable in the prediction of postoperative neurological deficit, but there is still a significant incidence of electrophysiological changes which are not associated with postoperative neurological deterioration. This problem is greater with cortical SEP than with spinal SEP (Nash and Brown 1989).

The role of cord monitoring in surgery for idiopathic scoliosis is now well established, but the position in neuromuscular scoliosis is much less clear. While it can be argued that the preservation of motor function is less important in patients who already have severe neurological disease than in patients who are neurologically intact, the preservation of sensory and sphincter function in patients who are often mentally retarded is of the utmost importance.

<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>True-negative</th>
<th>True-positive</th>
<th>No trace</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duchenne muscular dystrophy</td>
<td>20</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>Spinal muscle atrophy</td>
<td>8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Friedreich's ataxia</td>
<td>4</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Cerebral palsy</td>
<td>2</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Myelomeningocele</td>
<td>5</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Head injury</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Poliomyelitis</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Congenital muscular dystrophy</td>
<td>1</td>
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<tr>
<td>Congenital neuropathy</td>
<td>1</td>
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</table>
Technical problems seem to be more common when cord monitoring is undertaken in patients with neuromuscular disease (Forbes et al 1991; Loder, Thomson and LaMont 1991), but we are still convinced of its value.

Although several neuromuscular patients were included in the series reported by Forbes et al (1991), we are aware of only one other paper which comments in detail on the efficacy of spinal cord monitoring in neuromuscular cases (Loder et al 1991), and a comparison between that series and ours is interesting. There were no postoperative neurological deficits in either series, but Loder et al (1991) reported a true-positive rate of 45% in patients undergoing Luque instrumentation; in our series it was 28%. Their true-positive rate for all their neuromuscular scolioses was 44%, whereas ours was 25%. They reported a false-positive rate of 21%; in our series there were no false-positive results.

There are two possible explanations for these differences. First, the patient populations were quite different. There was a preponderance of boys with Duchenne muscular dystrophy in our series, accounted for by the senior author's interest in the surgery of that condition. When they are excluded, however, the proportions of other diagnoses are similar in the two series. Our true-positive rate then falls to 17% and the difference is more striking.

Secondly, Loder et al (1991), used cortical SEP monitoring as is the usual practice in North America (Nash and Brown 1989), whereas we used spinal SEP monitoring. It may be that the cortical method is even more sensitive than the spinal, causing the larger number of false-positive results in their series.

The relatively high rate of true-positive results in patients with cerebral palsy in our series is worthy of comment. In cerebral palsy the spinal cord may be more electrophysiologically sensitive, and minor levels of mechanical irritation may be enough to alter its electrical activity.

In conclusion, we have found spinal cord monitoring to be useful in neuromuscular scoliosis surgery. Although the predictive value of changes in the SEP trace for postoperative neurology is low, we think that these changes represent definite alterations in spinal cord physiology, and that the surgeon becomes aware of the danger in time to take the appropriate corrective action.

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REFERENCES


