Nerve Root Conduction Studies During Lumbar Disc Surgery*

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METHODS for assessment of motor and sensory nerve conduction in peripheral nerves have proved valuable in clinical practice.1–4,6,8 Malcomb2 reported on the reflex times of tendon jerks measured preoperatively. In addition he measured the speed of nerve conduction following stimulation within the theca of the cauda equina at the time of operation for removal of a compressing lesion; the affected root and the opposite normal one were both stimulated, and the results compared; there was slowing of the speed of the nerve-impulse conduction past the compressed segment of the nerve root.

The purpose of our study was to demonstrate the conduction deficit that exists across the segment of a nerve root as a result of compression by herniated disc material. This assessment was made at the time of operative decompression.

Most patients showed sufficient motor weakness, sensory disturbance, or reflex alteration for localization of the involved root. Only a few had preoperative myelographic or electromyographic examinations. The clinical material included 30 studies in 28 different patients, with 32 nerve root tests, four at L-4, 11 at L-5, and 17 at S-1. Three additional cases could not be categorized; in two of these, previous lumbar disc operations had caused scarring about the nerve roots which obscured the test results.

Methods

A Model B Teca Electromyograph with a stimulator synchronized to trigger the sweep of the cathode ray oscilloscope was used. A Polaroid Lane camera was mounted for a permanent record either from the direct sweep or from a Tektronix storage oscilloscope that was connected to the recording circuit.

After dissection of the disc space and removal of herniated disc material, paired electroencephalographic needle electrodes were inserted through the dural sleeve of the nerve root at locations above and below the site of compression (Fig. 1). These electrodes were used both for stimulating motor impulses to the muscles and for recording afferent combined antidromic motor and orthodromic sensory impulses following stimulation of the peroneal or tibial nerve in the popliteal space. A broad ground electrode was placed under the opposite thigh. In a few instances the studies were performed upon exposure of the nerve root, prior to manipulation or traction. Repeat studies following removal of disc material showed no change in recorded responses.

FIG. 1. Drawing to illustrate the exposed S-1 nerve root following partial removal of the laminae of L-5 and S-1 vertebrae. The EEG needle electrodes, 8 mm long, are inserted perpendicularly into the nerve root. The paired electrodes, preferably separated by at least 1 cm, are located above and below the disc.
Technique A, for Studying the Efferent Response. The appropriate pair of EEG electrodes was used to stimulate the nerve root above the compressed segment and again below it. A coaxial needle electrode in the appropriate muscle recorded the evoked muscle potential. In most cases the medial head of the gastrocnemius was used for recording responses to stimulation of the S-1 root and the peroneal muscle for the L-5 root. A stimulus of 0.1 ms duration was delivered to the nerve root through the paired EEG needles with rheostat control for gradual increase of output voltage. The voltage output of the stimulator had been previously measured at different settings of the rheostat dial with a storage oscilloscope. Generally, a stimulus strength from 50 to 100 V was required to assure a supramaximal stimulus delivered. Only when the threshold to stimulation was elevated was more voltage needed.

Technique B, for Studying the Afferent Response. The peroneal or tibial nerve was stimulated percutaneously and separately by a hand-held electrode in the popliteal space. The appropriate pair of EEG electrodes was used to record the compound nerve potential composed of antidromic motor and orthodromic sensory impulses, both from above and below the compressed root segment. For afferent recording it was important to maintain an equal distance between the electrodes of each pair. A distance of 1 cm was preferable since a shorter space tended to cause reduced amplitude of response. To stimulate the peroneal or tibial nerve percutaneously in the popliteal space, a stimulus of at least 0.2 ms duration was used at a maximum output of about 260 V.

An assumption was made that, in normal nerve conduction over a long segment covering more than 60 cm from the lumbosacral region to the knee, there would be no appreciable difference in evoked response between the two locations of electrodes, the more distal of each pair being separated by 2 to 3 cm. Admittedly, precise placement of the electrodes was difficult due to limited exposure of the nerve root. Also, oozing of blood in the operative field may have acted as an electrical shunt. These could have been factors in determining the size of the nerve action potential with respect to recording sites above and below the compressed root segment.

Results
After tracings had been accumulated from several patients, a system of grouping was devised. Each nerve root was assigned to one of six such groups with 11 subcategories (Fig. 2), the first and last being theoretical since there were no actual patients in these groups.

Group I (no patients) and Group II (13 roots) showed little or no appreciable difference between the efferent responses to stimulation above and below the disc. Categories 2 and 3 showed reduction or absence of response in the afferent recording above the disc.

Group III (10 roots) showed an impaired efferent response to stimulation above the disc. Categories 4, 5, and 6 showed reduced amplitude, increased latency, or complete absence of response. There was no response in afferent recording above the disc. When there was complete or almost complete block of impulses on stimulation above the disc, the afferent response was often absent below as well as above the disc (Category 6).

Group IV (6 roots) showed preserved conductivity but an elevated threshold to stimulation below the disc. Categories 7 and 8 showed reduction in response from afferent recording above the disc. When threshold to stimulation below the disc was very high, the response may have been absent on afferent recording from below the disc as well as above (Category 8).

Group V (3 roots) showed either no change or a moderate reduction in response to stimulation above the disc (Categories 9 and 10). However, there was no response from afferent recording either above or below the disc.

Group VI (no patients) showed a degenerated root with no response to stimulation or in afferent recording either above or below the disc.

We have reproduced tracings from representative records (Fig. 3). Figure 3 A illustrates identical motor responses in the peroneal muscle following stimulation of the L-5 nerve root above and below the disc (Group II, Category 3). Afferent recording from this nerve root is illustrated in Figure 4 C.

Figure 3 B illustrates the response in the medial gastrocnemius following stimulation of the S-1 nerve root (Group III, Category 4). There was reduction in the amplitude of the response when the nerve root was stimulated.