Matters arising

unacceptably high if we had used two standard deviations for even a few of the 10 comparisons. In the study of Katifi and Sedgwick, four criteria of abnormality (amplitude, latency, inappropriate latency compared to the segment above and below, and interside latency difference), five segments (L2, L3, L4, L5, and S1) and two sides were used for a total of 35 comparisons per patient. In this setting, a limit of two standard deviations is even less acceptable than it would have been in ours.

Katifi and Sedgwick claim a high sensitivity for DSEPs in the evaluation of lumbosacral root compression, suggesting that the technique "predicted root compression in 19 of 20 cases". Less stringent criteria for abnormality *always* leads to an increased sensitivity, but only at the expense of reduced specificity. A careful reading of their table 1, in fact, demonstrates this pitfall and the misleading conclusions which follow from it. They were able to detect correctly 74% (25/34) of the roots involved at surgery, but incorrectly identified 12 additional roots that were unaffected when explored. Moreover, in three instances (cases 2, 6 and 19) DSEPs only identified roots contralateral to the clinical signs and in one (case 2) contralateral to all of the symptoms as well. In another (case 10), the DSEP abnormality was contralateral to the surgically involved root. More troublesome from a clinical perspective, however, is the fact that in only four of the 21 patients (cases 1, 14, 18 and 20) did the DSEP accurately and completely predict the operative findings.

Some of these discrepancies could relate to surgically inapparent disease or subclinical compression as a result of severe and widespread pathology of the lumbosacral area. If such is the case, however, then patients with more restricted disease need to be studied (as we did) before the clinical utility of a new technique such as the recording of DSEPs can be accurately defined.

MICHAEL J AMINOFF
DOUGLAS S GOODIN

Clinical Neurophysiology Laboratories,
School of Medicine,
University of California,
San Francisco, Cal 94143-0114, USA

References

- 1 Katifi HA, Sedgwick EM. Evaluation of the dermatomal somatosensory evoked potential in the diagnosis of lumbosacral root compression. *J Neurol Neurosurg Psychiatry* 1987;50:1204-10.

- 2 Aminoff MJ, Goodin DS, Barbaro NM, Weinstein PR, Rosenblum ML. Dermatomal somatosensory evoked potentials in unilateral lumbosacral radiculopathy. *Ann Neurol* 1985;17:171-6.
- 3 Aminoff MJ, Goodin DS, Parry GJ, Barbaro NM, Weinstein PR, Rosenblum ML. Electrophysiologic evaluation of lumbosacral radiculopathies: Electromyography, late responses, and somatosensory evoked potentials. *Neurology* 1985;35:1514-8.
- 4 Katifi HA, Sedgwick EM. Somatosensory evoked potentials from posterior tibial nerve and lumbosacral dermatomes. *Electroencephalogr Clin Neurophysiol* 1986;65:249-59.

Katifi and Sedgwick reply

We are grateful to Aminoff and Goodin for their interest and critique of our paper.¹ Careful consideration of the points raised is given below but in the end we stand by our conclusion that the DSEP "... is a very accurate method of detecting abnormalities in root function".

1. Normal Data

Our normal regression lines² of latency on height and those of Aminoff and Goodin^{3,4} are plotted together in the fig. The regression lines of mean are almost parallel with ours but about 2 ms lower which seems a good correspondence between the two laboratories. The crucial difference lies in the standard error of estimate (SEE) which are 4.7 and 3.8 ms for L5 and S1 dermatomes respectively in the Aminoff and Goodin data^{3,4} but 2.90 and 2.95 in ours² (table 3). This difference is further compounded by their choice of +3 SEE as the upper limit of normal which gives a value some 10 ms higher than ours; even taking +2 SEE gives a figure 5 ms higher. One reason contributing to a higher SEE may be the smaller sample size of Aminoff and Goodin, 32 compared with 54 subjects in our series.²

2. Definition of abnormality

Selection of +2 or +3 SEE as the upper limit of normality depends on two related principles. First, the nature of the abnormality in the diseased population; do the latencies of patients with unequivocal root compression lie far to the right of the tail of the normal distribution or do they overlap? They overlap, most delays lie between 2 and 3 SEE of normal. The figure shows our 20 abnormal delays plotted. Second, how dangerous or misleading is a false positive result? Only experience allows one to balance carefully these factors. We opted to use +2 SEE which includes 95% of the population in question, the chances of wrongly

Fig The regression lines of the P50 latency on height are shown for our data and that of Aminoff and Goodin^{1,3} for L5 and S1 dermatomes. Lines representing +2 standard error of estimates are shown for both series and +3 SEE for Aminoff et al.³ Abnormal roots from our patients are plotted showing that these abnormalities would not have been detected if we had used the limits set by Aminoff and Goodin from their normal controls.

interpreting a normal result is only 2.5%. It is, after all, just as important not to have many false negatives as a normal result in a sensitive test is valuable in excluding root involvement. These criteria are safe as long as the referring doctors understand these implications.⁵

We routinely studied L5 and S1 and the other dermatomes only where clinically indicated, not all five roots as suggested. Interside differences of above 6.3 and 5.1 ms for L5 and S1 respectively were taken as abnormal by Aminoff and Goodin; our upper limits were 3.5 and 4.5 ms which represented 2SD.

3. Population of patients

We agree that part of our differences may relate to the different populations of patients studied. We used surgical findings as the "gold standard" of diagnosis; the surgeons were blind to the DSEP findings and they were not asked to pay attention to any particular root. Aminoff and Goodin used variable "gold standards" and their patients must have been less severely affected as only 8/19 came to surgery. In a further eight verification of the myelogram was by discography, now a largely abandoned procedure.⁶ In some the myelogram described a bulging as opposed to a prolapsed disc, a common finding in asymptomatic patients.⁷ In three more cases the EMG was the only abnormal finding and was performed on the symptomatic side only;⁸ one does not know whether the hard sign of fibrillation in muscles of a root distribution was seen or whether soft signs were relied on such as polyphasic potentials and a reduced interference pattern. One could therefore make a reasonable case against several of Aminoff and Goodin's patients having radiculopathy and this may explain some of their negative findings.

4. Operative findings and DSEP

The criticism that 12 roots were "incorrectly" identified raises interesting issues. For the reasons given above we accept the abnormalities in these roots as a true reflection of root dysfunction. Usually the "incorrect" root was an abnormality found in addition to the "correct" root. No comment from the surgeon does not mean that he identified the root in question as normal. The surgeon's brief comments should not be overinterpreted at this stage; it will take a study of more than our 20 and Aminoff and Goodin's 19 patients to sort out these discrepancies. We discussed in the text a number of explanations of unexpected DSEP abnormalities in roots. One cannot assume that the injury causing pain also causes delayed DSEPs simultaneously, we know from peripheral nerve decompression that pain is relieved immediately but conduction delays take time to resolve. It is possible that an abnormally conducting root which did not appear compressed at surgery may have been bowed and repeatedly stretched during active movement sufficiently to cause a conduction defect.

Anatomical variations must also be considered.^{8,9} Pre-fixed and post-fixed roots are possible; sometimes L5 and S1 are unevenly divided with the majority or even all the fibres passing through one intervertebral foramen.

In persisting with our conclusions that the DSEP is a very accurate method for detecting abnormalities in root function we are encouraged that other workers have reached similar conclusions.¹⁰⁻¹² There is ample evidence to justify further evaluation of the technique in larger numbers of patients and we are currently preparing our experience in 100 cases, most of whom were treated conservatively.

HA KATIFI
EM SEDGWICK

References

- 1 Katifi HA, Sedgwick EM. Evaluation of the dermatomal somatosensory evoked potential in the diagnosis of lumbo-sacral root compression. *J Neurol Neurosurg Psychiatry* 1987;50:1204-9.
- 2 Katifi HA, Sedgwick EM. Somatosensory evoked potentials from posterior tibial nerve and lumbo-sacral dermatomes. *Electroencephalogr Clin Neurophysiol* 1986;65:249-59.
- 3 Aminoff MJ, Goodin DS, Parry GJ, Barbaro NM, Weinstein PR, Rosenblum ML. Electrophysiological evaluation of lumbosacral radiculopathies: Electromyography, late responses, and somatosensory evoked potentials. *Neurology* 1985;35:1514-8.
- 4 Aminoff MJ, Goodin DS, Parry GJ, Barbaro NM, Weinstein PR, Rosenblum ML. Dermatome somatosensory evoked potentials in unilateral lumbosacral radiculopathy. *Ann Neurol* 1985;17:171-76.
- 5 American Electroencephalographic Society. Guidelines for Clinical Evoked Potential Studies. *J Clin Neurophysiol* 1984;1:3-53.
- 6 Clifford JR, Shapiro R. Lumbar discography: an outdated procedure. *J Neurosurg* 1986;63:686.
- 7 Kieffer SA, Sherry RG, Wellenstein DE, King RB. Bulging lumbar intervertebral disk: myelographic differentiation from herniated disk with nerve root compression. *AJR* 1982;138:709-16.
- 8 Neidre A, MacNab I. Anomalies of the lumbosacral nerve roots. *Spine* 1983;8:294-99.
- 9 Young A, Getty J, Jackson A, Kirwan E, Sullivan M, Parry CW. Variations in the pattern of muscle innervation by the L5 and S1 nerve roots. *Spine* 1983;8:616-24.
- 10 Dvorchak V, Scarff T, Bunch WH, Smith D, Boscardin J, Lebarge H, Ibrahim I. Dermatome somatosensory evoked potentials: Their use in lumbar radiculopathy. *Spine* 1984;9:291-93.
- 11 Scarff TB, Dallmann DE, Bunch WH. Dermatome somatosensory evoked potentials in the diagnosis of lumbar root entrapment. *Surgical Forum* 1981;32:489-91.
- 12 Machida M, Asai T, Sato K, Toriyama S, Yamada T. New approach for diagnosis in herniated lumbosacral disc. Dermatome somatosensory evoked potentials (DSEPs). *Spine* 1986;11:380-4.

Notices

Alumni Association for the National Hospital, Queen Square and the Institute of Neurology (London).

A meeting, open to anyone who has studied at the National Hospital for Nervous Diseases or the Institute of Neurology will be held during the American Academy of Neurology Meeting in Cincinnati, Ohio, on 19 April 1988, 7.00 a.m. Information may be obtained from Dr John C Steiner, Admirals Walk Building, 1095 Nimitzview Drive, Cincinnati, Ohio 45230.

The 18th International Epilepsy Congress.

This will be held in New Delhi, India, 17-21 October 1989. Information may be obtained from Professor M C Maheshwari, Secretary General, 18th International Epilepsy Congress-89, Department of Neurology, Neurosciences Centre, All India Institute of Medical Sciences, New Delhi-110029, India.

The Volvo Awards for Low Back Pain Research 1989

The Volvo Company has sponsored prizes of US \$8,000 each. Awards will be made competitively for papers in the following: (1) Clinical studies, (2) Bioengineering studies, (3) Studies in other basic science areas.

Enquiries should be made to: Professor Alf Nachemson, Department of Orthopaedics, Sahlgren Hospital, S-413 45 Göteborg, Sweden