Annals of the Royal College of Surgeons of England (1990) *vol.* 72, 321–323

A technique for monitoring evoked potentials during scoliosis and brachial plexus surgery

S K Anderson MB BS FFARCS
Registrar

M A Hetreed MB BS FFARCS
Consultant Anaesthetist

B A Loughnan MB ChB FFARCS*
Senior Registrar

Department of Anaesthesia, Royal National Orthopaedic Hospital, Stanmore, Middlesex

Key words: Cervical; Epidural; Spinal cord monitoring

A total of 40 patients undergoing scoliosis or brachial plexus surgery had bipolar electrodes inserted preoperatively in the cervical epidural space located by the 'hanging drop technique'. The angle of approach to the space was different for each spinal interspace used. Good quality recordings were obtained of SSEPs with no long-term complications and we recommend this as a safe technique.

Monitoring of somatosensory evoked potentials (SSEPs) is used to test spinal cord integrity during scoliosis surgery. Methods of recording the SSEPs traditionally use electrodes placed either on the scalp *(1,2)* or into the epidural space at the time of surgery *(3)*.

Although intraoperative insertion of the epidural electrode is the more widely accepted method of electrode placement, percutaneous insertion in the anaesthetic room offers the ability to monitor spinal cord impulse transmission in situations where the epidural space is not surgically accessible. Such procedures include spinal surgery using an anterior approach or brachial plexus surgery.

The aim of the present study is to describe this method of electrode placement and to document our experience.

Methods

A total of 40 patients, all ASA Grade I or II (22 male, 18 female) with a mean age of 20.8 years were studied. All were patients in whom monitoring of the spinal cord was deemed necessary. Full explanation of the necessary instrumentations were given to each patient. Diagnosis and operative procedures are listed in Table I.

Table I. Diagnosis and operative procedures

Diagnosis	
Adolescent idiopathic scoliosis	26
Neuropathic scoliosis	6
Acute spinal injury	1
Brachial plexus lesion	7
Operative procedures	
Posterior spinal fusion	24
Anterior spinal fusion	8
Combined anterior/posterior fusion	1
Brachial plexus exploration	7

Patients were premedicated with papaveretum 0.4 mg kg^{-1} and hyoscine 0.02 mg kg^{-1}, approximately 90 min before induction of anaesthesia. Anaesthesia was induced with thiopentone 4 mg kg^{-1} and intubation facilitated with vecuronium 0.08 mg kg^{-1}. The lungs were ventilated to normocapnia with 70% nitrous oxide in oxygen. Anaesthesia was maintained with enflurane up to 2%. Routine monitoring consisted of an electrocardiogram, end tidal carbon dioxide and direct arterial pressure via an indwelling intra-arterial cannula. Patients were then positioned for surgery, usually prone on a Montreal mattress (for anterior approaches to the spine and brachial plexus surgery, the position was lateral on the appropriate side). In all cases, the neck was fully flexed.

* Present appointment: Consultant Anaesthetist, Northwick Park Hospital, Harrow, Middlesex

Correspondence to: Dr S K Anderson, 27 Fyfield Road, Ongar, Essex CM5 0AG

The spinous process of C7 (vertebra prominens) was identified by palpating along the nuchal furrow until the first prominent spine was located. The identification was confirmed by extending the neck causing C7 to become impalpable whilst T1 immediately below remains prominent. In this way the spaces C6–C7 and C7–T1 were identified, marked and the more accessible chosen.

A small opening was made in the skin and a 10 cm Tuohy type needle (15G) with the tip modified to 45° was introduced through the skin and subcutaneous tissues into the chosen space. The needle was advanced until firmly fixed within the interspinous ligament. The introducer was then removed and the hollow needle primed with normal saline so that a drop was produced on the top of the bevel. The needle was then advanced carefully until the ligamentum flavum was breached. Location of the space is signalled by appreciable movement of the drop, usually associated with an appreciable ligamentous click. Saline was then injected into the needle to confirm that resistance to injection was appropriately low. A bipolar electrode (S-pace Ltd Cardiac pacing 3 FG) was then threaded approximately 4 cm into the epidural space, the needle removed and the electrode connected to a Medelec MS91 EMG recorder. Using standard EMG surface electrodes placed in the popliteal fossa of each side, each posterior tibial nerve was alternately stimulated using a square wave impulse of 0.2 ms duration at an intensity of 150 V. The stimulation frequency was 20 Hz with a resolution of 0.033 ms and the filters were set at 200 Hz to 2 kHz. Using the bipolar electrode, 1000 responses were averaged on the Medelec MS91.

The following data was recorded:

1 The sign identifying the space, eg a 'click' or movement of saline drop.
2 The depth of the epidural space.
3 The angle in the caudal direction between the needle and skin.
4 The length of electrode in the space.
5 The adequacy of the recording.

All patients were observed on the high dependency ward for at least 48 h postoperatively. They were also visited at 7 and 14 days after operation. The epidural puncture site was inspected and enquiries made about the presence of any local discomfort or headache.

Results

The 'hanging drop' technique located the epidural space in 36 patients (90%), with the feel of a ligamentous 'click' the next best identifier (55% of cases). In 4.7% of cases both the hanging drop and the click were positive but in only three patients (7.5%) was the epidural space detected by the click alone.

The measurements of depth of space and angle of insertion were normally distributed (Shapiro–Francia *W* test) and therefore the data is presented as mean and standard deviation (SD).

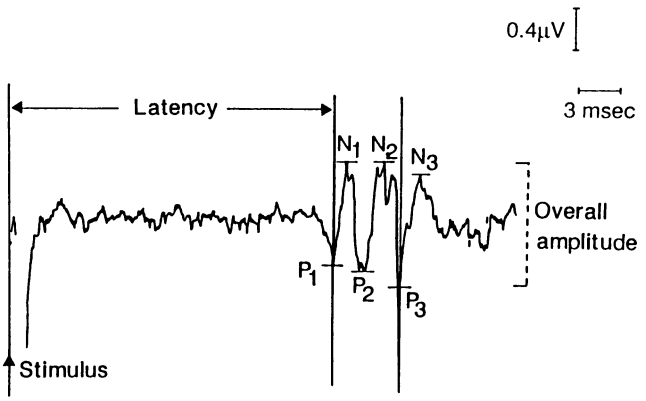

Figure 1. A typical somatosensory evoked potential recorded from the C7–T1 epidural space. There are three distinct peaks. Disappearance of one or more peaks or overall amplitude decreases of more than 50% are regarded as significant events. (Reproduced by permission of the *British Journal of Anaesthesia*.)

The mean depth of the epidural space was located at 4.2 cm (SD 0.99) from the skin for both the C7–T1 and C6–C7 interspace. The mean angle of insertion was 63° (SD 8.55) at the C6–C7 interspace and 74° (SD 12.06) at the C7–T1 interspace. The difference in angulation of the two spaces was significant ($P<0.01$) (unpaired t test).

The median length of electrode inserted into the space was 4.5 cm. At present, the electrodes used are unmarked for length so that the amount remaining in the epidural space could only be estimated at the time and measured later when the electrode was removed.

The recordings obtained were of good quality and provided adequate monitoring for the surgery undertaken. A typical tracing is shown in Fig. 1. Each showed the triple peak characteristic of SSEPs recorded from the epidural space. Disappearance of one of these peaks and/or decrease in overall amplitude by 50% or more is regarded as an event necessitating modification of the surgical manoeuvre where possible. In no case did the amplitude fall by 50% or more. However, in one patient, the later two peaks disappeared on the left side, and the surgeon confined his procedure appropriately. The patient complained of transitory numbness in the L4/5 distribution on the left side postoperatively. We found that in two patients requiring electrode re-insertion for a second procedure some weeks later, the recordings were reproducible.

There were two dural taps; both were symptom free in the follow-up period. Both were nursed supine with intravenous narcotics (for routine postoperative analgesia) for at least 48 h postoperatively. Neither was mobilised before 48 h. There was no complaint of local irritation or pain around the puncture site.

Discussion

Our study confirms the importance of the 'hanging drop' technique for location of the epidural space. Wittich *et al.*

(4) describe an almost identical method for identification of C7–T1 interspace. They performed this procedure with the patient awake and in the sitting position which enhances the negative pressure. They encountered no problems in over 200 patients in whom bupivacaine 0.5% was inserted into the C7–T1 epidural space to provide anaesthesia for head and neck surgery.

In most cases 4 cm of electrode remained in the epidural space intraoperatively. The recent development of an electrode with markings on it analogous to that seen in epidural catheters for local analgesic administration offers an advance in this respect.

The insertion of an electrode into the epidural space at the time of surgery has now become an accepted part of scoliosis surgery *(3,5)*. Although spinal cord conduction following median nerve stimulation can be recorded satisfactorily in some cases using electrodes placed on the skin over the C7 area, Jones and Small *(6)* have shown that this is not adequate for monitoring cord conduction following posterior tibial nerve stimulation. Ease and stability of placement are further points in favour of epidural recording.

Somatosensory evoked potentials recorded from the scalp are known to be significantly affected by anaesthetic agents, particularly the inhalational agents *(7)*. It has been shown elsewhere *(8)* that the extradurally recorded SSEPs are minimally affected by halothane to an end tidal concentration of 1.5%.

Insertion of the extradural electrode in the anaesthetic room before surgery allows us to investigate the effects of anaesthetic agents on extradural SSEPs. Our surgical colleagues have also expressed a preference for this mode of insertion as the electrode is outside their site of operation and less likely to be dislodged. It also makes spinal cord monitoring available for appropriate cases where the anterior approach is used and the surgeon may require intraoperative monitoring.

Although SSEPs can be measured from the spinous processes they are of low amplitude and compared to epidural recordings are less stable in form with a less stable baseline and the electrode is more likely to become displaced. Jones *et al. (3)* describe a stainless steel screw inserted into the spinous process as the basis for a recording electrode. Although satisfactory recordings were obtained, there was considerable disruption resulting from surgical manipulation or blood or instruments contacting the positive electrode and the technique was abandoned in favour of extradural recordings.

Brachial plexus surgery can be monitored using a spinal cord monitor. Testing the afferent conduction of a severed proximal nerve ending provides the surgeon with information about the likely functional success of nerve grafting to this servered end. In addition, SSEP monitoring, known to be little affected by anaesthetic agents may, in the future, be used for monitoring surgery of the thoracic aorta.

In studies by Jones *et al. (3)*, a unipolar electrode was used with a reference electrode inserted into nearby muscle. Other investigators *(11)* used a similar electrode placed subdurally, while Tamaki *et al. (12)* used a specially manufactured bipolar electrode to monitor spinal cord integrity. We have found that the 4G bipolar electrodes inserted intraoperatively, or the 3G inserted by the percutaneous route preoperatively, provide excellent recordings.

In summary, we have shown that the epidural space can easily be identified at the C7–T1 interspace or the C6–C7 interspace at a depth of about 4 cm and angulation around 70° in the caudal direction. The hanging drop technique was the most reliable indicator. The advantages of preoperative insertion mean that in centres with appropriate monitoring facilities, the insertion of an electrode into the cervical epidural space will come within the role of the anaesthetist.

References

1 Jones SJ, Edgar MA, Ransford AO, Thomas NP. A system for the electrophysiological monitoring of the spinal cord during operations for scoliosis. *J Bone Joint Surg* 1983; **65B**:134–9.

2 Nuwer MR, Dawson E. Intraoperative evoked potential monitoring of the spinal cord; A restricted filter, scalp method using Harrington rod instrumentation for scoliosis. *Clin Orthop* 1984;**183**:42–56.

3 Jones SJ, Edgar MA, Ransford AO. Sensory nerve conduction in human spinal cord: epidural recordings made during scoliosis surgery. *J Neurol Neurosurg Psychiatry* 1982; **45**:446–51.

4 Wittich DJ, Benny JJ, Davis RK. Cervical epidural anaesthesia for head and neck surgery. *Laryngoscope* 1984; **94**:615–19.

5 Youngman PME, Edgar MA, Posterior spinal fusion and instrumentation in the treatment of idiopathic scoliosis. *Ann R Coll Surg Engl* 1985;**67**:313–17.

6 Jones SJ, Small DG. Spinal and sub-cortical evoked potentials following stimulation of the posterior tibial nerve in man. *Electroencephalogr Clin Neurophysiol* 1978;**44**:299–306.

7 McPherson RW, Mahla M, Johnson R, Traystman RJ. Effects of enflurane, isoflurane and nitrous oxide on somatosensory evoked potentials during fontanyl anaesthesia. *Anesthesiology* 1985;**62**:626–33.

8 Loughnan BA, King M, Grundy EM, Young DL, Hall GM. An investigation on the effects of halothane on the epidurally recorded somatosensory evoked potential. *Br J Anaesth* 1989;**62**:297–300.

9 Nordwall A, Axelgaard J, Harado Y, Valencia P, McNeal DR, Brown JC. Spinal cord monitoring using evoked potentials recorded from the feline vertebral bone. *Spine* 1979;**4**:486–94.

10 Kaplan BJ, Friedman WA, Alexander JA, Hampson SR. Somatosensory evoked potential monitoring of spinal cord ischaemia during aortic operations. *Neurosurgery* 1986; **19**:82–90.

11 Whitte IR, Johnson IH, Besser M. Recording of spinal somatosensory evoked potentials for intraoperative spinal cord monitoring. *J Neurosurg* 1986;**64**:601–12.

12 Tamaki T, Tsuji H, Inoue S, Kobayashi H. The prevention of iatrogenic spinal cord injury utilizing the evoked spinal cord potential. *Int Orthop* 1981;**4**:313–17.

Received 22 February 1990