

Anaesthesia for surgical correction of Scoliosis with Spinal Cord Monitoring - a case series

Abstract

Objective: To share our experience of anaesthetic management of scoliosis with intra operative somatosensory evoked potential monitoring and wake up test.

Methods: All the cases of scoliosis surgery scheduled during a period of two years in which SSEP and intra-operative wake-up test was planned were included in the study. The patient in which intra-operative wake-up test was not planned were excluded from this case series.

Results: We managed a series of sixteen cases of scoliosis in our hospital. Eleven patients were female and five were male with the age ranging from six to twenty two years. SSEPs were monitored throughout the procedure and wake up test was done intraoperatively after surgical manipulation of spinal cord. Intra-operative wake-up test was completed successfully in all the patients. None of the patients had any neurological damage and were also successfully extubated at the end of procedure.

Conclusion: Intra-operative wake up test and SSEP monitoring are reliable methods for detection of intraoperative spinal cord ischemia during scoliosis surgery (JPMA 54:565;2004).

Introduction

Scoliosis is characterized by lateral and rotational deformity of the spine (Figure 1). The vertebrae and spinous processes are rotated in the area of the curvature towards the concave side of the curve.

The incidence of scoliosis in North America is 4/1000 live births¹ with a male: female ratio of 1:4.1 Females make up to 85% of adolescent scoliosis and usually have a right-sided curve. Scoliotic deformity significantly affects respiratory mechanics, gas exchange, pulmonary vasculature and chemical regulation of ventilation. The severity of pulmonary and cardiovascular involvement increases with the increase in the degree of curvature, often resulting in respiratory failure, Pulmonary hypertension and cor pulmonale.²

In 1966, the Scoliosis Research Society, a professional organization based in USA standardized the method of assessing the severity of scoliosis by defining the angle of scoliosis known as the "Cobb's angle"³ (Figure 2). Surgery is

usually considered when the Cobb's angle exceeds 50° in the thoracic, or 40° in the lumbar spine, as these are associated with restrictive pulmonary dysfunction, the most noticeable reduction being in vital capacity.⁴

Muscular dystrophy and cerebral palsy are important causes of scoliosis.⁵ Of the muscular dystrophies, Duchenne muscular dystrophy (DMD) is the most common and has a high incidence of cardiac abnormalities (50-70%). In addition association of scoliosis and malignant resulting in respiratory failure, Pulmonary hypertension and cor pulmonale.² In 1966, the Scoliosis Research Society, a professional organization based in USA standardized the method of assessing the severity of scoliosis by defining the angle of scoliosis known as the "Cobb's angle"³ (Figure 2). Surgery is usually considered when the Cobb's angle exceeds 50° in the thoracic, or 40° in the lumbar spine, as these are associated with restrictive pulmonary dysfunction, the most noticeable reduction being in vital capacity.⁴

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hyperthermia has also been reported.⁶ These all may present additional anesthetic concerns.

Surgical correction of scoliosis usually requires an anterior (thoracotomy / laparotomy) approach for release of the vertebrae in the supine/lateral position followed by a posterior approach in the prone position for placement of Harrington rod or modified Cotrel-Dubousset instrumentation.⁷ The stage when the spinal cord is at risk and any injury may lead to permanent neurological damage, if unrecognized, warrants monitoring of spinal cord function for a better outcome.

The incidence of motor deficit or paraplegia after surgical correction of scoliosis in the absence of spinal cord monitoring, has been quoted as between 3.7 and 6.9%.⁸ This can be reduced by intraoperative monitoring to 0.5%.⁹ The currently available methods to monitor the integrity of spinal cord include ankle clonus test, the Stagnara wake-

up test, Somatosensory evoked potentials (SSEP) and Motor Evoked Potentials (MEP).¹⁰ The commonly used methods

[(1)]

are wake up test and Somatosensory Evoked Potential Monitoring (SSEPs). SSEP is, overall a reliable technique with a high sensitivity (92%) and specificity (98.9%).⁹ However, its limitations and reports of false positive¹¹ and false negative¹² results have led to the development of Motor evoked potential (MEP) which can monitor motor function of spinal cord.

MEP is also less reliable as SSEP in patients with pre-existing neurological deficit¹³ and reports of false positive results¹⁴ suggest that this method of spinal cord monitoring also have sensitivity less than 100%.

Ankle clonus, which is repeated rhythmic movement elicited by the stretch reflex is normally absent in normal awake patients. However, this reflex can be elicited in normal patients under light plane of anaesthesia (during induction and recovery). The ankle clonus will be absent in presence of spinal cord injury. The proponent of its use

Table. Demographic data.

Case	Gender	Age (years)	Weight (kg)	Height (cm)	Cobb's angle (degrees)	*Wake-up test time (minutes)	Pulmonary function test (Yes/No)
1	Male	15	44.5	146	60	10	*PEFR
2	Female	18	49	151	40	8	Yes
3	Male	11	30	146	37	12	Yes
4	Female	22	45	153	48	3	Yes
5	Female	16	39	157	64	9	No
6	Female	13	41	152	72	14	Yes
7	Male	17	24	122	140	7	Yes
8	Male	12	47	145	65	8	No
9	Female	14	31	144	65	7	Yes
10	Female	11	35	136	68	10	Yes
11	Female	12	32.5	148	60	5	No
12	Male	12	42	135	105	5	Yes
13	Female	15	32	140	72	6	Yes
14	Female	14	54	159	60	8	No
15	Female	6	25	121	70	20	No
16	Female	14	27	125	58	11	Yes

point to a high level of sensitivity (100%) and specificity (99.7%).¹⁵ However, the test can only be performed intermittently and, the absence of the clonus could be the result of not only spinal cord damage, but also to an inadequate or too great a depth of anaesthesia. Furthermore, the presence of clonus does not exclude spinal cord damage, as other parts of the spinal cord may be damaged leaving the ankle stretch reflex intact.

The intraoperative wake-up test is a clinical method of assessing the integrity of motor fibres of spinal cord. The test involves waking the patient part way through the surgery and making a specified motor response in the lower limbs on verbal command.

This method has the advantage of being definite and simple to perform. However, the disadvantages are that it is not continuous and requires an anesthetic technique that should be reliable and short acting. The wake up test has been used not only as a planned monitoring technique¹⁶ but various studies have recommended this to be performed in cases where either ankle clonus test or electrophysiological monitoring (SSEP and MEP) techniques are not available, fail, or are equivocal.^{17,18}

Case Series

Anaesthetic Management

We have managed 16 cases of scoliosis surgery in year 2002 and 2003 in our hospital. Among these 11 were

females and 5 were males with age ranging from 6 to 22 years (mean=13.9 years), mean weight being 37.4 kg and mean height 142.5cms. The severity of disease was assessed by pulmonary function tests and radiologically by Cobb's angle ranging from 37 to 140 (Table).

All the cases of scoliosis surgery scheduled during a period of two years were included in the study. The patients who did not give consent were excluded from the study.

Pre-operative Evaluation / Preparation

All patients attended anaesthesia assessment clinic one week before surgery and were evaluated with special attention to respiratory, cardiovascular and neurological diseases in addition to routine preoperative assessment. The patients were explained about the intra operative wake up test in detail and were briefed that they will be awakened during the operation and will be asked to move first their hands and then feet. They were also ensured that they will not feel any pain during the procedure and should not move excessively when asked to move their limbs.

Routine investigations including Complete blood count, serum sodium and potassium, blood urea nitrogen, creatinine, prothrombin time, activated partial thromboplastin time, electrocardiogram and chest X-ray was done in all patients. Pulmonary function tests were performed in eleven patients where it was indicated on the basis of history or Cobb's angle. On an average 3 units of blood were crossed matched for majority of patients. All the patients were advised to start preoperative chest physiotherapy and incentive spirometry to improve the functional status of the lungs.

Intra-operative Management

In our series of the cases all the patients were visited by the primary anaesthetist a day before surgery and wake up test was rediscussed and explained. The patients were premedicated with

tablet midazolam, given an hour before surgery. After application of routine monitors all patients were given balanced general anaesthesia with pethidine 1mg/kg, thiopentone sodium 4-6 mg/kg and atracurium 0.5 mg/kg and were intubated with non kinkable polyvinyl reinforced endotracheal tube of appropriate size. After induction of anaesthesia, radial arterial catheter and central venous pressure line was inserted through antecubital veins. Temperature probe, urine output, inhalational agent monitor, baseline and later on continuous SSEPs were monitored in addition to the basic anaesthesia monitoring. Anaesthesia was maintained with isoflurane (MAC 0.8-1.0) and 60% nitrous oxide in oxygen, atracurium infusion was used for muscle relaxation. Injection Ketorolac (0.3mg/kg IV) was administered every six hours to all patients in order to augment the analgesia. A decrease in amplitude of SSEPs of more than 50% and an increase in latency of more than

15% indicated spinal cord ischemia (Figure 3). The surgeons were informed immediately who loosened the screws, released the pressure and waited until the perfusion of spinal cord was restored and amplitude and latency of SSEPs reverted back to normal. Attempts were made to minimize the variations in the depth of anaesthesia, analgesia, temperature and haemodynamics to have least effect on SSEPs.

The surgeons were requested to inform the anaesthetist at least an hour before the anticipated wake up test. During this hour atracurium infusion was stopped. Once patients started breathing spontaneously, isoflurane was substituted with sevoflurane and analgesia was maintained with 10-20 microgram of incremental fentanyl injection. Train of four twitches was monitored to ensure that patients had reversed from the effects of muscle relaxants. Fifteen minutes before the test time sevoflurane was also stopped but nitrous oxide in oxygen was continued. When the surgeons were ready for wake up test, nitrous oxide was also discontinued. Patients were called by their names repeatedly until they opened their eyes and moved hands first and then feet on command. After successful completion of wake up test the anaesthesia was recommenced by administering propofol bolus, 1mg/kg and patients were relaxed by atracurium 0.5 mg/kg. The rest of the surgery was completed routinely. At the end of surgery, patients were extubated when fully awake and movement of lower limbs was checked again.

The wake up test was successfully done in all the patients without any complications. The time taken by the patients from the time sevoflurane was

stopped to the completion of wake up test ranged from 3 to 20 minutes with an average of 8.9 minutes. The wake up test was successfully done in all the patients without any complications. The time taken by the patients from the time sevoflurane was stopped to the completion of wake up test ranged from 3 to 20 minutes with an average of 8.9 minutes.

Post-operative Management

Except for one patient, all the patients were kept in recovery room for overnight neurological monitoring of lower limbs. They remained stable without any neurological problem and were discharged to their respective wards the next day (Figure 4).

[(2)]

There was one patient with a Cobb's angle of 1400 and severe restrictive lung disease with reduced vital capacity (33% of the predicted value) on pulmonary function tests. At the end of surgery this patient was extubated when he was fully awake and maintaining adequate tidal volume. He was then shifted electively to ICU where he remained stable and had no respiratory or neurological complication.

In all the patients analgesia was maintained either with intravenous infusion of pethidine, 10-15 mg/hr or Patient Controlled Analgesia (PCA) with or without background infusion, supplemented with Ketorolac 10-15 mg 8 hourly. They were also interviewed twenty-four hours post operatively about intra operative wake up test. All the patients did recall that they were awakened during the

[(3)]

operation and were asked to move the limbs but none of them complained of any pain or discomfort during the test. All patients, except the last one, were followed for up to a period of six months and none of them had any psychological problems.

Discussion

The major concerns of the anaesthesiologists for scoliosis correction are prolonged surgery, prone positioning, intra operative blood loss, temperature maintenance and most important is to facilitate intraoperative spinal cord monitoring.

Iatrogenic neuropathy is a rare but well recognized and devastating complication of spinal surgery, which mandates an aggressive and reliable neurological monitoring. An ideal monitoring system should provide accurate and continuous real time feedback of global spinal cord function as irreversible ischemic damage can occur in the order of 5-6 minutes as shown in animal studies.¹⁹ A motor deficit is functionally more devastating to the patient than a sensory deficit. This is important to

consider when evaluating the methods of monitoring, as some of the available techniques monitor motor tracts (MEP) and some the sensory tracts (SSEP) of the cord. Despite the limitations and false positive and negative results of SSEPs^{11,12}, it is still widely used, as it provides continuous monitoring of spinal cord integrity. Its drawback to monitor only the sensory tract of spinal cord led to the development of motor evoked potential monitoring (MEPs), with a view that this combination may enhance the predictive value, but this remains technically demanding and, as yet, clinically unproven.¹⁴ These tests are not only costly but also have limited availability and need an expert interpreter. In addition these tests are affected by different anaesthetic agents and patient's hemodynamics^{20,21} and may be equivocal. Intra-operative wake-up test, although does not provide continuous monitoring but is least affected by these factors and also provides a visual confirmation of integrity of spinal cord function. Compared to wake-up test, the ankle clonus test provides a very brief period (time window) between anaesthesia and wakefulness when it is possible to elicit clonus, making it difficult to time it with light plane of anaesthesia.¹⁵ The other requirement to perform this test is that all muscle paralysis must be antagonized pharmacologically to elicit the clonus²² which may increase the chances of accidental tracheal extubation thus making this test less acceptable compared to wake-up test which does not require pharmacological reversal. Even with high sensitivity and specificity of ankle clonus test, there have been reports of false negative and false positive results which led to the recommendation for performing wake-up test in cases where this test is abnormal, absent or equivocal to confirm or exclude neurological compromise.¹⁵ The use of ankle clonus test as an alternative to "wake-up test" has been questioned recently in children.²³

Our choice for continuous monitoring by SSEPs was influenced by its availability, as MEPs monitoring is not available in our hospital. In order to increase our confidence and to overcome the limitations of SSEPs, we also used intraoperative wake-up test as it provided us, the chance to observe voluntary movements of the lower extremities on verbal command. This increases the confidence of the surgeon and is also not limited by the time window as ankle clonus test.

The important considerations which were in our minds was to use short acting anaesthetic and analgesic drugs, so that the patients can be prepared for wake up test quickly and remain pain

free, with minimal effect on SSEPs. Although the analgesic drugs used in our patients were less than ideal but the non availability of ultra short acting narcotic analgesic did not have any significant effect on the timing of wake-up test in our case series. The average time for wake-up test in our patients was approximately 9 minutes which is comparable to earlier studies in which ultra short acting analgesics like ramifenitil²⁴ or continuous infusion of fentanyl with or without inhalational anaesthetic agents were used.²⁵

Conclusion

The combination of a continuous spinal cord monitoring, with SSEP and intra-operative wake-up test provides a simple and reliable method to monitor spinal cord function during surgical correction of scoliosis. The wake up test, however, can not be applied indiscriminately to all cases of deformity of spine as patients with psychological problems or mentally retarded patients may not respond appropriately.

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