

## **Anesthesia Management for Scoliosis Correction Surgery at the Level of Thoracic Vertebra 4 - Lumbar Vertebra 3 with Intraoperative Neurophysiological Monitoring**

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### **ABSTRACT**

**Background:** Scoliosis correction surgery in cases of adolescent idiopathic scoliosis (AIS) with the help of intraoperative neurophysiological monitoring (IOM) is an operative technique that aims to increase the safety of surgery in spinal correction by providing a real-time assessment of the underlying nerve structure risk. The management of anesthetic techniques for osteotomy and posterior spinal fusion (PSF) with the help of this IOM requires the expertise of an anesthesiologist to understand influence of anesthetic drugs/ agents on IOM, especially in spinal surgery, the anesthetic technique to be chosen, as well as the selection of drugs and doses that support the operative implementation with this IOM. However, it is important because intraoperative neurophysiological monitoring can prevent intraoperative neurological injury.

**Case:** A 14-year-old girl with AIS lenke I who will undergo scoliosis correction surgery for thoracic vertebrae 4 to lumbar vertebra 3 with monitoring using IOM.

**Discussion:** Neurological injury is the most feared thing that occurs during spinal surgery. The use of intraoperative neurophysiological monitoring (IONM) in spinal surgery is widely used by surgeons to increase safety during direct surgery. Another advantage of using IOM is that it is very sensitive and specific, has a fast response time, and can detect damage at an early stage.

**Conclusion:** Management of AIS with posterior spine fusion can improve the patient's quality of life, but this must be accompanied by safety during surgery, one of which is the use of IOM.

**Keywords:** AIS; anesthesia management; IOM; laminectomy; scoliosis

## INTRODUCTION

Adolescent idiopathic scoliosis (AIS) is a complex structural disorder of the spine seen in children from 10 years of age up to the age of skeletal maturity, AIS can be diagnosed when a Cobb angle of  $10^\circ$  or more is found and accompanied by spinal.<sup>1</sup> Posterior spinal fusion (PSF) according to the Scoliosis Research Society is indicated with a curve that is more severe than  $40^\circ$ , there are several opinions stating that curve surgery is above  $50^\circ$ .<sup>2</sup>

Intraoperative neurophysiological monitoring (IONM) is frequently used to increase the safety of spinal surgery by providing a real-time assessment of the neural structures at risk. Currently, the most commonly used IONM techniques for spinal procedures include somatosensory sensory evoked potentials (SSEPs), motor-evoked potentials (MEPs), and spontaneous and triggered electromyography (EMG). The successful use of this technology requires smooth and coordinated 3-way communication between neurosurgeons, anesthesiologists and neurologists.<sup>3</sup>

This case report is made to provide information on anesthesia management for scoliosis correction surgery in case of AIS with intraoperative IOM.

## CASE

A 15 years old girl, weight 30 kg, with a diagnosis of adolescent idiopathic scoliosis lenke I (AIS lenke I) who underwent osteotomy and PSF with IOM. Lenke I underwent osteotomy and PSF with IOM.

### Anamnesis

Patients complain of frequent aches and pain in the back area when doing activities. Complaints increase when the patient is exercising. From the

autoanemesis of the parents, the shape of the patient's spine already looked different from birth, but it changed more and more as he got older.

### Physical Examination

On physical examination, the patient obtained a free airway with an open mouth of more than 3 fingers malampati I. The patient's breathing pattern was spontaneous 14 times per minute with symmetrical chest development during inspiration and expiration on inspection. On auscultation of vesicular breath sounds between the right and left, no additional sounds such as rhonchi and wheezing were found. Resonant percussion and vocal fremitus palpation are symmetrical left and right. Pulse oximetry reads 97% saturation with free air O<sub>2</sub> (21% FiO<sub>2</sub>). On touch, perfusion is warm, dry and red, with a capillary refill time of less than 2 seconds. Blood pressure 140/90 and mean arterial pressure (MAP) 107 mm Hg and pulse 87 beats per minute, radial pulse is regular and strong. Glasgow coma scale (GCS) score E4V5M6, isochor spherical pupil 3 mm in diameter with positive light reflex right and left. On examination of the patient's motor strength, the results were up to as high as C7, motor power 5/5, then as high as C8 1/2 and as high as Th1 1/1. the motoric power from L2 downwards is 3/2. Meanwhile, on sensory examination, it was normal in the upper extremities and decreased in both lower extremities. From physiological reflex examination, it was +2 in the right and left upper extremities and +4 in the right and left lower extremities. In this patient there was no urinary incontinence or alvi incontinence.

Work Up Evaluation

Hemoglobin 10.3 g/dL, Hematokrit 27%, Leukosit 12.240c /uL, Trombosit 158.000  $\mu$ L. PPT 10,6 (Control 9.3–11.4), aPTT 2.9,2 (Control 24.5–32.8), INR 0.99.

From a full spine CT scan, axial, coronal and sagittal + 3 D sections, xiposcoliosis thoracolumbales was found with a Cobb angle i.k 66 degrees with a peak curve of 1.k Vth9, no narrowing in the spinal canal and no hemivertebrae in the vertebral body (Figure.1).



**Figure 1.** Full spine CT scan, coronal axial and sagittal +3d sections showing xiposcoliosis thoracolumbales.

Anesthetic Management

During preparation for elective surgery, the patient was fasted and given intravenous fluids in the form of 0.9% NaCl 80 mL/hour. The patient's condition before induction of anesthesia was: blood pressure 120/80 mmHg, MAP 93 mmHg with a pulse of 100 beats per minute regular lifting strength in the radial artery. GCS score E4V5M6 with isochor round pupils 3 mm in diameter in the right and left eyes. Patients without respiratory distress on 99% pulse oximetry without supplemental oxygen.

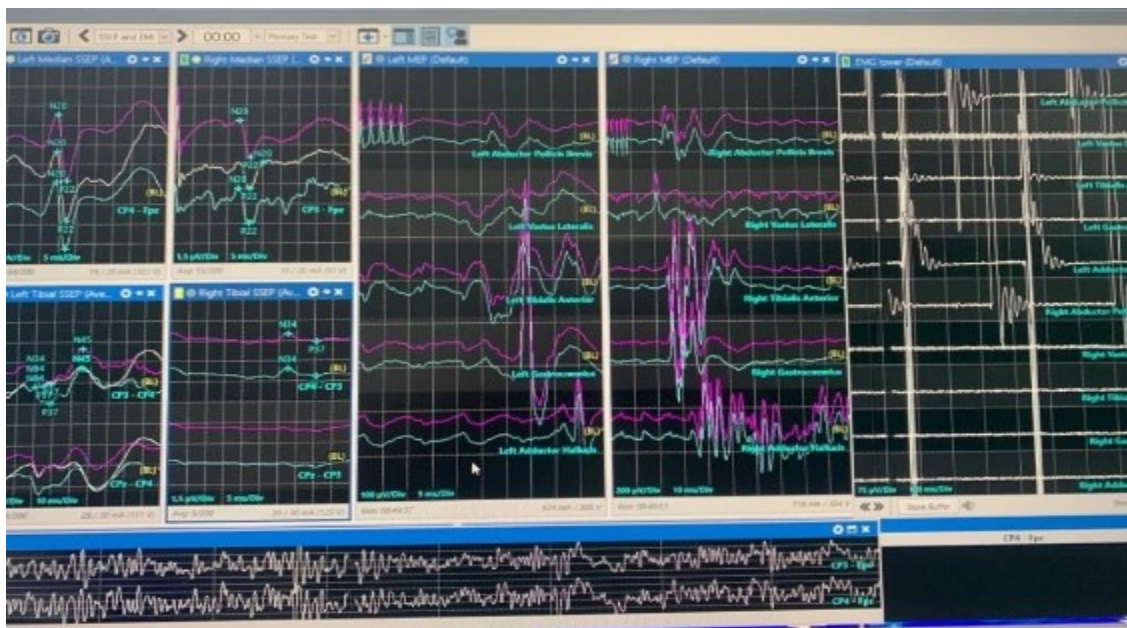
Before entering the operating room, the patient was premedicated with midazolam 2 mg intravenously. Induction was carried out with anesthetic drugs as follows: midazolam 3 mg, fentanyl 50 mcg, lidocaine 60 mg, propofol 100 mg and atracurium 25 mg intravenously then performed laryngoscopy with video laryngoscope and intubation with endotracheal tube non kink no. 7.5 and fixed. During surgery, maintenance was carried out with propofol 75–200 mg/hour and dexmedetomidine 0.2–05 mcg/kg/minute.

Then preparation for IOM installation was carried out and afterward the patient was positioned prone. At the start of surgery, a dissection was performed from the midline to the transversus processus. A bone graft is performed on the spinous process. Inferior spinal facetectomy was performed to increase flexibility and evaluated with IOM.

After that, a final neurofunctional evaluation was carried out with the IOM (Figure.2), a drain was placed and then it was closed. As Table 2 shows, the midazolam and propofol drugs we used during surgery did not interfere with the IOM. Nitous oxide give influence on motor evocated potentials and should be avoided.<sup>4</sup>

**Table 1.** Patient’s condition during and post surgery

During surgery	Post surgery
Blood pressure ranged from 100–120/62–80 mm Hg with MAP 75–90 mm Hg	blood pressure 112/78, MAP 89 mmHg
The pulse is between 55–100 beats per minute and pulse oximetry is 100%.	Pulse 61 beats per minute
The surgery lasted approximately 6 hours with fluid balance, namely 500 mL of 0.9% NaCl, 500 mL of Ringerfundin	Urine production 50 mL/hour
Estimated bleeding 300 mL, urine output during surgery 300 mL	Therapy: ringerfundin 1500 mL/24 hours, ondansetron injection 3 x 4 mg IV, omeprazole 1 x 40 mg IV, paracetamol 3 x 1 g IV, fentanyl if VAS > 3 and dexmedetomidine 0.1 mcg/kg/hour until by 24 hours
	postoperative laboratory tests: Hb 9.4 g/dL, hematocrit 26%, leukocytes 29.290/uL, platelets 260.000 µL



**Figure 2.** IOM graphic shown normal result without neural lesion

**Table 2.** Anesthetic drugs influence on motor evocated potentials<sup>4</sup>

Anesthetic drug	MEP-Latency	MEP-amplitude	Observation
Sevoflurane	Increase	Decrease	Use: MA-0.5
Nitrous oxide	Increase	Decrease	Strong effect, should be avoided
Fentanyl	Preserved	Slight depression	Dose dependent
Remifentanyl	Preserved	Decrease	Rapid metabolism-rapid titration
Propofol	Increase	Decrease	Dose dependent; Rapid metabolism-rapid titration
Thiopentone	High increase	High decrease	Marked suppression
Etomidate	Decrease	Increase	Enhances the potentials
Ketamine	Increase	Increase	Enhances the potentials
Midazolam	High increase	High decrease	Marked suppression; indicated only in premedication administration
Dexmedetomidine	Increase	Decrease	Use to lower other TIVA agents dose

The patient then extubated on the first day morning after operation. The patient's condition after extubation was as follows: clear airway with spontaneous breathing 15–16 breaths per minute, vesicular breath sounds in both lung fields without additional breath sounds, pulse oximetry reading 100% with 2 lpm nasal prong supplement. Blood pressure 131/77 mmHg with MAP 95 mmHg. Pulse 68 beats per minute, palpable regular and strong lift on the radial artery. Tympanic temperature 36.8°C. The patient's state of consciousness with GCS E4 V5 M6 with isochor 3 mm round pupils in the right and left eyes and positive light reflex. The patient was then transferred to the ward on the first postoperative day.

**DISCUSSION**

A 14-year-old girl with a diagnosis of AIS lenke I who underwent osteotomy and PSF with IOM. AIS is a complex structural disorder of the spine that is seen in children from 10 years of age to

the age of skeletal maturity. This condition affects 2-4% of adolescents, and is the most common type of scoliosis, with an incidence rate of 0.47-5.2% of all scoliosis.<sup>1</sup> The etiology of AIS itself is caused by congenital problems, developmental issues, and is polygenic.<sup>5</sup>

Treatment of Adolescent Idiopathic Scoliosis depends primarily on the size and localization of the deformity, and the potential for bone development.<sup>5</sup> Surgery for AIS itself can be performed with anterior spinal fusion (ASF), PSF or combined anterior/posterior.<sup>1</sup> Neurological injury is the most feared thing that occurs during spinal surgery.<sup>6</sup>

The use of IONM in spinal surgery is widely used by surgeons to increase safety during direct surgery. Another advantage of using IOM is that it is very sensitive and specific, has a fast response time, and can detect damage at an early stage. However, intraoperative

neurophysiologic monitoring cannot prevent intraoperative neurological injury.<sup>7</sup>

IOM has modalities such as motor evoked potentials (MEPs), somatosensory evoked potentials (SSEPs), electroencephalography (EEG), electromyography, brainstem auditory evoked potentials (BAEPs), and visual evoked potentials (VEPs).<sup>7</sup> Despite its shortcomings, IOM is expected to prevent postoperative neurological deficits, and to identify injuries that may occur to the spinal cord in a timely manner and take preventive or corrective measures.

In spinal surgery, monitoring of SSEPs is often performed to monitor the dorsal column. The medial column lemniscus pathway which plays a role in mediating tactile discrimination, vibration sensation, shape recognition and proprioception can be monitored via SSEPs.<sup>8</sup> The use of SSEPs is common in spinal surgery due to deformation and has a sensitivity of 25-92% with a specificity of 96%-100%. In research conducted by Cheng et, al. in 2016, monitoring SEP with MEP can increase specificity and sensitivity.<sup>9</sup>

MEP monitoring can be monitored through 3 components based on location, namely Direct waves, Neurogenic MEP, and Muscle MEP. Direct Waves or more commonly known as D Waves have corticospinal action potential compounds which can work when directly axonally activated. This can make it possible to monitor motor pathways from the cortex to spinal electrodes directly.<sup>8</sup> In addition, neurogenic MEP can monitor sensory responsiveness.<sup>9</sup>

The patient is a young woman with a diagnosis of AIS lenke 1, of course this situation will interfere with her daily life. Patients will experience an improvement in quality of life if the scoliosis correction surgical technique is carried out properly without any disturbance of neurological deficits, in this case the use of IOM in the scoliosis correction surgery technique is the right step to prevent the occurrence of postoperative neurological deficits. The successful use of IOM requires smooth and coordinated 3-way communication between neurosurgeons, anesthesiologists, and neurologists. It is necessary to carry out a preoperative examination, special attention should be paid to special attention such as the respiratory, cardiovascular and neurological systems. In addition, it is necessary to pay attention to the principles of anesthesia to achieve good recovery after spinal surgery.

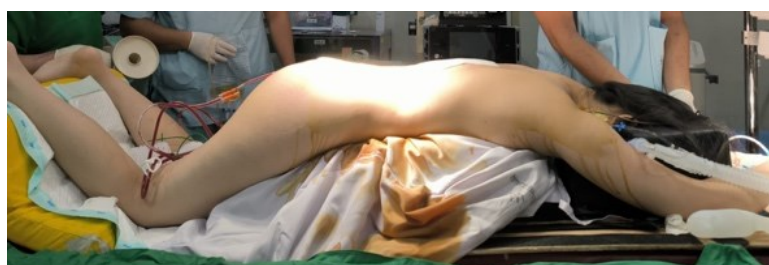
Preoperative assessment plays an important role to prevent and reduce the occurrence of complications in spinal surgery.<sup>10</sup> Respiratory examination during pre-surgery can help assess the severity of scoliosis, patients with a Cobb angle > 65° can cause spinal and chest wall deformities.<sup>11</sup> Apart from that, due to bone deformity there can be a decrease in lung volume which is characterized by a decrease in total lung capacity. A decrease in pulmonary expiratory flow rate can also occur due to a decrease in lung volume.<sup>12</sup> The Condition of scoliosis which has an impact on lung function means that medical personnel must be able to detect patients who are at risk of experiencing respiratory complications after surgery, by knowing the symptoms of lung pathology resulting from scoliosis such as ineffective coughing and a decrease in lung capacity of <40%.<sup>13</sup> To manage and

prevent the lung complications, all spinal fusion patients should have twice a day chest physio, starting in the immediate post-operative period. All patients' respiratory function is assessed by physiotherapy post operatively and treatment prescribed as indicated e.g. deep breathing exercises, bubble PEP and positioning.<sup>14</sup>

Heart function examination is needed to determine whether there is pulmonary hypertension or right ventricular heart failure due to severe scoliosis. Chest wall deformities in scoliosis patients can reduce cardiac output and inhibit heart filling.<sup>11</sup> According to Huh et.,al in 2015, scoliosis sufferers experienced mitral valve polaps four times more often than the normal adolescent population.<sup>12</sup> According to the American Heart Association, an evaluation of the condition of the heart should be carried out ideally 3 to 6 months before elective spinal surgery, which includes electrocardiography (ECG) and transthoracic echocardiography to assess heart function.<sup>13</sup> In spinal surgery, blood loss is one of the complications that often occurs, this can cause significant stress on already compromised heart function.<sup>6,13</sup>

Neurological checks in patients with spinal disorders often reveal neurological disorders such as weakness and muscle atrophy, leading to paraplegia or quadriplegia. Neurological deficits can occur during endotracheal intubation and bulbar involvement can be a risk factor for postoperative aspiration.<sup>15</sup>

Perioperative positioning of the patient plays an important role, when in the prone position, the arm should be abducted and no more than 90°, with slight internal rotation and placed in front of the plane of the body to reduce the risk of brachial plexus injury as figure 3 shows. Particular attention should be paid to the ulnar nerve at the elbow which is at risk of pressure-related injury when the arm is bent in the prone position. In this position monitoring is required to reduce abdominal pressure to improve ventilation and reduce pressure on the epidural veins.<sup>11,16</sup> The prone position has a higher chance of postoperative visual loss due to intraoperative hypotension, blood loss, and increased eye pressure during surgery.<sup>17</sup>



**Figure 3.** Prone position

Prone position during anesthesia is necessary to provide surgical access for a wide variety of surgical emergencies as elective procedures. Airway management in this position is a

challenge for the anesthesiologist because it creates obstructions that interfere with the ability to achieve endotracheal intubation. Endotracheal intubation can be accomplished safely

and effectively in a patient in prone position although by using direct laryngoscope than laryngeal mask airway.<sup>18</sup> In scoliosis patients, laryngoscopy and tracheal intubation are difficult, due to limited neck movement and a curved airway. The use of a video laryngoscope integrated with a monitor is recommended. Scoliosis patients have normal length of trachea and neck, but it has been found that there is a shortening of the length of the trachea in patients with scoliosis.<sup>19</sup> According to Ma et., al in 2016 fiberoptic guided intubation is the gold standard for elective management of difficult airways.<sup>20</sup>

Nerve damage in spinal surgery is the most feared intraoperative complication. Nerve damage occurs in 0.3 to 4% of spinal surgeries. According to the Scoliosis Research Society neurological deficits occurred in 86 of 11,741 pediatric idiopathic cases, with a prevalence rate of 0.73%.<sup>6</sup> Neurological monitoring must be a concern during spinal surgery, the use of Intraoperative Neurophysiology Monitoring becomes an aid during spinal surgery. According to Kundnani et., al in 2010 multimodality monitoring with SSEP and NMEP should become the standard monitoring in spine surgery.<sup>20</sup> In research conducted by Chung et., al in 2022, the use of IOM in 32 patients who experienced AIS and 37 patients who experienced neuromuscular scoliosis NMS showed that there were no neurological deficits.<sup>21</sup> Meanwhile, according to Lall et., al. in 2012 the use of IOM reduced the incidence of neurological deficits in spinal surgery by up to 50%. The combined use of SSEP and MEP monitoring has long been used in spine surgery. In the posterior surgical approach, the use of SSEP is sufficient, in its monitoring a decrease in amplitude of more than 50% or an increase in

latency of more than 10% is considered optimal.<sup>7</sup>

It is necessary to pay attention to the administration of anesthetic drugs during monitoring with IOM, the use of anesthetic agents, muscle relaxants can affect the IOM because anesthetic agents have an effect on synaptic nerves and muscle relaxants have an effect on neuromuscular junctions (NMJ).<sup>22</sup> During the use of IOM, Propofol is a suitable hypnotic drug but its administration can reduce mTc-MEP and SSEP amplitudes and increase SSEP latency, with optimal dosage administration it will reduce disruption of IOM function.<sup>23</sup> Administration of neuromuscular blocking agents can cause inhibition of neuromuscular signals resulting in a decrease in mTc-MEP amplitude.<sup>23</sup> When using muscle relaxants, MEP can be completely undetectable.<sup>22</sup> According to Bithal in 2014, selecting an anesthetic agent with a fast onset of action will provide an optimal effect on MEP monitoring. Hemodynamic monitoring should also not be manipulated with anesthetic agents, but by administering vasoactive drugs.<sup>24</sup> Oxygen monitoring also plays an important role, nervous tissue has high metabolic requirements, so it requires a continuous oxygen supply. MEP and SEP monitoring can be affected by changes in Arterial carbon dioxide (PaCO<sub>2</sub>) which will alter cortical blood flow with visible protrusions in SEP.<sup>23</sup>

The use of total intravenous anesthesia (TIVA) in spinal surgery is reported to provide better recovery side effects. Patients on propofol-based TIVA reported less pain when coughing and consumed less fentanyl PCA after spinal surgery.<sup>25</sup> The use of TIVA itself reduces the side effects of MEP and according to



a study conducted by Lin et., al in 2019, it showed that patients with propofol-based TIVA provided improvements in postoperative pain, as indicated by a decrease in the use of opioids at 2 days after surgery.<sup>26</sup> In addition, according to a study conducted by Cheng et., Al administration of propofol was associated with reduced postoperative pain and reduced use of PCA morphine postoperatively compared with patients given isoflurane.<sup>27</sup> Giving propofol can reduce the incidence of postoperative pain and chronic pain.<sup>26</sup> However, propofol has some disadvantages when administered in high doses, therefore adjunctive agents which decrease propofol infusion requirements may be administered. Dexmedetomidine is a highly selective  $\alpha_2$ -adrenergic agonist for the provision of short-term sedation (<24 h). Dexmedetomidine may be used as part of the anesthetic technique for posterior spinal instrumentation for scoliosis surgery repair that does not adversely affect SSEP or MEP monitoring.<sup>28</sup>

Patients who undergo PSF often experience postoperative pain, according to the study, 55 out of 105 patients experienced postoperative pain after the PSF procedure.<sup>29</sup> Postoperative pain is often the main obstacle in AIS patients due to inadequate pain control and PONV. In post-operative AIS, persistent chronic pain with a neuropathic component is often found, this is related to the use of opioids in the early post-operative period.<sup>30</sup> Administration of Paracetamol, NSAIDs, i.v. ketamine infusion, epidural analgesia, and morphine can reduce pain after spinal surgery.<sup>31</sup> According to Seki et., al in 2019, IV PCA or epidural anesthesia is recommended for pain management after PSF procedures for AI.<sup>32</sup>

## CONCLUSION

Management of Adolescent Idiopathic Scoliosis with posterior spine fusion can improve the patient's quality of life, but this must be accompanied by safety during surgery, one of which is the use of Intraoperative Neurophysiological Monitoring. Of course, this will be a challenge not only for surgeons, but also for anesthesiologists in choosing drug regimens or other procedures that can have an impact on the patient's neurological condition.

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