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Hemodynamic Stability During Severe Scoliosis Surgery Using A Dexmedetomidine-Based Anesthesia Regimen: A Case Report

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Abstract

Severe adult idiopathic scoliosis with a Cobb angle >80° is a complex condition that presents significant anesthetic challenges due to restrictive ventilatory impairment, potential hemodynamic instability, and the risk of massive blood loss during spinal surgery. A 20-year-old woman with an American Society of Anesthesiologists (ASA) Physical Status Classification II was diagnosed with Lenke type 3 idiopathic scoliosis (Cobb angle: 83°) and scheduled for spinal stabilization surgery. Preoperative evaluation revealed a Mallampati class II airway, preserved cardiac function (ejection fraction [EF] 62%), and restrictive pulmonary impairment with low cardiopulmonary risk. General anesthesia was administered using a combination of dexmedetomidine (0.3 mcg/kg/hour), fentanyl (3 mcg/kg), propofol (2 mg/kg), rocuronium (1 mg/kg), and desflurane (6–7 vol%). Intraoperative hemodynamic parameters remained stable. Postoperatively, the patient was successfully extubated in the operating room and transferred to the inpatient ward after 24 hours of intensive care unit (ICU) monitoring, with adequate pain control and no neurological complications. The dexmedetomidine-based anesthesia regimen provided hemodynamic stability, reduced the requirement for additional anesthetic agents, and supported early extubation without respiratory depression. A comprehensive anesthetic approach and blood conservation strategy contributed to optimal clinical outcomes. Comprehensive anesthesia management in severe scoliosis may improve physiological stability, reduce complications, and facilitate recovery.

INTRODUCTION

Scoliosis is a complex spinal deformity characterized by lateral deviation of the vertebral column accompanied by vertebral rotation and alterations in sagittal alignment. In severe scoliosis, progressive deformities can impair respiratory function due to thoracic wall restriction, ventilation–perfusion mismatch, reduced lung capacity, and cardiovascular compromise resulting from biomechanical changes within the thoracic cavity. In addition to causing functional limitations and reduced quality of life, severe scoliosis increases the risk of perioperative complications during spinal deformity correction procedures. Major scoliosis surgery, particularly posterior spinal fusion and spinal stabilization, is a highly complex procedure associated with substantial blood loss, significant hemodynamic fluctuations, prolonged operative duration, and the risk of postoperative neurological and respiratory complications (Hudec et al., 2023; Jin et al., 2022).

Anesthetic management in severe scoliosis surgery requires a comprehensive and multidisciplinary approach because the primary goal of anesthesia is not only to maintain an adequate depth of anesthesia but also to preserve tissue perfusion, ensure hemodynamic stability, and facilitate optimal postoperative neurological assessment. The use of high

concentrations of inhaled anesthetics and large doses of opioids may contribute to hypotension, delayed extubation, and an increased risk of postoperative respiratory complications (Joshi 2021; Misal et al. 2016). Therefore, various balanced anesthesia strategies have been developed to reduce reliance on conventional anesthetic agents while maintaining physiological stability during surgery. One increasingly utilized agent is dexmedetomidine, a selective α2-adrenergic agonist with sedative, analgesic, sympatholytic, and opioid-sparing effects without causing clinically significant respiratory depression (Hudec et al., 2023; Wishart & Kivlehan, 2021).

Dexmedetomidine has been shown to help maintain intraoperative hemodynamic stability by attenuating sympathetic responses to surgical stress, reducing the requirement for inhaled anesthetics, and supporting blood pressure control through decreased hypertensive responses and tachycardia during surgery. Furthermore, dexmedetomidine use has been associated with improved neurological recovery, reduced requirements for postoperative mechanical ventilation, and the potential for early extubation following scoliosis surgery. In settings with limited intraoperative neuromonitoring availability, an anesthetic approach that maintains spinal cord perfusion and minimizes hemodynamic fluctuations is critical to reducing the risk of neurological complications (Wishart & Kivlehan, 2021; Weissmann et al., 2020).

This case report aimed to highlight the anesthetic challenges associated with severe scoliosis surgery and describe the role of dexmedetomidine-based anesthesia in maintaining hemodynamic stability and supporting perioperative recovery. This case demonstrated that a dexmedetomidine-based balanced anesthesia regimen provided stable intraoperative hemodynamics during prolonged spinal surgery in the prone position, potentially reducing vasopressor requirements and the risk of spinal cord hypoperfusion (Kundra et al. 2019; Pacheco et al. 2024; Stephens et al. 2015). This approach also facilitated early extubation without respiratory depression, which was particularly beneficial in patients with restrictive pulmonary impairment. Additionally, dexmedetomidine as part of a multimodal analgesia strategy contributed to effective postoperative pain control with reduced opioid requirements, supporting faster recovery and shorter intensive care unit (ICU) stays. The report further emphasized the importance of integrating dexmedetomidine with blood conservation strategies, including cell salvage autotransfusion and tranexamic acid administration, to optimize perioperative outcomes in high-risk scoliosis surgery.

METHOD

This case report was prepared using a descriptive-analytical approach involving a patient who underwent spinal stabilization surgery for severe adult idiopathic scoliosis, Lenke type 3, with a Cobb angle of 83° at Prof. Dr. R.D. Kandou Manado Hospital in 2024. Data were obtained from the patient's medical records, including medical history, physical examination findings, supporting examinations (laboratory tests, radiological assessments, electrocardiography, echocardiography, and pulmonary function tests), intraoperative anesthesia management records, and postoperative clinical documentation from the intensive care unit (ICU) and inpatient ward.

Data collection was performed retrospectively by reviewing the patient's perioperative course, including preanesthetic evaluation, anesthesia induction and maintenance, intraoperative hemodynamic monitoring, postoperative pain management, and neurological outcomes. The analyzed clinical parameters included hemodynamic stability (blood pressure,

mean arterial pressure, heart rate, and oxygen saturation), early extubation success, estimated blood loss, transfusion requirements, and neurological outcomes.

The findings were analyzed descriptively by comparing the clinical course with relevant literature on anesthesia management in severe scoliosis surgery, particularly regarding the use of dexmedetomidine as a component of a balanced anesthesia regimen. This case report received approval from the patient and family, and patient confidentiality was maintained in accordance with medical ethics principles.

RESULTS AND DISCUSSION

Case Reports

Disease History

A 20-year-old woman is planned to undergo a preoperative anesthesia evaluation for posterior spinal stabilization for indications of Adult Idiopathic Scoliosis type Lenke 3 with a Cobb angle of 83°. The history of S-shaped spinal deformity has been known since birth and appears to be progressively more progressive since about eight years before hospitalization. At first, patients did not experience meaningful complaints, but in the past year they began to complain about lost body stiffness, pain when sitting for a long time, and shortness of breath, especially during activities. The patient had no history of other significant systemic diseases, had never undergone anesthesia before, and had no family history of similar abnormalities. A history of allergies to chickens and eggs manifested as pruritus, while a history of smoking and alcohol consumption was denied.

On physical examination, it was found that the body weighed 43 kg and the height was 150 cm. The general condition of the patient is quite good with the awareness of the compos mentis. Vital signs showed blood pressure of 128/89 mmHg, heart rate of 105 times per minute, breathing rate of 20 times per minute, body temperature of 36.5°C, and oxygen saturation of 99% in room air. Airway examination showed class II Mallampati with a 3-3-2 rating within normal limits with no predictive signs of difficult intubation. Examination of the cardiovascular system showed a regular heart sound without murmurs or gallops, while pulmonary auscultation showed a sound of vesicular breathing without rumbling or wheezing. Examination of the abdomen and extremities showed no significant abnormalities.

Supporting Examinations

Preoperative laboratory examination on March 1, 2024 showed leukocytes of 10,720/µL, hemoglobin of 11.7 g/dL, hematocrit of 35.8%, and platelets of 315,000/µL. Coagulation profiles were obtained at PT 13.9/14.0 seconds, INR 1.03/1.04, and APTT 32.7/29.8 seconds. Blood chemistry examination showed blood glucose 83 mg/dL, SGOT 20 U/L, SGPT 10 U/L, urea 17 mg/dL, creatinine 0.5 mg/dL, sodium 139 mmol/L, potassium 4.0 mmol/L, and chloride 93 mmol/L.

Thoracic photos show dextroconvex thoracic scoliosis without active lung abnormalities. Electrocardiography examination showed sinus tachycardia 107 times per minute with T-wave inversion, while follow-up evaluation showed sinus rhythm 86 times per minute with nonspecific T inversion considered to be normal variation. The Revised Cardiac Risk Index (RCRI/Lee score) assessment shows a low risk with an estimated major cardiovascular event of 0.9%. An echocardiography examination on December 19, 2023 showed good heart function with an ejection fraction of 62%, with no significant structural abnormalities, only mild valve

regurgitation was found. The function of the right ventricle is also good with a TAPSE of 2.2 cm and a low right atrial pressure of about 3 mmHg. The risk of major cardiovascular events in 30 days is estimated to be very low, which is about 0.4%.

Figure 1. Patient's thorax X-ray

Source: Authors' documentation based on patient's medical records

Pulmonary function examination on December 20, 2023 showed a restrictive pattern in accordance with thoracic deformity due to scoliosis. Based on the ARISCAT score, the patient obtained a score of 23 which is in the low risk category for postoperative pulmonary complications, with an estimated risk of around 1.6%. Based on the overall preoperative evaluation, the patient was classified as an American Society of Anesthesiologists (ASA) Physical Status II.

Anesthesia Management

Pre-anesthesia preparation is carried out through informed consent, preoperative fasting, preparation of blood products in the form of packed red cells, fresh frozen plasma, and platelets, as well as postoperative care planning in the intensive care unit (ICU). In the operating room, anesthesia machines, Macintosh direct laryngoscopes, video laryngoscopes, endotracheal tubes are non-kinking size 6.5–7.5, syringe pumps, fluid warmers, blower warmers, and cell saver autotransfusions. Intraoperative monitoring includes three-stage electrocardiography, noninvasive blood pressure, peripheral oxygen saturation, and capnography.

Patients were positioned supinated with stable initial hemodynamic conditions, namely blood pressure of 131/101 mmHg, mean arterial pressure (MAP) of 111 mmHg, heart rate of 92–93 times per minute, and oxygen saturation of 99–100%. Premediation was given in the form of ranitidine 50 mg, methylprednisolone 62.5 mg, and intravenous tranexamic acid 1000 mg. Anesthesia induction was performed using fentanyl 3 mcg/kgBB, propofol 2 mg/kgBB by titration, rocuronium 1 mg/kgBB, and dexmedetomidine as part of a balanced anesthesia regimen. Intubation was successfully carried out using a 3-degree Macintosh direct laryngoscope with Cormack-Lehane classification degree I and a 7.5-inch non-kinking endotracheal tube with a depth of 19 cm. Mechanical ventilation is regulated using pressure-controlled ventilation with volume guarantee (PCV-VG) mode with a tidal volume of 340 mL, respiratory rate of 12 times per minute, PEEP of 5 cmH_2O, and FiO_2 of 40%. Next, a central venous catheter is installed on the right internal jugular vein before the patient is positioned prone with pressure point protection and a neutral head-neck position.

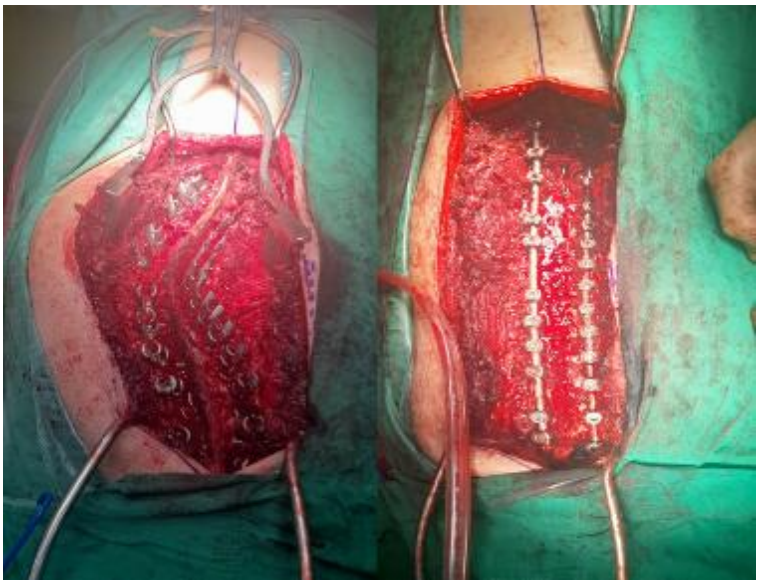

Figure 2. Intraoperative spine photo

Source: Authors' documentation based on patient's medical records

Anesthesia maintenance was conducted using a combination of dexmedetomidine 0.2–0.5 mcg/kgBB/hour, propofol 0.5–3 mg/kgBB/hour, desflurane 6–7 vol% (±1 minimum alveolar concentration/MAC), and additional rocuronium 0.2 mg/kgBB every 30–45 minutes. Rumatan fluid is given using Ringer Lactate. The surgical procedure lasted for approximately 8 hours with an estimated intraoperative bleeding of approximately 1200 mL or approximately 43% of the patient's estimated blood volume (~2800 mL). During surgery, the patient received 1000 mL of crystalloid fluid, 500 mL of colloid, 460 mL of packed red cell transfusion, and 400 mL of autotransfusion using a cell saver. Intraoperative urine production was recorded at 600 mL or around 1.66–1.7 mL/kgBB/hour.

During the intraoperative period, the hemodynamic condition was relatively stable with systolic blood pressure ranging from 80–100 mmHg, MAP maintained between 65–87 mmHg, heart rate 50–90 times per minute, oxygen saturation 99–100%, and $EtCO_2$ 30–38 mmHg. No episodes of severe hypotension or significant tissue perfusion disorders were found. Since intraoperative neuromonitoring facilities are not available, the integrity of the spinal cord is monitored through strict hemodynamic control, avoidance of over-deep anesthesia, and immediate postoperative neurological evaluation.

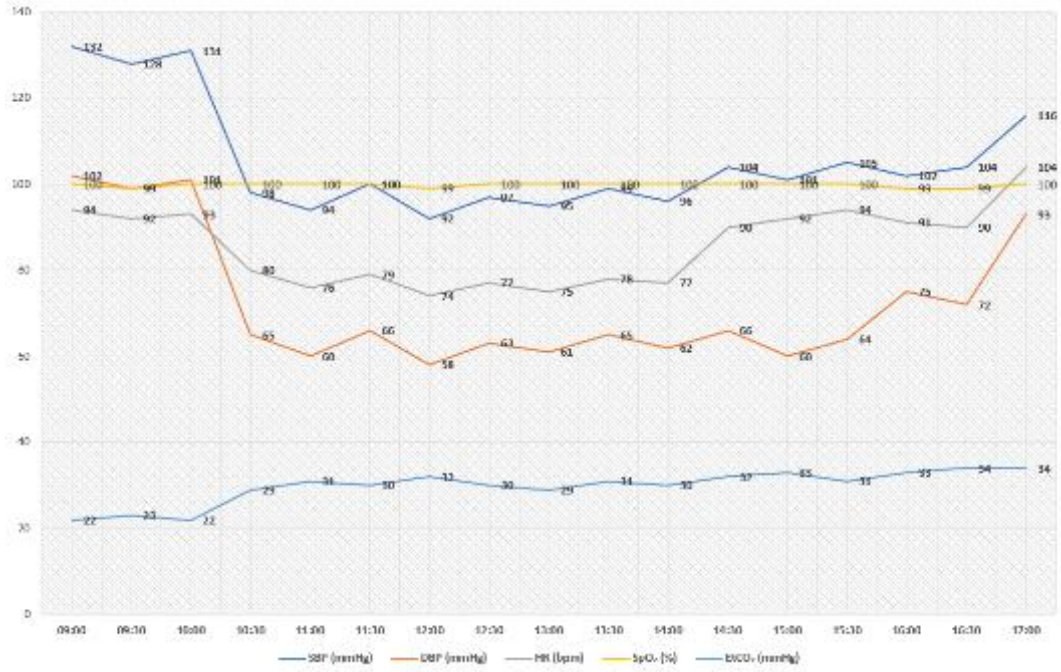

Figure 3. Hemodynamic monitoring during surgery

Source: Authors' analysis based on intraoperative monitoring data from patient's medical records

Postoperative Management

After the procedure is completed, the patient is repositioned supination and all anesthetic agents are phased out except for dexmedetomidine 0.2 mcg/kgBB/hour. Immediate postoperative evaluation showed adequate spontaneous ventilation, full consciousness with the Glasgow Coma Scale (GCS) 15, good protective reflexes, and stable hemodynamic conditions with blood pressure of 103/63 mmHg, heart rate of 92 beats per minute, and oxygen saturation of 99%. The patient was successfully extubated in the operating room and subsequently transferred to the ICU for further observation.

During treatment in the ICU, the patient's condition remained stable with a patented airway, breathing rate of 18 times per minute, oxygen saturation of 98% using a nasal cannula of 2–3 L/min, and a MAP of about 85 mmHg. Postoperative analgesia was administered using 1 gram of intravenous paracetamol every 8 hours and dexmedetomidine 0.2 mcg/kgBB/hour for 12 hours. Additional therapy included 500 mg of tranexamic acid every 8 hours for 24 hours and ondansetron 4 mg every 12 hours. Postoperative laboratory examination showed leukocytosis of 33,850/µL with other parameters still within adequate limits. Neurological evaluation did not show any motor or sensory deficits. Pain scores based on the Numeric Rating Scale (NRS) range from 2–3/10. As the clinical condition was stable with no respiratory or neurological complications, the patient was then transferred to the inpatient room for follow-up treatment.

Figure 4. (A,B) Postoperative patients: 24 hours in the ICU and (C) 72 hours postoperatively in the ward

Source: Authors' documentation based on patient's medical records

Severe adult idiopathic scoliosis with a Cobb angle of more than 80° is closely related to impaired respiratory mechanics due to decreased chest wall compliance and the formation of restrictive ventilation patterns (Jin et al., 2022; Hatef et al., 2022). Degrees of deformity are directly proportional to the decrease in vital capacity and total lung capacity, thereby increasing the risk of ventilation-perfusion disorders and perioperative respiratory complications (Jin et al., 2022; Levine et al., 2022; Zhou et al., 2022). In this case, the findings of pulmonary function tests showing a restrictive pattern were consistent with the basis of the pathophysiology, although clinically oxygen saturation was still within normal limits prior to surgery.

From a cardiovascular aspect, severe thoracic deformities have the potential to lead to increased pulmonary vascular resistance and right ventricular load, although clinical manifestations are highly dependent on the degree and duration of the disorder (Weissmann et al., 2020; Reysner et al., 2025; Jiang et al., 2023). In these patients, relatively good cardiac function based on echocardiography suggests that not all severe scoliosis is accompanied by significant cardiovascular impairment, so the individualized evaluation approach remains a key principle in anesthesia planning.

In the management of intraoperative anesthesia, the use of a combination of dexmedetomidine, propofol, and desflurane in this case provides a significant advantage to hemodynamic stability. Dexmedetomidine as a selective α2-adrenergic agonist has a sympatholytic effect that is able to decrease the stress response to surgery, thereby reducing fluctuations in blood pressure and heart rate (Weerink et al., 2017; Mahmoud et al., 2020; Cui et al., 2023). In addition, the sedative and analgesic effects of dexmedetomidine allow for a decrease in the need for other anesthetic agents such as propofol and inhaled anesthetics, thereby contributing to better hemodynamic stability during lengthy procedures such as spinal surgery (Weerink et al., 2017; Mahmoud et al., 2020).

The combination with propofol provides a fast and easily titrated hypnotic effect, while desflurane as a volatile agent with a low solubility coefficient allows for rapid control of the

depth of anesthesia as well as faster recovery. The synergy of these three agents allows the achievement of adequate anesthesia with minimal cardiovascular depressants. In this case, this is reflected in intraoperative hemodynamic stability with a MAP of 65–87 mmHg even though the patient is in a prone position and undergoing a long-duration procedure. This condition is in line with the literature that states that the balanced anesthesia technique with the addition of dexmedetomidine can improve hemodynamic stability and reduce the need for intraoperative vasopressors (Weerink et al., 2017; Mahmoud et al., 2020; Cui et al., 2023).

Another advantage of using this combination is its ability to support early extubation in the operating room. Dexmedetomidine is known to cause significant respiratory depression, thus allowing for a safer transition from mechanical ventilation to spontaneous ventilation (Mahmoud et al., 2020; Zhang et al., 2025). In addition, the use of desflurane, which has rapid elimination, helps accelerate the recovery of consciousness. In this case, the patient was successfully extubated in the operating room with stable hemodynamic conditions and adequate protective reflexes, demonstrating the success of the anesthesia strategy in supporting fast-track recovery in major spine surgery.

In the postoperative pain management aspect, the continuous use of dexmedetomidine plays an important role as part of a multimodal analgesia strategy. Dexmedetomidine has an analgesic effect by modulating pain pathways in the central nervous system and decreasing the release of nociceptive neurotransmitters (Mahmoud et al., 2020; Zhang et al., 2022). Continuous use at low doses (0.2 mcg/kgBB/hour) in this case provides adequate pain control with an NRS score of 2–3 without causing respiratory depression or excessive sedation. This is in line with recent evidence showing that postoperative dexmedetomidine infusions can reduce opioid needs, reduce the incidence of nausea and vomiting, and accelerate recovery of respiratory function (Zhang et al., 2025; Zhang et al., 2022).

In addition, the maintained postoperative hemodynamic stability also suggests that dexmedetomidine acts not only as an analgesic, but also as an agent that helps maintain autonomic balance after major surgery (Zhang et al., 2025; Zhang et al., 2022). This approach is particularly relevant in patients at risk of respiratory disorders, such as in scoliosis with a restrictive pulmonary pattern.

Blood loss management is a crucial aspect of major spine surgery. In this case, the use of cell saver autotransfusion makes an important contribution to blood conservation strategies. Autotransfusion allows the collection, processing, and refusion of the patient's own blood during surgery, thereby reducing the need for allogeneic transfusions (Moore & Forsthoefel, 2024; Beeton et al., 2023). This is important because allogeneic blood transfusions are associated with the risk of transfusion reactions, infections, and immunological disorders.

In this case, with an estimated bleeding of 1200 ml, the use of a cell saver resulted in a refusion of 400 ml, which contributed to maintaining hemodynamic stability and reducing the need for additional PRC transfusions. The literature suggests that the use of cell salvage in spinal surgery can significantly lower the need for allogeneic transfusions and improve the efficiency of intraoperative blood management (Moore & Forsthoefel, 2024; Beeton et al., 2023).

In addition, the combination of the use of tranexamic acid and autotransfusion techniques reflects the comprehensive approach to blood management that is currently recommended in high-risk surgeries. This strategy not only improves patient safety, but also contributes to better clinical outcomes. This case shows that the anesthesia approach with the

use of a combination of dexmedetomidine, propofol, and desflurane, supported by a continuous dexmedetomidine-based analgesia strategy and the application of autotransfusion cell saver, is able to provide optimal hemodynamic stability, support early extubation, and optimize bleeding management. This approach is in line with the concept of enhanced recovery after surgery (ERAS) in spinal surgery, which emphasizes physiological stability, reduction of complications, and acceleration of patient recovery (Zhang et al., 2025; Zhang et al., 2022; Moore & Forsthoefel, 2024; Beeton et al., 2023).

CONCLUSION

The management of perioperative anesthesia in patients with severe adult idiopathic scoliosis requires a comprehensive and individualized approach, particularly given the risks of respiratory compromise, hemodynamic instability, and substantial blood loss during surgery. In this case, the combination of dexmedetomidine, propofol, and desflurane-based anesthesia provided optimal hemodynamic stability during prolonged surgery in the prone position while supporting successful early extubation and favorable postoperative recovery. Continuous dexmedetomidine administration also contributed to adequate pain control without respiratory depression, while blood management strategies involving cell salvage autotransfusion were effective in reducing the need for allogeneic blood transfusion. Overall, this approach aligns with the principles of enhanced recovery after surgery (ERAS) and suggests that appropriate anesthetic planning may improve clinical outcomes in high-risk adult scoliosis surgery.

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