JNI Jurnal Neuroanestesi Indonesia **Case Report**

Spinal Cord Protection during Stabilization of Severe Thoraco–Lumbal Scoliosis with 90 Degree Cobb Angle

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Abstract

Introduction: Scoliosis correction surgery requires careful anesthetic management because of potential perioperative complications, including excessive bleeding, hypothermia, complications related to patient positioning, and the need for spinal cord protection.

Case: A 23-year-old woman weighing 32 kg with a height of 140 cm presented with a chief complaint of spinal deformity that had been present since childhood. On physical examination, her blood pressure was 119/79 mmHg, pulse rate was 112 beats/minute, respiratory rate was 20 breaths/minute, and SpO2 was 97% on room air and a Cobb angle of 90°. Anesthesia induction using propofol 70 mg, while tracheal intubation was facilitated with atracurium 0.5 mg/kg. Analgesia with fentanyl 2 µg/kg, and anesthesia with O2/air, sevoflurane, and atracurium infusion at 0.5 mg/kg/hour. Intravenous tranexamic acid 500 mg to minimize intraoperative bleeding. Intraoperative monitoring consisted of standard monitoring modalities, without the use of spinal cord monitoring. The surgical procedure lasted 4 hours and 20 minutes, with the patient positioned prone throughout the operation.

Discussion: The most important principle of anesthetic management in spinal surgery is a comprehensive and meticulous approach to patient positioning, ensuring safe alignment while maintaining adequate spinal cord perfusion pressure. Spinal cord protection was provided with methylprednisolone, hemodynamic stable, normothermia, good patient position.

Conclusion: Spinal cord protection did with avoid excessive bleeding, hypothermia, complications related to patient positioning, and maintaining adequate spinal cord perfusion pressure.

Keywords: Anesthesia management, thoracolumbal scoliosis, cobb angle, spinal cord protection

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Introduction

Scoliosis can be classified into several types, including congenital, neuromuscular, and idiopathic scoliosis. Neuromuscular scoliosis may arise from conditions such as cerebral palsy, spinal cord trauma, spinal muscular atrophy, spina bifida, and muscular dystrophy. Among these types, idiopathic scoliosis is the most common, accounting for approximately 65–80% of cases. Progressive spinal curvature may lead to pain as well as dysfunction of multiple organ systems. A comprehensive preoperative evaluation is essential before surgical correction to assess neurological status and determine the extent of associated organ dysfunction. Detailed intraoperative and postoperative management planning should also be considered carefully because of patient comorbidities, the possible need for intraoperative spinal cord monitoring, the risk of significant blood loss, and the potential for postoperative complications.[1-3]

Neuroprotection in spinal cord injury (SCI) refers to strategies aimed at reducing damage

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that occurs following injury or during surgical procedures performed before or during surgery. The primary objective is to improve functional outcomes by limiting secondary injury processes that develop within minutes, hours, and days after injury or surgery. Anesthetic challenges during scoliosis surgery include spinal cord trauma, massive bleeding, hypothermia, and peripheral nerve injury. Neuroprotection may be achieved through neuropharmacological interventions using agents such as methylprednisolone, minocycline, and glibenclamide. One example is methylprednisolone, which exerts neuroprotective and anti-inflammatory effects at the cellular level.[4]

Spinal cord protection during spine surgery is focused on minimizing the risk of spinal cord injury during procedures that may compromise spinal cord blood flow or increase pressure on the spinal cord. Protective strategies include hypothermia, maintenance of adequate blood pressure to ensure sufficient spinal cord perfusion, minimization of ischemic injury, avoidance of hypotension and anemia, as well as intraoperative spinal cord function monitoring combined with pharmacological interventions.[4] Surgical intervention is generally recommended when the Cobb angle exceeds 50° in the thoracic spine or 40° in the lumbar spine. The primary goals of surgery are to prevent further progression of the deformity, achieve spinal correction, and avoid subsequent respiratory and cardiovascular complications. Without appropriate treatment, idiopathic scoliosis may progress rapidly and can become fatal during the fourth or fifth decade of life due to pulmonary hypertension, right ventricular failure, or respiratory failure.[1,3,5]

The Cobb angle is a radiographic measurement used to determine the severity of scoliosis and guide therapeutic planning. It is measured on spinal X-rays by drawing lines along the superior and inferior endplates of the vertebrae with the greatest lateral inclination, followed by calculating the angle formed by the intersection of these lines. The Cobb angle remains the standard method for scoliosis assessment and is commonly considered the first objective indicator of disease severity. A Cobb angle ≥10° is diagnostic of scoliosis. Severity is generally classified as follows: 10–24° indicates mild scoliosis, 25–50° indicates moderate scoliosis, and >50° indicates severe scoliosis. Mild scoliosis is therefore defined by a Cobb angle ranging from 10° to 20°, while moderate scoliosis ranges from 20° to 40°. A Cobb angle >40° indicates severe scoliosis, and surgical intervention and/or bracing are usually indicated when the Cobb angle is ≥40°. Observation is generally recommended for patients with a Cobb angle <20°, although referral for physical therapy may still be considered appropriate.[6]

Scoliosis correction surgery is typically conducted with the patient in the prone position to optimize surgical access and visualization of the spinal structures. The procedure is frequently associated with prolonged operative times and presents significant perioperative challenges, including considerable blood loss, hypothermia, and postoperative pain. To preserve the integrity of intraoperative neuromonitoring signals, total intravenous anesthesia administered without neuromuscular blocking agents is commonly employed.[3]

Case

History

The patient was a 23-year-old woman weighing 32 kg with a height of 140 cm who presented with the main complaint of spinal deformity that had been present since childhood. She reported that her body posture had progressively become more tilted over time. The patient had no history of comorbid diseases such as hypertension, diabetes mellitus, or significant pulmonary disorders. However, she frequently experienced easy fatigability and shortness of breath during light to moderate physical activity. Despite these complaints, there was no history of sleep-related breathing disorders, such as sleep apnea, or nocturnal dyspnea causing awakening during the night. The patient also denied chest pain, palpitations, or any previous episodes of syncope. Further anamnesis revealed that the deformity had first been noticed at approximately 7 years of age and had progressively worsened with increasing age. The patient's parents had previously sought medical consultation during her childhood; however, no significant intervention was performed other than irregular physical therapy sessions. Family history did not reveal similar musculoskeletal abnormalities, and the patient was the first of two siblings. She was considered undernourished, which likely contributed to her low body weight. Past medical history revealed no known drug allergies, previous surgical procedures, or prior hospitalizations. In addition, the patient denied any history of long-term medication use or hormonal therapy. Her menstrual history was normal, without complaints of severe dysmenorrhea. The patient also denied smoking and alcohol consumption.

Physical Test

Vital sign examination revealed a blood pressure of 119/79 mmHg, pulse rate of 112 beats per minute, respiratory rate of 20 breaths per minute, and SpO_2 of 97% on room air. Inspection of the chest demonstrated a marked asymmetrical thoracic deformity, characterized by prominence of the ribs on the right side and depression on the left side. Chest wall movement appeared limited; however, there was no evidence of accessory respiratory muscle use. Pulmonary auscultation revealed no rhonchi or wheezing, while cardiac examination showed normal heart sounds without murmurs. Neurological examination demonstrated normal reflexes with no motor or sensory deficits. The thoracic radiograph shown below demonstrated severe scoliosis.

Figure 1. Photo Scoliosis and Thorax Photo

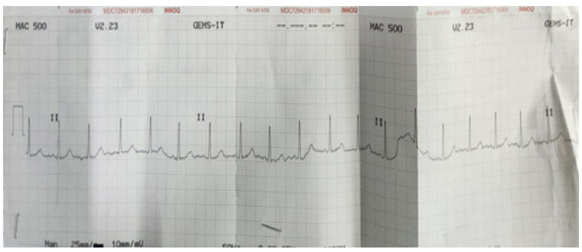


Figure 2. ECG

Laboratorium Test
Table 1. Blood test

Test	Result	Units	Normal Value
Hemoglobine	14.4	g/dL	11.7-15.5
Erythrocyte	5.00	mil/µL	4.10-5.10
Hematocrit	43	%	35-47
Blood Index			
MCV	85	Fl	80.0-97.0
MCH	28.8	Pg	27.0-31.0
MCHC	33.9	g/dL	32.0-35.0
Leukocyte	7.67	Th/mL	3.60-11.0
Thrombocyte	241	Th/mL	150-450
MPV	9,7	fL	7.4-10.4
Bleeding time	2.00	menit	1-3
Clotting time	10.00	menit	5-15
Blood group (ABO-Rh)	B/Rh+		
Blood sugar	110	mg/dL	55-180
SGOT (AST)	19	u/L	32
SGPT (ALT)	8	u/L	<31
Ureum	13	mg/dL	10-50
Creatinine	0.55	mg/dL	0.51-0.95

Anesthetic Management

Anesthesia was induced with propofol 70 mg, fentanyl 2 µg/kgBW, and muscle relaxation was achieved using atracurium 0.5 mg/kgBW. Ventilation was maintained with 100% oxygen and sevoflurane. Tracheal intubation was performed using a non-kinking endotracheal tube size 6.5. The patiet was then positioned prone for the surgical procedure. Anesthesia maintenance consisted of sevoflurane with O_2/air and continuous atracurium infusion at 0.5 mg/kgBW/hour.Spinal cord protection was achieved using basic neuroprotective measures, including maintenance of normoxia, normocapnia, normotension, normovolemia, and permissive hypothermia.

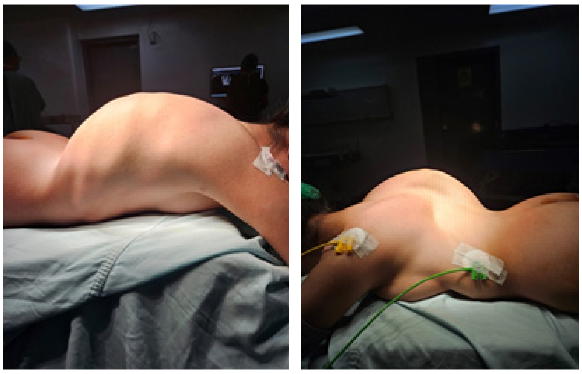
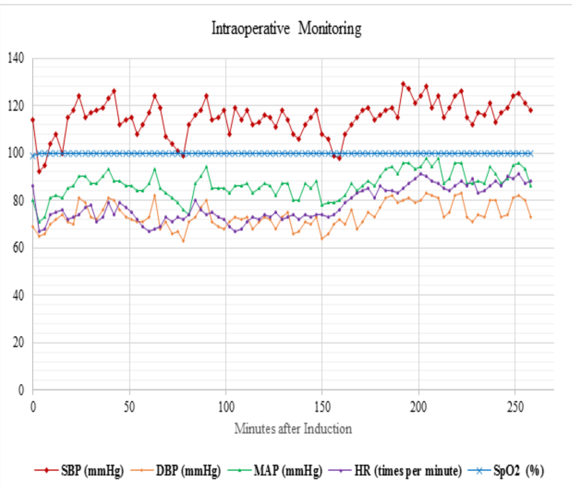


Figure 3. Patient in Prone Position

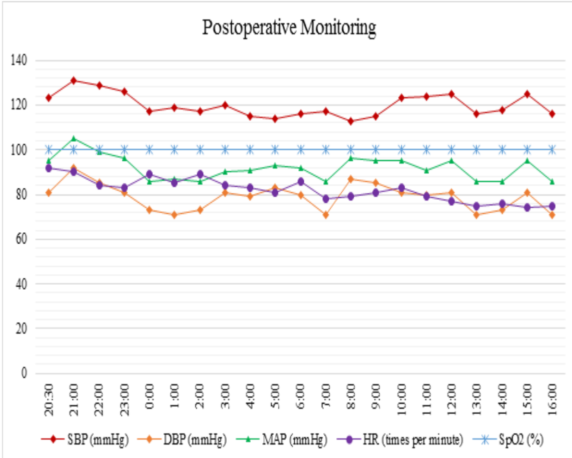
Pharmacological neuroprotection was provided with methylprednisolone administration, while intravenous tranexamic acid 500 mg was given to minimize intraoperative bleeding.

Intraoperative Monitoring.
Operating length: 4 hours 20 minutes, bleeding: 400 cc, fluid: RL 1000 mL



Postoperative Care

Monitoring in the ICU
In the Intensive Care Unit (ICU), the patient underwent continuous monitoring of neurological status and vital signs. The patient remained fully conscious, well oriented, and hemodynamically stable, requiring only minimal respiratory support with oxygen administration via nasal cannula at 3 L/minute. Pharmacological management included intravenous ceftriaxone 2 g every 24 hours, along with tranexamic acid 500 mg every 8 hours and vitamin K 10 mg



every 8 hours to maintain hemostasis. As the patient's condition remained stable throughout the 24-hour observation period without any adverse events, she was subsequently transferred from the ICU to the general inpatient ward.

Discussion

Scoliosis can be categorized into idiopathic, congenital, neuromuscular, and degenerative forms. Surgical management is typically reserved for patients with severe deformities, particularly those exhibiting symptoms such as cardiorespiratory impairment or neurological dysfunction. Corrective surgery for scoliosis is generally performed with the patient in the prone position to facilitate optimal surgical access. However, the procedure is often lengthy and carries significant perioperative risks, including substantial blood loss, hypothermia, and pronounced postoperative pain.[3,7] Total intravenous anesthesia without the use of neuromuscular blocking agents is frequently employed during scoliosis surgery to preserve the reliability of intraoperative neuromonitoring.

A loss of neuromonitoring signals is regarded as a highly sensitive and specific marker of spinal cord injury, necessitating prompt evaluation and intervention. Although the wake-up test remains the gold standard for assessing spinal cord integrity, its application is limited in pediatric and uncooperative patients, resulting in less frequent use in contemporary practice. Patients with neuromuscular scoliosis often have concomitant cardiorespiratory and neuromuscular disorders, which increase their susceptibility to postoperative complications. Enhanced Recovery After Surgery (ERAS) protocols incorporate a multidisciplinary perioperative strategy aimed at improving surgical outcomes through measures such as preemptive and multimodal analgesia, intraoperative tranexamic acid administration, early mobilization, optimization of nutritional status, and assessment of psychological well-being.[7] Anesthetic management for spinal surgery follows the principles of ABCDE neuroanesthesia, which include maintaining a patent airway at all times, controlled ventilation with normocapnia targets, preservation of normotension, maintenance of normal body temperature, and administration of anesthetic agents with spinal cord protective properties. Scoliosis correction surgery is associated with the potential for severe intraoperative blood loss and a high incidence of anesthetic as well as surgical complications.[7]

Pre-operative Assessment

Preoperative evaluation should encompass a comprehensive anesthetic history, with particular attention to any family history of anesthesia-related complications in pediatric patients. Essential clinical information includes the extent and anatomical location of spinal involvement, Cobb angle measurements, presenting symptoms, and the severity of functional limitations. A thorough assessment of associated comorbidities, especially cardiorespiratory and neuromuscular conditions, as well as manifestations of heart failure and exercise capacity, is crucial. Additionally, the evaluation should address the presence of ongoing symptoms, the patient's level of independence in activities of daily living, and overall nutritional status.[8,9]

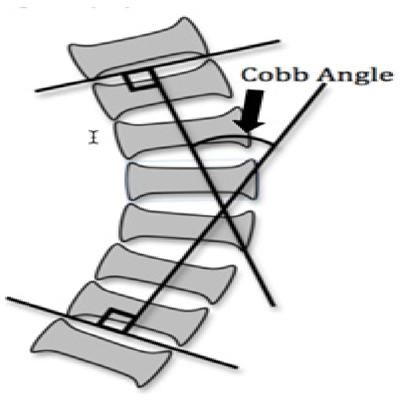


Figure 4. Assessment of Cobb angle for the degree of spinal curvature in scoliosis.[2]

Intraoperative Monitoring

Intraoperative monitoring of spinal medulla function considered standard in spine surgery is [7,10]:

(1) The wake up test
(2) Somatosensory evoked potentials (SSEP)
(3) Motor evoked potentials (MEPs)
(4) Dermatomal responses

Standard intraoperative monitoring during general anesthesia comprises pulse oximetry, electrocardiography (ECG), noninvasive blood pressure measurement, temperature monitoring, and urine output assessment. Depending on the patient's clinical status and the complexity of the procedure, additional monitoring techniques, including invasive arterial blood pressure monitoring, central venous pressure measurement, intraoperative neuromonitoring (IONM), and depth of anesthesia monitoring, may be indicated. Prolonged surgical procedures involving extensive exposure of body surface area increase the risk of perioperative hypothermia, which can negatively impact neuromonitoring accuracy, coagulation function, and postoperative recovery.[7,10]

Components of intraoperative neuromonitoring include motor evoked potentials (MEP), somatosensory evoked potentials (SSEP), electromyography (EMG), and the wake-up test. Neuromonitoring plays an important role in maintaining spinal cord integrity during surgery. In situations where intraoperative neuromonitoring signals become absent or unreliable, a wake-up test may be utilized to verify the integrity of spinal cord function. Surgical maneuvers involving spinal instrumentation, deformity correction, or traction can place the spinal cord at risk of ischemic or mechanical injury.[7] With regard to intraoperative neuromonitoring, volatile anesthetic agents may influence both somatosensory evoked potential (SSEP) and motor evoked potential (MEP) monitoring.

SSEP monitoring involves assessment of signal transmission that is typically initiated by stimulation of a peripheral nerve, generating responses within the somatosensory cortex. Hemodynamic disturbances, particularly hypotension, may alter both SSEP and MEP signals. In comparison with sevoflurane, propofol exerts a greater suppressive effect on SSEP signals, whereas neuromuscular blocking agents generally interfere minimally with MEP monitoring.[2]

Prone Position

Intraoperative airway management in the prone position is essential to ensure surgical safety and efficacy, as improper positioning can lead to severe complications. These include increased intraoperative bleeding, peripheral nerve compression, and postoperative blindness.[9,11]

Management of Hemodynamics

Intraoperative bleeding and surgical positioning significantly influence hemodynamic management during spinal surgery. The mandatory prone position can decrease cardiac output, elevate intra-abdominal pressure—leading to inferior vena cava obstruction—and exacerbate pulmonary complications.[1,9,11] Consequently, these physiological alterations affect heart-lung interactions and profoundly impact positive pressure ventilation. Safe patient positioning requires close coordination with the surgical team to mitigate avoidable injuries. Furthermore, propofol-based total intravenous anesthesia (TIVA) is preferred over inhalational agents when intraoperative spinal cord monitoring is utilized, as inhalational anesthetics compromise monitoring reliability. Specifically, isoflurane causes dose-dependent reductions in recorded somatosensory and motor evoked potentials, whereas propofol preserves these signals.[1,9]

Haemorrhage

Scoliosis correction surgery often requires a long midline incision with multilevel vertebral bone removal, resulting in prolonged operative duration. In the prone position, increased intra-abdominal pressure may lead to engorgement of the vertebral venous plexus, thereby contributing to significant intraoperative blood loss. Unanticipated hemorrhage may reach up to 50% of the patient's total blood volume; therefore, careful planning for major blood loss is essential throughout the procedure. One blood conservation strategy is intraoperative acute normovolemic hemodilution, which is occasionally used in adult patients. In this technique, 2–3 units of autologous blood are withdrawn at the beginning of surgery and replaced with an equal volume of colloid solution or approximately three times the volume of crystalloid solution, with the aim of reducing intraoperative red blood cell loss during bleeding.[1]

To reduce intraoperative blood loss during extensive procedures such as scoliosis correction, controlled (induced) hypotension may be applied as a pharmacological technique, targeting a systolic blood pressure around 80 mmHg. This approach has been adopted in some centers with the aim of minimizing bleeding by lowering perfusion pressure. However, reduced perfusion may also compromise oxygen delivery to vital organs, and the technique is associated with potential complications, including postoperative visual loss and anterior spinal cord ischemia. These complications may result in severe neurological outcomes such as postoperative paralysis; therefore, induced hypotension must be used cautiously, particularly in patients at increased risk of hypoperfusion to essential organs such as the kidneys, brain, heart, and eyes.[1] In the present case, systolic blood pressure was maintained within the range of 90–120 mmHg. Intraoperative blood loss was 400 mL in a patient weighing 32 kg, with an estimated blood volume of approximately 2,240 mL, corresponding to less than 20% of total blood volume. With the use of hemostatic agents as well as crystalloid and colloid administration, no blood transfusion was required.

Complication

Most surgical procedures carry a risk of complications; however, when surgery involves the spine and spinal cord, these risks may become more severe. Uncontrolled bleeding, for example, may lead to the formation of an epidural hematoma, which can cause spinal cord compression and potentially result in irreversible central nervous system injury.[8] In certain forms of non-idiopathic scoliosis, cardiac complications are commonly encountered. Postoperative pain following scoliosis correction is generally significant rather than minimal and therefore requires appropriate perioperative analgesic management. Surgical correction is typically indicated when the Cobb angle exceeds approximately 40–45 degrees. Continuous temperature monitoring is recommended during scoliosis surgery because of the prolonged operative time and extensive surgical exposure, both of which increase the risk of perioperative hypothermia. Although uncommon, central retinal artery occlusion represents a serious complication that may arise from sustained direct ocular compression during the procedure.[1]

Post-Surgical Care

Close monitoring in the post-anesthesia care unit (PACU) is crucial for the early identification and management of postoperative complications, including surgical site hemorrhage, hemodynamic instability, respiratory compromise, spinal cord injury, and dural tears. In patients requiring postoperative mechanical ventilation, a wire-reinforced endotracheal tube should be exchanged for a conventional endotracheal tube to minimize the risk of airway obstruction, as deformation resulting from patient biting may compromise the lumen of the reinforced tube.[2,7] Postoperative complications may include persistent hypotension, bleeding, urinary retention, nerve root injury, and cauda equina syndrome, which can manifest as urinary or fecal incontinence, perineal sensory loss, and lower limb motor weakness. Additional risks include thromboembolic events and airway complications.

One of the most critical complications is post-extubation airway obstruction, which can be life-threatening, particularly in patients who have undergone spinal fusion and are immobilized with stabilization devices. Airway compromise may result from hematoma formation or neurological injury.[2,7,12] Scoliosis and other spine surgeries are often associated with severe postoperative pain; therefore, effective analgesia is crucial. A multimodal analgesic strategy is recommended, combining regional or local anesthetic techniques, opioids, ketamine, and nonsteroidal anti-inflammatory drugs (NSAIDs), when not contraindicated. Wound infiltration with local anesthetics at the end of surgery can provide postoperative pain relief. Opioids are typically supplemented with regular paracetamol and NSAIDs if appropriate. In scoliosis surgery, analgesia may be further enhanced by placement of an epidural catheter at the end of the procedure, as performed by the surgeon. Additionally, local anesthetics and opioids may be administered into the epidural space prior to closure. More commonly, however, patient-controlled analgesia (PCA) combined with scheduled oral or rectal analgesics is used effectively.[2,13]

The incidence of thromboembolism following spinal surgery ranges from 0.395% to 15.5%. For prophylaxis, intermittent pneumatic compression devices should be used. The use of heparin must be carefully balanced against the risk of increased bleeding, particularly in cases where regional anesthesia has been employed. Regular application of compression stockings and sequential compression devices (SCDs) is also recommended.[12] Following posterior spine surgery, several risk factors increase the likelihood of airway complications, including operative duration exceeding 5 hours, exposure of more than three vertebral levels, prone positioning, significant intraoperative blood loss, and large-volume fluid transfusion. Even after successful extubation, these factors may still contribute to risk, as airway edema can develop several hours postoperatively.[2,7]

Extubation should ideally be performed when the patient is fully awake and able to maintain their airway independently. In cases where the risk of reintubation is high, a tracheal tube exchange catheter may be utilized. This catheter can be inserted into the endotracheal tube and left in place during extubation, allowing rapid reintubation over the catheter if necessary. However, prolonged sedation and mechanical ventilation should be avoided, as they may obscure signs of postoperative neurological injury. Careful handling is also essential during patient repositioning to prevent disruption of spinal fixation devices.[2,7]

Conclusion

The most important principle of anesthetic management in spinal surgery is a comprehensive and meticulous approach to patient positioning, ensuring safe alignment while maintaining adequate spinal cord perfusion pressure. This is achieved by preserving normal respiratory and cardiovascular function, as well as maintaining normovolemia and normothermia throughout the perioperative period. The incidence of spinal cord injury and neurological deficits can be reduced through careful preoperative optimization, appropriate surgical technique, strict hemodynamic control, and continuous intraoperative monitoring of spinal cord function. Of particular importance is effective postoperative pain management, along with careful consideration of the potential need for intensive care unit (ICU) admission for close monitoring in the immediate postoperative period.

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