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Literature Review

REGIONAL ANESTHESIA SUBARACHNOID BLOCKADE (RASAB) IN SCOLIOSIS PATIENTS

Eko Setijanto[1], **Kiel Pino Putra**[1a]

[1] Department of Anesthesiology and Intensive Therapy, Faculty of Medicine, Sebelas Maret University, Solo, Indonesia
[a] Corresponding author: kielpinoputra@student.uns.ac.id

ABSTRACT

Introduction: Scoliosis is a three-dimensional spinal deformity that is mainly determined based on the lateral curvature of the spine. Furthermore, regional anesthesia often infiltrates the peripheral nerves with an anesthetic agent and blocks transmission to avoid or relieve pain. A previous study revealed that scoliosis in patients is one of the factors affecting the success of spinal anesthesia. **Objective:** To obtain a theoretical basis that can support the solution to the RASAB problem. The acceptance of the theory is the first step to providing a better understanding of the study problem based on the scientific framework of thinking. Furthermore, the similarities, differences, and views of several pieces of literature that discussed related issues were evaluated in this review. **Review:** Regional anesthesia subarachnoid blockade (RASAB) or spinal anesthesia, is a procedure, which involves the administration of local anesthetic drugs into the subarachnoid space. Furthermore, the process is carried out between the lumbar (L) vertebrae L2-L3, L3-L4, or L4-L5. Spinal anesthesia is often used in surgical procedures involving the lower abdomen, pelvis, perineum, and lower extremities. **Conclusion:** In the setting of scoliosis, spinal anesthesia is challenging, but is not an absolute contraindication. Patients with scoliosis have unique characteristics, hence, anesthetists need to understand the impact of the disease on the body.

Keywords: Lumbar Spine; Regional Anesthesia; Scoliosis; Spinal Anesthesia; Subarachnoid.

ABSTRAK

Pendahuluan: Skoliosis adalah kelainan bentuk tiga dimensi tulang belakang yang sebagian besar ditentukan berdasarkan kelengkungan lateral tulang belakang. Anestesi regional terdiri atas prosedur infiltrasi saraf perifer dengan agen anestesi dan memblokir transmisi untuk menghindari atau menghilangkan rasa sakit. Kondisi skoliosis pada pasien dapat menjadi salah satu faktor yang mempengaruhi keberhasilan anastesi spinal. **Tujuan:** Untuk mendapatkan landasan teori yang bisa mendukung pemecahan masalah *regional anesthesia subarachnoid blockade* (RASAB). Teori yang didapatkan merupakan langkah awal agar peneliti dapat lebih memahami permasalahan yang sedang diteliti dengan benar sesuai dengan kerangka berpikir ilmiah. Peneliti mencari kesamaan, perbedaan, memberikan pandangan, membandingkan dan meringkas beberapa literatur yang membahas masalah terkait. **Review:** *Regional anesthesia subarachnoid blockade* (RASAB) atau yang dapat disebut dengan anestesi spinal, merupakan prosedur anestesi dengan melakukan pemberian obat anestetik lokal ke dalam ruang *subarachnoid*. Prosedur ini dilakukan pada ruang *subarachnoid* di daerah antara vertebra lumbal (L) L2-L3 atau L3-L4 atau L4-L5. Anestesi spinal seringkali digunakan pada prosedur bedah yang melibatkan perut bagian bawah, panggul, perineum, dan ekstremitas bawah. **Kesimpulan:** Pada keadaan skoliosis, tindakan anestesi spinal menjadi sulit untuk dilakukan, namun bukan kontraindikasi absolut. Pasien dengan skoliosis merupakan populasi dengan karakteristik khas sendiri. Dokter anestesi perlu memahami dengan baik dampak penyakit ini pada tubuh.

Kata kunci: Vertebra Lumbar; Anestesi Regional; Skoliosis; Anestesi Spinal; Subarakhnoid.

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INTRODUCTION

Anesthesiology is a branch of medical science that underlies various actions, including the administration of anesthesia, maintaining the safety of surgery patients, as well as providing Basic Life Support (BLS), intensive treatment to critically ill inpatients, inhalation therapy, and chronic pain management (1). Several stages must be carried out in the management of anesthesia during surgical procedures, including pre-anesthesia, which consists of mental and physical readiness of patients, anesthetic planning, prognosis determination, and preparation on the day of surgery (2). Furthermore, the anesthetic management stage comprises premedication, anesthesia and maintenance, recovery, and post-anesthesia care phases(2,3).

Scoliosis is a three-dimensional deformity of the spine that is primarily determined by the lateral curvature of the spine (4). This disorder is divided into structural and nonstructural (postural) types (5). Structural scoliosis can be reclassified into idiopathic and non-idiopathic with unknown and known causes, respectively (6). The incidence of this condition varies in different countries, between 2% and 13.6% (7). The leading causes of scoliosis are still unknown, but several etiologies, such as genetic factors, growth, hormonal dysfunction, changes in bone mineral density, abnormalities in body tissues, abnormal platelet levels, biomechanical aspects, and central nervous system abnormalities, affect the incidence (8). Previous studies revealed that it can be treated using different methods, such as conservative treatment or surgery with specific indications (7,9).

Regional anesthesia often infiltrates the peripheral nerves with an anesthetic agent, thereby blocking transmission to avoid or relieve pain (10). This procedure differs from this general method because it does not affect the patient's level of consciousness to alleviate pain. Furthermore, regional anesthesia subarachnoid blockade (RASAB), or spinal anesthesia, is an anesthetic procedure, which involves the administration of local anesthetic drugs into the subarachnoid space (11). This procedure is often performed in the space between the lumbar (L) vertebrae L2-L3, L3-L4, or L4-L5. Several studies have reported the use of spinal anesthesia in surgical procedures involving the lower abdomen, pelvis, perineum, and lower extremities (9,12,13).

A previous study revealed that scoliosis in patients is one of the factors affecting the success of spinal anesthesia (14). Several risks associated with clinical conditions have also been reported in patients with this condition who were administered with anesthetic agents, especially among severe cases (7,15). Patients with scoliosis are a population of people with unique characteristics due to their condition. Therefore, thos study aims to provide in-depth knowledge to anesthesiologists on the reduction of anesthetic errors and complications. The similarities, differences, views of several literature that discussed related issues were collected and then compared.

This literature review used previous articles obtained with the keywords "Regional anesthesia subarachnoid blockade" and "scoliosis" from online journals. The articles were then sorted, classified, and selected based on the predetermined criteria. The data obtained were analyzed using descriptive analysis based on structured evaluation, classification, and grouping of the selected literature. Subsequently, the data were combined and processed into a review discussing RASAB in scoliosis patients.

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REVIEW

REGIONAL ANESTHESIA

Regional anesthesia is the temporary blocking of pain impulses from a part of the body through the sensory nerves. During the process, the motor function can be partially or totally affected, but the patient remains conscious (2).

Regional Anesthesia/ Analgesia Division (2)

Central or neuraxial block includes spinal, epidural, and caudal blocks. Euroaxial n-block often causes a sympathetic and motor blockage, as well as sensory analgesia depending on the dose, concentration, and volume of the local anesthetic drug.
Furthermore, the peripheral or nerve blocks consist of topical anesthetics, local infiltration, field blockage, and intravenous regional analgesia.

Regional Anesthesia Advantages(2)

1. Minimal tools, relatively simple techniques, and lower costs.
2. Relatively safe for patients who are not fasting (emergency surgery, full stomach) because they remain conscious during the process.
3. There were no airway or respiratory complications.
4. No pollution of the operating room by anesthetic gas.
5. Postoperative care is lighter.

Regional Anesthesia Disadvantages (2)

1. Not all patients want regional anesthesia.
2. Requires patient cooperation.
3. Difficult to carry out in children.
4. Not all surgeons prefer regional anesthesia.
5. There is a possibility of failure of the regional anesthetic technique.

Regional Anesthesia Preparation (2)

Regional anesthetic preparation is similar to the general method because it also anticipates systemic toxic reactions, which can be fatal, and require resuscitation mechanisms. For example, spinal/epidural anesthetic drugs that enter the blood vessels can cause cardiovascular collapse as well as cardiac arrest. Failure of this method is also anticipated, and it is often continued with general anesthesia.

SPINAL ANESTHESIA

Definition (16,17)

Spinal anesthesia is the administration of a local anesthetic into the subarachnoid space. This process is also known as intradural spinal analgesia/block or intrathecal block (16). Furthermore, to reach the cerebrospinal fluid, the syringe penetrates the subcutaneous, supraspinous, and interspinous ligaments, as well as the epidural space, ligamentum flavum, dura mater, and subarachnoid space (16).

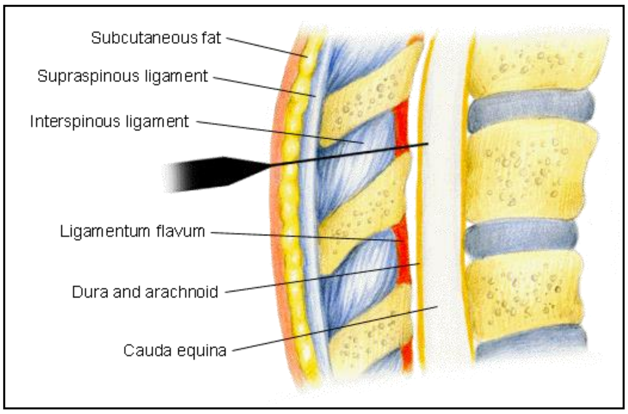

Figure 1. Location of Needle Insertion in Spinal Anesthesia (17)

The spinal cord is surrounded by cerebrospinal fluid in the spinal canal, which is covered by the meninges, including the dura

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mater, fat, and venous plexus. In adults, it ends as high as L1, but terminates at the level of L2 and L3 in children and infants, respectively. Therefore, spinal anesthesia/analgesia is often performed in the subarachnoid space between the L2-L3, L3-L4, or L4-L5 vertebrae (16).

Spinal Anesthesia Indications and Contraindications

Indication:(16)

1. Lower extremity surgery
2. Pelvic surgery
3. Actions around the perineal rectum
4. Obstetric-gynecological surgery
5. Urological surgery
6. Lower abdominal surgery
7. In pediatric upper and lower abdominal surgery, it is usually combined with mild general anesthesia.

Table 1. Contraindications for Spinal Anesthesia (16).

Contraindications		
Absolute	**Relatively**	**Controversy**
a. Infection at the injection site	a. Sepsis	a. history of spinal surgery at the injection site
b. The patient's refusal	b. Uncooperative patient	b. Complicated operation
c. Coagulopathy or blood clotting disorders	c. Existing neurological deficit	c. Long operation
d. Severe hypovolemia	d. Demyelinized lesion	d. Massive blood loss
e. ICT Improvement	e. Lesion or stenosis of heart valves	e. Maneuvers that inhibit respiration
	f. Left ventricular outflow obstruction or hypertrophic obstructive cardiomyopathy	
	g. Severe spinal deformity	

Preparation for Spinal Anesthesia (16)

The preparation for spinal anesthesia is similar to general anesthesia, where the area around the puncture site is first examined for potential difficulties. The possible difficulties include anatomical spine abnormalities and obesity, which causes the inability to palpate the spinous process protrusion. Furthermore, the following must be noted:

a. Informed consent: The patient must not be forced to agree to spinal anesthesia
b. Physical examination: No specific abnormalities, such as spinal deformities were found
c. Recommended laboratory tests
d. Hemoglobin, Hematocrit, PT (Prothrombin Time), PTT (Partial Thromboplastin Time)
e. Spinal analgesia equipment
   Monitoring instrument: blood pressure, pulse, and oxygen saturation
   Resuscitation equipment
   Spinal needle: with a sharp tip (spinal bamboo tip / Quincke-Bacock) or a pencil tip (pencil point white care)

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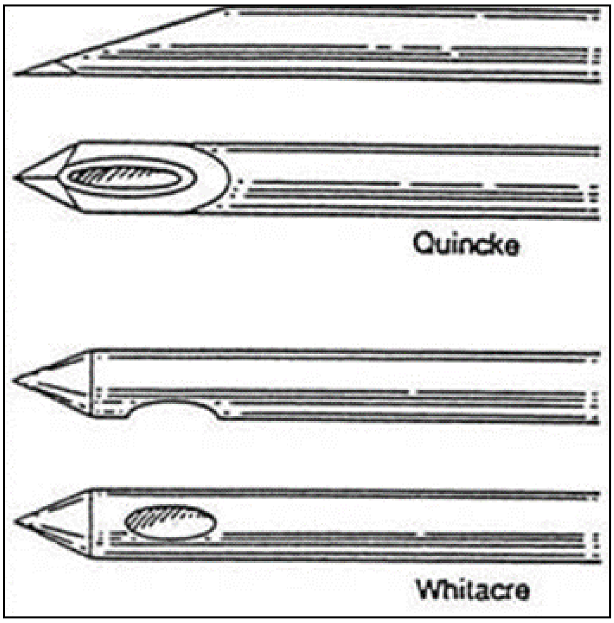

Figure 2. Spinal Needle (16).

Local Anesthetics for Spinal Analgesia

The specific gravity of cerebrospinal fluid (CSF) at 37° C is 1.003-1.008, and local anesthetics with a specific gravity equal to CSF are called isobaric. Meanwhile, those with values lower and higher than the cerebrospinal fluid are known as hypobaric and hyperbaric, respectively. Local anesthetics that are often used are the hyperbaric types, which are obtained through mixing with dextrose. An example of the common hypobaric type is tetracaine produced through mixing with water injection.

Table 2. Drugs for Spinal Anesthesia (16).

Drugs Used	Duration of Anesthesia during surgery
0.5% Tetracaine in 5% dextrose	90-120 minutes
5% Lidocaine in dextrose and 7.5% in water	45-60 minutes
0.75% Bupivacaine in 8.5% dextrose in water	90-120 minutes
0.5% Bupivacaine in 8% dextrose in water	90-120 minutes but not yet FDA approved
5% Meperidine in 10% dextrose, equal volume to hyperbaric	45-50 minutes

The Spinal Anesthetic Technique (16)

The sitting or the lateral decubitus sleeping position with a puncture in the midline is the most common method used for spinal anesthesia. The process is often carried out on the operating table without being moved again, and only a slight change in the patient's position is required. Excessive position variation in the first 30 minutes can cause the spread of the drug.

a. After monitoring, put the patient to sleep, for example, in the lateral decubitus position. Give a head pillow to increase the comfort level and stabilize the spine. Make the patient bend maximally for easy palpation of the spinous process. Another common position used for this process is sitting.
b. The intersection of the line connecting the two iliac crest lines, namely, L2-L3, L3-L4, or L4-L5. Puncture at L1-L2 or above increases the risk of trauma to the spinal cord.
c. Sterilize the puncture site with betadine or alcohol.

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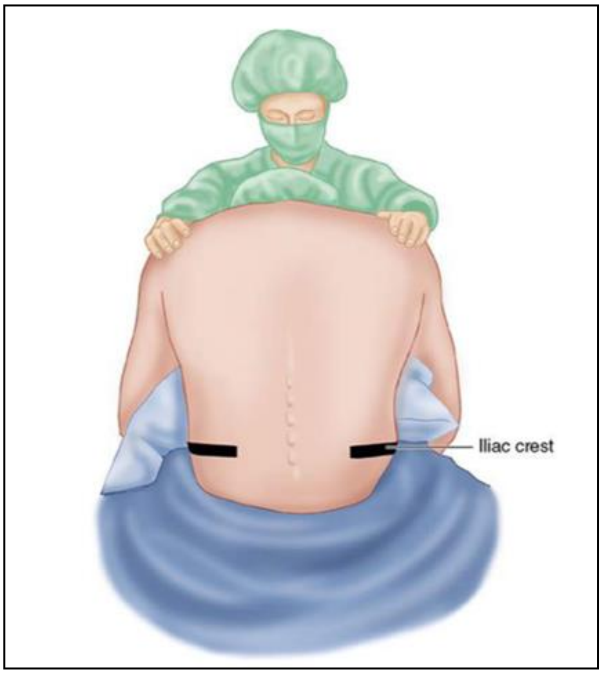

Figure 3. Sitting Position in Spinal Anesthesia (16).

d. Give local anesthesia at the puncture site, for example, with 2-3 ml of 1-2% lidocaine.
e. The median or paramedian puncture method. 22G, 23G, and 25G can be used for large spinal needles. For the small 27G or 29G, it is advisable to use a needle guide, namely an ordinary 10 cc syringe. Furthermore, insert the introducer about 2cm deep, slightly in the cephalic direction, then insert the spinal needle and the mandrin into the hole. During the use of a sharp needle (Quincke-Babcock), the incision (bevel) must be parallel to the dura mater, namely in the sleeping position on the side of the bevel pointing up or down to avoid leakage of liquor, which can result in post-spinal headache. After the resistance disappears, the spinal needle mandrin is removed. Insert a syringe filled with the drug, and insert slowly (0.5 ml/sec) with a slight aspiration to ensure it is in a good position. If the liquid does not come out, the turn can be turned 90º, and a catheter can be inserted for continuous spinal analgesia.

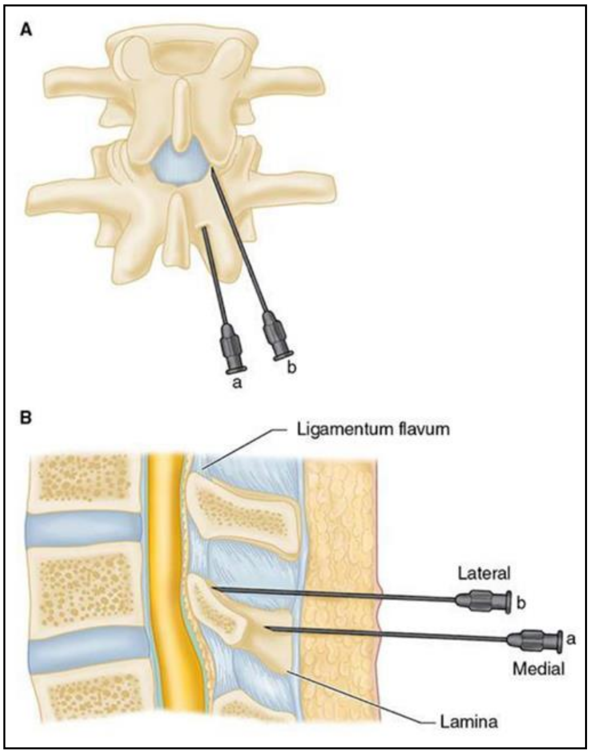

Figure 4. Needle Puncture in Spinal Anesthesia (16).

f. The sitting position is often used for perineal surgery, such as hemorrhoid surgical procedures (hemorrhoids) with hyperbaric anesthesia. Furthermore, the Adult Skin-Ligamentum flavum distance is ± 6cm.
   a. Local anesthetic distribution depends on:
      i. Main factor:
         1. Local anesthetic specific gravity (baricity)
         2. Patient position
         3. Local anesthetic dose and volume
      ii. Additional factors
         1. Injection height
         2. Injection speed/barbotage
         3. Needle size
         4. Patient's physical condition

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5. Intra-abdominal pressure

b. The duration of action of local anesthetics depends on:
   i. Types of local anesthetics
   ii. The size of the dose
   iii. Vasoconstrictor
   iv. The magnitude of the local anesthetic distribution

c. Complications of spinal anesthesia:
   i. Severe hypotension: Venous pooling occurs due to the sympathetic block. In adults, it is prevented by giving 1000 ml of electrolyte fluid or 500 ml of colloid before the procedure.
   ii. Bradycardia: can occur in the absence of hypotension or hypoxia due to the block to T2.
   iii. Hypoventilation: is caused by phrenic nerve paralysis or respiratory control center hypoperfusion
   iv. Nerve vessel trauma
   v. Nerve trauma
   vi. Nauseous vomit
   vii. Hearing disorders
   viii. High spinal block or total spinal

d. Postoperative complications
   i. Injection site pain
   ii. Back pain
   iii. Headache due to liquor leakage
   iv. Urinary retention
   v. Meningitis

Physiological Effects of Neuraxial Block

a. Cardiovascular Effects:

Sympathetic block often causes a decrease in blood pressure, thereby leading to hypotension. Furthermore, the effect of sympathectomy depends on the height of the block. In the spinal cord, 2-6 dermatomes are above the level of sensory block, while the blockage often occurs at the same level in the epidural (18).

Hypotension can be prevented with the administration of fluids (pre-loading) to reduce the relative hypovolemia caused by vasodilation before spinal/epidural anesthesia. The condition can also be treated by giving fluids and vasopressors, such as ephedrine (19).

A high spinal block on cardio accelerator fibers at T1-T4 can cause bradycardia and cardiac arrest (20).

b. Respiration Effect:

A high spinal block of more than the T5 dermatome can lead to hypoperfusion of the respiratory center in the brainstem as well as respiratory arrest (21).

There can also be blockage of the phrenic nerve, causing disturbances in the movement of the diaphragm and abdominal muscles required for inspiration and expiration (22).

c. Gastrointestinal Effects:

Nausea and vomiting induced by 20% neuraxial block can cause gastrointestinal hyperperistalsis due to increased parasympathetic activity and blocked sympathetic system. Meanwhile, this is advantageous in abdominal surgery because bowel contractions often lead to maximal operating conditions (23).

SCOLIOSIS

Definition

Scoliosis is a complicated spinal deformity involving the lateral curvature and rotation of the spine, as well as angulation of the ribs, which leads to the deformation of the thoracic ribs. Furthermore, this condition was first introduced by Galen, a Greece doctor. Scoliosis refers to the lateral curvature of the

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spine, but it is often used generically to refer to all spinal deformities in children (24).

Previous reported showed that the prevalence of spinal curvature > 10°, 20°, and 30° is 1.5%-3%, 0.3%-0.5%, and 0.2%-0.3%, respectively. The male-to-female prevalence ratio depends on the patient's age, but scoliosis requiring surgical correction is more common in women. The ratio increased with the severity of the curvature, namely 2:1 and 10:1 for the curvature of 10° and > 30° (24).

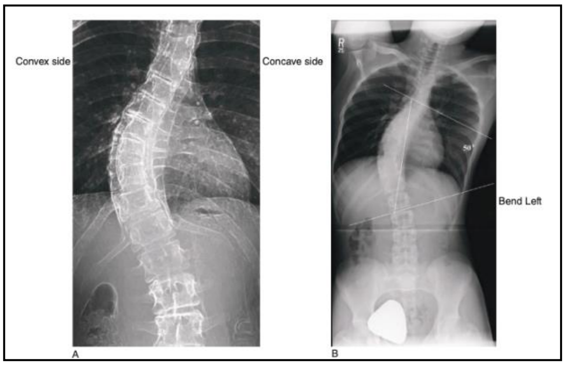

Figure 5. Radiological Features of Scoliosis Patients. (9)

Classification

There are several etiological classifications for structural scoliosis. Furthermore, the types include idiopathic, congenital, neuromuscular, myopathies, trauma, and tumors. Idiopathic scoliosis is the most common, accounting for 70% of all cases and it often occurs in infantile and juvenile forms (25). A previous study revealed that its adolescent form is the most common in the United States (24).

Neuromuscular scoliosis can be caused by cerebral palsy, muscular dystrophy, poliomyelitis, and familial dysautonomia. It has also been reported to be associated with a significantly increased intraoperative blood loss compared to the idiopathic type (26). Congenital scoliosis is often induced by congenital abnormalities, such as hemivertebrae and fused ribs. A previous study stated that Neurofibromatosis and Marfan syndrome have an association with scoliosis. Furthermore, these underlying conditions can have a significant impact on the anesthetic plan (24).

In 1948, John Cobb developed a method for measuring the magnitude of spinal curvature (27) using a posteroanterior radiograph of the spine (28). This technique helps surgeons to identify the vertebrae that are most tilted above and below the curve's apex. The Cobb angle is often calculated between the intersecting lines drawn perpendicular to the top of the affected vertebra above and the bottom of the bottom-most affected vertebra. In 1966, the Scoliosis Research Society standardized a method for assessing the severity of scoliosis. A perpendicular line (2) is drawn from the bottom of the lowest vertebra (1), whose bottom slopes toward the concave of the curve, and another (4) from the top of the highest vertebra (3) whose top slopes toward the concave. The angle (5) where the lines intersect is known as the Cobb angle. Several studies have documented that the more severe the thoracic curve, the greater the impairment in lung function. Surgical treatment is usually recommended for curves greater than 45 to 50°, and those > 60 degrees are associated with decreased lung function (24).

Impact of Scoliosis on the Body

Scoliosis patients undergoing surgical correction often have several challenges due to the pathophysiological disturbances caused by the disease (24).

a. Abnormalities in Lung Function

A restrictive pattern with decreased lung volume is the most common PFT abnormality in thoracic scoliosis. The most significant declines occurred in vital

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capacity, which reduced to 60% to 80% of the estimate. There was also a decrease in the total lung, functional residual, and inspiratory capacities, as well as expiratory reserve volume also decreased. Furthermore, increased residual volume has been reported in patients with congenital and idiopathic scoliosis, 3 years after corrective spinal fusion. (24)

These abnormalities in lung function are often caused by abnormal thoracic cage geometry due to a marked decrease in chest wall compliance rather than abnormalities in the lungs or the respiratory muscles. On dynamic magnetic resonance imaging, adolescent girls with idiopathic scoliosis and healthy controls showed no difference in diaphragmatic movement. Changes in chest wall compliance can be replicated in regular volunteers with chest straps. The exceptions include congenital and infantile scoliosis, where lung growth can be impaired early in development by a thoracic deformity (24).

b. Abnormalities in Blood Gas Analysis

Based on data from a previous study, patients with thoracic scoliosis had arterial oxygen desaturation compared to normal controls. Arterial hypoxemia can be caused by ventilation/perfusion (V/Q) inequalities. Decreased diffusion capacity and alveolar hyperventilation also play a role in this condition. Furthermore, these differences are related to the population of patients studied, and/ or the severity of scoliosis. Severe and long-lasting scoliosis can lead to severe deformity, alveolar hypoventilation, carbon dioxide retention, and severe hypoxemia. This condition can increase the risk of premature death from respiratory failure after the age of 40 years when it is not treated properly (24).

c. Abnormalities in the Cardiovascular System

Patients with scoliosis can have increased pulmonary vascular resistance and hypertension, thereby leading to right ventricular hypertrophy and perfusion failure. Previous studies revealed that several factors often cause increased pulmonary vascular resistance. Furthermore, hypoxemia can lead to increased pulmonary vasoconstriction, vascular resistance, and artery pressure. Chronic hypoxemia causes hypertension due to vascular changes, and this makes pulmonary hypertension irreversible. Several studies reported that deformities in the chest wall compress several parts of the lung, thereby leading to increased resistance of the blood vessels in the area. Pulmonary vascular growth can be impaired if scoliosis develops in the first 6 years of life due to chest wall deformities (24).

Patients with high-grade scoliosis and pulmonary hypertension are at risk for cor pulmonale (29). This often occurs due to loss of lung capillaries and subsequent arterial hypoxemia. Hypoxia caused by pulmonary vasoconstriction occurs due to a decrease in PaO2. The continuity of this condition can lead to hypertrophy of the vascular smooth muscle in the lungs, and permanently increased vascular resistance. This increased resistance is then transmitted back to the right ventricle, where it causes hypertrophy and cardiomyopathy. In patients with known or suspected cardiac disorders, consultation with a cardiologist during the perioperative period as well as invasive

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cardiac monitoring during the operative period are necessary (24).

SPINAL ANESTHESIA IN SCOLIOSIS

Indications for surgery in patients with scoliosis depend on the type. In idiopathic scoliosis, the indicators include a progression curve above 40 degrees with non-operative treatment, 40–45° curvature in skeletally immature patients, and a curve of > 50° in adolescents and adults. Furthermore, the indications for surgery in people with the congenital type depend on the underlying anomaly and the prediction of its development. For scoliosis that are secondary to neuromuscular disease, surgery can be indicated to improve wheelchair posture, assist nursing care and prevent the development of restrictive lung defects in patients with compromised respiratory function (9,30).

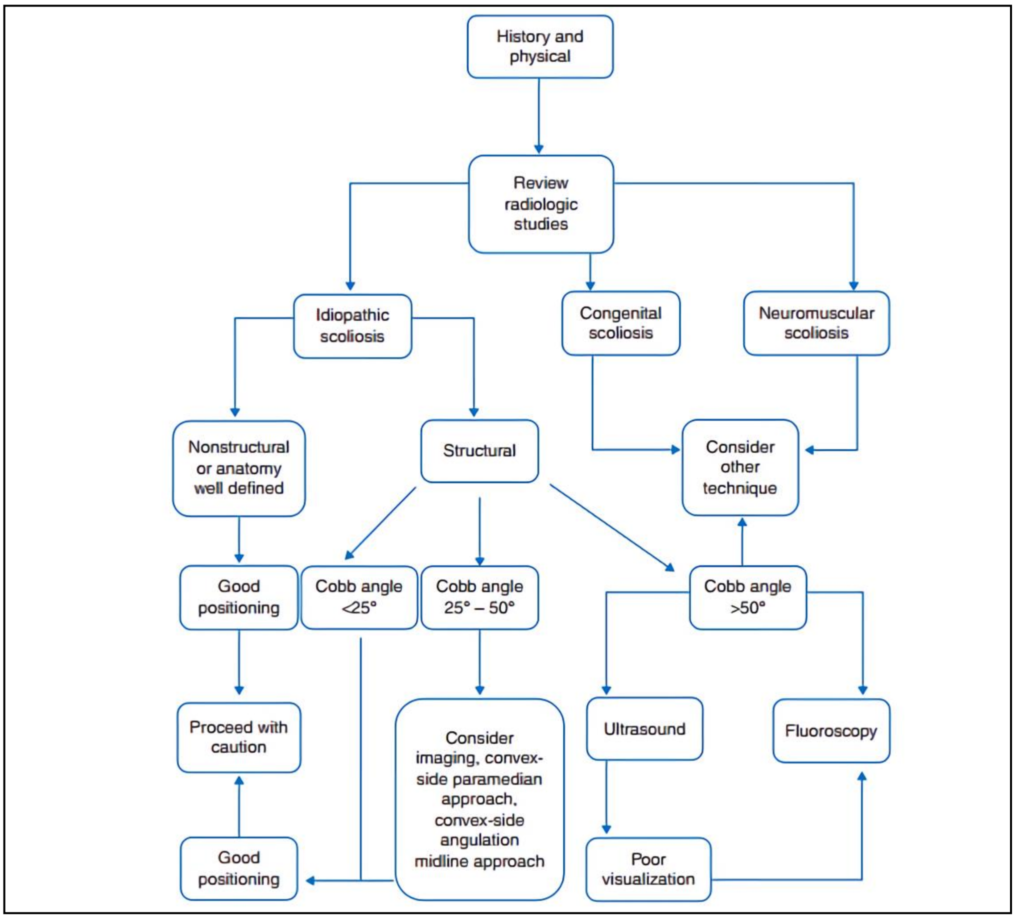

Figure 6. Radiological Features of Scoliosis Patients (30).

Several imaging procedures, such as spinal X-rays, CT scans, and MRIs can help with regional anesthesia for patients with scoliosis. In some literature, spinal anesthesia in scoliosis patients has several risks. The process is often performed in the intrathecal space, which contains spinal fluid, and is safe for multiple operations. In a patient with severe scoliosis, the first intrathecal injection of 6 mg hyperbaric bupivacaine caused inadequate motor and sensory block. However, blockage at Th 10 level was achieved through the injection of 6.25 mg of hypobaric bupivacaine (2 ml). Due to the unexpected effect of the local anesthetic fluid, the treatment was changed to an intrathecal

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injection of 12.5 mg hypobaric bupivacaine (4 ml) at the second operation. The sensory block was then regained at Th 10, and the patient was reported to be satisfied with each of these anesthetics and had no complications (9,30).

CONCLUSION

In the setting of scoliosis, it is very challenging to carry out spinal anesthesia, but it is not an absolute contraindication. Furthermore, this anesthetic method in scoliosis patients can pose a variety of risks. Some of the difficulties include the inability to puncture the spinal needle, wrong insertion of syringe, and administering anesthetic drugs to an inappropriate space.

Patients with scoliosis have unique characteristics, and anesthesiologists need to understand the impact of the disease on the body. It is also necessary to carry out holistic management from the beginning of the preoperative to postoperative stage to get maximum results. Therefore, accuracy and experience are needed to minimize the risk of the process to ensure its continuity.

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Conflict of Interest

The authors declare no conflict of interest.

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Authors' Contribution

All authors have contributed to all processes in this study.

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