

## Role of Thoracic Spinal Anaesthesia in Modern Practice – A Critical Review

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### Abstract

Thoracic spinal anaesthesia (TSA) is gaining increasing recognition as a valuable regional anaesthetic technique in modern surgical practice, particularly for patients who are at high risk for complications associated with general anaesthesia. With the growing volume and complexity of surgical procedures worldwide, the demand for safer, targeted anaesthetic approaches has expanded. TSA involves intrathecal injection of local anaesthetic agents at thoracic vertebral levels, producing segmental sensory, motor, and sympathetic blockade suitable for a range of surgical interventions.

Advances in anatomical knowledge and imaging modalities, especially MRI and ultrasound guidance, have improved the safety profile of this technique. Studies demonstrate a relatively wider posterior cerebrospinal fluid space in the thoracic region, offering a protective margin during needle placement. Although technical challenges exist due to narrow interlaminar spaces and angulated spinous processes, refined approaches such as paramedian insertion and optimal patient positioning enhance procedural success. Compared with general and lumbar spinal anaesthesia, TSA offers several advantages, including reduced cardiopulmonary complications, improved perioperative analgesia, attenuated surgical stress response, earlier return of gastrointestinal function, decreased postoperative nausea and vomiting, and shorter hospital stay.

The use of lower doses of local anaesthetic also contributes to greater haemodynamic stability. TSA has been successfully employed in breast surgery, abdominal cancer procedures, laparoscopic cholecystectomy, nephrectomy, and selected thoracic surgeries, particularly in elderly and high-risk patients with compromised pulmonary function. Despite its benefits, potential complications such as hypotension, bradycardia, post-dural puncture headache, neurological injury, and infection must be considered. Careful patient selection, adherence to contraindications, and informed consent remain essential. Overall, TSA represents a safe and effective alternative anaesthetic modality with expanding clinical applications.

**Keywords:** Regional Anaesthesia, Spinal Anaesthesia, Thoracic spinal anaesthesia (TSA), Modern Practice.

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### Introduction

Since the beginning of the anaesthetic era 175 years ago, the number of patients undergoing general or regional anaesthesia each year has been increasing.[1] An estimated 310 million major surgical procedures were carried out globally in 2020.[2] Thanks to developments in contemporary anaesthesia, patients undergoing complicated surgical operations can now be safely put to sleep using either general or regional anaesthesia.[3–7] There are recognised benefits, drawbacks, and procedure-specific hazards associated with these anaesthetic procedures.[8, 9] Regional or general anaesthesia can be administered safely in the majority of patient populations. However, the approach will be determined by procedural or

patient-specific characteristics in a limited fraction of individuals. [10, 11] In this patient population, regional anaesthesia—more especially, neuraxial anaesthesia techniques—becomes useful. Patients undergoing surgery with serious medical conditions who are deemed to be at higher risk for general anaesthesia are usually treated with thoracic segmental spinal anaesthesia. For the majority of procedures, general anaesthesia is the norm; however, there are several disadvantages, such as adverse medication reactions, a longer recovery period, and insufficient pain management. Thoracic segmental spinal anaesthesia is currently receiving more attention for a number of popular operations. In these specific situations, intrathecal injection of

anaesthetics into the desired body height and above where the spinal cord terminates has been shown to be beneficial. Because they are afraid of damaging the spinal cord, anesthesiologists are reluctant to provide spinal anesthesia above the conus medullaris. However, thoracic spinal anesthesia has proven to be a safe and efficient technique for many surgeries, such as abdominal cancer surgery, breast cancer lumpectomies, and laparoscopic cholecystectomies. [12, 13, 14]

By injecting a concentrated local anesthetic into the subarachnoid space, pharmacologic denervation at the level of the spinal cord causes significant sensory, motor, and sympathetic blocking, which leads to spinal anesthesia.[15, 16]Although spinal anesthesia can theoretically be administered at most thoracic and lumbar spinal levels, it is thought to be safer to do so below the spinal cord's termination in order to prevent iatrogenic damage to the cord.[17, 18] Most adult patients are thought to have their spinal cords terminate at L1/L2.[19] All neuraxial anesthesia (NA) procedures, thoracic spinal anesthesia—spinal anesthesia injected at spinal levels above L1/L2—is arguably the most contentious. The main problems with this procedure include fear of iatrogenic damage to the spinal cord, cephalad distribution of the local anesthetic resulting in a full block, and hemodynamic instability due to block of the cardioaccelerator fibres. [ 20–25]

**Anatomy and Physiology:** Although the lumbar and thoracic parts of the spine share a similar structure, there are notable variations that are crucial for administering anaesthesia in the thoracic spine. To better characterise the area within the spine for regional anaesthesia, anatomical studies have been conducted using MRI. The mid to lower thoracic portion of the cord is located anteriorly, where there is a CSF-filled space between the dura and the cord, according to these MRI pictures. In contrast, the dura mater in the lumbar region is touched posteriorly by the spinal cord and cauda equina. This has shown that the thoracic spinal cord's posterior subarachnoid area is deeper. The distance between the dura mater and spinal cord in the thoracic spine was measured at 7.75 mm at T5 and 5.88 mm at T10 in one MRI imaging research involving fifty participants.[26]

There may be a minimum safe distance before the spinal needle makes touch with the spinal cord tissue during intrathecal injections at mid-thoracic levels.

Next, because of overlap from the vertebral lamina, the interlaminar gaps in the thoracic spine are smaller and more difficult to reach with a needle. On the other hand, there is more room between the lumbar vertebra's lamina and they do not overlap. Additionally, the lumbar vertebra points posteriorly, whereas the thoracic vertebra's spinous processes point inferiorly.[27]

If a midline route is used, the thoracic spinal processes' slanted position will change the needle's angle and perhaps complicate the treatment. The layers of anatomy crossed during thoracic segmental spinal anesthesia are identical to those in the lumbar area, where spinal anesthesia is often administered.

The epidermis, supraspinous ligament, interspinous ligament, ligamentum flavum, dura mater, subdural space, arachnoid mater, and subarachnoid space are the layers the needle passes through when using the midline method. The epidermis, subcutaneous fat, paraspinal muscles, ligamentum flavum, dura mater, subdural space, arachnoid mater, and subarachnoid space are all penetrated by the needle during the paramedian method.[28]

**Advantages of Thoracic Spinal Anaesthesia:** It is vital to compare thoracic spinal anesthesia with other possibilities in order to understand the suggested advantages of this acceptable, successful, and sometimes even better treatment. The next section discusses comparisons with thoracic epidural anesthesia, spinal anesthesia, and general anesthesia. In contrast to general anesthesia, spinal anesthesia offers a number of benefits. These include: fewer cardiac and respiratory complications;[ 28–29] a more marked suppression of the neuroendocrine stress response to surgery;[ 31], better intraoperative and postoperative pain control; [32] an earlier recovery of gastrointestinal function; [33] less nausea and vomiting following surgery; [34] an earlier discharge from the hospital and ambulation; [35] a decreased risk of deep vein thrombosis; [36] lower rates of surgical site infections; [ 37 ] fewer blood transfusions; and lower costs.[32], The absence of airway equipment and its possible drawbacks is a major benefit of spinal anesthesia.[38],

The use of spinal anesthesia at the thoracic vertebral level is known as thoracic spinal anesthesia. It has been reported at thoracic levels up to T10/T11.,[39] and as high as the T4/T5 intervertebral region. Using a long-acting local anesthetic agent, such as levobupivacaine, bupivacaine, or ropivacaine, with both hyperbaric formulations.[40] Compared to conventional lumbar spinal anesthesia, thoracic spinal anesthesia offers several advantages. High doses of bupivacaine (20–40 mg) at a lumbar puncture site or low doses (5 mg) at a thoracic puncture site can be used to establish a high thoracic block using spinal anesthesia for surgical operations involving the upper abdomen or lower thoracic dermatomes. [ 41]

Vasodilation of the blood vessels and a decrease in preload occur when the sympathetic block reaches the lower limbs during lumbar spinal anesthesia. A reduced drop in preload and blood pressure is observed with thoracic spinal anesthesia because the sympathetic block is limited to fewer dermatomes

with little involvement of the lower limbs.[14] Instability and a shorter duration of motor and sensory blockage compared to standard dosages of lumbar spinal anesthesia. A lower volume of local anesthetic is required for sufficient nerve blockade because the thoracic nerve roots are thinner than the lumbar nerve roots and there is less cerebrospinal fluid volume at this level, enabling more effective nerve blockade due to less dilution of the local anaesthetic agent.[42]

Despite its many advantages, thoracic spinal anaesthesia carries some risks and challenges. patient selection depends on both Surgical and patient factors –

**Surgical considerations:** Numerous surgical procedures have been carried out under thoracic spinal anesthesia. Lower limb orthopaedic surgery, abdominal cancer surgery, breast surgery, laparoscopic cholecystectomy, open nephrectomy, cystectomy, and Caesarean delivery are among them. When doing thoracic procedures on patients with severe respiratory conditions, NA has been the only anesthetic method employed. An awake, spontaneously breathing patient, quicker recovery, shorter hospital stays, lower expenses, non-inferior efficacy assumption compared to conventional techniques, and fewer minor and major morbidities are all advantages of awake thoracic surgery under NA.

Resection of pulmonary nodules, wedge resection of non-small cell lung cancer, video thoracoscopic mastectomy, video thoracoscopic talc pleurodesis, treatment of anterior mediastinal masses, treatment of thoracic empyema, and thymectomy in myasthenia gravis patients are among the procedures that have involved awake thoracic surgery under thoracic epidural anesthesia.[7]

Anaesthetic objectives in cardiac surgery include optimizing the myocardial oxygen supply/demand ratio, reducing the neuroendocrine stress response, and maintaining hemodynamic stability.[43] To accomplish the aforementioned objectives, a high-dose opioid anesthetic method is frequently employed. Nevertheless, this method also prolongs hospital stays and the need for artificial ventilation.[44]

#### **Patient factors**

**Patients with impaired pulmonary function:** Avoiding medications that affect mucociliary clearance, avoiding mechanical ventilation, reducing atelectasis, guaranteeing sufficient analgesia, and promoting early mobilization are the objectives of anesthetic care in patients with chronic respiratory diseases.[45] In patients with severe respiratory conditions, general anesthesia is linked to a higher risk of ventilator dependency,

postoperative respiratory problems, and mortality.[30]

**Patients at high risk of general anaesthesia-related complications:** Thoracic spinal anaesthesia offers a possible alternative in patients who are at high risk of perioperative morbidity and death under general anaesthesia, with specific reference to elderly geriatric patients with diminished physiological reserve and various comorbidities. [18]

**Technical factors:** Thoracic spinal anaesthesia has been described between vertebral levels T4–T11. For colon resection surgery, a thoracic spinal anaesthesia at T4/T5, with a local anaesthetic volume of 1.7 ml, resulted in a sensory block distribution between T3 and L5.[39] For gastrectomy surgery, a thoracic spinal anaesthesia level between T6 and T8 with a local anaesthetic volume ranging between 0.9 and 1.2 ml is recommended, reaching a sensory block level up to T4.[46] Case reports describe gastrostomy surgeries performed with thoracic spinal anaesthesia at T8/T9 using a local anaesthetic volume of 1 ml, resulting in a sensory block level distribution from T3 to T12.[47]

**Finding the right space:** When delivering thoracic spinal anesthesia in certain centers, ultrasound is frequently utilized to establish and confirm the exact intervertebral level, and this technique is recommended. It is possible to determine the proper thoracic intervertebral level, measure the depth up to the ligamentum flavum and posterior dura, and identify anatomical abnormalities of the vertebral column by incorporating an ultrasound assessment of the thoracic spine into the preparation stage of the procedure. [25]

**Patient positioning:** Compared to the supine and lateral positions, the head-down sitting position enhances the posterior separation of the dura mater and spinal cord, which reduces the possibility of spinal cord injury during the thoracic spinal needle insertion. Because the vertebral spaces are separated, it has been found that the sitting position, with the patient's shoulders relaxed and head and back bent, offers the most direct path to the subarachnoid space. [48-51]

**Cutting needle vs pencil point needle:** Imbelloni and associates assessed the frequency of paraesthesia and neurological problems following thoracic spinal anesthesia in 300 patients using a cutting type needle as opposed to a pencil tip needle in 2010. They came to the conclusion that the two needles did not significantly differ from one another.[52] In 2020, it was discovered that the pencil point needle's aperture terminates 1.7 mm from the needle tip; hence, in order for CSF to show, the needle must be advanced at least 2 mm into the

subarachnoid space, increasing the risk of unintentional cord puncture. The cutting type needle seems to be a safer option because it has a terminal orifice.[53]

**Median vs paramedian approach:** The midline is located while using the median method for thoracic spinal anesthesia. The dura mater, ligamentum flavum, supraspinous and interspinous ligaments, and epidural space are all traversed by the spinal needle. The ligamentum flavum is directly punctured by the spinal needle when using the paramedian technique. The median method is described as technically more complex in thoracic spinal anesthesia compared with the paramedian technique for various reasons: Ossification of the ligamentum flavum may obstruct needle advancement, the sharply angled spinous processes from T4 to T9 pointing caudally may hinder the midline insertion of the needle, and midline gaps between the elastic fibers of the ligamentum flavum filled with epidural fat and vessels connecting the venous plexuses may prevent the typical tactile sensation provided by needle penetration. Finding the epidural space prior to dural puncture as an extra precaution

A method that involves using an epidural needle and the "loss of resistance to air" technique to first identify the epidural space and then slowly advancing the spinal needle through the epidural needle has been described by several authors.[25]

**Locating the epidural space before dural puncture as an added safety measure:** A method that involves using an epidural needle and the "loss of resistance to air" technique to first identify the epidural space and then slowly advancing the spinal needle through the epidural needle has been described by several authors. [25, 54]

**Confirmation of spinal needle orifice in subarachnoid space:** Until the dural puncture is verified by free flow of CSF through the needle, the progress of the spinal needle is described as "very slow and cautious. [18, 23] The local anesthetic is only administered when CSF free flow is observed.

#### **Isobaric, hypobaric, and hyperbaric solutions**

Hyperbaric solutions seem to affect the posterior (sensory) roots more than the anterior (motor) roots in the supine posture, leading to a more noticeable sensory block than motor block. The opposite is true for isobaric and hypobaric solutions, when the blockade of the anterior roots results in a stronger motor than sensory block. [55, 56]

**Indications thoracic segmental spinal anesthesia:** Currently, certain operations and patient demographics are most suited for thoracic segmental spinal anesthesia. These usually involve patients who are unwilling to undergo general anesthesia or

who are deemed to be at a high risk of perioperative morbidity and mortality during the surgery.[13]

Laparoscopic cholecystectomies, breast cancer procedures, and abdominal cancer surgeries have all been successfully completed. In the future, the technique may assist healthy patients as well because in some of these procedures, the process was carried out on healthy persons with outstanding results. Before this method is recommended for regular usage, more research involving a greater number of patients must prove its safety.

Before proceeding, signed informed consent from the patient is necessary for this procedure. The indication for thoracic segmental spinal anesthesia and what to expect during the procedure, as well as the benefits, risks, and alternative procedures should be described in detail for the patient. A patient must be informed of what to expect after the procedure is performed and that they will be awake during surgery. This will cause a great deal of anxiety in many patients, and as such, they should be informed of feeling certain aspects of the procedure, such as tugging or pain from pneumoperitoneum due to insufflation during a laparoscopic case.[41]

**Contraindications:** Every neuraxial anesthetic has significant known contraindications. The patient's rejection or lack of permission, a local infection at the operation site, a genuine drug allergy, and high intracranial pressure—which raises the chance of uncal herniation when CSF is lost through the needle—are the essential contraindications. Furthermore, if it is anticipated that the procedure will take longer than the nerve block, spinal anesthesia should not be used.

Preexisting neurological conditions (such as multiple sclerosis and other demyelinating illnesses), sepsis, severe hypovolemia, and coagulopathy are the relative contraindications.

Depending on the severity of coagulopathy, spinal anesthesia may be recommended. Other related contraindications include significant mitral and aortic stenosis and left ventricular outflow restriction, as observed with hypertrophic obstructive cardiomyopathy.[58]

**Complications:** There are major and minor complications to the thoracic spinal blockade; however, the major complications are rare. The most serious complications of thoracic spinal anesthesia include:[11]

- Direct needle trauma
- Infection (abscess, meningitis)
- Vertebral canal hematoma
- Spinal cord ischemia
- Arachnoiditis
- Total spinal anesthesia
- Cardiovascular collapse

- Death Minor complications

On the other hand, are common and shouldn't be disregarded. Some of the more common minor complications include hypotension, nausea/vomiting (typically caused by hypotension), bradycardia, paraesthesia, transient mild hearing impairment, backache, urinary retention, and TNS. Lastly, post-dural puncture headaches, which are considered a "minor" complication, can be severely debilitating for patients and are common in occurrence.[12][13][14]

**Clinical Significance:** Thoracic segmental spinal anesthesia offers many benefits not available with general anesthesia or with lumbar spinal anesthesia in some cases. This technique has made it possible to perform certain major operations on an awake patient at high risk for morbidity and mortality under general anesthesia. Other benefits include better pain control than opioids and a decrease in the opioid requirement during or after a procedure, which lowers the incidence of the side effects with these drugs. Furthermore, there is an earlier recovery of bowel function and decreased complications which result in a shorter length of in-hospital stay and patient satisfaction.[14] This procedure can also be valuable for postop pain in combination with other modalities. Lastly, the anesthetic dose is lower, so hemodynamic instability becomes minimal. [42]

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