pagepress

Advances in Anesthesia and Pain Medicine

Advances in Anesthesia and Pain Medicine 2026; 4:68
doi:10.4081/aapm.2026.68

Low-concentration dual-baricity thoracic segmental spinal anesthesia for laparoscopic cholecystectomy: a retrospective case series

Paolo Scimia,[1] Massimiliano Luca D'Agostino,[2] Antonio De Cato,[2] Franco Marinangeli,[2] Simone Cicconi,[3] Riccardo Moretti,[4] Federica Venturoni,[1] Fabrizio Fattorini,[5,6] Roberto Starnari,[7] Domenico Pietro Santonastaso,[8] Luca Gentili[9]

[1]Department of Anesthesia and Intensive Care, G. Mazzini Hospital, Teramo; [2]Department of Clinical Medicine, Public Health and Life Science, University of L'Aquila; [3]Department of Surgery, S. Omero Hospital, Sant'Omero (TE); [4]Department of Anesthesia and Intensive Care, S. Omero Hospital, Sant'Omero (TE); [5]Department of Anesthesia, San Sebastiano Hospital, Frascati (RM); [6]School of Specialization in Anesthesia, Intensive Care and Pain Medicine, Sapienza University of Rome; [7]Department of Anesthesiology, IRCSS Istituto Nazionale di Ricovero e Cura per Anziani, Ancona; [8]Anestesia and Intensive Care Unit, Emergency Department, Maurizio Bufalini Hospital, Cesena; [9]Department of Anesthesia and Intensive Care Unit, S. Maria Goretti Hospital, Latina, Italy

Abstract

Laparoscopic cholecystectomy (LC) is usually performed under general anesthesia (GA), which provides airway protection and optimal surgical conditions but may expose vulnerable patients to cardiopulmonary stress and other anesthesia-related adverse effects. Thoracic segmental spinal anesthesia (TSSA) may represent an alternative in selected patients. We evaluated the feasibility, safety, and perioperative outcomes of a low-concentration dual-baricity TSSA protocol for LC. This retrospective descriptive case series included 26 consecutive patients undergoing LC between February 2025 and February 2026. Spinal anesthesia was performed at T9-T10 using 2 mL of hypobaric ropivacaine 0.25% followed by 4 mL of isobaric ropivacaine 0.25% (total dose 15 mg), without intrathecal adjuvants. Sedation was achieved with intravenous dexmedetomidine, midazolam, and fentanyl. Intraoperative adverse events, postoperative pain, motor block, analgesic requirements, recovery quality, and patient satisfaction were recorded. All procedures were completed under TSSA without conversion to GA. One patient required conversion from laparoscopic to open cholecystectomy, with no change in anesthetic technique. No intraoperative abdominal pain, hypotension, nausea, or vomiting occurred; shoulder pain was reported in 11.54% of patients. Postoperative nausea and vomiting occurred in 3.85%. Mean Bromage score was 0.03±0.19. Mean Visual Analog Scale (VAS) scores were 0±0 at 0 hours, 1.8±2.05 at 12 hours, and 0.73±1.66 at 24 hours. Mean Quality of Recovery-15 questionnaire (QoR-15) score was 145.96±3.15, and all patients reported the highest satisfaction score. Low-concentration dual-baricity TSSA provided effective surgical anesthesia with preserved spontaneous ventilation, stable hemodynamics, minimal motor blockade, low postoperative pain, and high patient satisfaction. This technique may represent a feasible alternative to GA in appropriately selected patients.

Key words: awake laparoscopic surgery; dual baricity technique; laparoscopic cholecystectomy; neuraxial anesthesia; thoracic segmental spinal anesthesia.

Correspondence to: Luca Gentili, Department of Anesthesia and Intensive Care Unit, S. Maria Goretti Hospital, Via Lucia Scaravelli, Latina, Italy.
E-mail: luca.gentili89@gmail.com ; Tel.: +39 3397108156.

Introduction

Conventionally, laparoscopic cholecystectomy (LC) is performed under general anesthesia (GA), which remains the standard of care in clinical practice.[1] This is primarily due to its ability to provide optimal surgical conditions, ensure airway protection, and allow controlled ventilation during pneumoperitoneum, which significantly alters respiratory and cardiovascular physiology.[2] However, GA is not without risks, particularly in patients with significant cardiopulmonary comorbidities and in those at increased risk of postoperative delirium.[3] Over the past two decades, thoracic segmental spinal anesthesia (TSSA) has emerged as a feasible alternative for LC, with accumulating evidence supporting its safety, reproducibility, and favorable perioperative outcomes in selected patient populations. Despite these encouraging findings, TSSA has not achieved widespread acceptance among anesthesiologists, largely due to concerns regarding potential spinal cord injury associated with thoracic puncture. Nevertheless, magnetic resonance imaging studies have demonstrated that the thoracic subarachnoid space is wider than traditionally assumed, providing a safe margin between the dura mater and the spinal cord. These observations suggest that, when performed by experienced clinicians using appropriate technique, thoracic spinal puncture can be considered a safe and reproducible procedure.[4,5]

Previous studies[6-8] have shown that TSSA for LC in high-risk patients with multiple comorbidities and/or American Society of Anesthesiologists (ASA) physical status IV or higher

may offer clear advantages by avoiding GA and its associated complications. In these reports, TSSA is typically performed using relatively high concentrations of local anesthetics (commonly 0.5%), often combined with intrathecal adjuvants to enhance block density and duration. Although effective, such strategies may be associated with a more pronounced sympathetic blockade, potentially leading to hemodynamic instability and respiratory impairment – factors that may limit the broader adoption of this technique.

Beyond fragile or severely compromised patients, the potential benefits of TSSA may also extend to otherwise healthy individuals undergoing elective LC.[9] This application has received comparatively limited attention, despite increasing patient interest in avoiding GA and its related side effects.[10] In this setting, careful optimization of anesthetic management becomes essential in order to minimize physiological disturbances while preserving adequate surgical conditions.

In the present study, we explore a refined TSSA approach based on the use of reduced concentrations of local anesthetic, aimed at mitigating hemodynamic and respiratory impact without compromising anesthetic efficacy. In addition, we investigate the sequential use of two different anesthetic baricities (isobaric and hypobaric) within a single protocol to improve tolerance of pneumoperitoneum and attenuate diaphragmatic irritation. Importantly, the same intrathecal anesthetic mixture was successfully applied to both high-risk patients and ASA I-II individuals who explicitly requested this anesthetic technique, supporting its broader applicability. Sedation was achieved with intravenous dexmedetomidine, midazolam, and fentanyl, avoiding intrathecal adjuvants and allowing for a more predictable spinal block profile.

By emphasizing feasibility, safety, and patient acceptability across both high-risk and otherwise healthy populations, this study aims to support the evolving view that thoracic spinal anesthesia for LC should not be regarded solely as a rescue or niche strategy, but rather as a valid anesthetic option within an individualized, patient-centered approach.

Materials and Methods

Study design

This retrospective descriptive case series included consecutive patients undergoing LC under thoracic spinal anesthesia between February 2025 and February 2026. Demographic and clinical characteristics are summarized in Table 1.

Inclusion and exclusion criteria

Eligible participants were adult patients scheduled for LC with an ASA physical status ranging from I to IV. The cohort included patients with contraindications to GA, patients who refused GA, and patients who elected thoracic spinal anesthesia after comprehensive preoperative counseling.

Patients with contraindications to neuraxial anesthesia, including coagulopathy, local infection at the puncture site, or patient refusal, were excluded.

Table 1. Demographic information of the sample (n=26; 15 females).

Variable	Mean±SD
Age	52±15.1
Height (cm)	168.48±10.05
Weight (kg)	76.16±14.28
BMI	26.78±3.78

SD, standard deviation; BMI, body mass index.

Procedure

The anesthetic technique was performed according to the protocol described by Vailati *et al.*[11] Standard monitoring included peripheral oxygen saturation, non-invasive blood pressure, electrocardiography, and bispectral index monitoring. Sedation depth was assessed clinically using the Richmond Agitation-Sedation Scale and instrumentally using BIS monitoring.

All patients received a 1000 mL crystalloid preload and premedication with intravenous midazolam (1 mg) and fentanyl (50 µg). With the patient in the sitting position, the T9-T10 intervertebral space was identified using the inferior angle of the scapula as an anatomical landmark. After skin antisepsis and sterile draping, a median approach was used to access the subarachnoid space with a 27G Whitacre spinal needle. During needle advancement, particular attention was paid to performing frequent checks for cerebrospinal fluid approximately every 2 mm, as relying solely on the perception of a dural "click" may be misleading and potentially unsafe at the thoracic level (Figure 1).[12] Intrathecal anesthesia consisted of 2 mL of hypobaric ropivacaine 0.25% followed by 4 mL of isobaric ropivacaine 0.25%, for a total dose of 15 mg, prepared in separate syringes. After injection, patients were positioned supine with a 5° anti-Trendelenburg tilt and received supplemental oxygen via nasal cannula (2 L/min).

Sedation was achieved with a dexmedetomidine loading dose (1 µg/kg over 10 minutes), followed by continuous infusion (0.7-1.2 µg/kg/h), with additional midazolam and fentanyl as required. Sensory block level was assessed using pinprick and cold sensation testing before surgical incision.

Data collection

The following variables were recorded and subsequently analysed. Intraoperative variables included abdominal pain, shoulder pain, nausea, vomiting, hypotension, and bradycardia. Postoperative variables included pain intensity assessed using the Visual Analog Scale (VAS; 0 = *no pain*, 10 = *worst imaginable pain*), postoperative nausea and vomiting (PONV), urinary retention, analgesic requirements, and hospital stay. Motor block was assessed clinically at the end of surgery, and patient satisfaction was evaluated using a 4-point Likert scale. Recovery quality was evaluated on the first postoperative day using the Italian-validated version of the Quality of Recovery-15 questionnaire (QoR-15).[13]

Statistical analysis

Data were collected and organized using Microsoft Excel (Microsoft Corporation, Redmond, WA, USA). Continuous variables were expressed as mean ± standard deviation, while categorical variables were reported as frequencies and percentages.

Statistical analyses were performed using IBM SPSS Statistics for Macintosh, version 25.0 (IBM Corp., Armonk, NY, USA). Given the descriptive nature of the study, no inferential statistical analysis was conducted.

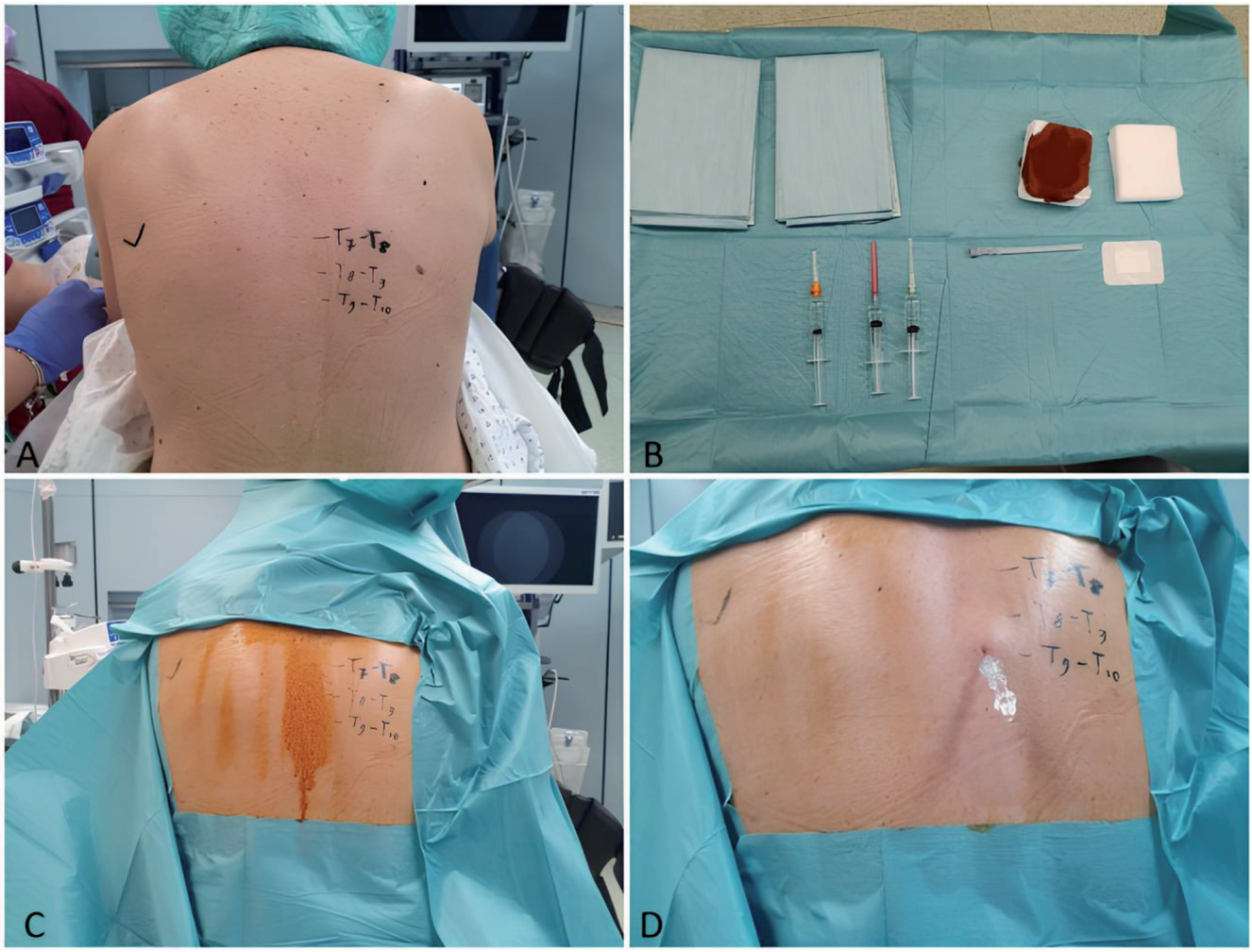

Figure 1. Thoracic segmental spinal anesthesia technique for laparoscopic cholecystectomy. A) Pre-procedural identification of thoracic anatomical landmarks in the sitting position. The inferior angle of the scapula, corresponding approximately to the T7 vertebral level, was used as a reference point. The T7-T10 interspaces were marked to guide accurate localization of the T9-T10 puncture site. B) Sterile preparation of materials, including spinal needles and separately prepared syringes containing hypobaric and isobaric ropivacaine 0.25%, reflecting the dual-baricity protocol. C) Skin antisepsis and sterile draping of the thoracic region prior to neuraxial access, performed using maximal barrier precautions. D) Final appearance of the thoracic region after completion of the intrathecal injection at the T9-T10 interspace, demonstrating the precise puncture site and maintenance of the sterile field.

Results

All 26 patients successfully underwent LC under TSSA, with no conversion to GA. One patient required conversion from laparoscopic to open cholecystectomy; however, the spinal block provided adequate surgical anesthesia, and no modification of the anesthetic strategy was required.

Regarding intraoperative variables, no patients reported abdominal pain, nausea, or vomiting. Hypotension was not observed in any of the enrolled patients. Intraoperative shoulder pain was reported in 11.54% of patients. All intraoperative variables are summarized in Table 2.

With respect to postoperative outcomes, no patients reported shoulder pain. PONV occurred in 3.85% of the sample. The mean Bromage score at the end of surgery was 0.03±0.19, indicating minimal motor blockade. Postoperative pain scores were low, with a mean VAS of 0±0 at 0 hours, 1.8±2.05 at 12 hours, and 0.73±1.66 at 24 hours.

Analgesic requirements were modest: 53.85% of patients required paracetamol, 34.62% required ketorolac, and 38.5% required no postoperative analgesic medication. The mean hospital stay was 1.84±0.73 days. All patients reported the highest level of satisfaction (Likert score = 3).

Furthermore, the high scores recorded on the postoperative QoR-15I confirm an elevated level of quality of recovery experienced by the patients (145.96±3.15). Postoperative variables are summarized in Table 3.

Table 2. Intra-operative variables assessed (n=26; 15 females).

Variable	%
Abdominal pain	0
Shoulder pain	11.54
Nausea and vomiting	0
Hypotension	0

Table 3. Post-operative variables assessed (n=26; 15 females).

Variable	Value
Bromage score (mean±SD)	0.03±0.19
PONV	3.85%
Urinary retention	0%
Shoulder pain	0%
VAS (mean±SD)	
0 h	0±0
1.2 h	1.8±2.05
24 h	0.73±1.66
Paracetamol required	53.85%
Toradol required	34.62%
No medication required	38.5%
Hospital Stay (mean±SD)	1.84±0.73
QoR-15 (mean±SD)	145.96±3.15
Level of patient satisfaction	
0	0%
1	0%
2	0%
3	100%

SD, standard deviation; PONV, post-operative nausea and vomiting; VAS, Visual Analog Scale; QoR-15, Quality of Recovery-15.

Discussion

The present case series describes a novel TSSA technique for LC, based on the use of a single long-acting local anesthetic, ropivacaine 0.25%, administered at a reduced concentration and total dose, combined with a dual-baricity strategy. This approach differs from many previously published protocols, in which higher concentrations of local anesthetics – frequently 0.5% – and intrathecal adjuvants are employed to ensure block density and duration.[7,14] In contrast, our protocol was intentionally designed to favor differential block, hemodynamic stability, and preservation of spontaneous ventilation.[8,11]

The choice of ropivacaine 0.25% as the sole intrathecal agent reflects a deliberate attempt to minimize sympathetic and motor blockade while maintaining adequate sensory anesthesia. Ropivacaine is known for its favorable cardiovascular safety profile and greater sensory-motor differentiation compared with other long-acting local anesthetics. This effect is partly related to its lower lipophilicity compared with bupivacaine and levobupivacaine, which contributes to a more pronounced differential block with reduced motor involvement. In this series, this pharmacological profile was reflected by the minimal motor blockade observed at the end of surgery, with near-zero Bromage scores in all patients. From a clinical perspective, this translated into preserved lower limb function and facilitated early mobilization.[15] By reducing the anesthetic concentration, we aimed to achieve a selective segmental block capable of covering the surgical dermatomes and the afferent pathways responsible for referred shoulder pain, without inducing clinically relevant diaphragmatic dysfunction. In our series, cranial sensory spread was systematically assessed by pinprick testing in the subclavicular region, corresponding to upper thoracic and lower cervical dermatomes. Importantly, spontaneous ventilation was preserved in all patients, and no clinical signs of respiratory compromise were observed. This finding is particularly relevant in the setting of pneumoperitoneum, where diaphragmatic irritation and hypercapnic stress may challenge anesthetic management.

A key technical feature of our protocol is the dual-baricity strategy. The sequential administration of hypobaric followed by isobaric ropivacaine, combined with mild anti-Trendelenburg positioning, appeared to facilitate controlled cranial spread of the anesthetic solution. This approach may have contributed to effective tolerance of pneumoperitoneum and adequate control of intraoperative shoulder pain. In a previous study,[8] the use of hypobaric solutions was associated with high patient satisfaction and low conversion rates to GA. Our findings are consistent with this experience and further support the physiological rationale that modulation of baricity can influence selective sensory distribution while limiting excessive anterior root involvement.

An additional advantage of employing a single, fixed concentration of ropivacaine 0.25% lies in the simplification of drug preparation, reduction of potential dosing errors, and improved reproducibility of the technique, in line with the "bundle" approach proposed for TSSA.[11,14] Moreover, the hemodynamic profile observed in our case series – characterized by the absence of clinically significant hypotension – appears consistent with the use of a reduced local anesthetic concentration. Previous reports have described lower rates of severe hypotension and bradycardia when segmental thoracic spinal anesthesia is performed with lower doses compared with traditional lumbar spinal anesthesia using higher concentrations.[6,8,9] Although our study was not designed for comparative analysis, the present findings suggest that reducing local anesthetic concentration may attenuate cardiovascular instability without compromising surgical feasibility.

The prevention of pneumoperitoneum-related shoulder pain remains a relevant concern during LC under spinal anesthesia. One strategy described in the literature involves the use of an intermediate cervical plexus block to reduce phrenic afferent transmission.[16] However, this additional block may increase procedural complexity and patient discomfort. In our experience, the combination of low-concentration local anesthetic and dual-baricity modulation provided satisfactory control of shoulder pain without the need for supplementary regional techniques.

Our results also indicate that the anesthetic conditions achieved with TSSA may remain adequate even in the event of surgical conversion. In our series, one patient required conversion from laparoscopic to open cholecystectomy; nevertheless, the established spinal block provided sufficient surgical anesthesia without the need to convert to GA. This observation supports the robustness of the segmental thoracic block obtained with our protocol.

In one patient, insertion of an orogastric tube was required for gastric decompression. Owing to the controlled level of dexmedetomidine-based sedation, the patient tolerated both placement and maintenance of the tube without discomfort or the need for modification of the anesthetic plan. This highlights the importance of bal-

anced intravenous sedation when performing LC under TSSA.

Another relevant aspect of our approach is the avoidance of intrathecal opioids. Sedation was achieved exclusively with intravenous dexmedetomidine and low doses of midazolam and fentanyl, thereby limiting opioid-related adverse effects. Consistent with previous studies on TSSA,[7,8] postoperative analgesic requirements in our cohort were modest. Postoperative pain was effectively managed with paracetamol or non-steroidal anti-inflammatory drugs, and no patient required opioid administration, including the individual converted to open surgery. The low incidence of postoperative nausea and vomiting likely contributed to the uniformly high levels of patient satisfaction observed in our sample.[8,11]

Motor block at the end of surgery was minimal, as reflected by the low Bromage scores, facilitating early mobilization and functional recovery. The achievement of a differential block – characterized by adequate sensory anesthesia, stable pneumoperitoneum tolerance, preserved spontaneous ventilation, and minimal lower limb motor impairment – may represent one of the most clinically relevant aspects of this technique. Similar findings have been reported in recent studies employing low-dose hyperbaric or isobaric local anesthetics for segmental thoracic injections, with early ambulation and favorable recovery profiles.[9,17] This feature is particularly aligned with enhanced recovery after surgery principles, which emphasize early mobilization and reduced opioid exposure.

Although TSSA has traditionally been recommended primarily for high-risk patients with cardiopulmonary comorbidities,[18] our experience suggests that the same protocol can be applied safely to patients with ASA physical status I-IV who prefer to avoid GA. This perspective aligns with a growing body of literature advocating a more individualized and patient-centered approach to anesthetic planning.[8,11] However, this broader applicability should be interpreted with caution and is appropriate only when the technique is performed by experienced clinicians with a thorough knowledge of thoracic spinal anesthesia and strict adherence to safety principles, as emphasized in recent literature.[19]

The main limitations of the present study include its retrospective observational design, the relatively small sample size, the absence of a control group, and its single-center nature. Furthermore, outcomes were assessed descriptively without comparative statistical analysis. Therefore, our findings should be interpreted with caution. Larger prospective controlled studies will be necessary to further define optimal dosing, baricity management, and patient selection criteria, as well as to confirm the reproducibility of this protocol in different clinical settings.

Conclusions

This case series suggests that TSSA using low-dose (0.25%) ropivacaine administered with a dual-baricity strategy at the T9-T10 level can provide effective surgical anesthesia for LC under spontaneous ventilation. The approach was associated with stable hemodynamic and respiratory profiles, satisfactory control of pneumoperitoneum-related shoulder pain, minimal motor blockade, and limited postoperative analgesic requirements.

In this cohort, the technique was successfully applied across different ASA risk categories and was associated with high patient satisfaction. While larger prospective studies are needed, low-dose dual-baricity TSSA may represent a feasible and patient-centered anesthetic option for appropriately selected individuals undergoing LC.

References

1. Donmez T, Erdem VM, Uzman S, et al. Laparoscopic cholecystectomy under spinal-epidural anesthesia vs. general anaesthesia: a prospective randomised study. Ann Surg Treat Res 2017; 92:136-42.
2. Thangavelu R. Laparoscopy and anesthesia: a clinical review. Saudi J Laparosc 2018;3:6-15.
3. Sadeghirad B, Dodsworth BT, Schmutz Gelsomino N, et al. Perioperative factors associated with postoperative delirium in patients undergoing noncardiac surgery: an individual patient data meta-analysis. JAMA Netw Open 2023;6:e2337239.
4. Imbelloni LE, Quirici MB, Ferraz Filho JR, et al. The anatomy of the thoracic spinal canal investigated with magnetic resonance imaging. Anesth Analg 2010;110:1494-5.
5. Hamdi T, Mastari ES, Lubis AP, et al. Effectiveness and safety of thoracic segmental spinal anesthesia for breast surgery: A systematic review and meta-analysis. Narra J 2025;5:e1630.
6. Chandra R, Misra G, Datta G. Thoracic spinal anesthesia for laparoscopic cholecystectomy: an observational feasibility study. Cureus 2023;15:e36617.
7. Aljuba YM, Alkadi AT, Hamamdh MG. Segmental thoracic spinal anesthesia for critical patients undergoing abdominal surgeries: a case series and literature review. Cureus 2024;16: e74348.
8. Vincenzi P, Stronati M, Garelli P, et al. Segmental thoracic spinal anesthesia for laparoscopic cholecystectomy with the "hypobaric" technique: a case series. Local Reg Anesth 2023;16:31-40.
9. van Zundert AA, Stultiens G, Jakimowicz JJ, et al. Laparoscopic cholecystectomy under segmental thoracic spinal anaesthesia: a feasibility study. Br J Anaesth 2007;98:682-6.
10. Mohsen KM. Role of thoracic spinal anesthesia in laparoscopic cholecystectomy: a literature review. J Adv Med Med Res 2023;35:94-100.
11. Vailati D, Basta B, Starnari R, Fattorini F. A bundle for thoracic segmental spinal anaesthesia: it is time to move forward. J Anesth Analg Crit Care 2025;5:35.
12. van Zundert A, Paliwal NW, Khan IA. SAFE-TSSA: an expert consensus-based checklist for safer thoracic segmental spinal anaesthesia. Br J Anaesth 2026;136:1080-2.
13. Picconi E, Iacobucci T, Adducci E, et al. Translation and validation of the Italian version of the postoperative quality of recovery score QoR-15. Minerva Anestesiol 2020;86:787-9.
14. Chandra R, Khan IA, Paliwal NW, et al. A randomized controlled trial comparing isobaric versus hypobaric plus isobaric bupivacaine in thoracic segmental spinal anesthesia for the reduction of shoulder pain during laparoscopic cholecystectomy. Cureus 2025;17:e97048.
15. Virupakshamma D, Bhandi S. A clinical comparison between ropivacaine-clonidine combination and ropivacaine (plain) in brachial plexus block by supraclavicular approach. Academia Anesthesiol Int 2019;4:1-4.
16. Forasassi L, Marrone F, Starnari R, Pullano C. Awake robot-assisted laparoscopic prostatectomy under neuraxial anaesthesia and intermediate cervical plexus block. Ann Case Report 2024; 9:2039.
17. Imbelloni LE, Gouveia MA. A comparison of thoracic spinal anesthesia with low-dose isobaric and low-dose hyperbaric bupivacaine for orthopedic surgery: a randomized controlled trial. Anesth Essays Res 2014;8:26-31.
18. Scimia P, DE Cato A, D'Agostino ML, et al. Tailored thoracic

spinal anesthesia for laparoscopic management of acute abdominal emergency in a frail patient affected by advanced systemic sclerosis. Minerva Anestesiol 2026;92:241-2.

19. Paliwal NW, Khan IA. Enhancing the safety of thoracic segmental spinal anaesthesia: do's and don'ts. Indian J Anaesth 2025;69:509-11.

Received: 5 May 2026; Accepted: 16 July 2026.

Contributions: Paolo Scimia: conceptualization, project administration, writing – review & editing, supervision; Massimiliano Luca D'Agostino, Antonio De Cato: conceptualization, methodology, investigation, data curation, formal analysis; Luca Gentili: project administration, writing – original draft, writing – review & editing, supervision; Franco Marinangeli, Federica Venturoni: visualization; Simone Cicconi, Riccardo Moretti: data curation; Fabrizio Fattorini, Domenico Pietro Santonastaso: visualization, supervision; Roberto Starnari: conceptualization, methodology. All authors have read and approved the final version of the manuscript and agreed to be accountable for all aspects of the work.

Conflict of interest: the authors have no conflict of interest to declare. DPS is Editor-in-Chief of Advances in Anesthesia and Pain Medicine.

Ethics approval and consent to participate: this retrospective descriptive case series was conducted in accordance with the ethical principles of the Declaration of Helsinki. Given its non-interventional design and its representation of routine clinical practice, formal Institutional Review Board approval was not required according to local regulations. Informed consent was obtained from the patients.

Consent for publication: written informed consent was obtained from all patients for both the anesthetic procedure and the use of anonymized clinical data and associated images for scientific and publication purposes.

Availability of data and materials: the datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.