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Original Research Article

Thoracic segmental spinal anaesthesia over general anaesthesia for gynaecologic laparoscopy surgeries

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ABSTRACT

Background: Gynaecologic laparoscopic procedures have traditionally relied on general anesthesia (GA), but thoracic segmental spinal anesthesia (TSSA) has emerged as a promising alternative. This research evaluates the efficacy, safety and patient outcomes when comparing TSSA to GA for gynaecologic laparoscopic surgeries.
Methods: A prospective randomized controlled trial (RCT) was done involving 126 patients scheduled for gynaecologic laparoscopy. Patients were allocated at random to the TSSA group (group.) (n=63) or the GA group. (n=63). Primary outcomes were hemodynamic stability, recovery profiles, post-operative pain scores and complications related to anesthesia. Secondary outcomes were patient satisfaction, cost evaluation and quality of surgical field visualization.
Results: TSSA provided superior hemodynamic stability with lower fluctuations in blood pressure along with heart rate (HR) ($p<0.001$). TSSA was associated with greatly lessened post-operative pain ($p<0.001$), faster recovery times ($p<0.001$), earlier ambulation ($p<0.001$) and lessened postoperative nausea and vomiting (PONV) ($p<0.002$). Patient satisfaction scores were higher in the TSSA group. ($p<0.001$), while cost analysis revealed a 66.18% drop in anesthesia-related expenses. Surgeon satisfaction regarding surgical field quality showed no noteworthy difference between techniques ($p=0.34$).
Conclusions: TSSA appears to be a secure and efficient alternative to GA for gynaecologic laparoscopic surgeries. It offers superior recovery profiles, enhanced patient comfort and economic benefits without compromising surgical conditions.

Keywords: General anesthesia, Gynaecologic laparoscopy, Hemodynamic stability, Patient outcomes, Thoracic segmental spinal anesthesia

INTRODUCTION

Gynaecologic laparoscopy represents one of the most common surgical procedures performed globally, with applications ranging from diagnostic evaluations to complex interventions including hysterectomies, myomectomies and adnexal surgeries.[1] Traditionally, GA is considered the benchmark for laparoscopic procedures due to its ability to provide complete immobility, controlled ventilation to manage the physiological effects of pneumoperitoneum and airway protection.[2] However, GA is associated with several notable drawbacks, including PONV, delayed recovery, potential for airway complications and higher incidence of PO cognitive dysfunction, chiefly in elderly patients.[3] Additionally, the physiological stress response triggered by GA can lead to immunosuppression and increased PO inflammatory responses. Recently, interest has increased in regional anesthesia techniques for laparoscopic procedures. While conventional spinal anesthesia has been successfully employed for lower abdominal and pelvic procedures, its application in laparoscopy has been limited due to

concerns about inadequate block height, patient discomfort from diaphragmatic irritation and respiratory compromise.[1] "Thoracic segmental spinal anesthesia (TSSA)" has arisen as a promising technique that addresses these limitations. TSSA involves the administration of small doses of local anaesthetic directly into the thoracic subarachnoid space, producing a segmental block that covers the surgical dermatomes while minimizing the effects on respiratory muscles and providing adequate sensory and motor blockade for laparoscopic procedures.[4] Early clinical experiences suggest that TSSA may offer several advantages over GA, including improved hemodynamic stability, lessened PO pain, faster recovery and potentially lessened healthcare costs.[5]

Despite these potential benefits, there remains a paucity of high-quality evidence comparing TSSA with GA specifically for gynaecologic laparoscopic procedures.[6] Most existing studies have small sample sizes, focus on lower abdominal laparoscopy or lack comprehensive evaluation of both patient-centered outcomes and surgical conditions.[7]

The present study aims to address this gap by conducting a comprehensive comparison of TSSA versus GA for gynaecologic laparoscopic surgeries. We hypothesized that TSSA would provide superior recovery profiles and patient satisfaction while maintaining comparable surgical conditions to GA. This research evaluates multiple dimensions including hemodynamic stability, recovery parameters, PO pain scores, complications, cost analysis and both patient and surgeon satisfaction. The findings may greatly impact anaesthetic practice for gynaecologic laparoscopy, potentially offering an evidence-based alternative that enhances patient outcomes while addressing the growing demand for efficient healthcare resource utilization.

METHODS

Study design and ethical considerations

From November 2023 through August 2024, researchers at Private Gynaecology Hospital conducted this prospective randomised controlled trial. All subjects were given a thorough rundown of the anaesthetic procedures, along with any hazards and advantages, before they were asked to sign an informed permission form.

Patient selection

A total of 126 adult female patients scheduled for elective gynaecologic laparoscopic procedures were enrolled. The inclusion criteria were age 18-65 years, "American Society of Anaesthesiologists (ASA) physical status I-II'', BMI 18.5-35 kg/m^2 and scheduled for laparoscopic procedures including hysterectomy, myomectomy, diagnostic laparoscopy, ovarian cystectomy, salpingectomy with anticipated surgical duration of less than 120 minutes.

Exclusion criteria included patient refusal, contraindications to spinal anesthesia (coagulopathy, local infection, severe spinal deformity, increased intracranial pressure), history of allergic reactions to local anaesthetics, severe cardiopulmonary disease, hepatic or renal insufficiency, previous abdominal surgery with anticipated adhesions, anticipated difficult airway and psychiatric disorders that might affect pain assessment.

Randomization and blinding

The patients were divided into two groups, TSSA (n=63) and GA (n=63), using computer-generated random numbers in a 1:1 ratio. The allocation was kept secret by opening opaque, sequentially numbered envelopes right before anaesthesia was given. Outcome assessors and data analysers were blinded to group. allocation, but the anaesthesiologists conducting the operations could not be completely blinded because of the procedures' unique characteristics.

Anaesthetic techniques

Preoperative preparation

All patients received standard preoperative evaluation including detailed history, physical examination and routine laboratory investigations. Patients were instructed on the use of the Visual Analog Scale (VAS) for pain assessment. Standard fasting guidelines were followed and oral premedication with 0.5 mg alprazolam the night before surgery was administered to both groups.

TSSA technique (group T)

Patients were positioned in the sitting position with careful attention to optimal flexion of the spine. Under strict aseptic precautions, the T10-T11 intervertebral space was identified and infiltrated with 2 ml of 2% lidocaine. A 25-gauge Quincke type point spinal needle was inserted at this level using a midline approach with the bevel oriented cephalad. After confirming clear cerebrospinal fluid flow, 10 mg of 0.5% levobupivacaine mixed with 50 µg Dexmedetomidine (total volume 2.5 ml) was injected slowly over 30 seconds.

Patients were positioned supine with a 15° Trendelenburg tilt for 10 minutes to attain a sensory block spanning T4 to L1 dermatomes. Sensory blockade was evaluated via the pinprick method, while motor block was assessed using the modified Bromage scale. Oxygen was administered via face mask at 4 l/min throughout the procedure. Intraoperative sedation consisted of midazolam (0.5-1 mg) and propofol infusion (25-50 µg/kg/min) titrated to maintain Ramsay sedation score of 2-3.

GA technique (group G)

Anaesthesia was induced using 0.2 mg of glycopyrrolate, 1 mg of midazolam, 2 mg/kg of propofol and 1.5 mg/kg of

succinyl scholin after three minutes of preoxygenation with 100% oxygen. The patient remained anaesthetised with isoflurane in an oxygen tank after tracheal intubation. The goal of the volume-controlled mechanical ventilation was to keep the end-tidal CO_2 between 35 and 40 mmHg. On the basis of haemodynamic responses, more atracurium (0.1-0.5 mg/kg) was given as needed for maintenance.

Surgical technique

Standard gynaecologic laparoscopic techniques were employed for all patients. Pneumoperitoneum was established using CO_2 insufflation through a Veress needle at the umbilicus, with intra-abdominal pressure maintained at 10-12 mmHg in the TSSA group. and 12-14 mmHg in the GA group. A 30° Trendelenburg position was used for optimal surgical field exposure. The number of trocars, surgical approach and techniques were standardized for specific procedures and performed by the same team of experienced laparoscopic gynaecologist.

In the TSSA group, surgical team was instructed to use gentle manipulation of tissues, avoid excessive stretching of the peritoneum and regularly communicate with patients regarding any discomfort. If patients in the TSSA group. experienced intolerable shoulder pain or discomfort despite supplemental analgesia (fentanyl 25-50 µg IV) and adjustments to pneumoperitoneum pressure, conversion to GA was performed and documented.

Intraoperative monitoring and management

Standard monitoring included "electrocardiography, non-invasive blood pressure (NIBP), pulse oximetry, capnography (in GA group.) and temperature". In the TSSA group., respiratory rate and pattern were closely monitored. Hemodynamic parameters were recorded at baseline, after induction/spinal anesthesia, after pneumoperitoneum and every 5 minutes thereafter.

Hypotension (defined as systolic BP<90 mmHg or >20% decrease from baseline) was treated with intravenous ephedrine 5-10 mg and additional fluid boluses. Bradycardia (HR<50 beats/min) was treated with atropine 0.5 mg IV. Shoulder tip pain in the TSSA group. was initially managed with reassurance, additional fentanyl (25-50 µg IV) and if necessary, drop of pneumoperitoneum pressure to 8-10 mmHg.

Postoperative care and assessment

Upon completion of surgery, patients in Group G received reversal of neuromuscular blockade with neostigmine (50 µg/kg) and glycopyrrolate (10 µg/kg). Extubation was performed when standard criteria were met. All patients were transferred to the PACU where monitoring was continued.

Paracetamol 1 g intravenously every 6 hours and 50 mg of intravenous tramadol as a rescue medication for pain scores of 4 or higher on the Visual Analogue Scale (VAS) were administered following surgery. The patient was given IV ondansetron 4 mg for PONV. We tracked the occurrence of PONV, total analgesic usage and time to first analgesic request.

Discharge from the PACU was permitted once patients reached a modified Aldrete score of 9 or higher. Criteria for hospital discharge included adequate pain control with oral analgesics, absence of PONV, resumption of oral intake, successful ambulation and normal urination.

Outcome measures

Primary outcomes

Hemodynamic stability (intraoperative BP and HR variations). Recovery profile (time to first ambulation, time to oral intake, PACU stay duration). Postoperative pain scores at rest and with movement (VAS 0-10) at 1, 2, 4, 8, 12 and 24 hours. Anesthesia-related complications (hypotension, bradycardia, respiratory depression, PONV, urinary retention, post-dural puncture headache)

Secondary outcomes

Patient satisfaction score (5-point Likert scale). Surgeon satisfaction regarding surgical field visualization and operating conditions (5-point Likert scale). Cost analysis of anesthetic techniques (medication costs and disposable costs). Conversion rate from TSSA to GA. Duration of hospital stay.

Statistical analysis

Assuming a standard deviation of 2.0, an alpha of 0.05 and 90% power, the sample size was calculated to detect a 1.5-point difference in VAS pain levels at 6 hours post-op. In order to account for potential attrition, the number of individuals each group was raised from 56 to 63. The statistical package SPSS v25.0 (IBM Corp.) was used for the data analysis. Mean±SD or median (IQR) were used to summarise continuous data and the Student's t-test or Mann-Whitney U test, depending on distribution, were used to compare them. Using either Fisher's exact or Chi-square tests, categorical variables were evaluated and given as counts (percentages). Results from repeated-measures ANOVA with Bonferroni post-hoc correction were used to analyse repeated measurements, such as haemodynamic variables and pain scores. A significance level of $p<0.05$ was used.

RESULTS

Demographic and perioperative characteristics

Of 152 patients assessed for eligibility, 126 met inclusion criteria and were randomized. All patients completed the study protocol with no dropouts (Figure 1). The demographic characteristics, ASA physical status, types of

surgical procedures and duration of surgery were comparable between the groups (Table 1).

Hemodynamic parameters

Patients in the TSSA group. demonstrated superior hemodynamic stability likened to those in the GA group. Mean arterial pressure (MAP) and HR fluctuations from baseline were greatly lower in the TSSA group., especially after pneumoperitoneum and during maintenance of anesthesia (Figure 2). The incidence of hypotension requiring vasopressor treatment was greatly higher in the GA group. (37.3% vs 14.3%, p<0.001).

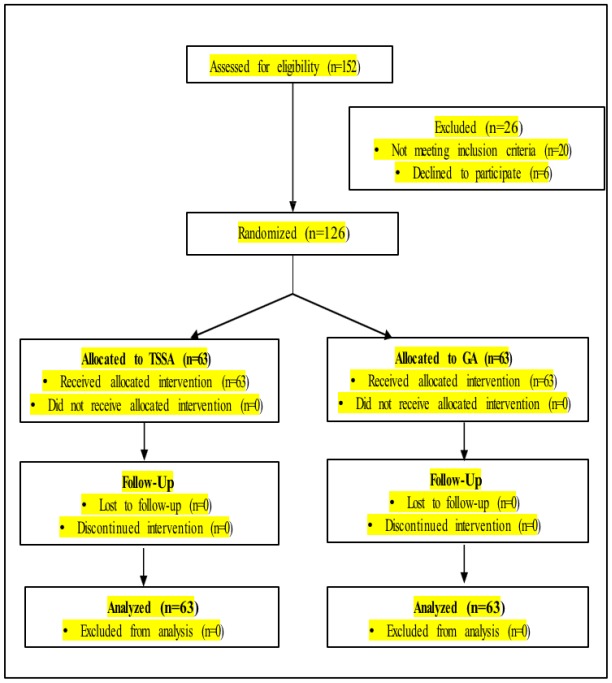

Figure 1: CONSORT flow diagram.

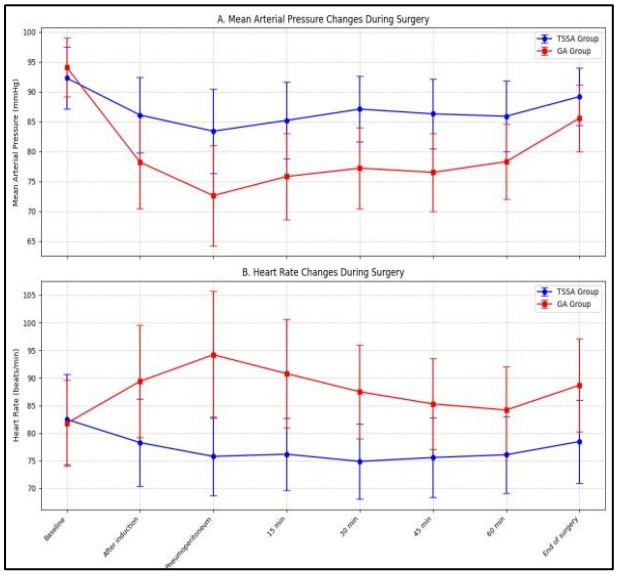

Figure 2: Hemodynamic changes during surgery.

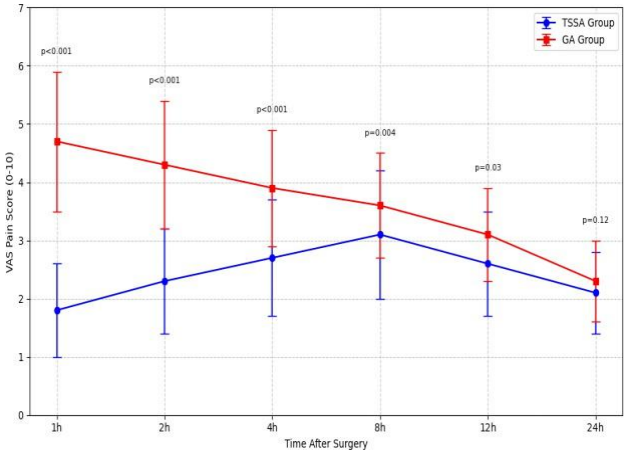

Figure 3: Postoperative pain scores (VAS) at different time points.

Recovery profiles and postoperative pain

Recovery profiles showed marked differences between the groups, with TSSA patients demonstrating greatly shorter time to first ambulation, earlier resumption of oral intake and lessened PACU stay (Table 2). The time to first analgesic request was greatly longer in the TSSA group. (245.3±92.6 min vs. 78.4±32.7 min, p<0.001). Postoperative pain scores were greatly lower in the TSSA group at all-time points up to 12 hours POly (Figure 3). At 24 hours, pain scores were comparable between groups. The total analgesic consumption (measured as tramadol equivalent) during the first 24 hours was greatly lower in the TSSA group. (62.5±38.4 mg vs. 156.3±52.1 mg, p<0.001).

Anesthesia-related complications

The incidence of PONV was greatly lower in the TSSA group. likened to the GA group. (12.7% vs. 38.1%, p=0.002). Two patients (3.2%) in the TSSA group. developed post-dural puncture headache, which resolved with conservative management (hydration, caffeine and analgesics) within 48 hours. Four patients (6.3%) in the TSSA group. experienced urinary retention requiring temporary catheterization likened to two patients (3.2%) in the GA group., but this difference was not statistically noteworthy (p=0.40). In the TSSA group., 14 patients (22.2%) reported shoulder tip pain during pneumoperitoneum. This was successfully managed with reassurance and supplemental fentanyl in 12 patients, while two patients required drop of pneumoperitoneum pressure to 8 mmHg. No patient in the TSSA group. required conversion to GA.

Patient and surgeon satisfaction

Patient satisfaction scores were greatly higher in the TSSA group. likened to the GA group. (4.3±0.6 vs. 3.4±0.9 on a 5-point Likert scale, p<0.001). The main factors contributing to higher satisfaction in the TSSA group.

were lessened PONV, better pain control, faster recovery and the ability to communicate during the procedure. Surgeon satisfaction scores regarding surgical field visualization and operating conditions were comparable between the two group.s (4.1±0.7 in TSSA vs. 4.3±0.6 in GA, p=0.34). Surgeons noted that despite the lower pneumoperitoneum pressure in the TSSA group., adequate surgical field exposure was achieved in all cases.

Cost analysis

The cost analysis demonstrated a noteworthy drop in anesthesia-related expenses in the TSSA group. (Table 3). The total anesthesia cost was 66.18% lower in the TSSA group. likened to the GA group., primarily due to lessened medication costs, elimination of airway management supplies and shorter PACU stay.

Table 1: Demographic and perioperative characteristics.

Characteristic	TSSA Group (n=63)	GA Group (n=63)	P value
Age (years)	38.4±9.7	39.1±8.9	0.67
BMI (kg/m^2)	26.2±4.3	25.8±4.1	0.59
ASA status (I/II)	41/22	39/24	0.71
Type of surgery			
Laparoscopic myomectomy	16 (25.4%)	17 (27.0%)	0.84
Total laparoscopic hysterectomy	19 (30.2%)	18 (28.6%)	0.85
Diagnostic laparoscopy	12 (19.0%)	11 (17.5%)	0.82
Ovarian cystectomy	9 (14.3%)	10 (15.9%)	0.8
Ectopic pregnancy (salpingectomy)	7 (11.1%)	7 (11.1%)	1
Duration of surgery (minutes)	72.3±22.8	75.1±24.6	0.51
Duration of pneumoperitoneum (minutes)	58.4±18.5	62.1±20.3	0.27
Intraperitoneal pressure (mmHg)	10.3±1.2	13.2±0.9	<0.001*

Values are presented as mean±SD or number (percentage). *Statistically noteworthy difference.

Table 2: Recovery profiles and postoperative outcomes.

Parameter	TSSA Group (n=63)	GA Group (n=63)	P value
Time to first ambulation (min)	163.5±42.3	286.4±65.8	<0.001*
Time to oral intake (min)	102.6±28.4	218.3±45.7	<0.001*
PACU stay duration (min)	38.7±12.5	76.4±18.3	<0.001*
Time to first analgesic request (min)	245.3±92.6	78.4±32.7	<0.001*
Total analgesic consumption in 24h (mg tramadol)	62.5±38.4	156.3±52.1	<0.001*
Hospital stay (hours)	27.3±8.6	32.8±10.2	0.002*
PONV (n, %)	8 (12.7%)	24 (38.1%)	0.002*
Urinary retention requiring catheterization (n, %)	4 (6.3%)	2 (3.2%)	0.4
Post-dural puncture headache (n, %)	2 (3.2%)	0 (0%)	0.15
Patient satisfaction score (1-5)	4.3±0.6	3.4±0.9	<0.001*
Surgeon satisfaction score (1-5)	4.1±0.7	4.3±0.6	0.34

Values are presented as mean±SD or number (percentage). *Statistically noteworthy difference.

Table 3: Cost analysis (in USD).

Cost component	TSSA group	GA group	Difference (%)
Anesthetic medications	≈4.5	≈18	-75%*
Disposables	≈7	≈16	-56.25%*
Total anesthesia cost	≈11.5	≈34	-66.18%*

Values are presented as mean±SD. *Statistically noteworthy difference (p<0.001).

DISCUSSION

This prospective RCT comparing TSSA with GA for gynaecologic laparoscopic procedures demonstrated several noteworthy advantages of TSSA in terms of hemodynamic stability, recovery profiles, PO pain control and cost-effectiveness, while maintaining comparable surgical conditions and safety profiles. The superior hemodynamic stability observed in the TSSA group. is consistent with findings from a recent randomized trial comparing TSSA and GA in laparoscopic cholecystectomy, which showed fewer cardiovascular fluctuations with TSSA.[5] This can be attributed to the limited sympathetic blockade achieved with low-dose, segmental spinal anesthesia likened to the more profound cardiovascular effects of general anaesthetic agents.[9] The

lessened incidence of hypotension in our TSSA group. (14.3% vs. 37.3%) may have important clinical implications, particularly for patients with cardiovascular comorbidities who may benefit from more stable hemodynamic during surgery.

One of the most striking differences observed was in the recovery profiles and PO pain scores. The TSSA group. demonstrated greatly faster recovery with and resumption of oral intake. This finding is consistent with the retrospective cohort study by Warta et al, which showed that a preoperative spinal anesthesia in patients undergoing laparoscopic hysterectomy greatly lessened PO pain scores and inpatient opioid consumption.[10] The prolonged analgesic effect of intrathecal local anaesthetic and opioid combination likely contributed to the greatly longer time to first analgesic request and lower total analgesic consumption in the TSSA group. These findings have important implications for enhanced recovery after surgery (ERAS) protocols in gynaecologic laparoscopy.[11]

A notable finding was the greatly lower incidence of PONV in the TSSA group. (12.7% vs. 38.1%). PONV remains one of the most distressing complications following laparoscopic procedures, with an incidence ranging from 20–50%.[12] The lessened PONV in our TSSA group. is likely multifactorial, resulting from avoidance of inhalation anaesthetics and opioid-sparing effects. This finding is particularly important since PONV is consistently rated as one of the most undesirable outcomes by patients and a common cause of delayed discharge and patient dissatisfaction.

The concern regarding shoulder tip pain during laparoscopy under regional anesthesia has been addressed in our study with a multimodal approach including optimal positioning, limited pneumoperitoneum pressure (10-12 mmHg), adequate sedation and supplemental analgesia as needed. The incidence of shoulder pain in our TSSA group. (22.2%) is consistent with prior studies reporting that a substantial proportion of patients undergoing gynaecologic laparoscopy experience shoulder discomfort, often beginning on the first PO day.[13] Importantly, none of our TSSA patients required conversion to GA, suggesting that with appropriate patient selection and management, TSSA provides adequate conditions for completion of gynaecologic laparoscopic procedures.

The comparable surgeon satisfaction scores between the two groups are noteworthy. Despite the lower pneumoperitoneum pressure in the TSSA group. (10-12 mmHg vs. 12-14 mmHg), adequate surgical field visualization was achieved in all cases. This finding supports the concept that lower intra-abdominal pressures may be sufficient for many laparoscopic procedures, potentially reducing the physiological impact of pneumoperitoneum on cardiovascular and respiratory systems. Joshipura et al, similarly reported that laparoscopic procedures can be successfully performed with pneumoperitoneum pressures as low as 8-10 mmHg without compromising surgical safety and noted that low-pressure pneumoperitoneum greatly lessened PO pain, analgesic requirement and hospital stay.[14]

The cost analysis demonstrated a substantial drop (66.18%) in anesthesia-related expenses with TSSA likened to GA. This finding has noteworthy implications for healthcare resource utilization, particularly in resource-limited settings. A 2021 systematic review analysing outpatient procedures confirmed that local or regional anaesthesia is associated with greatly lower total anesthesia-related costs than general anaesthesia, primarily due to savings on drugs, staff time, operating room usage and shorter post-anaesthesia recovery periods.[15]

The economic advantage, combined with improved recovery profiles and patient satisfaction, makes TSSA an attractive option for healthcare systems aiming to optimize resource allocation while improving patient outcomes.

Despite these advantages, TSSA is not without limitations. The technique requires specific expertise in thoracic spinal anesthesia, which may not be available in all settings. The potential for serious complications such as high spinal block or post-dural puncture headache necessitates careful patient selection, meticulous technique and appropriate monitoring capabilities. Additionally, while our study showed excellent results for procedures lasting up to 120 minutes, the applicability of TSSA for more complex or prolonged laparoscopic procedures requires further investigation.

The strengths of our study include its prospective randomized design, comprehensive assessment of multiple outcome parameters and inclusion of various gynaecologic laparoscopic procedures. However, some limitations should be acknowledged. Complete blinding was not feasible due to the nature of the interventions. The study was conducted at a single center with experience in thoracic segmental spinal anesthesia, potentially limiting generalizability. Furthermore, we excluded patients with noteworthy comorbidities (ASA III-IV), for whom the hemodynamic benefits of TSSA might be even more pronounced.

CONCLUSION

Thoracic segmental spinal anesthesia represents a viable and potentially superior alternative to general anesthesia for gynaecologic laparoscopic procedures. TSSA provides better hemodynamic stability, improved recovery profiles, superior PO pain control, lessened PONV, higher patient satisfaction and noteworthy cost savings likened to GA, while maintaining comparable surgical conditions. These findings suggest that TSSA should be considered as part of enhanced recovery protocols for gynaecologic laparoscopy in appropriately selected patients. Future research should focus on refining the technique, expanding

its application to more complex procedures and evaluating long-term outcomes including chronic pain and quality of recovery.

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