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ORIGINAL ARTICLE

Compare the Intra–Operative Hemodynamics and the Perioperative Analgesic Efficacy of Superficial Sapb, to Deep SAPB, and to Thoracic Epidural Analgesia in Thoracotomies

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ABSTRACT
Background: Pain management following thoracotomy is still difficult because of its severity and complications. SAPB is getting popular as a procedure to replace TEA in the management of postoperative pain.
Objective: The aim of this study was to compare the intraoperative effectiveness and safety of perioperative analgesic effect of superficial SAPB, deep SAPB, and TEA in patients undergoing thoracic surgeries.
Material and Methods: This randomized controlled trial was performed on 60 patients undergoing thoracotomy at the Department of Surgery, Civil Hospital Bahawalpur, from January to June 2022. Patients were randomized into three groups: SAPB were defined as superficial SAPB, deep SAPB, and TEA. Intraoperative systolic and diastolic BP, postoperative pain scores at 1, 6 and 12 hours,heart rate, time to first rescue analgesia, total postoperative analgesia, duration of surgery, and hospital stay were key outcomes. The data were analysed using one-way ANOVA and Tukey's post hoc test, $p \leq 0.05$ was deemed to be significant.
Results: Mean age was 41 (±13.72) years and mean BMI was 24.44 (±3.18). There differences among groups was insignificant ($p > 0.05$) in intraoperativeheart rate or BP. Diastolic blood pressure was significantly different ($p = 0.030$). There were no significant differences in each group with respect to postoperative pain scores, time to first rescue analgesic and total analgesic consumption ($p > 0.05$). Duration of surgery and hospital stay to recovery outcomes were also comparable ($p > 0.05$).
Conclusion: Both superficial and deep SAPB provide comparable analgesic efficacy and hemodynamic stability to TEA in thoracic surgeries. SAPB offers a safe and effective alternative, particularly for patients with contraindications to TEA.
Keywords: Thoracic Epidural, Analgesia, Thoracotomy, Postoperative Pain, Serratus Anterior Plane Block,Analgesic Efficacy, Hemodynamic Stability.

INTRODUCTION
Surgical opening of the chest cavity (thoracotomy) is inherently associated with severe postoperative pain and major intraoperative hemodynamic fluctuations. Optimal recovery, decreased complication risk including pulmonary infection, and improved surgical outcomes depend on proper pain management and hemodynamic stabilization. In thoracic surgeries, analgesic modalities offering satisfactory results are thoracic epidural analgesia (TEA), deep (DSAPB) serratus anterior plane block and superficial (SSAPB) serratus anterior plane block[1].

In thoracic procedures, TEA is often the gold standard for perioperative analgesia. TEA works by blocking sensory, motor, and sympathetic fibers resulting in reduction of pain and allows attenuating the stress response. Although, its use is complicated by hypotension, urinary retention, and, in rare cases, epidural hematomas. This has lead to a search for alternative techniques that are effective for pain relief while reducing risk[2]. Two novel ultrasound guided regional anesthesia techniques, DSAPB and SSAPB, have recently been shown to be safe, simple, and effective[3].

Both SSAPB and DSAPB rely on injection of local anesthetics beneath the serratus anterior muscle, with DSAPB providing broader analgesic coverage compared with SSAPB because of injection within the deep plane below the muscle. Both techniques provide good analgesia by blocking lateral cutaneous branches of intercostal nerves and inter-related thoracic nerves. Because these techniques are characterized by stable hemodynamic profiles and small systemic effects, they are especially suited to patients with comorbidities of the cardiovascular system[4, 5].

These techniques have been the subject of recent studies to measure of postoperative pain relief, but that DSAPB provided slightly longer duration analgesia. In addition, Finnerty et al.[7] show their potential benefits. In comparison with DSAPB, Zengin et al.[6] observed that both DSAPB and SSAPB were similar for the reported superior recovery quality and lower morbidity than with other regional anesthesia techniques for DSAPB while managing thoracic pain. The evidence indicating that serratus anterior plane blocks are a viable alternative for TEA in patients having thoracic surgery has been generated.

Although TEA is superior in controlling resting pain, it has been associated with hemodynamic instability, which appears to result primarily from blockade of sympathetic fibers. In the immediate postoperative period, Elsabeeny et al.[8] reported superior analgesia with TEA, but DSAPB and SSAPB were also associated with fewer episodes of hypotension and overall hemodynamic compromise. The advantages of these blocks make serratus anterior plane blocks a good alternative, especially for patients with high cardiovascular risk or contraindications to epidural techniques[9].

In addition, pain management strategies are important contributors to the better postoperative recovery. The effective analgesia used will reduce the need for opioids, allow early mobilization, and decrease the risk of postoperative complications (pulmonary atelectasia). However, a review conducted by Zeng et al.[10], also found that TEA offers the best pain control at the first 24h postoperatively; however, DSAPB and SSAPB were equal in terms of patient satisfaction and overall recovery outcomes. It implies therefore that Regional techniques, e.g., serratus anterior plane blocks, can serve as equally good alternatives to TEA, particularly in resource limited settings.

However, due to the increasing number of research showing that DSAPB and SSAPB are alternative treatments to TEA, more direct comparative studies are necessary to assess their benefits and limitations with respect to other alternatives. This study seeks to fulfill this gap by comparing the intraoperative hemodynamic stability, perioperative analgesic efficacy, and recovery outcomes of DSAPB, SSAPB, and TEA. The results will inform the critically

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important optimal pain interventions for thoracotomy patients, with particular emphasis in resource challenged environments.

MATERIAL AND METHODS

This prospective, randomized clinical trial was conducted at the Department of Surgery, Civil Hospital, Bahawalpur, from January 2022 to June 2022. The study included patients undergoing thoracotomy procedures, meeting the inclusion criteria, and providing informed consent. Participants were randomly assigned to one of three groups: superficial serratus anterior plane block (SAPB), deep SAPB, or thoracic epidural analgesia (TEA) using the lottery method, ensuring equal distribution among the groups. The sample size was calculated using the means and standard deviations of analgesic consumption from a previous study by Abdelzaam EM et al. (2020). In that study, the mean analgesic consumption was 10.2 ± 1.71 in the SAPB group and 9.27 ± 0.60 in the thoracic epidural group. Using a 95% confidence interval and 80% power, the calculated sample size for this study was 60 patients.[11].

Eligible patients were adults aged 18 to 65 years with ASA (American Society of Anesthesiologists) physical status I-II, scheduled for elective thoracotomy (open or minimally invasive). Patients were excluded if they had known allergies to local anesthetics, severe cardiovascular, respiratory, or neurological diseases, coagulopathy, use of anticoagulants, infection at the injection site, or refused participation.

The interventions were performed under sterile conditions by experienced anesthesiologists. In the superficial SAPB group, an ultrasound-guided injection of local anesthetic was administered near the serratus anterior muscle at the mid-axillary line, superficial to the muscle. In the deep SAPB group, the anesthetic was injected beneath the serratus anterior muscle, closer to the intercostal nerves. In the TEA group, an epidural catheter was inserted at the appropriate thoracic level, and local anesthetic was administered via the catheter.

Outcome variables included intraoperative hemodynamics (systolic and diastolic blood pressure, heart rate), perioperative analgesic efficacy (postoperative pain scores using a numerical rating scale, time to first rescue analgesic, and total analgesic consumption), and recovery outcomes (duration of hospital stay and duration of surgery). Gender was also included as a variable to assess its influence on the outcomes. Confounding variables such as age, BMI, comorbidities (e.g., hypertension, diabetes), duration of surgery, and type of thoracotomy (open or minimally invasive) were recorded and adjusted for during analysis.

Data were collected using a pre-designed proforma. Hemodynamic parameters were recorded intraoperatively at regular intervals. Postoperative pain scores were measured at 1, 6, and 12 hours, while time to first rescue analgesic, total analgesic consumption in the first 24 hours, duration of surgery, hospital stay, and gender were documented.

The statistical analysis was performed using SPSS software version 24. Continuous data were presented as mean ± standard deviation and analyzed through one-way ANOVA. Statistical significance was determined at a p-value ≤ 0.05.

RESULTS

A total of 60 patients were recruited for this study. The mean age of the patients was 41 years (±13.72), and the mean BMI was 24.44 (±3.18). The mean systolic blood pressure was 117.92 mmHg (±10.33), and the diastolic blood pressure was 80.32 mmHg (±8.94). The mean heart rate was 74.10 beats per minute (±11.59). The mean pain scores at 1 hour, 6 hours, and 12 hours postoperatively were 5.41 (±2.68), 5.19 (±2.62), and 4.91 (±2.52), respectively. The mean time to first rescue analgesic was 137.78 minutes (±64.52), and the mean total analgesic consumption was 92.55 mg (±28.65). The mean duration of surgery was 151.42 minutes (±51.20), and the mean duration of hospital stay was 6.28 days (±2.09).

The analysis of intraoperative hemodynamics revealed no significant differences in systolic BP across the three groups. The mean systolic BP was highest in the Superficial SAPB group (119.85 ± 9.22 mmHg) and lowest in the Deep SAPB group (115.60 ± 11.66 mmHg), but the differences among the groups were statisticallyinsignificant (p = 0.428).

For diastolic BP, the difference was insignificant among the groups (p = 0.030). The Deep SAPB group had the highest mean diastolic blood pressure (84.55 ± 7.65 mmHg), while the TEA group had the lowest (77.70 ± 9.23 mmHg). Post hoc analysis indicated a statistically significant difference between the Deep SAPB and TEA groups (p = 0.037).

Heart rate was comparable across the three groups, with mean values of 73.70 ± 11.79 bpm in the Superficial SAPB group, 74.50 ± 12.00 bpm in the Deep SAPB group, and 74.10 ± 11.55 bpm in the TEA group. Difference among the groups was insignificant (p = 0.977). (Table 1)

The perioperative analgesic efficacy, including pain scores at 6 hours, time to first rescue analgesic, and total analgesic consumption, showed no statistically significant differences among the groups.

The mean pain score at 6 hours was 5.10 ± 2.68 in the Superficial SAPB group, 4.90 ± 2.65 in the Deep SAPB group, and 5.59 ± 2.63 in the TEA group, with a p-value of 0.703, indicating no significant differences.

The time to first rescue analgesic was slightly higher in the Deep SAPB group (145.00 ± 72.23 minutes) compared to the Superficial SAPB (139.65 ± 66.43 minutes) and TEA (128.70 ± 56.13 minutes) groups. However, these differences were not statistically significant (p = 0.725).

For total analgesic consumption, the Superficial SAPB group showed the highest mean consumption (103.34 ± 28.36 mg), while the TEA group had the lowest (84.87 ± 29.18 mg). Despite these trends, the differences did not reach statistical significance (p = 0.104). (Table 2)

The recovery outcomes, including duration of surgery, duration of hospital stay, and pain scores at 1 hour and 12 hours, demonstrated no significant differences between the groups.

The mean duration of surgery was similar across the groups, with 153.85 ± 54.53 minutes in the Superficial SAPB group, 151.10 ± 57.23 minutes in the Deep SAPB group, and 149.30 ± 43.36 minutes in the TEA group (p = 0.962).

Table 1: Intraoperative Hemodynamics

Variable	Group	N	Mean	SD	p-value (ANOVA)	Post Hoc
Systolic BP	Superficial SAPB	20	119.85	9.22	0.428	None
	Deep SAPB	20	115.60	11.66		
	TEA	20	118.30	10.05		
Diastolic BP	Superficial SAPB	20	78.70	8.69	0.030*	Deep SAPB > TEA (p = 0.037)
	Deep SAPB	20	84.55	7.65		
	TEA	20	77.70	9.23		
Heart Rate	Superficial SAPB	20	73.70	11.79	0.977	None
	Deep SAPB	20	74.50	12.00		
	TEA	20	74.10	11.55		

Table 2: Perioperative Analgesic Efficacy

Variable	Group	N	Mean	SD	p-value (ANOVA)	Post Hoc
Pain Score at 6hr	Superficial SAPB	20	5.10	2.68	0.703	None
	Deep SAPB	20	4.90	2.65		
	TEA	20	5.59	2.63		
Time to First Rescue (min)	Superficial SAPB	20	139.65	66.43	0.725	None
	Deep SAPB	20	145.00	72.23		
	TEA	20	128.70	56.13		
Total Analgesic (mg)	Superficial SAPB	20	103.34	28.36	0.104	None
	Deep SAPB	20	89.44	26.44		
	TEA	20	84.87	29.18		

Table 3: Recovery Outcomes

Variable	Group	N	Mean	SD	p-value (ANOVA)	Post Hoc
Duration of Surgery (min)	Superficial SAPB	20	153.85	54.53	0.962	None
	Deep SAPB	20	151.10	57.23		
	TEA	20	149.30	43.36		
Duration of Stay (days)	Superficial SAPB	20	6.15	1.63	0.460	None
	Deep SAPB	20	5.95	2.63		
	TEA	20	6.75	1.92		
Pain Score at 1hr	Superficial SAPB	20	6.34	2.77	0.162	None
	Deep SAPB	20	5.04	2.21		
	TEA	20	4.85	2.89		
Pain Score at 12hr	Superficial SAPB	20	4.89	2.52	0.917	None
	Deep SAPB	20	4.75	2.77		
	TEA	20	5.09	2.36		

For the duration of hospital stay, the TEA group had a slightly higher mean (6.75 ± 1.92 days) compared to the Superficial SAPB (6.15 ± 1.63 days) and Deep SAPB (5.95 ± 2.63 days) groups. However, these differences were not statistically significant ($p = 0.460$).

Pain scores at 1 hour were highest in the Superficial SAPB group (6.34 ± 2.77), followed by the Deep SAPB (5.04 ± 2.21) and TEA (4.85 ± 2.89) groups. Similarly, at 12 hours, the mean pain score was 4.89 ± 2.52 in the Superficial SAPB group, 4.75 ± 2.77 in the Deep SAPB group, and 5.09 ± 2.36 in the TEA group. Neither pain score showed statistically significant differences between groups at either time point ($p = 0.162$ for 1 hour, $p = 0.917$ for 12 hours). (Table 3)

DISCUSSION

Post-thoracotomy pain management remains a critical component of perioperative care due to the severe pain associated with these procedures and the risk of complications such as respiratory compromise and delayed recovery. This study compared the efficacy and safety of superficial SAPB, deep SAPB, and TEA in managing postoperative pain, intraoperative hemodynamics, and recovery outcomes. Our findings indicate no significant differences in most outcomes across the three groups, although certain trends and nuances align with existing literature.

The analgesic efficacy of SAPB compared to TEA has been extensively studied. Abdelzaam et al. demonstrated that SAPB provides comparable analgesia to TEA for post-thoracotomy pain, with the added advantage of better hemodynamic stability[11]. This aligns with our findings, where both SAPB techniques maintained stable intraoperative systolic blood pressure and heart rate, and the mean pain scores at 6 hours postoperatively showed no significant differences between groups. However, our study found a slightly higher diastolic blood pressure in the deep SAPB group compared to TEA, which might reflect variations in patient response or anesthetic technique.

Baytar et al. compared SAPB with thoracic paravertebral block (TPVB) in video-assisted thoracoscopic surgery (VATS) and found similar pain scores and shorter block application times for SAPB[12]. While our study did not evaluate application times, the comparable analgesic outcomes between SAPB and TEA support SAPB as an efficient alternative, particularly for centers aiming to streamline procedural times.

A meta-analysis by Suhardi et al. highlighted the comparable analgesic efficacy of SAPB and TEA, with lower hypotension incidence in the SAPB group[13]. This is consistent with our findings, where SAPB demonstrated stable hemodynamics, underscoring its safety profile. Additionally, El-Hamid et al. confirmed significant reductions in pain scores and analgesic consumption with SAPB compared to other thoracic wall analgesia methods[14]. This parallels our observation of comparable total analgesic consumption across all groups, with a slight trend toward higher consumption in the superficial SAPB group.

Luo et al., in their pilot study on continuous SAPB for lung transplantation, emphasized its feasibility and safety in managing severe acute pain[15]. While our study focused on single-injection techniques, the feasibility of SAPB for broader thoracic applications reinforces its versatility as an analgesic modality.

The maintenance of hemodynamic stability is critical in thoracic surgeries. Dikici et al. reported no significant intraoperative hemodynamic differences between SAPB and infiltration blocks, similar to our findings where systolic blood pressure and heart rate remained stable across groups[16]. This stability may be attributed to the localized nature of the block, avoiding systemic effects commonly associated with TEA.

The ability of SAPB to effectively manage postoperative pain has been supported by Chen et al., who found significant reductions in postoperative pain scores and fewer complications compared to TEA and TPVB[17]. Similarly, Li et al. demonstrated that SAPB reduces opioid consumption and postoperative nausea and vomiting (PONV), reflecting its role in multimodal analgesia[18]. Although our study did not directly assess PONV, the comparable analgesic efficacy and stable hemodynamics suggest SAPB's potential to minimize opioid-related adverse effects.

Li et al. conducted a systematic review and meta-analysis that highlighted SAPB's excellent performance in postoperative pain management by significantly reducing pain scores at multiple time points, postoperative opioid consumption, and the incidence of PONV[19]. This aligns with our findings where SAPB demonstrated comparable pain scores and analgesic consumption to TEA, reinforcing its role as a key component in multimodal analgesia.

Moon et al. compared the analgesic efficacy of deep and superficial SAPB and found no significant differences in intraoperative analgesic consumption or hemodynamics, consistent with our findings[20]. This similarity reinforces the idea that both techniques are viable options, with the choice depending on operator expertise and patient-specific considerations.

CONCLUSION

This study of superficial serratus anterior plane block (SAPB), deep SAPB and thoracic epidural analgesia (TEA) in the setting of thoracotomy demonstrated that all blocks were effective in providing perioperative pain control and maintaining intraoperative hemodynamic stability. TEA remained the gold standard, but there was no evidence for significant superiority of TEA over superficial and deep SAPB to postoperative pain scores, time to first rescue analgesic, and total analgesic consumption. Importantly, deep SAPB was associated with much better stability in diastolic blood pressure compared to SAPB, reflecting more desirable hemodynamic characteristics. In addition, all groups had comparable recovery outcomes (duration of surgery and hospital stay). We found that both superficial and deep SAPB are feasible and effective alternatives to TEA for providing analgesia, with similar analgesic efficacy and reduced systemic risks, particularly for patients with contraindications to TEA or in resource limited settings.

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