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# Serratus anterior plane block in pain management after thoracotomy surgery: A randomized single-blinded clinical trial and literature review

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# Abstract

### Background

Post-thoracotomy pain is often severe and prolonged and leads to chronic post-surgical pain syndromes or respiratory complications. Accordingly, it is imperative to ascertain and implement optimal pain control strategies to enhance clinical outcomes. This study aimed to assess the promising efficacy of the serratus anterior plane block (SAPB) against standard analgesia in acute post-thoracotomy pain management.

### Method

In this assessor-blinded clinical trial, 120 eligible patients scheduled for thoracotomy surgery were randomly assigned (1:1) to either of two groups: one group received only conservative pain control medication, while the other group underwent additional SAPB (30 mL 0.25% bupivacaine + dexmedetomidine 0.5 µg/kg) to manage postoperative pain. Pain intensity was evaluated using the visual analog scale (VAS 0–10) at intervals of 6, 12, and 24 hours post-surgery.

### Results

The pain scores in both groups showed a significant decrease throughout the study period. In addition, the SAPB group reported significantly lower pain scores at all three checkpoints compared to the control group. Pain intensity was not correlated with age, gender, BMI, operation duration, or surgical procedure types.

### Conclusion

SAPB significantly aids mitigation of early post-thoracotomy pain as a multimodal analgesia without occurrence of any serious side effects.

*Trial registration: Iranian Registry of Clinical Trials (IRCT20230416057931N1|| https://irct.behdasht.gov.ir/trial/70771), 02.10.2023*


# Introduction

Thoracic surgery, including thoracotomy, is a common therapeutic approach for conditions ranging from infections to malignancies. Thoracotomy is frequently associated with severe postoperative pain that may persist for an extended period following surgery and develop into post-thoracotomy pain syndrome (PTPS), a neuropathic pain condition localized along the incision site that impairs physical function. Patients undergoing thoracotomy often require higher doses of analgesic medications compared with those undergoing abdominal procedures (1–4). Inadequate management of acute post-thoracotomy pain can adversely affect recovery and rehabilitation and lead to respiratory complications such as hypoventilation, hypoxemia, atelectasis, pneumonia, and, in severe cases, respiratory failure (5–7).

Factors such as surgical technique and patient age have been identified as significant risk factors for PTPS, which affects more than half of thoracotomy patients (4).

Given the complex pathophysiology of post-thoracotomy pain, a multimodal approach targeting multiple pain pathways is increasingly recommended for achieving better acute pain control (4, 8). Rational combination of analgesic techniques with different mechanisms of action can enhance pain relief and minimize side effects (5). An optimal strategy for post-thoracotomy pain management typically includes a regional block in conjunction with systemic analgesics such as opioids and nonsteroidal anti-inflammatory drugs (NSAIDs) (8). These traditional analgesics are commonly prescribed, but must be used cautiously. NSAIDs can reduce inflammation and opioid requirements but carry risks of coagulopathy, renal dysfunction, and gastrointestinal bleeding, particularly in older patients. Opioids, while effective for severe pain, are associated with numerous adverse effects, including respiratory depression, sedation, constipation, urinary retention, nausea, vomiting, and pruritus. Therefore, opioids are considered a reserve therapy for cases where pain does not respond to NSAIDs as a first-line treatment option (5, 8).

Regional analgesic techniques for thoracotomy such as intercostal, thoracic paravertebral, and thoracic fascial plane blocks, offer effective pain relief by targeting thoracic peripheral nerves with minimal complications (9, 10). Among them, the serratus anterior plane block (SAPB) is a relatively novel regional technique that provides analgesia across the hemithorax from T2 to T9 dermatomes. By blocking the lateral and anterior cutaneous branches of the intercostal nerves, SAPB offers effective pain relief with few complications, such as local anesthetic hypersensitivity, pneumothorax, or block failure. It is particularly advantageous due to its applicability in most thoracotomy cases, ease of performance in the supine position, and suitability for patients with coagulopathy, traumatic injuries, and head or neck injuries (11–14).

Recent studies have demonstrated SAPB to be a safe and effective method for pain control following thoracotomy yet its efficacy compared to conventional analgesia and its impact across diverse patient subgroups remain underexplored (15–17). This study addresses the critical gap in understanding SAPB's role in optimizing multimodal pain management strategies, ultimately enhancing clinical practice and patient outcomes following thoracotomy.

## Materials and Methods

# Study design and participants

This randomized assessor-blinded clinical trial was conducted at the Shariati Hospital, Tehran, Iran. Our trial population was randomly selected from patients aged 18 years or above who were scheduled for posterolateral thoracotomy. We employed the American Society of Anesthesiologists classification of physical status (ASA PS) as a grading system to assess the preoperative health and determine surgical risk. The ASA system defines patients into six groups (18); however, we only included cases that were

categorized as I (mild underlying disease) and II (controlled underlying disease and no functional limitation). Moreover, participants who met the following criteria were excluded: a history of local anesthetic hypersensitivity, any coagulation disorders, unstable hemodynamics (systolic blood pressure < 90 mm-Hg or mean arterial pressure < 60 mm-Hg), infection at incision sites, and refusal to participate in the study.

Pain intensity was assessed at 6, 12, and 24 hours post-surgery using the visual analog scale (VAS). The VAS is a simple self-report tool consisting of a 100-mm horizontal line representing pain intensity, with 0 indicating “no pain” and 10 representing “the worst imaginable pain” (19).

## Concealment and Randomization

Participants were randomly assigned to either the intervention (SAPB) or control group via an online block randomization tool (20) using sealed opaque envelopes, which were opened by the surgical team. As SAPB was performed under general anesthesia; therefore, patients were blinded to group allocation. Allocation was also concealed from outcome assessors.

## Intervention and data collection

All consenting participants completed a demographic information checklist before surgery. Intraoperative and post-anesthesia monitoring included continuous electrocardiogram (ECG), pulse oximetry (PO), non-invasive blood pressure (BP) measurement, and oxygen at 4 L/min via nasal cannula prior to anesthesia. Detailed hemodynamic parametrs were not formally included for analysis.

All patients underwent posterolateral thoracotomy under general anesthesia. In the intervention group, SAPB was performed before surgical wound closure. The anesthetic mixture consisted of dexmedetomidine (0.5 μg/kg) and 30 mL of 0.25% bupivacaine diluted in 2 mL of normal saline. The solution was injected gradually into the fascia between the serratus anterior and latissimus dorsi muscles with a 22-gauge needle while patients were in the lateral position. The control group did not receive a sham injection. Both groups received standard postoperative pain management, consisting of diclofenac suppositories or intravenous paracetamol, along with intramuscular morphine (5 mg) every 8 hours. Additional rescue analgesia with intravenous morphine (2–3 mg) was administered in cases of breakthrough pain (VAS > 6). The incidence of nausea and vomiting was recorded after recovery from anesthesia.

# Statistical analysis

The sample size was calculated based on the study by Ökmen et al. (15) and assuming 80% power and a significance level of 0.05. The minimum required sample size was calculated as 60 participants per group to detect a clinically meaningful difference in pain intensity scores.

$$n = \frac{\left(Z_{\alpha/2} + Z_{\beta}\right)^2 \times 2\sigma^2}{\left(\mu_1 - \mu_2\right)^2} = \frac{(1.96 + 0.84)^2 \times 2 \times 0.967^2}{(0.5)^2} \approx 60$$

All statistical analyses were performed using SPSS software version 27.0 (IBM Corp., Armonk, NY, USA). Categorical variables (e.g., gender, underlying disease, surgical incision site, and postoperative complications) were summarized as frequencies and percentages (n, %). Quantitative variables (e.g., age, BMI, operation duration, and pain intensity scores), were expressed as mean ± standard deviation (SD). The Mann-Whitney U test was used to compare quantitative variables between the SAPB and control groups, as most did not follow a normal distribution on the Shapiro-Wilk test. The Chi-square test was applied to evaluate associations between categorical variables. Multivariate linear regression was performed to evaluate the effect of our intervention on pain scores in all time checkpoints. The model was adjusted with age, gender, BMI, surgical procedure, and operation duration. Interaction between treatment group and gender was also examined in sensitivity analyses to assess whether the analgesic effect of SAPB differed between males and females at any time checkpoint. All tests were two-tailed, and a p-value of less than 0.05 was considered to indicate significance. Results are presented as mean differences with corresponding 95% confidence intervals (95% CI).

We used the CONSORT reporting guideline to draft this manuscript, and the CONSORT reporting checklist when editing (21), included in supplements.

## Results

One hundred twenty patients were randomized equally to the SAPB (Intervention) and control groups (Fig. 1). Table 1 presents the baseline characteristics of participants by study group. The mean age was 47.87 ± 14.64 years, with 36% female participants. Mean operative duration for the whole cohort was 3.87 ± 1.74 hours. The two groups were comparable in terms of age, BMI, operation duration, comorbidities, surgical incision site, or postoperative complications. On the other hand, there was a significant difference in gender distribution between the groups. The proportion of female patients in the control group (50%) was significantly higher than in the SAPB group (23.3%, *P* = 0.032). No significant differences were observed between groups regarding postoperative nausea or vomiting (*P* = 0.48 and *P* = 0.62, respectively). No SAPB-related adverse events requiring intervention, such as hemodynamic instability, hypersensitivity to local anesthetic, pneumothorax, or block failure, were reported in the intervention group.

Postoperative pain scores (VAS) at 6, 12, and 24 hours post-surgery were significantly lower in the SAPB group (Table 2). Multivariate linear regression model for adjusted variables (i.e., group, age, gender, BMI, type of surgical procedure, and duration of operation) confirmed that the treatment effect of SAPB remains associated with significantly lower postoperative pain at all three postoperative time checkpoints with no significant influence of the aforementioned covariates (Tables 3–5). Despite significant imbalance in gender distribution, sensitivity analysis (including the interaction term between treatment group and gender) did not show significant interaction effects at any time point and

adjustment for gender did not change the results. This indicates that the analgesic benefit of SAPB was similar in males and females.

## Discussion

This study demonstrates that the SAPB may be regarded as a safe and effective method for management of post-thoracotomy pain. Patients receiving SAPB experienced significantly better pain control compared to standard analgesic therapy alone. The adjusted analysis did not show significant associations between SAPB efficacy and demographic or procedural factors such as age, gender, BMI, operation duration, or surgical procedure. Hence, SAPB retained its significant performance in efficient reduction of post-thoracotomy pain after 6, 12, and 24 hours. Interestingly, patients undergoing esophagectomy experienced significantly higher pain scores at 6 hours postoperatively, even after adjustment for treatment group and other covariates. This effect disappeared at 12 and 24 hours. This early difference is likely attributable to the greater extent of surgical trauma and extensive manipulation of the esophagus and mediastinum in esophagectomy compared with other procedures such as lobectomy or hydatid cystectomy.

Several previous studies have supported the efficacy of SAPB in managing post-thoracotomy pain using various methodologies. In a retrospective clinical trial with a similar design to ours, researchers compared SAPB with standard pharmacologic therapy. They found that patients in the SAPB group required less morphine and experienced greater pain relief during the first 24 hours post-surgery, with no increase in complications such as nausea, vomiting, respiratory depression, or hypotension (15). These results align with the outcomes of our own trial.

A randomized controlled trial that followed thoracotomy patients with chest malignancies over an extended period reported that continuous SAPB significantly reduced the incidence and severity of post-thoracotomy pain syndrome compared with patient-controlled intravenous analgesia (PCA). The SAPB group had a significantly lower risk of PTPS at 8 weeks post-surgery, along with lower VAS scores and opioid requirements at 8 and 12 weeks compared to the PCA group. The SAPB group also exhibited a lower incidence of adverse effects, including nausea and vomiting, sedation, dizziness, constipation, urinary retention, excessive sweating, dry mouth and itching (22). In contrast, our study found no significant difference in manifestation of nausea and vomiting between groups.

Comparative studies have evaluated SAPB against other regional block techniques and yielded mixed findings. A trial involving lung cancer patients undergoing lobectomy confirmed that thoracic paravertebral block (TPVB) and SAPB effectively reduced pain and opioid consumption in the first 24 hours after thoracotomy (16). Furthermore, an observer-blinded randomized trial involving patients with ASA PS class II and III undergoing thoracotomy, recommended SAPB as a safe and more effective alternative to thoracic epidural analgesia (TEA) for thoracotomy pain management (17). Similarly, pediatric trials have shown SAPB to be superior to intercostal nerve block (ICNB) and pectoral nerve (Pecs) II block for postoperative pain control following thoracic surgery, with a significant difference

appearing at 12 hours post-surgery (23, 24). Conversely, other investigations have suggested that TEA, erector spinae plane block (ESPB), and TPVB may outperform and provide longer-lasting analgesia than SAPB (25–27). Additionally, both ESPB and SAPB techniques improved respiratory function (27). Despite evidence favoring other techniques for acute pain control and duration of analgesia, SAPB remains advantageous due to its ease of performance and low complication rate, particularly regarding hypotension and bradycardia (16). Continuous SAPB via catheter placement can extend its analgesic effect (28, 29). Furthermore, the choice of anesthetic agents for nerve block can enhance efficacy; for instance, adding dexmedetomidine to levobupivacaine in SAPB significantly reduced VAS scores compared with levobupivacaine alone (30).

Our study encountered several limitations, including a limited number of patients and relatively short follow-up duration, which prevents assessment of chronic outcomes such as possible alleviation of PTPS or rebound pain. Additionally, we were unable to evaluate cumulative opioid or NSAID consumption data, which could provide further insight into analgesic effectiveness. As this is a single-center trial, generalizability may be limited. Despite these limitations, the findings have clinical and theoretical implications in thoracic surgery, where effective pain management is critical to preventing complications like hypoventilation and atelectasis. SAPB may represent a minimally invasive and technically straightforward alternative for ASA III-IV as well, whereas complex regional techniques such as TEA or TPVB are less feasible. The ability to perform SAPB in the supine position and its safety profile make it particularly advantageous for critical patients and advocates reduced opioid use. Future studies with larger populations and longer follow-up durations are recommended to provide more robust conclusions and further refine post-thoracotomy pain management protocols.

## Conclusion

This study suggests that SAPB might be an effective, safe, and easily applicable regional analgesic technique for early management post-thoracotomy pain. SAPB enhances patient comfort and may facilitate faster recovery by significantly reducing postoperative pain intensity without increasing complications. These findings contribute to the growing evidence supporting regional blocks in thoracic surgery and highlight advantages of SAPB over traditional analgesia.

## Abbreviations

SAPB: Serratus anterior plane block

ASA PS: The American Society of Anesthesiologists classification of physical status

PTPS Post-thoracotomy pain syndrome

NSAID: Non-steroidal anti-inflammatory drugs

BMI: Body mass index

VAS: Visual analog scale

TEA: Thoracic epidural analgesia

ESPB: Erector spinae plane block

TPVB: Thoracic paravertebral block

PCA: Patient-controlled analgesia

Pecs II: pectoral nerves (Pecs) II block

ICNB: Intercostal nerve block

# Declarations

**Ethical approval and consent to participate**

The Medical Research Ethics Committee of Shariati Hospital, affiliated with Tehran University of Medical Sciences, approved this clinical research (Approval code: IR. TUMS.SHARIATI.REC.1402.038). The study protocol was also registered on the Iranian registry website for clinical trials (ID: IRCT20230416057931N1, *02.10.2023* || https://irct.behdasht.gov.ir/trial/70771) (31). All participants received comprehensive information about the study's aims, procedures, potential benefits, and risks, and signed an informed consent form after clarification of any questions or withdrawn if they wished to forfeit while receiving standard care. Participants were assured of the confidentiality of their personal data, and the contact information of the assigned researcher was provided for any inquiries. All procedures were adhered to the tenets of the Declaration of Helsinki (1964) and its later amendments about biomedical studies involving human participants.

**Competing interests:**

All authors declare that they have no conflict of interest.

# Use of AI tools

The authors used AI-based tools only for language editing and grammar checking. No content was generated by AI, and the authors take full responsibility for the integrity and originality of the manuscript.

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# Author Contribution

RE and KN designed the current study. RE, FE, TS, NM and AM conducted the surgery and the SAPB teqnique on the patients and also along with YF contributed to evaluation of the patients. YF contributed to data curation and primary draft. AE performed data analysis and completed the draft. All authors provided critical opinions regarding the final manuscript. All authors take full responsibility for their contribution to this study and also they all reviewed and approved the final manuscript.

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# Data Availability

All data from the present clinical trial, except for the personal information of participants, are available from the corresponding author upon reasonable request.

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# Tables

**Table 1.** Baseline characteristics of the included patients

| Variables | | Total: (n=120) | SAPB group: (n=60) | Control group: (n=60) | P |
|---|---|---|---|---|---|
| **Age, years (mean ± SD)** | | 47.87 ± 14.64 | 49.07 ± 14.31 | 46.67 ± 15.1 | 0.64 |
| **Gender, n (%)** | **Female** | 44 (36.7) | 14 (23.3) | 30 (50.0) | 0.03 |
| | **Male** | 76 (63.3) | 46 (76.7) | 30 (50.0) | |
| **Underlying disease, n (%)** | **No** | 36 (30.00) | 16 (26.70) | 20 (33.30) | 0.57 |
| | **Yes** | 84 (70.00) | 44 (73.30) | 40 (66.70) | |
| **BMI, kg/m$^2$ (mean ± SD)** | | 24.19 ± 3.508 | 24.83 ± 3.06 | 23.55 ± 3.83 | 0.11 |
| **Surgery incision sites, n (%)** | **4th intercostal space** | 36 (30.0) | 20 (33.3) | 16 (26.7) | 0.45 |
| | **5th intercostal space** | 44 (36.7) | 24 (40.0) | 20 (33.3) | |
| | **6th intercostal space** | 36 (30.0) | 16 (26.7) | 20 (33.3) | |
| | **7th intercostal space** | 4 (3.3) | 0 (0.0) | 4 (6.7) | |
| **Surgical Procedure, n (%)** | **Hydatid Cystectomy** | 16 (13.3) | 9 (15) | 7 (11.7) | 0.44 |
| | **Lobectomy** | 21 (17.5) | 11 (18.3) | 10 (16.7) | |
| | **Esophagectomy** | 10 (8.3) | 4 (6.7) | 6 (10) | |
| | **Metastatectomy** | 8 (6.7) | 4 (6.7) | 4 (6.7) | |
| | **Mediastinal** | 2 (1.7) | 1 (1.7) | 1 (1.7) | |
| | **Others** | 3 (2.5) | 1 (1.7) | 2 (3.3) | |
| **Operation duration, hours (mean ± SD)** | | 3.87 ± 1.742 | 3.73 ± 1.187 | 4 ± 2.17 | 0.90 |
| **Complications, n (%)** | **Nausea** | 22 (18.3) | 12 (20.0) | 10 (16.7) | 0.73 |
| | **Vomiting** | 16 (13.3) | 6 (10) | 10 (16.7) | |
| | **No complication** | 82 (68.3) | 42 (70.0) | 40 (66.6) | |

**Table 2.** Comparison of pain scores (VAS) in the three assessment checkpoints between two groups

| Pain intensity | | SAPB group: (N=60) | Control group: (N=60) | P |
|---|---|---|---|---|
| **6 h after surgery** | **Mean ± SD** | 3.30 ± 1.56 | 6.27 ± 1.80 | <0.001 |
| | **95% CI** | 2.91 – 3.69 | 5.82 – 6.73 | |
| **12 h after surgery** | **Mean ± SD** | 1.73 ± 1.23 | 5 ± 1.23 | <0.001 |
| | **95% CI** | 1.42 – 2.04 | 4.69 – 5.31 | |
| **24 h after surgery** | **Mean ± SD** | 1.30 ± 1.39 | 3.77 ± 1.46 | <0.001 |
| | **95% CI** | 0.95 – 1.65 | 3.40 – 4.14 | |
| **First 24 h after surgery P-value** | | <0.001 | <0.001 | |

**Table 3.** Multivariate regression analysis for the first time checkpoint (6h)

| Pain score (6h) | | Coefficient | P | 95% CI |
|---|---|---|---|---|
| **Group** | **Control** | baseline | | |
| | **Intervention** | -2.95 | 0.00 | -3.85 – -2.05 |
| **Age** | | -0.01 | 0.36 | -0.05 – 0.02 |
| **Gender** | **Female** | baseline | | |
| | **M** | 0.10 | 0.84 | -0.90 – 1.10 |
| **BMI** | | 0.06 | 0.38 | -0.08 – 0.21 |
| **Surgical procedure** | **cystectomy** | baseline | | |
| | **lobectomy** | 0.43 | 0.46 | -0.73 – 1.59 |
| | **esophagectomy** | 2.55 | 0.01 | 0.72 – 4.37 |
| | **metastatectomy** | 0.57 | 0.45 | -0.94 – 2.08 |
| | **mediastinal** | 2.00 | 0.13 | -0.59 – 4.58 |
| | **others** | -0.56 | 0.61 | -2.78 – 1.66 |
| **Operation duration** | | -0.18 | 0.26 | -0.51 – 014 |

**Table 4.** Multivariate regression analysis for the second time checkpoint (12h)

| Pain score (12h) | | Coefficient | P | 95% CI |
|---|---|---|---|---|
| **Group** | **Control** | baseline | | |
| | **Intervention** | -3.20 | 0.00 | -3.91 – -2.48 |
| **Age** | | -0.01 | 0.71 | -0.03 – 0.02 |
| **Gender** | **Female** | baseline | | |
| | **M** | -0.08 | 0.84 | -0.87 – 0.71 |
| **BMI** | | -0.03 | 0.59 | -0.14 – 0.08 |
| **Surgical procedure** | **cystectomy** | baseline | | |
| | **lobectomy** | 0.27 | 0.56 | -0.64 – 1.18 |
| | **esophagectomy** | 0.90 | 0.21 | -0.54 – 2.34 |
| | **metastatectomy** | 0.17 | 0.77 | -1.02 – 1.36 |
| | **mediastinal** | 0.17 | 0.86 | -1.86 – 2.22 |
| | **others** | -0.77 | 0.38 | -2.52 – 0.98 |
| **Operation duration** | | -0.10 | 0.42 | -0.36 – 0.15 |

**Table 5.** Multivariate regression analysis for the third time checkpoint (24h)

| Pain score (24h) | | Coefficient | P | 95% CI |
|---|---|---|---|---|
| **Group** | **Control** | baseline | | |
| | **Intervention** | -2.46 | 0.00 | -3.30 – -1.62 |
| **Age** | | 0.01 | 0.66 | -0.02 – 0.04 |
| **Gender** | **Female** | baseline | | |
| | **M** | -0.11 | 0.81 | -1.05 – 0.83 |
| **BMI** | | -0.02 | 0.74 | -0.16 – 0.11 |
| **Surgical procedure** | **cystectomy** | baseline | | |
| | **lobectomy** | -0.14 | 0.80 | -1.22 – 0.94 |
| | **esophagectomy** | -0.28 | 0.74 | -1.99 – 1.42 |
| | **metastatectomy** | -0.34 | 0.63 | -1.75 – 1.07 |
| | **mediastinal** | -0.13 | 0.92 | -2.54 – 2.29 |
| | **others** | -1.13 | 0.28 | -3.20 – 0.94 |
| **Operation duration** | | 0.07 | 0.64 | -0.23 – 0.37 |

# Figures

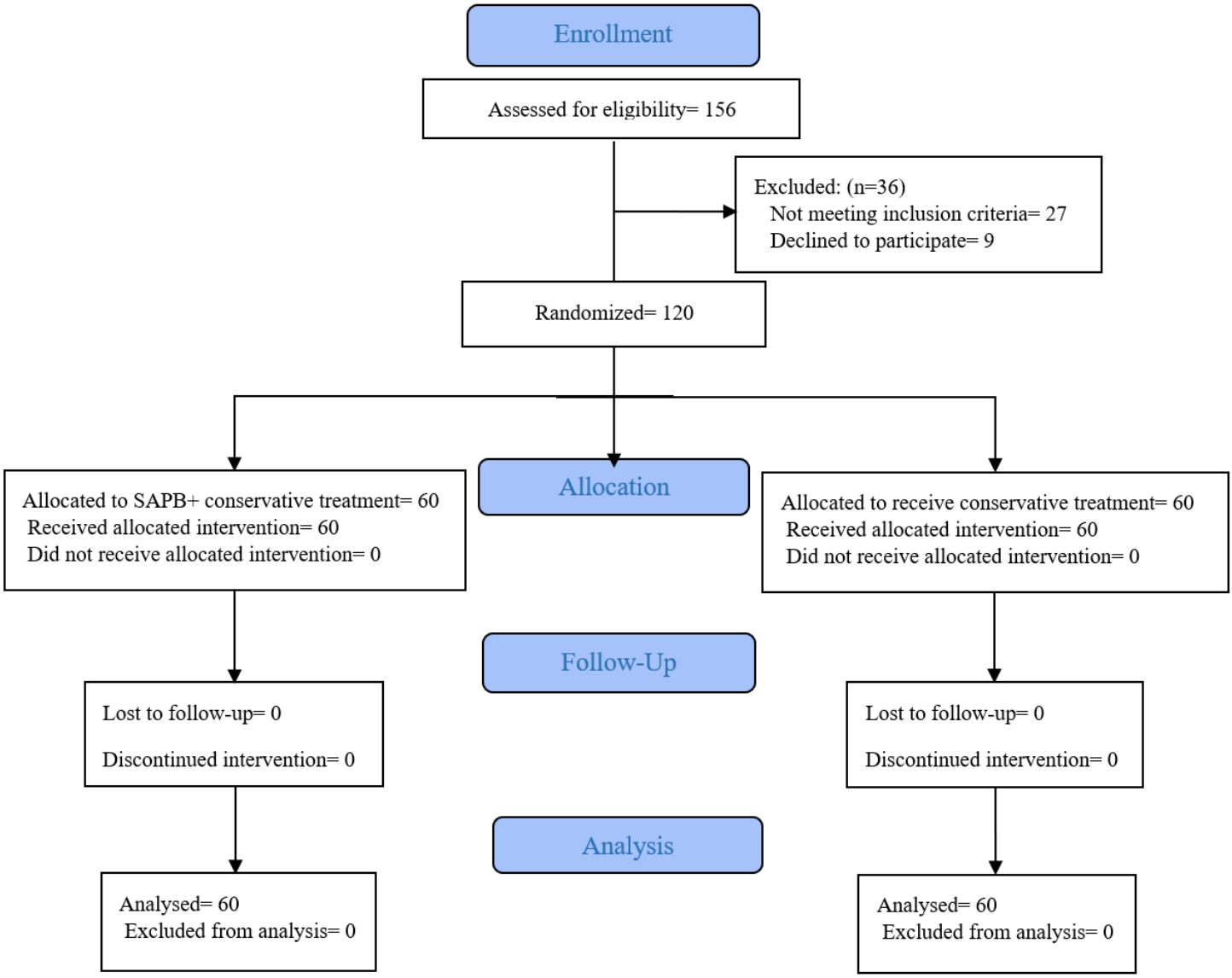



**Figure 1**

CONSORT flow diagram of study