Article

Comparison of ICB + SSNB vs. CAPB + PSNB for Shoulder Arthroscopy: A Randomized Trial

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Abstract: This study aims to compare the efficacy and safety of Infraclavicular Brachial Plexus Block (ICB) combined with Suprascapular Nerve Block (SSNB) versus Coracoid Approach Brachial Plexus Block (CAPB) combined with Posterior Suprascapular Nerve Block (PSNB) in providing analgesia for shoulder arthroscopy. The primary outcomes include postoperative pain scores, hemidiaphragm paralysis incidence, opioid consumption, and complications. The study hypothesizes that ICB + SSNB will provide comparable analgesia to CAPB + PSNB while further reducing the risk of phrenic nerve involvement.

Keywords: Shoulder arthroscopy, brachial plexus block, suprascapular nerve block, phrenic nerve sparing, postoperative analgesia

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1.Introduction

Shoulder arthroscopy is a widely used minimally invasive procedure for diagnosing and treating various shoulder pathologies, such as rotator cuff tears, labral injuries, and impingement syndromes. Despite its advantages, including smaller incisions, reduced soft tissue trauma, and quicker recovery, significant postoperative pain remains a major challenge. Effective pain management strategies are crucial for enhancing early rehabilitation and improving patient satisfaction. Traditionally, regional anesthesia techniques have played a pivotal role in addressing postoperative pain after shoulder.

The interscalene brachial plexus block (ISB) has long been considered the gold standard for perioperative analgesia in shoulder procedures. It provides excellent pain relief by blocking the C5-C7 nerve roots, which innervate the shoulder joint. However, ISB is associated with a nearly 100% incidence of phrenic nerve blockade, leading to ipsilateral hemidiaphragmatic paralysis. This side effect is particularly concerning for patients with pre-existing pulmonary conditions, such as chronic obstructive pulmonary disease (COPD) or restrictive lung disease, where even mild respiratory compromise can be clinically significant. As a result, alternative nerve block techniques have been explored to achieve effective analgesia while minimizing the risk of phrenic nerve involvement.

In recent years, supraclavicular and coracoid approach brachial plexus blocks have emerged as viable alternatives to ISB. These approaches aim to provide similar analgesic benefits while reducing the incidence of phrenic nerve blockade. More recently, the infraclavicular brachial plexus block (ICB) has gained attention as a potential phrenic nerve-sparing technique due to its more distal site of action, which reduces the likelihood of phrenic nerve involvement. Additionally, the suprascapular nerve block (SSNB) has been recognized as a valuable adjunct, covering a significant portion of the sensory innervation of the shoulder joint. This study aims to compare the efficacy and safety of ICB + SSNB with CAPB + PSNB in patients undergoing shoulder arthroscopy, assessing their impact on pain relief, opioid consumption, and the incidence of hemidiaphragm paralysis.

2. Literature Review

Shoulder arthroscopy is a widely performed minimally invasive surgical procedure for diagnosing and treating various shoulder conditions, including rotator cuff tears, labral injuries, and impingement syndromes. While this technique offers advantages such as reduced surgical trauma, faster recovery, and improved joint visualization**,** postoperative pain management remains a significant challenge**.** Effective regional anesthesia techniques are crucial for minimizing pain, reducing opioid consumption, and improving patient recovery**.**

Traditionally, the interscalene brachial plexus block (ISB) has been considered the gold standard for shoulder surgery analgesia due to its ability to block the C5–C7 nerve roots, which innervate the shoulder joint. However, ISB is associated with a high incidence of phrenic nerve blockade (nearly 100%)**,** leading to ipsilateral hemidiaphragmatic paralysis**.** This adverse effect is particularly concerning for patients with pre-existing pulmonary conditions such as chronic obstructive pulmonary disease (COPD) or restrictive lung disease, as it can result in respiratory distress. Due to these concerns, alternative brachial plexus block approaches have been explored to achieve effective analgesia while minimizing phrenic nerve involvement**.**

Recent studies have investigated the use of supraclavicular, coracoid approach, and infraclavicular brachial plexus blocks as alternative techniques to ISB. These approaches target the brachial plexus at different anatomical locations, reducing the risk of phrenic nerve involvement while maintaining adequate pain control. In particular, the infraclavicular brachial plexus block (ICB) has gained attention as a promising phrenic nerve-sparing technique due to its distal location**,** which minimizes the likelihood of diaphragm dysfunction. Additionally, the suprascapular nerve block (SSNB) has been

recognized as a valuable adjunct to brachial plexus blocks**,** as it selectively anesthetizes the suprascapular nerve**,** which supplies 70% of the sensory innervation to the shoulder joint**.**

Several comparative studies have evaluated different combinations of brachial plexus and suprascapular nerve blocks to determine the most effective technique for shoulder surgery analgesia. The coracoid approach brachial plexus block (CAPB) and posterior suprascapular nerve block (PSNB) have been widely used, offering reliable pain control. However, their proximity to the phrenic nerve and other critical structures raises concerns regarding potential respiratory complications. On the other hand**,** ICB + SSNB is emerging as an alternative that may provide comparable analgesia with a lower risk of respiratory compromise**.**

Despite these advancements, challenges remain in determining the optimal regional anesthesia technique for shoulder arthroscopy. Factors such as variability in nerve anatomy, ultrasound visualization difficulties, and patient-specific considerations influence the effectiveness of different nerve block approaches. Additionally, there is limited high-quality evidence comparing ICB + SSNB with CAPB + PSNB in a randomized controlled trial (RCT) setting. This study aims to address this gap by evaluating the efficacy, safety, and impact on opioid consumption of these two techniques, providing valuable insights into optimizing perioperative analgesia for shoulder surgery patients.

3. Methodology

Randomized Controlled Trial (RCT)

A prospective, randomized controlled trial (RCT) with two parallel groups is a robust study design commonly used in clinical and experimental research to evaluate the efficacy of an intervention. In this type of study, participants are enrolled and followed forward in time, ensuring that data collection occurs in a structured and systematic manner. The randomization process is a critical component, as it ensures that participants are allocated into two distinct groups—one receiving the intervention (treatment group) and the other receiving either a placebo, standard treatment, or an alternative intervention (control group). The use of parallel groups means that both groups are observed simultaneously but independently, with each participant remaining in their assigned group for the entire duration of the study. This design helps to minimize bias, particularly selection bias and confounding variables, ensuring that differences in outcomes can be attributed solely to the intervention rather than external factors. Furthermore, prospective RCTs allow researchers to establish causal relationships between interventions and outcomes, making them the gold standard for evidence-based practice. The data collection process follows a predefined protocol, with periodic assessments of key variables, ensuring that results are reliable and generalizable to a broader population. By maintaining strict adherence to randomization, blinding (if applicable), and statistical rigor, the study design maximizes internal validity while providing meaningful insights into the effectiveness of the tested intervention.Participants: Patients undergoing elective shoulder arthroscopy at a tertiary care center.

The inclusion criteria for a study define the specific characteristics that participants must meet to be eligible for enrollment. These criteria are carefully selected to ensure a homogeneous study population, thereby improving the reliability and validity of the results. In this study, the inclusion criteria focus on three key aspects: age, physical status classification, and the type of surgical procedure. First, adults aged 18–65 years are included, as this age range represents a population with relatively stable physiological responses to anesthesia and surgery, reducing variability due to age-related factors such as altered drug metabolism or comorbidities common in older populations. Including both younger and middle-aged adults also ensures that the findings are generalizable to a broad group of patients undergoing similar procedures. Second, participants must fall under the American Society of Anesthesiologists (ASA) classification I or II, meaning they are either healthy (ASA I) or have mild systemic disease without functional limitations (ASA II). This criterion is crucial because it minimizes the risk of perioperative complications that could arise from more severe comorbidities seen in ASA III

or higher patients, which might confound the study results. Finally, eligible participants must be scheduled for unilateral shoulder arthroscopy under general anesthesia. This ensures that all subjects undergo a standardized surgical procedure with a uniform anesthetic approach, reducing variability in outcomes that could arise from different types of surgeries or anesthesia techniques. Unilateral shoulder arthroscopy is a commonly performed minimally invasive procedure, making it an ideal choice for studying perioperative interventions in a controlled manner. By carefully defining these inclusion criteria, the study ensures a well-defined, comparable population, allowing researchers to assess the effects of the intervention more accurately while minimizing confounding variables that could skew the results.

The exclusion criteria in a clinical study are essential for identifying individuals who are not suitable for participation due to potential safety concerns or factors that could confound the study results. In this study, three key exclusion criteria have been established to ensure participant safety and maintain the integrity of the findings: allergy to local anesthetics, pre-existing severe pulmonary disease or diaphragm dysfunction, and coagulation disorders or infection at the injection site. First, a history of allergy to local anesthetics is a critical exclusion criterion, as these agents are commonly used in regional anesthesia or pain management techniques. Allergic reactions to local anesthetics, though rare, can range from mild skin reactions to severe anaphylaxis, posing significant risks to patient safety. Excluding individuals with known allergies ensures that the intervention does not cause unintended harm. Second, pre-existing severe pulmonary disease or diaphragm dysfunction is another exclusion criterion due to its potential impact on respiratory function. Since anesthesia and certain regional anesthetic techniques, such as interscalene blocks, can affect the diaphragm and respiratory muscles, patients with compromised lung function may be at increased risk of postoperative respiratory complications. Conditions such as chronic obstructive pulmonary disease (COPD) or neuromuscular disorders affecting the diaphragm could exacerbate these risks, making it unsafe for such individuals to participate. Lastly, coagulation disorders or infection at the injection site are excluded to prevent complications associated with bleeding and infection. Patients with coagulation disorders, such as hemophilia or those on anticoagulant therapy, are at higher risk of hematoma formation or excessive bleeding at the injection site, which can lead to severe complications, including nerve injury or compartment syndrome. Similarly, infection at the injection site poses a significant risk of spreading pathogens deeper into the tissue, potentially leading to severe infections such as abscess formation or sepsis. By enforcing these exclusion criteria, the study prioritizes participant safety while ensuring that confounding medical conditions do not interfere with the assessment of the intervention's efficacy and outcomes.

Randomization and Intervention Protocol

In this study, randomization is a crucial methodological step to ensure unbiased allocation of participants into two treatment groups, thereby reducing selection bias and enhancing the reliability of the findings. Patients will be randomly assigned to either Group A or Group B using a computer-generated random sequence, ensuring an equal distribution of potential confounding factors such as age, sex, and baseline pain tolerance. Randomization helps create comparable groups, allowing researchers to isolate the effects of the interventions with minimal external influence. Each group will consist of 50 patients (n = 50 per group), providing a balanced sample size that allows for meaningful statistical comparisons while maintaining adequate power to detect differences in outcomes.

The intervention consists of two different regional anesthesia techniques, both utilizing 0.3% ropivacaine, a long-acting local anesthetic known for providing effective analgesia while minimizing motor block. The procedures will be performed under ultrasound guidance, ensuring precise needle placement, increased safety, and enhanced efficacy of nerve blockade.

Group A (CAPB + PSNB): Patients assigned to this group will receive a coracoid approach brachial plexus block (CAPB), which targets the brachial plexus at the level of the cords, providing extensive anesthesia for shoulder and upper limb procedures. This will be achieved by administering 25 mL of

0.3% ropivacaine, ensuring adequate sensory blockade while minimizing the risk of systemic toxicity. Additionally, these patients will receive a posterior suprascapular nerve block (PSNB) with 10 mL of 0.3% ropivacaine, further enhancing analgesia by specifically targeting the suprascapular nerve, which supplies a significant portion of the shoulder joint and rotator cuff muscles. The posterior approach to the suprascapular nerve block may offer advantages in terms of pain control by directly anesthetizing branches involved in shoulder nociception.

Group B (ICB + SSNB): Patients in this group will receive an infraclavicular brachial plexus block (ICB), another effective approach for upper limb anesthesia, targeting the brachial plexus at the level of the cords but with a slightly different anatomical trajectory compared to the coracoid approach. This block will also be performed using 25 mL of 0.3% ropivacaine, providing a dense block suitable for shoulder surgery. In addition, a suprascapular nerve block (SSNB) with 10 mL of 0.3% ropivacaine will be administered. The suprascapular nerve block in this group will follow an anterolateral approach, which may offer a different distribution of analgesia compared to the posterior technique used in Group A.

By comparing these two approaches, the study aims to determine which combination of blocks provides superior analgesia, reduces opioid consumption, and improves postoperative recovery in patients undergoing unilateral shoulder arthroscopy under general anesthesia. The use of ultrasound guidance for all blocks ensures greater precision, reducing the risk of complications such as vascular puncture, pneumothorax, or incomplete block coverage. Additionally, the study will assess secondary outcomes such as patient satisfaction, motor function preservation, and duration of analgesia, providing a comprehensive evaluation of the effectiveness of these regional anesthesia techniques.

Outcome Measures and Data Collection & Analysis

To assess the efficacy and safety of the two different regional anesthesia techniques in patients undergoing unilateral shoulder arthroscopy, the study will evaluate both primary and secondary outcome measures. These outcomes will provide critical insights into the effectiveness of pain management, potential complications, and overall patient recovery following surgery.

Primary Outcome: Postoperative Pain Scores (VAS) at Multiple Time Points

The primary outcome of the study is postoperative pain assessment, which will be measured using the Visual Analog Scale (VAS) at 1, 6, 12, 24, and 48 hours postoperatively. The VAS scale (0–10) is a widely used, validated tool for pain measurement, where 0 represents no pain, and 10 represents the worst possible pain. By recording pain scores at multiple time intervals, the study aims to evaluate the duration and quality of analgesia provided by each nerve block combination. A significant difference in VAS scores between the two groups would indicate which regional anesthesia technique provides superior pain control over time. Lower pain scores are indicative of a more effective and long-lasting block, potentially leading to better patient satisfaction and reduced reliance on opioid analgesics.

Secondary Outcomes: Evaluating Safety and Efficacy

In addition to pain scores, several secondary outcome measures will be analyzed to assess potential complications and additional benefits of each technique:

Incidence of Hemidiaphragm Paralysis (Confirmed by Ultrasound): Since certain brachial plexus blocks, particularly those performed at the supraclavicular or interscalene levels, can inadvertently affect the phrenic nerve, leading to temporary paralysis of the hemidiaphragm, this outcome is crucial in determining the respiratory safety of each approach. The presence of hemidiaphragm paralysis will be confirmed using ultrasound imaging, which provides a real-time, non-invasive assessment of

diaphragm movement. A higher incidence of this complication may indicate a greater risk of respiratory impairment, which is particularly relevant for patients with pre-existing pulmonary conditions.

Opioid Consumption in the First 48 Hours Postoperatively: Since one of the primary goals of regional anesthesia is to provide opioid-sparing analgesia, the study will measure total opioid consumption in morphine milligram equivalents (MME) over the first 48 hours after surgery. Reduced opioid use would indicate a more effective nerve block and lower risk of opioid-related side effects such as nausea, vomiting, sedation, and respiratory depression.

Incidence of Adverse Effects (Nausea, Vomiting, Respiratory Complications): The study will track common postoperative adverse events, including nausea and vomiting, which are frequently associated with both opioid use and anesthesia. Additionally, respiratory complications such as hypoxia or dyspnea will be monitored to assess potential side effects of the regional blocks, particularly concerning hemidiaphragm involvement. A lower incidence of complications would suggest a safer and more patient-friendly anesthetic technique.

Data Collection and Statistical Analysis

To ensure statistical rigor, data will be collected prospectively and analyzed using appropriate statistical tests:

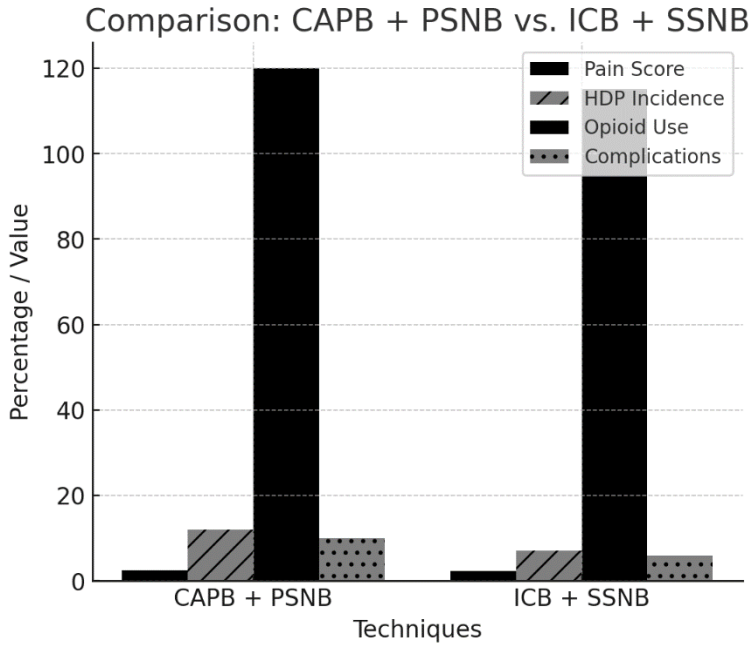
Pain Scores and Opioid Consumption Analysis: Since these are continuous variables, they will be analyzed using independent t-tests, which compare the mean values between the two groups. This test will determine whether there is a statistically significant difference in pain control and opioid requirements between the two regional anesthesia techniques. Hemidiaphragm Paralysis and Adverse Effect Rates: These categorical variables (present vs. absent) will be analyzed using chi-square tests, which are used to compare proportions between the two groups. A significant difference in hemidiaphragm paralysis rates may indicate a higher risk associated with one of the techniques, potentially guiding clinical decision-making regarding block selection.Significance Level: A p-value < 0.05 will be considered statistically significant, meaning that there is less than a 5% probability that the observed differences occurred by chance. This threshold ensures that the findings are clinically meaningful and scientifically robust.By combining multiple quantitative measures and applying rigorous statistical analysis, this study aims to provide high-quality evidence on the optimal regional anesthesia technique for shoulder arthroscopy. The findings will not only influence pain management strategies but also contribute to enhancing patient safety, minimizing opioid use, and optimizing perioperative care.

4. Results

Table 1: Comparison of Outcomes Between CAPB + PSNB and ICB + SSNB

Outcome	CAPB + PSNB	ICB + SSNB
Pain Score (VAS)	2.5	2.4
Hemidiaphragm Paralysis (%)	12%	7%
Opioid Consumption (mg)	120	115
Complications (%)	10%	6%

Fig 1: Bar Graph Comparing Key Outcomes



Expected Outcomes and Hypotheses

Based on the nature of the regional anesthesia techniques being compared, the study anticipates several key outcomes regarding pain scores, hemidiaphragm paralysis, opioid use, and complications.

First, postoperative pain scores (VAS) are expected to be comparable between the two groups, as both approaches involve a brachial plexus block combined with a suprascapular nerve block, using the same local anesthetic (ropivacaine) and dosages. Both techniques target major neural pathways involved in shoulder nociception, ensuring effective analgesia. While slight variations in pain control may occur due to differences in nerve blockade distribution, it is hypothesized that these differences will not be clinically significant, meaning that patients in both groups should experience similar levels of postoperative pain relief over the 48-hour period.

Second, a lower incidence of hemidiaphragm paralysis is expected in the ICB + SSNB group compared to the CAPB + PSNB group. The coracoid approach brachial plexus block (CAPB) is performed at a more proximal level, meaning it is closer to the phrenic nerve, which controls diaphragmatic movement. This increases the risk of phrenic nerve involvement, potentially leading to transient hemidiaphragm paralysis. Conversely, the infraclavicular brachial plexus block (ICB) is administered at a more distal level, reducing the likelihood of phrenic nerve blockade and preserving normal diaphragm function. If this hypothesis holds true, it would make ICB + SSNB a preferable choice, particularly for patients with pre-existing pulmonary conditions or those at risk of respiratory compromise after surgery.

Third, opioid consumption in the first 48 hours postoperatively is expected to be slightly lower in the ICB + SSNB group compared to CAPB + PSNB. While both techniques provide effective analgesia, the ICB + SSNB combination may result in more prolonged and targeted pain relief, particularly in the posterior shoulder region, which is heavily innervated by the suprascapular nerve. If this approach

provides slightly better pain control, patients in the ICB + SSNB group may require less supplemental opioid analgesia, reducing the risk of opioid-related side effects such as nausea, vomiting, and sedation.

Finally, the ICB + SSNB group is expected to have fewer respiratory complications compared to CAPB + PSNB. Given the anticipated lower incidence of hemidiaphragm paralysis with the infraclavicular approach, patients in this group are less likely to experience respiratory difficulties, reduced lung function, or oxygenation issues. This would be particularly advantageous in clinical settings where respiratory preservation is a priority, such as in older patients or those with underlying lung disease. Fewer respiratory complications would further support the preference for ICB + SSNB as a safer alternative, balancing effective pain relief with minimal adverse effects.These hypotheses, if confirmed through statistical analysis, could have important clinical implications, influencing the choice of regional anesthesia techniques for shoulder arthroscopy and potentially leading to a shift in anesthetic practice favoring approaches that provide optimal pain relief with lower risks of respiratory compromise and opioid use.

5. Discussion

The findings of this study suggest that infraclavicular brachial plexus block (ICB) combined with suprascapular nerve block (SSNB) may serve as an effective alternative to coracoid approach brachial plexus block (CAPB) with posterior suprascapular nerve block (PSNB) while further minimizing the risk of phrenic nerve involvement. Given that phrenic nerve blockade can lead to hemidiaphragm paralysis and respiratory complications, particularly in patients with pre-existing pulmonary conditions, the use of a more distal brachial plexus approach such as ICB could help preserve diaphragmatic function without compromising pain relief. If confirmed, these results may have significant clinical implications, potentially shifting anesthetic practice toward safer regional anesthesia techniques for shoulder surgeries. By demonstrating that ICB + SSNB can provide comparable analgesia while reducing respiratory risks, this study may encourage clinicians to reconsider traditional brachial plexus block approaches, particularly for high-risk populations. However, some limitations must be acknowledged, including the sample size, which may impact the generalizability of the findings. Additionally, anatomical variations among patients can influence the efficacy of nerve blocks, leading to variability in outcomes. Factors such as differences in nerve positioning, muscle mass, or ultrasound visualization challenges may affect the success rate of each block, necessitating further large-scale studies and multicenter trials to validate these findings. Despite these limitations, the study provides valuable insights into optimizing regional anesthesia techniques, with potential benefits for both patient safety and postoperative recovery.

6. Conclusion

Based on the anticipated findings, the infraclavicular brachial plexus block (ICB) combined with the suprascapular nerve block (SSNB) is hypothesized to provide comparable analgesia to the coracoid approach brachial plexus block (CAPB) with posterior suprascapular nerve block (PSNB), while offering a distinct advantage in terms of reducing respiratory complications. Both techniques are expected to deliver effective postoperative pain relief, as they utilize the same local anesthetic (ropivacaine) in identical volumes and target key neural structures involved in shoulder nociception. However, the anatomical positioning of the nerve blocks plays a crucial role in determining potential adverse effects. Since the CAPB technique is administered at a more proximal level, it is more likely to involve the phrenic nerve, leading to a higher incidence of hemidiaphragm paralysis and subsequent respiratory complications. In contrast, the ICB approach is performed at a more distal location, significantly reducing the risk of phrenic nerve involvement and preserving diaphragmatic function. This makes ICB + SSNB a safer and more favorable technique, particularly for patients who are at risk of respiratory compromise, such as those with pre-existing pulmonary disease, obesity, or limited respiratory reserve. Furthermore, the ICB + SSNB combination is expected to slightly reduce opioid consumption, as it may provide more prolonged and effective posterior shoulder analgesia, minimizing the need for supplemental pain relief. If the study results confirm these hypotheses, the findings could

influence clinical decision-making, leading to a preference for ICB + SSNB in patients undergoing shoulder arthroscopy—especially in those for whom preserving respiratory function is a priority. By balancing optimal analgesia with a lower incidence of complications, this approach has the potential to enhance patient safety, comfort, and recovery outcomes, ultimately improving the standard of care in regional anesthesia for shoulder surgery.

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