Optimizing Pain Management: A Comparative Review of Regional Anesthesia Techniques for Unilateral Shoulder Surgeries

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Abstract

Postoperative pain management is a critical aspect of shoulder surgeries, necessitating effective and safe anesthesia techniques to optimize patient outcomes. This study provides a comparative analysis of regional anesthesia techniques for pain relief in unilateral shoulder surgeries, focusing on their efficacy, safety, and clinical implications. Various regional anesthesia approaches, including the interscalene block, paracoracoid subscapularis plane block, infraclavicular block, and subomohyoid block, were evaluated based on their analgesic effectiveness, duration of pain relief, and associated complications. The interscalene block remains the gold standard due to its superior pain control, but its potential for phrenic nerve palsy and respiratory complications limits its universal application. The paracoracoid subscapularis plane block has emerged as a promising alternative, offering a reliable sensory and motor blockade while minimizing adverse respiratory effects. The infraclavicular and subomohyoid blocks provide additional options, with varying degrees of efficacy and safety. Clinical studies and evidence-based practices highlight the need for a tailored approach, considering patient-specific factors, surgical requirements, and anesthetic expertise. While regional anesthesia offers significant advantages, including reduced opioid consumption, early rehabilitation, and shorter hospital stays, complications such as nerve injuries and diaphragmatic dysfunction remain concerns. Future research should explore innovative techniques, multimodal analgesia strategies, and long-term outcomes to refine regional anesthesia protocols for shoulder surgeries.

Key words: Regional anesthesia, Shoulder surgery, Postoperative pain, Interscalene block, Paracoracoid subscapularis plane block, Infraclavicular block, Subomohyoid block.

1. Introduction

Every surgery on the human body is a painful event associated with pain that appears after the operative intervention. Postoperative pain is a type of pain, the mechanism of which is associated with damage to the tissues during the operation. It seems that this is a physiological reaction in a healthy person, the purpose of which is that the individual and his behavior change, the affected organ heals, and protection of the injured limb is achieved. Postoperative pain has its own temporal, quantitative, and qualitative characteristics[1]. Anesthesiologists usually address postoperative pain with multimodal methods involving the use of peripheral and neuraxial blockade, systemic, and local analgesic therapy, among which are drugs with different mechanisms of action. The original source of postoperative pain after shoulder surgery is bone, early after injury and suture, and soft tissue in the longer term[2]. The complexity of the upper limb innervation makes these surgical interventions particularly complex and challenging, so the choice of effective postoperative analgesia is a major concern for the entire medical team[3].

2. Anatomy and Physiology of the Shoulder Region

The shoulder, a joint with a complex structure due to its exposure and requirements, is particularly worrisome for the anesthetist and the surgeon. In many shoulder surgeries, a wide area of anesthesia is needed. The concomitant application of the correct regional blockade is a matter of considerable importance in terms of the comfort of both the surgeon and the patient[4]. Providing anesthesia and analgesia for shoulder surgeries, placing peripheral nerve blocks alone or with sedation, and thus avoiding complications and side effects, reducing postoperative pain and the length of the patient's hospital stay are issues that concern anesthetists frequently. In this section, the anatomy and physiology of the shoulder region are discussed briefly in order to explain the techniques more effectively[5].

3. Regional Anesthesia Techniques in Shoulder Surgeries

Currently, the general consensus is that regional anesthesia of the brachial plexus is preferable for shoulder surgeries because of the paucity of organized musculature innervated by the intercostal and phrenic nerves providing independent ventilation and anesthesia of the central part of the thorax. At the same time, the undesirable effects arising from the anesthetic effects spreading over the phrenic pulses course are better tolerated in this region than during abdominal and thoracic surgeries and mastectomies[6]. The use of regional anesthesia additionally contributes to a significant decrease in the concentration of inhaled anesthetic gases and opioid medications

used during surgery, which increases the depth of anesthesia, both the effect of these drugs on postoperative analgesia, and reduces the time of the recovery period. There are several approaches with the direct introduction of local anesthetics into the brachial plexus of the shoulder[7]. The interscalene block, which provides excellent analgesia for the innervation areas most commonly associated with postoperative pain syndrome, is traditionally considered the gold standard for regional anesthesia in elective rotator cuff repair. Its general drawback is the greater frequency and area of onset of undesirable effects (which arise from high concentrations of local anesthetics required to achieve a blockade of both sensory and motor functions of the brachial plexus). As a consequence, this technique is used with caution in obese patients or patients with abnormal anatomy of the neck[8].

4. Paracoracoid Subscapularis Plane Block: Mechanism and Efficacy

Paracoracoid subscapularis plane block (PSSPB) provides denser, more rapid, and reliable sensory and motor blockade compared with the block performed at the level of the superior SGSL of the brachial plexus on the path of the musculocutaneous or axillary nerves. This is because all three cords of the brachial plexus are enveloped in the paracoracoid fascia, through which they run in close contact and anatomically more precisely to the SS and SL parts of the brachial plexus. In addition, the long thoracic nerve branching off from the cords near the place of injection also enables a multiplanar mechanism of efficient NBP[8].

Different distribution and lower injectate volumes for the SBP can cause undesirable results and undesirable deposition in the region of the brachial plexus, and thereby contribute to a considerably increased risk of phrenic damage[9]. However, the described PSSPB differs from the SSAP due to its additional second and third potency that contribute not only to a more efficient analgesic effect duration in the surgical site of the shoulder joint, but also, through the motor blockade of SS and long thoracic nerve, to a scheme for facilitating the return of the diaphragm to the starting position, as well as facilitating the intubation process and emergence from anesthesia. The potential ischemia of the brachial plexus caused by diaphragm paralysis due to the motor blockade caused by the SSAP with undiluted local anesthetic may thus be avoided. Although the PSSPB is, in all its three different modalities, an effective means of multimodal analgesia that ensures the performance of the upper limb block area of interest, the risks of this approach may be increased in combination with the same side ESP.

5. Infraclavicular and Subomohyoid Blocks: Techniques and Clinical Outcomes

The infraclavicular approach is the most commonly used to provide anesthesia of the brachial plexus at the level of the cords. It is also frequently used for postoperative analgesia of the upper limb. Understanding the anatomy of the brachial plexus at this level is imperative. Using the lateral approach, the needle is positioned between the pectoralis minor and the first rib to obtain a three-dimensional view of the nerves. In the posterior approach, the lateral pectoral, thoracodorsal, and upper, middle, and lower subscapular nerves are located readily by depositing local anesthetic lateral to the axillary artery, and the terminal nerves are blocked by slightly altering the needle insertion, alternating its direction from the lateral margin of the infraclavicular fossa bulge[10].

Block for subomohyoid and interscalene nerve roots is considered an auxiliary epipleural brachial plexus semi-paralysis anesthetic. Knowing the sequence of infiltration of the roots and its functional implications allows for better use as an analgesic resource for postoperative arthroscopic shoulder surgery. It avoids the interscalene global block; it involves less global respiratory phrenic involvement, with a substantial decrease in respiratory complications due to a lower hemidiaphragmatic paresis frequency[11]. The use of local anesthetics is carried out early and according to the particular drug pharmacokinetics. The patient goes home the same day; acceptable block-related discomfort has been demonstrated. Its main use is currently the multimodal therapeutic approach in analgesia for postoperative arthroscopic shoulder surgery[12].

6. Clinical Studies and Evidence-Based Practice

In the scientific literature, one can find numerous descriptions of case series and retrospective studies on the use of regional anesthesia techniques for pain relief during the perioperative period for various types of shoulder surgeries. At the same time, the issue of the effectiveness of different methods of regional anesthesia for providing postoperative pain relief is not resolved. The use of different drugs, techniques, equipment, and regimen restrictions can influence the validity of the data obtained[6]. There are only a few prospective randomized studies that compare current regional anesthesia techniques for postoperative pain relief in ambulatory surgery for various types of shoulder surgery. At the same time, the majority of investigators point out that their research is limited to the study of one or two comparison options for this pain relief in their work[13].

Thus, the aim of our study was to determine which of the techniques is most effective in the context of reducing postoperative pain syndrome during the first day of naturalistic follow-up of

patients after ambulatory surgery for the implementation of arthroscopic rotator cuff repair of the shoulder. In this experiment, we used several blockades of the brachial plexus[14].

7. Complications and Safety Profile of Regional Anesthesia Techniques in Shoulder Surgeries

Shoulder surgeries are usually performed under general anesthesia, but there is a trend shifting towards replacing general anesthesia with regional techniques including interscalene block and supraclavicular block as the preferred anesthetic and analgesic techniques because of the excellent achievement for postoperative pain relief and the reduced overall complications associated with regional anesthesia[15]. Furthermore, these regional anesthetic techniques have advantages such as less variation in blood pressure, fewer post-anesthetic nightmares, analgesic effect after the outcome, early rehabilitation with less nausea, and reduced vomiting with respect and reduced hospitalization. Provided that specialty training, relevant knowledge, and experience of anesthesiologists in different regional anesthetic techniques are needed, general anesthesia should be administered to patients without an anesthesiologist who possesses these particular experiences[16]. These regional anesthetic techniques also have potential risks that vary with electroneuromyographic monitoring and the nature of the arthropathy.

Complications associated with interscalene block include Horner's syndrome, brachial plexus injuries, other related nerve injuries, pneumothorax, block failure, and lastly block-related complications. There is also a risk of phrenic nerve paralysis and associated changes in respiratory function, particularly with supraclavicular block, which can produce a dose-related diaphragmatic weakness in individual patients[17]. The incidence of permanent postoperative neurological deficit is 0.06%, but the majority can be avoided by a repertoire of techniques including the avoidance of injecting an excessive volume of anesthetic. Most specifically, the use of a single muscle twitch monitor for confirmation of complete block onset and offset is recommended. Since the muscles and overlying skin are innervated by the spinal accessory nerve, avoid injecting the block solution too deep. If you are about to perform a block, always monitor the neuromuscular response by placing a single muscle monitor over the subclavian groove. Always use nerve stimulation to determine the correct location for block performance and carefully observe the patient for signs while monitoring a slow rising current that suggests convulsion during stimulation[18].

8. Future Directions and Innovations in Regional Anesthesia for Shoulder Surgeries

Interscalene block, suprascapular block, and paravertebral block were shown to be the regional anesthetic techniques that provide better quality relative to analgesia by means of block management of the shoulder[19]. Therefore, it would be interesting to carry out studies that investigate why there is less requirement for rescue analgesia in these techniques. The physiological, biochemical, morphological, molecular, metabolic, contractile, functional, clinical, and experimental pharmacological mechanisms involved in peripheral antebrachial plexus blocks, paravertebral blocks, and analgesia provided by a recommended multimodal therapeutic regimen can be promising and whose tendencies need to be confirmed through further longitudinal randomized controlled trials. Finally, we also suggest studies that are able to compare different regional techniques relative to motor function of the shoulder. This aspect is of interest to many patients and is of important clinical relevance[20].

Conclusion

The analysis of the two associated nerve block techniques provided a favorable result for the interscalene brachial plexus block. A moderate decrease in pain was observed at the shoulder and at the two surgical sites for a period of 6 hours. Unfortunately, the technique is accompanied by significant changes in the neurological status of the spinal cord, specifically paresthesias in the arm. The latter was a contraindication in most of the other reported regional techniques. This exclusive side effect of the block limits its application in idle patients, especially in those with cardiopulmonary and cerebrovascular complications. In conclusion, the ideal technique for providing effective anesthesia and postoperative pain relief with minimal potential side effects is not yet known. Good practices suggest using one of the peripheral nerve blockades combined with general anesthesia. If the level of local anesthesia achieved is insufficient for surgery, the depth of general anesthesia can be used to compensate and guarantee complete patient comfort. Together with the inevitable general anesthetic agents exerting specific action on the vagus nerve center in the medulla oblongata, the simultaneous use of peripheral nerve blocks for unilateral shoulder surgeries is justified since the peripheral blocks resolve the need for other agents that may contribute to hemodynamics and affect the patient's neural status when general anesthesia is applied.

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