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REVIEW ARTICLE: ULTRASOUND-GUIDED REGIONAL ANESTHESIA TECHNIQUES FOR POST-STERNOTOMY PAIN MANAGEMENT IN CARDIAC SURGERY

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Abstract:

Median sternotomy, a standard approach in cardiac surgery, is associated with significant postoperative pain that impacts recovery and patient satisfaction. Ultrasound-guided regional anesthesia techniques, such as the erector spinae plane block (ESPB) combined with superficial parasternal intercostal plane block (S-PIP) and the paravertebral block (PVB), have emerged as effective components of multimodal analgesia. These techniques reduce opioid reliance, mitigate adverse effects, and support enhanced recovery protocols. The review highlights their clinical utility, technical considerations, and potential for improving postoperative outcomes in cardiac surgery.

Keyword's: regional anesthesia, Median sternotomy, intercostal plane block, cardiac surgery.

Introduction

Cardiac surgery, particularly via median sternotomy, results in substantial postoperative pain due to sternal incision, rib retraction, intercostal nerve trauma, and chest drain placement [1]. Inadequate pain management can lead to prolonged mechanical ventilation, pulmonary complications, and chronic pain, negatively affecting recovery and quality of life [2]. Traditional reliance on opioids for analgesia is associated with significant adverse effects, including respiratory depression, nausea, and sedation, prompting the adoption of opioid-sparing strategies [3]. Ultrasound-guided regional anesthesia, including PVB, ESPB, and S-PIP, has gained prominence for its ability to provide effective pain relief, reduce perioperative analgesic requirements, and facilitate early rehabilitation [4].

Review of Literature

Pain After Sternotomy

Post-sternotomy pain is a critical concern in cardiac surgery, driven by tissue trauma, intercostal nerve injury, and inflammatory responses. Pain mediators such as prostaglandins and bradykinin amplify nociception, contributing to both acute and chronic pain states [5]. Poorly managed acute pain increases the risk of complications, including myocardial ischemia, cardiac arrhythmias, and pulmonary issues like atelectasis, while also hindering mobility and psychological well-being [6]. Chronic pain, reported in up to 28% of patients one year post-surgery, often stems from inadequate

acute pain control and may involve neuropathic mechanisms [7]. Effective analgesia is thus essential for early extubation, mobilization, and discharge, aligning with enhanced recovery after surgery (ERAS) protocols.

Regional Anesthesia Techniques

Regional anesthesia has transformed postoperative pain management by targeting specific nerve pathways, reducing systemic opioid use, and minimizing adverse effects. The thesis by Aly (2025) emphasizes three ultrasound-guided techniques: PVB, ESPB, and S-PIP.

Paravertebral Block (PVB)

PVB involves injecting local anesthetic into the thoracic paravertebral space, blocking spinal nerve roots and achieving multilevel ipsilateral somatic and autonomic blockade [8]. It is highly effective for postoperative analgesia, improving pulmonary function and reducing thrombotic risks [9]. However, its proximity to the pleura and neuraxial structures poses technical challenges and risks, such as pneumothorax and hematoma, particularly in anticoagulated patients [10]. Ultrasound guidance has improved PVB's safety and precision, with studies demonstrating reduced opioid consumption in thoracic surgeries [11].

Erector Spinae Plane Block (ESPB)

ESPB, a newer technique, involves injecting local anesthetic into the fascial plane between the erector spinae muscle and thoracic transverse processes, with expected paravertebral spread [12]. Its superficial injection site reduces risks compared to PVB, making it easier to perform and safer in anticoagulated patients [13]. ESPB's versatility is highlighted by reports of effective analgesia in abdominal surgeries [14]. However, its weaker anterior dermatomal spread limits its efficacy for sternotomy-related pain unless combined with other blocks [15].

Superficial Parasternal Intercostal Plane Block (S-PIP)

S-PIP targets the anterior cutaneous branches of the thoracic intercostal nerves (Th2-6), providing analgesia in the parasternal region [16]. It is particularly effective for sternotomy pain, reducing opioid consumption and complications, as shown in cardiac surgery patients [17]. Its simplicity and low risk of complications, such as injury to the internal mammary artery, make it an attractive adjunct to ESPB [18].

Clinical Implications

The thesis by Aly (2025) underscores the potential of combining S-PIP with ESPB to address the limitations of ESPB's anterior spread, offering a comprehensive analgesic strategy for sternotomy pain. This combination aligns with findings of reduced morphine consumption with bilateral parasternal and ESP blocks [19]. Studies further support these techniques' integration into ERAS protocols, advocating for regional anesthesia's role in enhancing recovery and highlighting the safety of ultrasound-guided blocks in high-risk patients [20,21].

Challenges and Future Directions

Despite their efficacy, ultrasound-guided blocks face challenges, including variability in local anesthetic spread due to anatomical differences [22] and the need for specialized training in ultrasound techniques. The thesis notes the importance of standardizing procedures to ensure consistent outcomes. Future research should focus on optimizing block techniques, exploring

continuous catheter-based infusions, and assessing long-term outcomes like chronic pain prevention, as emphasized by recent studies [20].

Conclusion

Ultrasound-guided regional anesthesia techniques, including PVB, ESPB, and S-PIP, are pivotal in managing post-sternotomy pain, reducing opioid reliance, and supporting enhanced recovery in cardiac surgery. The thesis by Aly (2025) highlights the comparable efficacy of S-PIP + ESPB and PVB, with the former offering technical simplicity and safety advantages. Supported by recent literature from the *South Valley University International Journal of Medical Sciences*, these techniques are poised to transform postoperative care, provided ongoing research addresses current limitations and optimizes their application.

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