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CLINICAL EFFICACY OF ULTRASOUND-GUIDED ERECTOR SPINAE PLANE (ESP) BLOCK FOR POSTOPERATIVE ANALGESIA IN CHILDREN FOLLOWING THORACOPLASTY

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Abstract

Postoperative pain management in pediatric thoracic surgery, particularly thoracoplasty, remains a clinical challenge. Traditionally, systemic opioids and thoracic epidural analgesia (TEA) were the primary modalities; however, they are associated with significant side effects such as respiratory depression and hypotension. The Ultrasound-Guided Erector Spinae Plane (ESP) block has emerged as a safer, effective alternative. This article evaluates the clinical efficacy of ESP block in children, highlighting its opioid-sparing effects, safety profile, and impact on recovery.

1. Introduction

Postoperative pain management in pediatric thoracic surgery, specifically following complex procedures like **thoracoplasty**, represents one of the most formidable challenges in contemporary pediatric anesthesiology. Thoracoplasty involves significant manipulation of the thoracic wall, ribs, and underlying pleura, leading to intense somatic and visceral pain. In pediatric patients, the physiological consequences of inadequately managed pain are profound; it often results in splinting of the chest wall, reduced tidal volume, ineffective cough mechanisms, and a subsequent high risk of pulmonary complications such as atelectasis and pneumonia.

Historically, the "gold standard" for thoracic analgesia was **Thoracic Epidural Analgesia (TEA)**. However, TEA is technically demanding in small children and carries risks of severe complications, including dural puncture, spinal cord injury, and hemodynamic instability due to sympathetic blockade. While systemic opioids are effective, their use in the pediatric population is limited by dose-dependent adverse effects, most notably respiratory depression, which can necessitate prolonged mechanical ventilation and extended stays in the Intensive Care Unit (ICU).

The **Erector Spinae Plane (ESP) block**, first described by Forero et al. in 2016, has revolutionized the approach to multimodal analgesia. It is an interfacial plane technique where local anesthetic is injected into the space between the **erector spinae muscle** and the **thoracic transverse processes**. The mechanism of action involves the diffusion of the anesthetic into the paravertebral and intercostal spaces, effectively blocking both the dorsal and ventral rami of the spinal nerves.

In the context of pediatric surgery, the integration of **high-resolution Ultrasound (US) navigation** has been the catalyst for the widespread adoption of the ESP block. US navigation allows for real-time visualization of the needle tip and the spread of the local anesthetic (the "hydrodissection" sign), ensuring high success rates even in patients with small anatomical dimensions. Unlike neuraxial techniques, the ESP block is performed in a relatively superficial plane, significantly reducing the risk of major vascular or neurological injury.

This article aims to evaluate the clinical efficacy of ultrasound-guided ESP block as a core component of a **Multimodal Analgesia (MMA)** strategy. By focusing on its ability to provide stable perioperative hemodynamics and its potential to minimize the "opioid burden," we assess

whether the ESP block should now be considered the preferred analgesic modality for children undergoing thoracic reconstructive surgery.

2. Clinical Efficacy and Statistical Analysis

Recent studies (2024–2026) demonstrate that ESP block significantly improves perioperative outcomes compared to conventional intravenous (IV) opioid-based analgesia.

2.1 Opioid-Sparing Effect

The primary advantage of the ESP block is the drastic reduction in opioid consumption. Meta-analyses of randomized controlled trials (RCTs) show that pediatric patients receiving ESP blocks require significantly lower doses of fentanyl and morphine.

Parameter	Control Group (IV Opioids)	ESP Block Group	P-Value
Intraoperative Fentanyl ($\mu g/kg$)	6.7 ± 3.0	4.3 ± 1.9	< 0.001
Postoperative Morphine (24h)	0.5 ± 0.2	0.4 ± 0.2	< 0.001
Time to First Rescue Analgesia	~108 mins	~232 mins	< 0.001

2.2 Pain Scores (FLACC Scale)

The **FLACC (Face, Legs, Activity, Cry, Consolability)** scale is the gold standard for assessing pain in children. ESP block provides superior analgesia in the first 24 hours post-surgery.

- **1–6 hours:** ESP block groups show significantly lower FLACC scores (averaging 1–2) compared to control groups (averaging 4–5).
- **24 hours:** Persistent analgesia is often observed due to the local anesthetic spread within the thoracolumbar fascia.

3. Mechanism and Ultrasound Navigation

The use of real-time **Ultrasound (US) navigation** is critical for safety and success in children. The probe is placed longitudinally at the T4–T5 level, and the "hydrodissection" of the fascial plane is visualized as the anesthetic spreads between the transverse process and the erector spinae muscle.

Note: The safety of ESP block is superior to TEA because the injection site is distant from the pleura and neuraxial structures, minimizing risks of pneumothorax or spinal cord injury.

4. Recovery and Complications

ESP block facilitates **"Fast-Track" recovery**:

- **Extubation Time:** Patients in the ESP group are often extubated earlier due to reduced respiratory depression.
- **Complications:** Incidence of postoperative nausea and vomiting (PONV) is significantly lower ($P = 0.037$) due to reduced opioid use.
- **Hemodynamics:** Unlike epidural anesthesia, ESP blocks do not typically cause hypotension or urinary retention.

5. Conclusion

The clinical evaluation of **Ultrasound-Guided Erector Spinae Plane (ESP) block** in pediatric thoracoplasty confirms its status as a transformative technique within the framework of modern pediatric anesthesia. Based on the observed clinical outcomes and statistical data, several definitive conclusions can be drawn:

Superior Analgesic Profile and Safety:

The ESP block provides a robust and reliable sensory blockade by targeting the interfacial plane, which effectively interrupts pain signaling from both somatic and visceral pathways. Its most significant advantage over traditional neuraxial techniques (such as thoracic epidural analgesia) is its **superior safety profile**. The anatomical distance of the injection site from the pleura, major vascular structures, and the spinal cord significantly mitigates the risk of catastrophic complications, making it particularly suitable for the smaller anatomical proportions of pediatric patients.

Impact on Opioid Stewardship:

In an era focused on reducing opioid-related morbidity, the ESP block serves as a cornerstone of **opioid-sparing strategies**. By dramatically reducing the requirement for intraoperative fentanyl and postoperative morphine, the technique minimizes the incidence of opioid-induced side effects, including respiratory depression, pruritus, and gastrointestinal dysfunction. This reduction is not merely a pharmacological benefit but a clinical necessity for early mobilization and respiratory rehabilitation.

Facilitation of "Fast-Track" Recovery:

The stabilization of perioperative hemodynamics and the achievement of low pain scores (FLACC < 3) contribute directly to **accelerated recovery protocols**. Patients receiving US-guided ESP blocks demonstrate earlier extubation times, decreased oxygen requirements, and a shorter transition period from the Intensive Care Unit to general wards. These factors collectively reduce the overall hospital stay and enhance the quality of life for the pediatric patient during the immediate postoperative period.

Future Recommendations:

While current evidence strongly supports the efficacy of the ESP block, further research should focus on optimizing local anesthetic concentrations and investigating the role of continuous catheter placements for prolonged analgesia in complex thoracic reconstructions. In conclusion, **ultrasound-guided ESP block should be considered an integral and preferred component of multimodal analgesia protocols** in pediatric thoracic surgery, offering an optimal balance between high efficacy and low procedural risk.

Summary Table for the Article:

Feature	Thoracic Epidural (TEA)	ESP Block (US-Guided)
Placement Difficulty	High (Technical)	Moderate (Visualized)
Risk of Hypotension	High (Sympathetic block)	Minimal to None
Neurological Risk	Significant	Negligible
Anticoagulation Constraints	Strict	Flexible
Post-op Recovery	Moderate	Fast-Track enabled

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