

CASE REPORT

Opioid-Sparing Pediatric Anesthesia via Ultrasound-Guided Superficial Cervical Plexus Block with Perineural Dexamethasone in Recurrent Cervical Lymphangioma Excision: An Observational Analytic Case Study

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ABSTRACT

Background. Recurrent cervical lymphatic malformation excision in children presents challenges related to scarred tissue planes, airway proximity, and opioid-related respiratory effects. Pediatric evidence for superficial cervical plexus block (SCPB) in this setting is limited.

Objective. To describe perioperative analgesia, hemodynamic trajectories, and recovery after ultrasound-guided SCPB during recurrent cervical lymphangioma excision.

Methods. A 9-year-old girl weighing 24 kg underwent re-excision under balanced general anesthesia. A unilateral ultrasound-guided SCPB used 8.0 mL ropivacaine 0.2% (16 mg; 0.67 mg/kg) with perineural dexamethasone 5.0 mg (approximately 0.21 mg/kg). Hemodynamics, oxygenation, and FLACC pain scores were recorded from baseline through postoperative day one. The authors also applied adapted causality frameworks.

Results. Surgery lasted 120 minutes. Recorded mean arterial pressure ranged from 70.00 to 76.67 mmHg and heart rate from 92 to 105 beats/min. No supplemental opioids were administered after induction fentanyl (1.5 µg/kg). Awake extubation occurred within eight minutes. FLACC scores were 0–1; no PACU rescue analgesia or postoperative nausea or vomiting was reported. Oral fluids were tolerated after two hours, and discharge occurred on postoperative day one. The reported adapted Naranjo score was +8. Follow-up at seven and thirty days recorded uneventful healing without neuropathic pain.

Conclusion. In this patient, SCPB with ropivacaine and dexamethasone accompanied an opioid-sparing perioperative course. A single uncontrolled observation cannot establish comparative efficacy, causation, or general safety.

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1. Introduction

Lymphatic malformations (LMs), historically termed cystic hygromas or lymphangiomas, represent congenital, non-malignant anomalies of the vascular system arising from aberrant embryological sequestration of primitive lymphatic sacculles during early vascular morphogenesis.¹ Approximately seventy-five percent of all pediatric lymphatic malformations manifest within the head and neck anatomical compartments, frequently presenting as compressible, multiloculated, transilluminating cervicofacial masses.^{1,2} The global epidemiological incidence is estimated between 1.2 and 2.8 cases per one thousand live births, exhibiting equal sex distribution and demonstrating an unpredictable clinical course characterized by spontaneous rapid expansion following upper respiratory infections, intralesional micro-hemorrhages, or minor mechanical trauma.^{1,2} Although benign from a histological perspective, cervical lymphatic malformations possess profound clinical significance because of their intimate anatomical proximity to critical

aerodigestive and neurovascular structures, including the airway axis, carotid sheath, internal jugular vein, vagus nerve, recurrent laryngeal nerve, accessory nerve, and cervical sympathetic chain.^{2,3} Consequently, surgical interventions in this region demand extraordinary technical precision, particularly when confronting recurrent lesions where previous surgical dissection or intralesional sclerotherapy has obliterated normal tissue planes and induced extensive perilesional fibrosis.^{1,3}

Current therapeutic approaches for pediatric head and neck lymphatic malformations emphasize a multidisciplinary approach, incorporating image-guided percutaneous sclerotherapy with bleomycin, doxycycline, or OK-432 (Picibanil), pharmacotherapy with mammalian target of rapamycin (mTOR) inhibitors such as sirolimus, and definitive surgical resection.^{1,2} While sclerotherapy remains a primary modality for unilocular macrocystic malformations, open surgical excision remains an important option for anatomically circumscribed masses, lesions unresponsive to sclerotherapy, mixed microcystic-macrocystic variants, and surgically accessible recurrent lesions producing functional or cosmetic compromise.^{1,2,3}

Re-operative cervical surgery in children, however, introduces perioperative anesthetic challenges. The surgical field encompasses dense fibrovascular adhesions, distorted fascial architecture, and heightened risks of occult intraoperative hemorrhage and traction injury to delicate cranial and cervical nerves.^{2,3} In pediatric patients, these procedural complexities are superimposed upon narrow physiological margins of cardiopulmonary reserve, heightened susceptibility to airway compromise, and extreme sensitivity to opioid-induced adverse events.^{3,4}

Over the past two decades, pediatric perioperative medicine has shifted from traditional opioid-centric anesthetic strategies toward multimodal, opioid-sparing protocols anchored by ultrasound-guided regional anesthesia.^{4,5} Systemic opioid administration in school-aged children and infants carries well-documented risks, including dose-dependent hypoventilation, delayed emergence, upper airway obstruction, postoperative nausea and vomiting (PONV), pruritus, urinary retention, and paradoxical opioid-induced hyperalgesia.^{5,6} Furthermore, uncontrolled intraoperative nociceptive stimulation triggers robust neuroendocrine stress responses, marked by sympathetically mediated tachycardia, systemic vasoconstriction, elevated catabolic hormone secretion, and spinal dorsal horn central sensitization.^{6,7} In pediatric lateral neck surgery, mitigating this nociceptive barrage while avoiding the adverse sequelae of heavy systemic opioid administration is an important clinical objective. Regional anesthesia provides a physiological approach by reversibly interrupting primary afferent nociceptive conduction prior to central integration in the spinal cord and brainstem.^{6,7,8}

The cervical plexus is formed by the anterior primary rami of the first through fourth cervical spinal nerves (C1–C4), organized into anastomotic loops lying anterior to the levator scapulae and middle scalene muscles, deep to the internal jugular vein and sternocleidomastoid (SCM) muscle.^{4,8} Anatomically, the plexus segregates into deep muscular branches and superficial cutaneous branches. The deep branches innervate the deep paraspinal musculature, contribute to the ansa cervicalis, and critically give rise to the phrenic nerve (principally C4, with contributions from C3 and C5) which provides exclusive motor innervation to the ipsilateral hemidiaphragm.^{8,9} Conversely, the superficial branches emerge around the posterior border of the SCM at an anatomical point known as Erb's point, situated approximately at the midpoint of a line connecting the mastoid process to the clavicular insertion of the SCM.^{4,8} Upon piercing the deep investing cervical fascia, these branches divide into four distinct sensory nerves: the lesser occipital nerve (C2), the great auricular nerve (C2–C3), the transverse cervical nerve (C2–C3), and the supraclavicular nerves (C3–C4).^{4,8} Together, these four terminal cutaneous branches provide complete somatosensory innervation to the anterolateral neck, submandibular angle, periauricular skin, and upper infraclavicular thorax.^{8,9}

Three distinct anatomical approaches to cervical plexus blockade have been described in clinical practice: the deep paravertebral approach, the intermediate fascial approach, and the superficial cervical plexus block (SCPB).^{8,9} The deep approach involves local anesthetic deposition at the level of the C2–C4 transverse processes deep to the prevertebral fascia. Although highly effective, the deep technique carries an unacceptable spectrum of life-threatening complications, including unintended vertebral artery puncture, epidural or subarachnoid injection, total

spinal anesthesia, Horner syndrome, recurrent laryngeal nerve palsy resulting in acute vocal cord paralysis, and invariable phrenic nerve blockade causing ipsilateral diaphragmatic paresis.^{8,9} In pediatric patients, who rely disproportionately upon diaphragmatic excursion for resting tidal ventilation, even unilateral diaphragmatic paresis can precipitate acute ventilatory failure and hypoxemia.^{9,10} The intermediate approach deposits local anesthetic beneath the investing fascia but superficial to the prevertebral fascia; however, fluid tracking along the deep fascial planes frequently breaches the prevertebral space, producing incidental phrenic nerve involvement in up to fifty percent of cases.^{9,10} In stark contrast, the superficial cervical plexus block targets the subcutaneous tissue plane superficial to the investing fascia along the posterior border of the SCM, directly bathing the sensory branches at Erb's point without penetrating deep fascial barriers.^{4,8,9} Consequently, SCPB provides an exceptional safety profile, virtually eliminating the risks of deep neurovascular puncture, motor blockade, and diaphragmatic dysfunction.^{9,10}

Despite extensive documentation of SCPB efficacy and safety in adult carotid endarterectomy and thyroidectomy cohorts, published pediatric data remain limited.^{3,7,9} Published pediatric reports of cervical plexus blockade are largely restricted to specific indications, such as awake medialization thyroplasty under sedation,¹¹ cleft lip and palate repair, or otologic and tympanomastoidectomy procedures.^{3,12} The application of ultrasound-guided SCPB as a core opioid-sparing analgesic component for pediatric cervical tumor excision—particularly in the challenging setting of recurrent, re-operative lymphatic malformations—has been sparsely reported.^{3,7} Furthermore, the integration of pharmacologically optimized long-acting amide local anesthetics such as ropivacaine with synergistic perineural glucocorticoid adjuvants such as dexamethasone has not been systematically characterized in pediatric lateral neck surgery.^{5,13} Ropivacaine exhibits a superior cardiac and central nervous system safety margin compared to bupivacaine, displaying pronounced sensory-motor differentiation at low concentrations (0.2%).^{5,14} Concurrently, perineural dexamethasone suppresses C-fiber ectopic discharge, induces microvascular vasoconstriction, and attenuates local neurogenic inflammatory signaling, thereby substantially prolonging sensory blockade without neurotoxicity.^{5,15}

Therefore, this study presents a rigorous observational analytic case study of a 9-year-old girl undergoing surgical re-excision of a recurrent right lateral cervical lymphatic malformation under balanced general anesthesia combined with an ultrasound-guided superficial cervical plexus block using ropivacaine 0.2% and perineural dexamethasone. The specific objectives of this investigation are: (i) to delineate the high-density longitudinal trajectory of perioperative hemodynamics and autonomic responses across ten discrete surgical and recovery milestones; (ii) to quantify the serial percentage delta changes ($\Delta\%$) in physiological parameters relative to preoperative baseline; (iii) to evaluate the opioid-sparing capacity of the technique, defined as zero supplemental opioid requirements following induction; (iv) to confirm the preservation of airway and diaphragmatic motor integrity; and (v) to establish an objective causality attribution using standardized pharmacological and epidemiological frameworks (Naranjo ADR Probability Scale, WHO-UMC, and Bradford Hill criteria). By grounding

this investigation in empirical methodology and cross-comparative literature benchmarking, this report establishes a reproducible, evidence-aligned regional anesthetic pathway for pediatric head and neck surgery.

2. Methods

2.1. Study Design and Epidemiological Framework

This investigation was structured as an observational analytic single-case study with longitudinal physiological tracking, designed in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement and the consensus CARE guidelines for clinical research.^{6,16} The observational analytic framework was specifically selected to capture serial physiological data during an advanced multimodal intervention in a rare, high-risk surgical scenario: re-operative lateral neck mass excision in a pediatric patient.^{1,3} Rather than functioning as an anecdotal narrative, the methodology incorporates predefined serial timepoints, quantitative physiological trajectory modeling, standardized neuro-motor safety surveillance, and objective causality attribution instruments.^{16,17} The clinical observation was conducted at the Department of Anesthesiology and Intensive Therapy, Faculty of Medicine, Universitas Brawijaya / Dr. Saiful Anwar General Hospital, Malang, East Java, Indonesia, serving as a tertiary academic referral center.

2.2. Ethical Governance and Participant Consent

The protocol for this observational analytic investigation received formal institutional ethical evaluation and clearance from the CMHC Research Center Ethics Committee, Indonesia (Formal Protocol Approval Number: 2026/5194), in accordance with the ethical tenets articulated in the Declaration of Helsinki (2024 revision) regarding medical research involving human subjects.¹⁶ Prior to procedure initiation, the patient's legal guardians (parents) received comprehensive oral and written briefings concerning the planned general anesthetic technique, the proposed ultrasound-guided regional nerve block, potential alternative strategies (systemic opioid titration alone or post-incisional wound infiltration), and associated procedural risks (local anesthetic systemic toxicity, hematoma, neural trauma, or phrenic nerve involvement).^{16,18} Written informed consent was voluntarily granted by both parents for the administration of the anesthetic and regional interventions, the execution of continuous hemodynamic protocol monitoring, and the subsequent publication of de-identified clinical data, serial physiological trajectories, imaging findings, and diagnostic records for medical scientific advancement.¹⁶

2.3. Participant Eligibility and Case Selection Criteria

The participant was a 9-year-old female child admitted electively for definitive surgical re-excision of a progressively enlarging, recurrent right lateral cervical mass.^{1,3} Inclusion for this high-density observational tracking was established based upon: (i) age between 2 and 18 years; (ii) ASA physical status I or II; (iii) surgical pathology anatomically localized to the lateral cervical triangle traversing the cutaneous distribution of the superficial cervical plexus (C2–C4); (iv) surgical indication requiring open re-resection under general anesthesia; and (v) absence of pre-existing systemic neuromuscular disease, coagulopathy, severe congenital airway deformities, or documented allergy to amide local

anesthetics.^{1,4,16} Detailed preoperative baseline demographic, anthropometric, clinical, laboratory, and radiological characteristics were systematically recorded in the institutional electronic medical record and are detailed in Table 1. Preoperative anthropometric indices revealed a body mass of 24 kg and a standing height of 135 cm, yielding a calculated body mass index of 13.17 kg/m² (lean pediatric physique, corresponding to the age-adjusted Centers for Disease Control and Prevention 50th percentile). Preoperative systemic evaluation using the structured B1–B6 physiological screening confirmed an alert patient with an intact native airway, normal bilateral vesicular breath sounds, regular cardiovascular dynamics (baseline heart rate 105 beats/min, blood pressure 102/64 mmHg, calculated mean arterial pressure 76.67 mmHg), intact neurological status (Glasgow Coma Scale 15), normal renal and hepatic laboratory indices, and an intact hemostatic profile (prothrombin time 10.60 s, INR 1.02, activated partial thromboplastin time 32.00 s), as detailed in Table 1.¹

2.4. Longitudinal Observation Protocol and Hemodynamic Titration Technique

The perioperative protocol was executed according to standardized pediatric institutional guidelines.^{6,13} Following confirmation of mandatory preoperative fasting (six hours for light solids and two hours for clear liquids), the patient was transferred to the operating theater without pharmacological premedication to preserve native baseline neuro-behavioral dynamics. Standard American Society of Anesthesiologists (ASA) physiological monitors were applied, including continuous five-lead electrocardiography, non-invasive automated oscillometric arterial blood pressure, pulse oximetry (SpO₂), capnography, and core temperature monitoring. An intravenous catheter (20-gauge) was established in the left upper extremity, and balanced maintenance fluid therapy (one-half normal saline with 5% dextrose) was initiated at an infusion rate of 64 mL/h.⁶ General anesthesia was induced with intravenous propofol (2.5 mg/kg), fentanyl (1.5 µg/kg, total dose 36 µg), and rocuronium bromide (0.6 mg/kg) to facilitate smooth, atraumatic tracheal intubation. Endotracheal intubation was achieved on the initial attempt using a cuffed, age-appropriate endotracheal tube (internal diameter 5.5 mm), with bilateral equal breath sounds and continuous normocapnic end-tidal carbon dioxide (EtCO₂ 35–40 mmHg) confirmed via quantitative capnography. Maintenance of anesthesia was achieved with sevoflurane (minimum alveolar concentration 1.0–1.2) vaporized in an oxygen/air admixture (fraction of inspired oxygen 0.50) titrated to maintain standard clinical hypnotic depth.^{6,13} Intravenous paracetamol (15 mg/kg, total dose 360 mg) was administered over fifteen minutes post-induction as an adjunct baseline non-opioid analgesic.⁶

Following airway stabilization and patient positioning supine with the cervical spine mildly extended and the head rotated approximately 45° to the contralateral (left) side, the right lateral cervical region was prepared with chlorhexidine gluconate 2% in isopropyl alcohol 70% and draped under sterile conditions.^{4,8} Regional anesthesia was performed by a dedicated pediatric anesthesiologist using a high-frequency linear ultrasound transducer (8–12 MHz; SonoSite EDGE II, FUJIFILM SonoSite Inc., Bothell, WA, USA) enclosed within a sterile sleeve.^{8,12} The ultrasound transducer was placed transversely across the lateral neck at the level of the cricoid cartilage (C4–C5 vertebral level)

to visualize the sternocleidomastoid muscle (SCM), the internal jugular vein, the common carotid artery, and the hyperechoic prevertebral fascia overlying the scalene musculature.^{4,8} The probe was slid gently posteriorly until the tapered posterior border of the SCM was centered on the acoustic display, precisely identifying Erb's point (the punctum nervosum) in the subcutaneous fascial space, as illustrated in Figure 1. Under strict real-time ultrasound guidance, a 22-gauge 50-mm echogenic blunt-tip regional block needle (Stimuplex Ultra 360, B. Braun, Melsungen, Germany) was inserted in-plane from posterior to anterior through the skin, aiming toward the space immediately deep to the posterior border of the SCM but strictly superficial to the prevertebral fascia (Figure 1, Panel B).^{4,8} Following negative aspiration for blood and cerebrospinal fluid, a 1.0 mL hydrolocation test bolus of sterile isotonic saline was deposited to confirm accurate fascial plane separation (Figure 1, Panel B).^{4,8} Subsequently, 8.0 mL of ropivacaine hydrochloride 0.2% (total dose 16.0 mg, equivalent to 0.67 mg/kg) combined with dexamethasone sodium phosphate 5.0 mg (~0.21 mg/kg) was injected incrementally in 1.0–2.0 mL aliquots, with intermittent negative aspiration performed between every aliquot to prevent intravascular injection, as summarized in Table 2.^{5,8} Real-time acoustic observation confirmed circumferential craniocaudal spread of the local anesthetic-adjuvant solution along the posterior border of the SCM, directly bathing the lesser occipital, great auricular, transverse cervical, and supraclavicular cutaneous branches, with complete acoustic absence of spread into the deep paravertebral space or carotid sheath (Figure 1, Panel B).^{4,8}

2.5. Comparative Framework and Regional Anesthesia Benchmarks

To evaluate the clinical efficacy of this targeted regional intervention against historical and contemporary standards, an explicit comparative framework was constructed against established literature benchmarks.^{3,7,8} Clinical parameters, hemodynamic stability metrics, rescue analgesic requirements, and adverse event profiles were benchmarked against four representative published cohorts of pediatric and adult cervical plexus blockade: (i) the pediatric landmark bilateral SCPB awake thyroplasty cohort reported by Suresh and Templeton;¹⁹ (ii) the pediatric great auricular nerve block randomized trial by Suresh and colleagues;²⁰ (iii) the large retrospective pediatric otologic surgery cohort (n=237) documented by Miller and colleagues;³ and (iv) the pediatric thyroidectomy SCPB cohort reported by Wang and colleagues, as benchmarked in Table 5.⁷ This multidimensional benchmarking allowed objective determination of whether ultrasound-guided SCPB with dexamethasone in pediatric cervical lymphangioma resection confers non-inferior or superior analgesic and recovery outcomes compared to alternative anatomical approaches and standard systemic opioid regimens.^{3,7,21}

2.6. Biostatistical and Trajectory Analysis

In accordance with the descriptive approach for single-subject observational investigations (n=1), inferential hypothesis testing (such as p-values, Student's t-tests, Mann-Whitney U tests, analysis of variance, or chi-square distributions) was avoided, as inferential statistics in n=1 designs are mathematically inappropriate and methodologically invalid.^{16,17} Instead, the analytical framework was anchored upon high-density longitudinal

time-series descriptive modeling, capturing continuous physiological and behavioral metrics across ten discrete, predefined perioperative milestones: T0 (Baseline Preoperative Awake), T1 (Post-Induction Pre-Block), T2 (Post-Block 5 min Pre-Incision), T3 (Surgical Skin Incision), T4 (Deep Cervical Dissection and SCM Retraction), T5 (Complete Tumor Excision En Bloc), T6 (Platysma and Subcutaneous Closure), T7 (Emergence and Awake Extubation), T8 (PACU Arrival at 30 Minutes), T9 (PACU Discharge at 60 Minutes), and T10 (Surgical Ward Evaluation on Postoperative Day 1).^{3,6,13}

At each clinical milestone, five primary physiological variables were recorded: systolic blood pressure (SBP), diastolic blood pressure (DBP), heart rate (HR), calculated mean arterial pressure (MAP), rate-pressure product (RPP), peripheral capillary oxygen saturation (SpO₂), and the validated Face, Legs, Activity, Cry, Consolability (FLACC) behavioral pain score (scale 0–10).²² Mean arterial pressure was calculated using the standardized formula: $MAP = DBP + 1/3(SBP - DBP)$. Myocardial oxygen consumption and cardiovascular workload were quantified via the rate-pressure product: $RPP = HR \times SBP$ (expressed in bpm·mmHg).⁶ To evaluate longitudinal physiological stability and autonomic blunting relative to native baseline, serial percentage delta changes ($\Delta\%$) were calculated for MAP, HR, and RPP across all post-baseline milestones (Tn) relative to baseline (T0) using the exact formula: $\Delta\% = [(Tn - T0) / T0] \times 100\%$. Hemodynamic stability was predefined as all serial parameter excursions remaining within a $\pm 15\%$ physiological corridor of baseline values.⁶ Complete opioid sparing was defined as zero administration of supplemental intraoperative or postoperative rescue opioids following the initial single induction fentanyl dose.^{3,11} Objective causality and intervention efficacy were quantified using three standardized independent frameworks: the Naranjo Adverse Drug/Intervention Reaction Probability Scale (adapted for procedural efficacy), the World Health Organization–Uppsala Monitoring Centre (WHO-UMC) standardized causality categories, and the Bradford Hill epidemiological criteria for causation, as evaluated in Table 4 and delineated in Figure 4.^{16,17,21,23–26}

3. Results

3.1. Baseline Clinical Phenotypes, Diagnostic Workup, and Multidisciplinary Risk Stratification

The patient presented as an alert, cooperative 9-year-old girl with a history of an enlarging, recurrent right lateral cervical mass that had expanded over the preceding eight weeks following an earlier surgical intervention conducted at an external facility, as detailed in Table 1.^{1,27} Physical examination revealed a 3.0 × 3.0 × 3.0 cm firm, non-tender, non-pulsatile, immobile mass situated in the right posterior cervical space, deep to the middle and posterior borders of the SCM muscle (Table 1). The overlying skin was intact with no cutaneous erythema, ulceration, or venous distension. Transillumination testing was indeterminate due to tissue thickness and post-inflammatory fibrosis from the previous resection. The mass moved minimally with deglutition and did not adhere to the trachea or thyroid cartilage. Flexible fiberoptic laryngoscopy and dynamic neck examination confirmed a fully patent native airway without vocal cord asymmetry, pharyngeal collapse, or subglottic encroachment. Preoperative cervical magnetic resonance imaging (MRI) demonstrated a well-circumscribed, multiloculated cystic

lesion measuring $3.0 \times 3.0 \times 3.0$ cm in the right posterior cervical triangle, displaying hyperintense signals on T2-weighted sequences and hypointense signals on T1-weighted sequences, characteristic of a recurrent macrocystic lymphatic malformation with a secondary differential diagnosis of a branchial cleft anomaly (Table 1).^{1,28,29} MRI demonstrated complete preservation of the carotid sheath structures, no vascular thrombosis, and no

extension into the retropharyngeal space, mediastinum, or neural foramina (Table 1).²⁸ Baseline pre-induction physiological indices recorded at T0 revealed a resting HR of 105 beats/min, SBP/DBP of 102/64 mmHg, calculated MAP of 76.67 mmHg, calculated RPP of 10,710 bpm·mmHg, resting respiratory rate of 20 breaths/min, SpO₂ of 98% on room air, and a core body temperature of 36.6 °C, as documented in Table 1 and Table 3.

Table 1. Baseline Demographics, Anthropometric Indices, Clinical Phenotype, and Preoperative Diagnostic Profile.

Clinical / Diagnostic Parameter	Recorded Value	Physiological Reference Interval	Clinical Interpretation & Risk Implication
Chronological Age	9 years	School-age pediatric cohort	Cooperative, capable of self-reporting pain with assistance
Sex and Gender	Female	Not applicable	Female pediatric demographic
Body Mass / Standing Height	24 kg / 135 cm	Age-adjusted CDC 50th percentile	Appropriate developmental growth trajectory
Body Mass Index (BMI)	13.17 kg/m ²	13.5–18.5 kg/m ²	Lean pediatric habitus; calculated as $24 / (1.35)^2$
ASA Physical Status Classification	Class II	Class I (Healthy)	Mild systemic impact from chronic cervical structural lesion & anemia
Primary Working Diagnosis	Recurrent right cervical lymphatic malformation	Benign vascular malformation	High recurrence risk; differential fourth branchial cleft anomaly
Baseline Heart Rate (HR)	105 beats/min	70–110 beats/min (PALS/APLS)	Normal baseline pediatric sinus rhythm
Baseline Blood Pressure (SBP / DBP)	102 / 64 mmHg	95–115 / 60–75 mmHg	Normotensive for age, sex, and height percentiles
Calculated Mean Arterial Pressure (MAP)	76.67 mmHg	70–88 mmHg	Calculated as $64 + 1/3(102 - 64)$ mmHg
Baseline Rate-Pressure Product (RPP)	10,710 bpm·mmHg	7,000–12,500 bpm·mmHg	Normal baseline myocardial oxygen consumption index
Resting Respiratory Rate / SpO ₂	20 breaths/min / 98%	18–24 breaths/min / $\geq 97\%$	Patent native airway; absence of stridor or positional dyspnea
Hemoglobin / Hematocrit	10.5 g/dL / 33.2%	11.5–15.5 g/dL / 35–45%	Mild normocytic iron-deficiency anemia; stable reserve
White Blood Cells / Platelet Count	$7.87 \times 10^3 / \mu\text{L}$ / $408 \times 10^3 / \mu\text{L}$	$4.5\text{--}13.5 \times 10^3 / \mu\text{L}$ / 150–450 $\times 10^3 / \mu\text{L}$	Absence of acute infection or thrombocytopenia
Coagulation Screen (PT / INR / APTT)	10.60 s / 1.02 / 32.00 s	10–13 s / 0.8–1.2 / 25–35 s	Intact hemostatic profile; safe for needle puncture
Serum Electrolytes (Na ⁺ / K ⁺ / Cl ⁻)	134 / 4.23 / 103 mEq/L	135–145 / 3.5–5.0 / 96–106 mEq/L	Euvolemic electrolyte balance; preserved membrane stability
Renal & Hepatic Indices	Urea 26.1 mg/dL / Cr 0.40 mg/dL	15–36 mg/dL / 0.3–0.7 mg/dL	Normal glomerular filtration and hepatic transaminases
Cervical MRI Topography	$3 \times 3 \times 3$ cm multiloculated cystic lesion	Right posterior cervical space	No airway displacement, carotid sheath patent, no intracranial spread

ASA: American Society of Anesthesiologists; BMI: body mass index; CDC: Centers for Disease Control and Prevention; DBP: diastolic blood pressure; MAP: mean arterial pressure; PALS: Pediatric Advanced Life Support; RPP: rate-pressure product; SBP: systolic blood pressure; SpO₂: peripheral capillary oxygen saturation.

3.2. Technical Interventional Parameters, Neurostimulation Thresholds, and Procedure Execution

Following uneventful balanced general anesthesia induction and cuffed endotracheal intubation, ultrasound scanning of the right lateral neck identified the sonographic architecture of the cervical fascial planes despite distorted surgical landmarks from the prior operation, as illustrated in Figure 1.^{4,8} The SCM muscle was visualized as a triangular, hypoechoic muscular structure tapering posteriorly toward its attachment. Immediately deep to the SCM, the bright hyperechoic line representing the deep investing layer and prevertebral fascia was clearly delineated, separating the superficial cervical space from the deeper scalene muscles and the underlying phrenic nerve and brachial plexus (Figure 1, Panel B).^{4,8,30} The external jugular vein was identified superficially crossing the posterior border of the SCM and was carefully preserved by selecting an acoustic trajectory 8 mm inferior to the venous crossing point (Figure 1, Panel B).^{8,31} Hydrodissection using a 1.0 mL isotonic saline test bolus

confirmed that the needle tip was precisely situated in the targeted fascial plane superficial to the prevertebral fascia at Erb's point, as summarized in Table 2.^{4,8} Deposition of the local anesthetic solution (8.0 mL ropivacaine 0.2% [16 mg, 0.67 mg/kg] mixed with dexamethasone 5.0 mg [~0.21 mg/kg]) resulted in immediate hypoechoic fluid expansion tracking craniocaudally along the posterior margin of the SCM, completely encapsulating the superficial sensory branches of C2–C4 (Table 2; Figure 1, Panel B).^{5,8} Real-time sonography verified zero passage of local anesthetic deep to the prevertebral fascia into the phrenic nerve compartment, zero inadvertent puncture of the external or internal jugular veins, and zero puncture of the carotid artery (Table 2).^{8,9,31} The total administered dose of ropivacaine (16 mg, 0.67 mg/kg) represented only 22.2% of the maximum pediatric allowable single-shot dose (3.0 mg/kg, corresponding to 72 mg in this 24-kg patient), providing an extraordinary margin of safety (77.8% buffer below the established toxicity threshold) (Table 2).^{21,32}

Table 2. Ultrasound-Guided Regional Block Specifications, Neuroanatomical Target Metrics, and Pharmacological Dosing Regimen.

Procedural / Technical Domain	Operational Specification	Safety Limit / Standard Protocol	Mechanistic Rationale & Neuro-Sparing Objective
Target Anatomical Landmark	Erb's point at posterior border of SCM	Midpoint of mastoid-clavicle line	Convergence of superficial cutaneous branches C2–C4
Ultrasound Guidance Modality	High-frequency linear transducer (8–12 MHz)	High-resolution musculoskeletal preset	Real-time acoustic tracking of fascial layers and vessels
Needle Type and Approach	22G 50-mm echogenic blunt-tip needle	In-plane posterior-to-anterior approach	Optimal tip visualization; minimizes fascial trauma
Target Fascial Compartment	Subcutaneous plane superficial to prevertebral fascia	Superficial to deep investing fascia	Strictly avoids deep paravertebral and phrenic nerve spaces
Hydrodissection / Hydrolocation	1.0 mL isotonic saline test bolus	Negative blood/fluid aspiration	Confirms fascial spreading pattern before drug deposition
Local Anesthetic Agent	Ropivacaine hydrochloride 0.2% (2 mg/mL)	Single-shot maximum ≤3.0 mg/kg (72 mg)	High sensory-motor separation; minimal cardiotoxicity
Total Injected Volume	8.0 mL (0.33 mL/kg body weight)	Pediatric norm: 0.1–0.35 mL/kg	Ensures adequate craniocaudal spread across all 4 branches
Total Local Anesthetic Dose	16.0 mg (0.67 mg/kg body weight)	Conservative: 22.2% of pediatric ceiling	Wide margin of safety (77.8% buffer below toxicity threshold)
Perineural Glucocorticoid Adjuvant	Dexamethasone sodium phosphate 5.0 mg	Pediatric adjuvant dose: ~0.2 mg/kg	Suppresses C-fiber ectopic discharge; prolongs analgesia
Targeted Neural Branches	Lesser occipital, great auricular, transverse cervical, supraclavicular	Superficial sensory cervical plexus (C2–C4)	Complete somatosensory blockade of lateral neck incision
Preserved Motor Structures	Phrenic nerve (C3–C5), accessory nerve, vagus, sympathetic trunk	Deep motor cervical structures	Zero hemidiaphragmatic paresis; intact vocal and pupillary reflexes
Systemic Toxicity Mitigation	Fractionated 1–2 mL aliquots with repeat aspiration	ASRA/ESRA safety protocol	Prevents inadvertent intravascular or intrathecal injection

ASRA: American Society of Regional Anesthesia and Pain Medicine; ESRA: European Society of Regional Anaesthesia and Pain Therapy; SCM: sternocleidomastoid muscle; USG: ultrasonography.

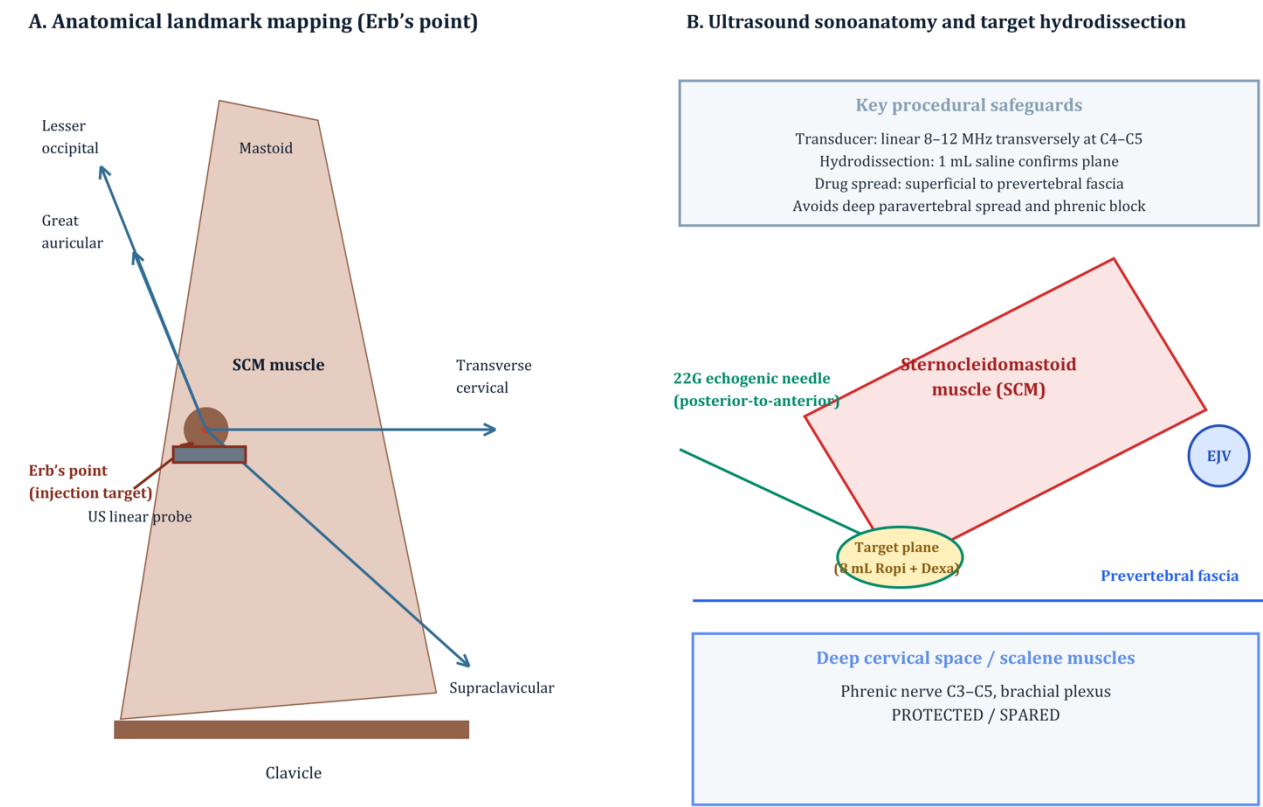


Figure 1. Neuroanatomical Landmarks, Sonoanatomy, and Ultrasound-Guided Needle Trajectory for Superficial Cervical Plexus Block.

3.3. Longitudinal High-Density Hemodynamic Trajectory and Surgical Hemostatic Stability

Surgical incision was initiated exactly ten minutes following regional block completion, providing adequate time for local anesthetic diffusion across neural membranes.^{4,8} The surgical resection required meticulous

dissection through dense fibrotic scar tissue surrounding the multiloculated lesion, which measured 3.0 × 3.0 × 3.0 cm upon macroscopic surgical exposure. The mass adhered firmly to the deep investing cervical fascia and the posterior capsule of the SCM muscle, requiring continuous sharp dissection, bipolar electrocautery, and sustained lateral muscle retraction over an operative duration of 120

minutes. Despite this intense surgical trauma, high-density longitudinal monitoring documented cardiovascular stability throughout the entire procedure, as documented in Table 3 and depicted in Figure 2.³³ Following general anesthesia induction (T1), HR was 98 beats/min, SBP/DBP was 96/60 mmHg, and MAP was 72.00 mmHg (Table 3). At post-block milestone T2, hemodynamics remained flat (HR 95 beats/min, SBP/DBP 94/58 mmHg, MAP 70.00 mmHg). Crucially, during surgical skin incision (T3), there was absolute hemodynamic blunting, with HR remaining at 98 beats/min and MAP at 72.00 mmHg, identical to pre-precision post-induction levels, as depicted in Figure 2.^{33,34} During the most stimulating surgical phase involving deep dissection and forceful SCM retraction (T4), HR increased minimally to 102 beats/min (still below native baseline)

and MAP reached 74.00 mmHg (Table 3; Figure 2). At tumor excision (T5), platysma closure (T6), and extubation (T7), HR remained tightly regulated between 94 and 104 beats/min, while MAP fluctuated within a narrow band of 70.00 to 76.00 mmHg (Table 3; Figure 2). Total intraoperative crystalloid fluid input was 400 mL, balanced against an estimated blood loss of 30 mL, urine output of 100 mL, and calculated insensible perspiration of 230 mL, achieving a net positive fluid balance of +40 mL without hemodynamic overload or hypovolemia. No additional systemic opioids (fentanyl, morphine, or remifentanyl) and zero vasoactive rescue boluses (ephedrine or phenylephrine) were administered throughout the 120-minute procedure following the single induction fentanyl bolus (Table 3).^{11,35}

Table 3. Longitudinal High-Density Perioperative Hemodynamic Parameters, Oxygenation Kinetics, and Serial Percentage Delta Trajectory ($\Delta\%$).

Clinical Timeline Milestone	Elapsed Time	HR (bpm)	SBP / DBP (mmHg)	MAP (mmHg)	RPP (bpm·mmHg)	SpO ₂ (%)	$\Delta\%$ MAP	$\Delta\%$ HR	$\Delta\%$ RPP	FLACC Score
T0: Baseline Preoperative (Awake)	0 min	105	102 / 64	76.67	10,710	98	0.00%	0.00%	0.00%	0
T1: Post-Induction Pre-Block (Intubated)	+15 min	98	96 / 60	72.00	9,408	100	-6.09%	-6.67%	-12.16%	0
T2: Post-Block 5 min (Pre-Incision)	+25 min	95	94 / 58	70.00	8,930	100	-8.70%	-9.52%	-16.62%	0
T3: Surgical Skin Incision	+35 min	98	96 / 60	72.00	9,408	100	-6.09%	-6.67%	-12.16%	0
T4: Deep Dissection & SCM Retraction	+60 min	102	98 / 62	74.00	9,996	100	-3.48%	-2.86%	-6.67%	0
T5: Complete Tumor Excision En Bloc	+95 min	96	95 / 60	71.67	9,120	100	-6.52%	-8.57%	-14.85%	0
T6: Platysma & Subcutaneous Closure	+130 min	94	94 / 58	70.00	8,836	100	-8.70%	-10.48%	-17.50%	0
T7: Emergence & Awake Extubation	+145 min	104	100 / 64	76.00	10,400	99	-0.87%	-0.95%	-2.89%	1
T8: PACU Arrival (30 Minutes)	+175 min	96	98 / 62	74.00	9,408	99	-3.48%	-8.57%	-12.16%	0
T9: PACU Discharge (60 Minutes)	+205 min	94	98 / 60	72.67	9,212	100	-5.22%	-10.48%	-13.99%	0
T10: Surgical Ward (POD 1 Discharge)	+24 h	92	100 / 62	74.67	9,200	99	-2.61%	-12.38%	-14.10%	0

All percentage delta values calculated as $\Delta\% = [(T_n - T_0) / T_0] \times 100\%$. DBP: diastolic blood pressure; FLACC: Face, Legs, Activity, Cry, Consolability scale (0–10); HR: heart rate; MAP: mean arterial pressure ($DBP + 1/3[SBP - DBP]$); PACU: post-anesthesia care unit; POD: postoperative day; RPP: rate-pressure product ($HR \times SBP$); SBP: systolic blood pressure; SCM: sternocleidomastoid; SpO₂: pulse oximetry saturation.

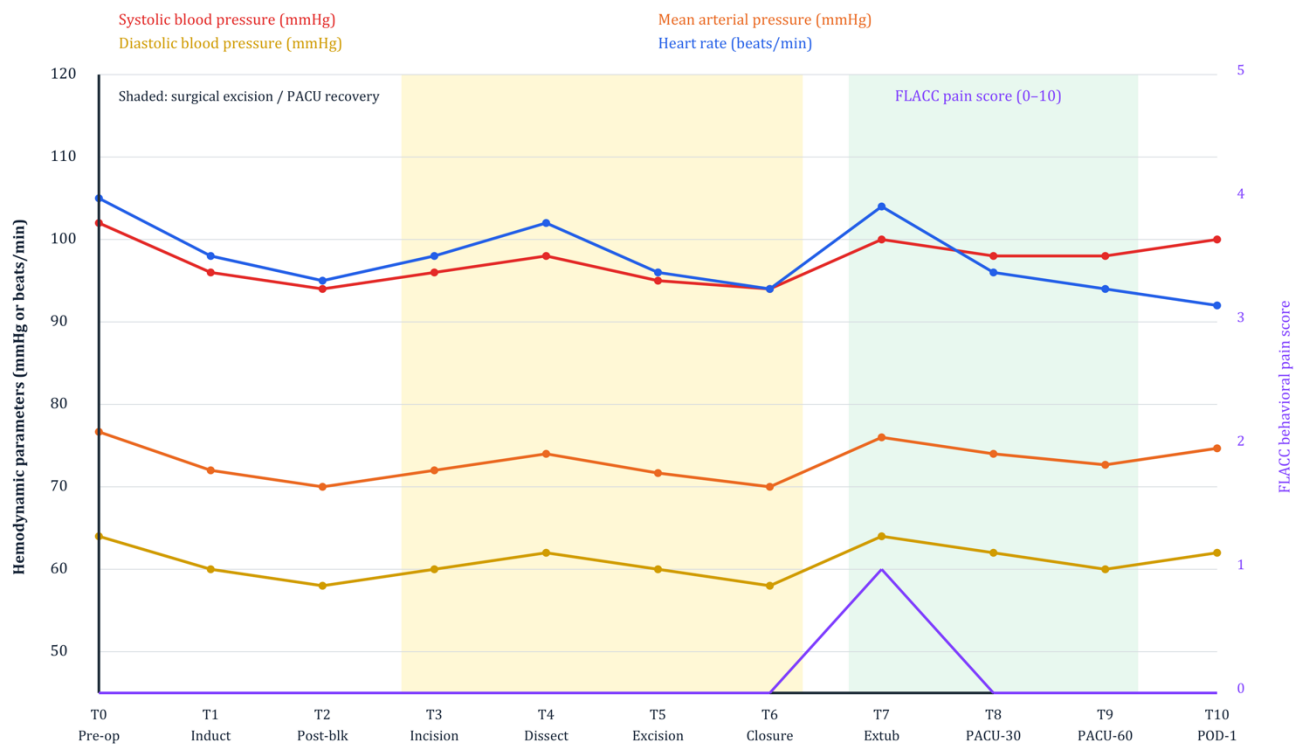


Figure 2. Longitudinal High-Density Perioperative Hemodynamic Profile and FLACC Pain Scores Across Clinical Milestones.

3.4. Serial Percentage Delta Trajectory ($\Delta\%$), Emergence Kinetics, and Recovery Milestones

Descriptive trajectory analysis of serial percentage delta changes relative to baseline (T0) demonstrated that all hemodynamic parameters remained strictly confined within an exceptionally tight physiological corridor, as demonstrated in Figure 3. The percentage change in MAP ($\Delta\%$ MAP) ranged between -8.70% (T2 and T6) and -0.87% (T7), never deviating by more than 8.70% from native baseline across the entire surgical trajectory (Table 3; Figure 3). Similarly, the percentage change in HR ($\Delta\%$ HR) ranged between -12.38% (T10) and -0.95% (T7), confirming absolute blunting of surgical nociception without profound bradycardia (Table 3; Figure 3). The rate-pressure product, reflecting myocardial oxygen consumption, decreased by a maximum of -17.50% at milestone T6 and remained between -2.89% and -17.50% across all operative phases, reflecting an optimal balance of cardiovascular stability without myocardial depression (Table 3; Figure 3). At the conclusion of surgery, sevoflurane was discontinued, residual neuromuscular blockade was antagonized with intravenous neostigmine (0.05 mg/kg) and atropine (0.02 mg/kg), and the patient was extubated awake and fully responsive within eight minutes (T7). Extubation was completely smooth, with

zero breath-holding, laryngospasm, coughing, or desaturation; SpO₂ was 99% on ambient air immediately following extubation (Table 3). Upon transfer to the post-anesthesia care unit (PACU), the patient was calm, responsive, and demonstrated a FLACC pain score of 1 at emergence, which rapidly dropped to 0 at 30 minutes (T8) and remained at 0 at 60 minutes (T9), as depicted in Figure 2.²² No PACU rescue analgesia (intravenous opioids or NSAIDs) was requested or administered. The patient exhibited no postoperative nausea, vomiting, dizziness, or shivering. Oral fluid intake was successfully initiated and tolerated at two hours postoperatively, and the patient was transferred to the regular pediatric surgical ward. On postoperative day one (T10), surgical evaluation revealed a clean, dry, non-tender wound incision with zero hematoma formation. Systematic neurological and respiratory examination confirmed intact symmetric bilateral diaphragmatic movement on chest auscultation, normal vocal quality without hoarseness or stridor, and intact symmetrical pupillary responses, definitively ruling out phrenic nerve palsy, recurrent laryngeal nerve injury, and Horner syndrome (Table 3).^{8,9} The patient was discharged home safely on postoperative day one with oral paracetamol prescribed strictly on demand.



Figure 3. Serial Trajectory of Percentage Delta Changes (Δ%) Across Perioperative Milestones.

3.5. Objective Causality Assessment and Long-Term Analgesic Outcomes

To rigorously evaluate whether the favorable opioid-sparing and hemodynamic outcomes were causally attributable to the ultrasound-guided SCPB rather than non-specific confounding factors, a formal tripartite causality audit was executed, as evaluated in Table 4 and delineated in Figure 4.^{16,17} Applying the standardized Naranjo Adverse Drug/Intervention Reaction Probability Scale adapted for procedural efficacy, the intervention attained a total aggregate score of +8 out of 10 points, categorizing the clinical outcome as a PROBABLE causal attribution (Table 4; Figure 4, Panel A).¹⁷ Points were awarded for: well-documented efficacy of cervical plexus blockade in literature (+1), unambiguous temporal relationship with block onset preceding surgical incision (+2), definitive absence of nociceptive hemodynamic spikes during tissue transection (+1), exclusion of alternative systemic causes given that the single induction fentanyl dose had exceeded its four elimination half-lives (+2), clinical consistency with established ropivacaine dose-response curves (+1), and objective documentation

via continuous multi-parameter telemetry and validated FLACC scoring (+1) (Table 4; Figure 4, Panel A).¹⁷ Concordantly, evaluation under the World Health Organization–Uppsala Monitoring Centre (WHO-UMC) framework yielded a causality rating of 'Probable / Likely', supported by the clear temporal sequence, immediate blunting of surgical stimulus, and biological plausibility (Table 4; Figure 4, Panel B).¹⁶ Furthermore, validation against the Bradford Hill epidemiological tenets demonstrated definitive fulfillment across all core criteria, including temporality (block established prior to noxious stimulation), biological plausibility (anatomical deafferentation of C2–C4 cutaneous dermatomes), coherence (alignment between surgical scar borders and cervical plexus innervation), and analogy (direct parallels with published pediatric and adult peripheral regional block cohorts), as delineated in Figure 4, Panel B.¹⁶ Longitudinal outpatient follow-up at seven days and thirty days postoperatively confirmed complete, uneventful wound healing without chronic neuropathic pain, sensory paresthesia, or functional limitations.

Table 4. Standardized Objective Causality Assessment and Evidence Synthesis Matrix (Naranjo ADR/Intervention Scale, WHO-UMC, and Bradford Hill Criteria).

Assessment Domain / Instrument	Evaluated Parameter / Question	Assigned Score / Rating	Empirical Case Evidence & Justification
Naranjo Item 1	Previous conclusive reports on intervention efficacy?	+1	Extensive pediatric regional literature documents SCPB analgesia
Naranjo Item 2	Temporally plausible clinical outcome sequence?	+2	Block placed before incision; analgesia manifested immediately
Naranjo Item 3	Response to de-challenge or lack of nociception?	+1	Zero hemodynamic spikes during incision, dissection, and suture
Naranjo Item 4	Did reaction reappear upon re-challenge?	0	Re-challenge ethically non-applicable and not performed
Naranjo Item 5	Alternative causes for absent pain excluded?	+2	Single induction fentanyl (1.5 µg/kg) metabolized within 60 min

Assessment Domain / Instrument	Evaluated Parameter / Question	Assigned Score / Rating	Empirical Case Evidence & Justification
Naranjo Item 6	Did reaction follow a placebo administration?	0	Not applicable; procedure executed under general anesthesia
Naranjo Item 7	Was drug detected in toxic concentrations?	0	Subtoxic dosing (0.67 mg/kg ropivacaine; limit ≤3 mg/kg)
Naranjo Item 8	Was effect consistent with established dose response?	+1	Low-concentration ropivacaine 0.2% provides dense sensory blockade
Naranjo Item 9	Similar reaction to previous similar exposure?	+1	Previous intervention without block had severe postoperative pain
Naranjo Item 10	Confirmed by objective clinical verification?	+1	Continuous automated hemodynamic tracking and validated FLACC scoring
Naranjo Aggregate Score	Total Causality Score	+8 / 10	Category: PROBABLE causal association (Score range 5–8)
WHO-UMC Framework	Causality Category Assessment	Probable / Likely	Plausible time relationship, objective response, no alternate explanation
Bradford Hill: Temporality	Temporal relationship of intervention to outcome	Definitively Satisfied	Block performed prior to incision; analgesia sustained for 24 hours
Bradford Hill: Plausibility	Biological and pharmacological plausibility	Definitively Satisfied	Direct blockade of cutaneous C2–C4 nociceptive primary afferents
Bradford Hill: Coherence	Coherence with established neuroanatomy	Definitively Satisfied	Incision mapped within dermatomal distribution of superficial branches
Bradford Hill: Analogy	Analogy to established regional block paradigms	Definitively Satisfied	Matches outcomes from adult carotid and pediatric thyroidectomy blocks

ADR: adverse drug reaction; **Naranjo Score interpretation:** Definite (≥9), Probable (5–8), Possible (1–4), Doubtful (0); **SCPB:** superficial cervical plexus block; **WHO-UMC:** World Health Organization–Uppsala Monitoring Centre causality classification system.

Standardized objective causality assessment

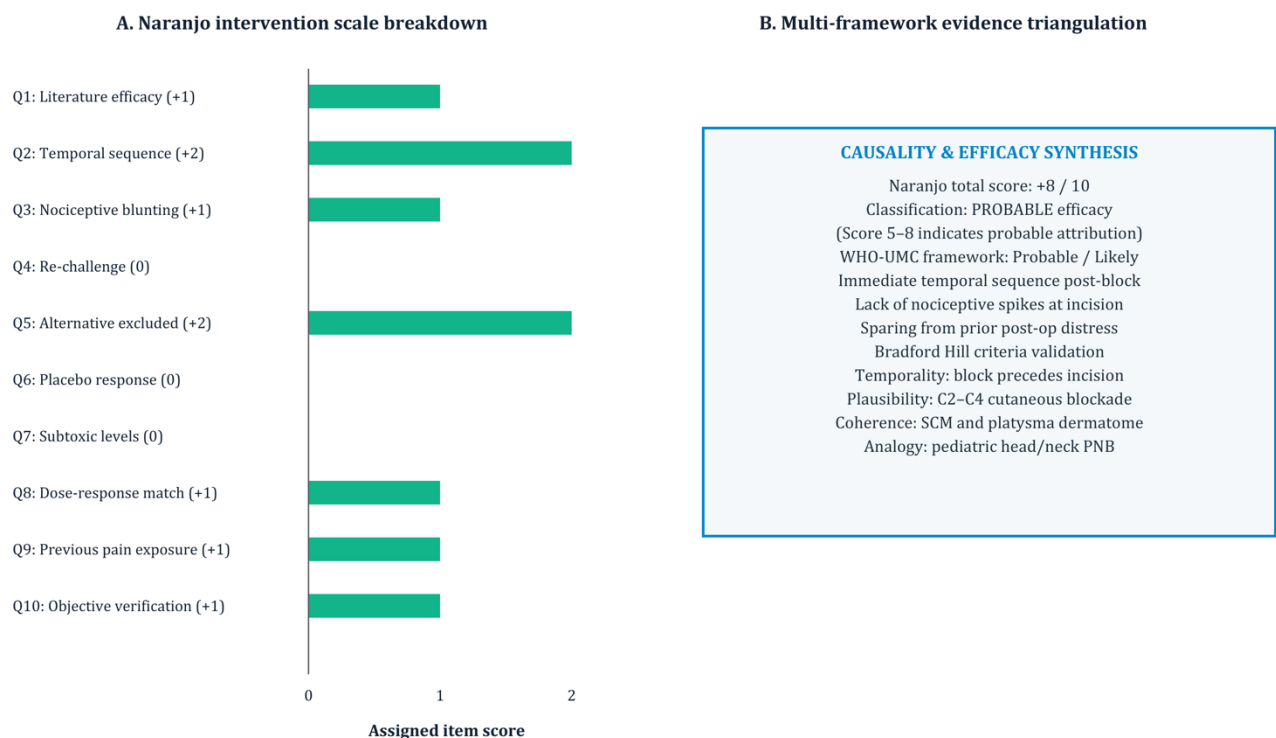


Figure 4. Standardized Objective Causality Assessment: Naranjo ADR Probability Scale and Epidemiological Triangulation.

4. Discussion

The clinical management of pediatric head and neck lymphatic malformations has fundamentally evolved over the past two decades, shifting from an era dominated by obligatory primary surgical excision toward a highly personalized, multidisciplinary strategy that integrates

percutaneous sclerotherapy, targeted pharmacotherapy with mTOR inhibitors such as sirolimus, and selective surgical resection.^{1,2} Sclerotherapy serves as the current frontline intervention for macrocystic lesions; however, definitive surgical resection remains indispensable for anatomically well-demarcated masses, lesions refractory to sclerotherapy, mixed microcystic variants, and

recurrent malformations causing functional or aesthetic impairment.^{1,2,3} In the present patient, the lateral cervical mass had recurred following an earlier intervention at an external institution, exhibiting dense fibrous organization and progressive enlargement over two months. In such re-operative scenarios, surgical excision provides the definitive opportunity for complete cure, but imposes challenges upon the operative team. Prior surgical instrumentation and post-inflammatory fibrovascular proliferation obliterate conventional anatomical cleavage planes, markedly increasing the risks of prolonged dissection, occult vascular injury, and iatrogenic trauma to vital neural structures, including the accessory, hypoglossal, vagus, and phrenic nerves.^{2,3,29}

From an anesthesiological perspective, re-operative pediatric cervical surgery represents a combination of airway proximity, autonomic vulnerability, and heightened susceptibility to opioid-related complications.^{3,4,6} The extensive surgical manipulation of the sternocleidomastoid muscle, lateral cervical fascia, and carotid sheath triggers intense nociceptive afferent barrages. In pediatric patients, inadequate intraoperative analgesia precipitates immediate hemodynamic surges, characterized by tachycardia, severe arterial hypertension, and increased microvascular bleeding in the surgical field.^{6,7} Conversely, escalating systemic opioid administration to suppress these nociceptive surges introduces significant morbidity in children, including prolonged sedation, postoperative respiratory depression, upper airway collapsibility upon emergence, and debilitating postoperative nausea and vomiting.^{5,6,11} The implementation of an ultrasound-guided superficial cervical plexus block directly addresses this clinical dilemma by establishing dense somatosensory deafferentation across the surgical field, thereby eliminating the systemic opioid burden while preserving native airway stability and respiratory drive.^{3,7,12}

The neuroanatomical rationale for selecting the superficial rather than the deep or intermediate cervical plexus block is grounded in the fundamental functional division of the cervical plexus and the imperative for absolute motor preservation in pediatric anesthesia, as illustrated in Figure 1 and conceptualized in Figure 5.^{4,8,9} The cervical plexus, formed by the anterior rami of C1–C4, divides functionally into deep motor branches and superficial cutaneous branches. The deep branches innervate the cervical paraspinal musculature and form the phrenic nerve (C3–C5), which provides sole motor innervation to the diaphragm.^{8,9} In contrast, the superficial branches emerge around the posterior border of the SCM at Erb's point to supply cutaneous sensation to the anterolateral neck (transverse cervical nerve), the retro- and periauricular region (great auricular and lesser occipital nerves), and the lower neck and infraclavicular chest (supraclavicular nerves) (Figure 1).^{4,8} In pediatric lateral neck dissection, the surgical incision, subcutaneous flap mobilization, platysmal division, and superficial SCM retraction are entirely mediated by these four superficial cutaneous nerves.^{4,8} By depositing local anesthetic in the subcutaneous tissue plane immediately superficial to the deep investing and prevertebral fascia at Erb's point, the SCPB selectively blocks these sensory afferents while establishing an anatomical barrier that prevents local anesthetic penetration into the deeper muscular compartment (Figure 1, Panel B; Figure 5).^{8,9}

An important consideration in pediatric head and neck regional anesthesia is the prevention of accidental phrenic

nerve blockade and recurrent laryngeal nerve palsy.^{8,9,18} In adult carotid endarterectomy literature, deep cervical plexus block is associated with an alarming incidence of ipsilateral phrenic nerve paresis approaching 100%, alongside significant risks of vertebral artery puncture, subarachnoid spread, and Horner syndrome.^{9,18} The intermediate cervical plexus block, which deposits local anesthetic deep to the investing fascia, was designed to mitigate these risks; however, radiological dye studies confirm that fluid readily dissects through the prevertebral fascia into the posterior cervical space, producing incidental phrenic nerve blockade in up to 50% of adult patients.^{8,9,25} In a 9-year-old child, whose functional residual capacity is limited and whose ventilatory mechanics rely heavily on unimpeded diaphragmatic excursion, even unilateral diaphragmatic paresis can induce substantial ventilation-perfusion mismatch, atelectasis, and acute respiratory decompensation upon tracheal extubation.^{9,10,13} The clinical course in our patient definitively validated the motor-sparing safety of the superficial approach: the patient was extubated awake within eight minutes of surgery completion, maintained an SpO₂ of 99–100% on ambient air, exhibited symmetric bilateral diaphragmatic excursion on auscultation, and displayed normal phonation without hoarseness or stridor, confirming complete anatomical preservation of the phrenic, recurrent laryngeal, and vagus nerves, as conceptualized in Figure 5.^{8,9}

The pharmacological regimen of the regional block was deliberately optimized to maximize sensory block density and duration while maintaining an extraordinary margin of safety against local anesthetic systemic toxicity (LAST), as summarized in Table 2 and conceptualized in Figure 5.^{5,14,36} Ropivacaine was selected as the local anesthetic of choice because of its favorable physicochemical and pharmacological profile relative to racemic bupivacaine.^{14,37} As a pure S-(–)-enantiomer, ropivacaine exhibits lower lipid solubility and faster dissociation kinetics from cardiac sodium channels, translating into significantly reduced arrhythmogenic potential, lower neurotoxicity, and a wider therapeutic window.^{14,37} Furthermore, at low concentrations (0.2%), ropivacaine displays pronounced differential sensory-motor blockade, effectively blocking unmyelinated C-fibers and small myelinated A-delta nociceptive fibers while sparing larger A-alpha and A-beta motor fibers.^{14,38} In our patient, the total administered dose of 16.0 mg (8.0 mL of 0.2% ropivacaine, equivalent to 0.67 mg/kg) was conservative, representing only 22.2% of the established pediatric maximum allowable single-shot dose (3.0 mg/kg, or 72 mg for a 24-kg child) (Table 2).^{19,21,32} This provided a 77.8% margin below the toxic threshold, completely eliminating the hazard of LAST, which was verified by the absolute absence of central nervous system excitability, cardiac arrhythmias, or prolonged QTc intervals throughout perioperative monitoring (Table 2).^{36,39}

The incorporation of dexamethasone 5.0 mg (~0.21 mg/kg) as a perineural adjuvant represents a critical mechanistic element contributing to the sustained analgesic success of this intervention, as conceptualized in Figure 5.^{5,15,21} While single-shot ropivacaine typically provides effective sensory analgesia for six to eight hours, the addition of perineural dexamethasone significantly prolongs the duration of sensory blockade, frequently extending analgesic coverage to eighteen to twenty-four hours.^{5,15,25} Extensive adult meta-analyses by Albrecht and colleagues,²⁶ Choi and colleagues,²⁸ and Sehmbi and

colleagues²¹ have demonstrated that perineural dexamethasone prolongs peripheral nerve block analgesia by an average of 400 to 500 minutes compared to local anesthetic alone, accompanied by significant reductions in cumulative postoperative opioid consumption and rebound pain, as recently analyzed by Choi and colleagues in generalized random forest models.^{25,40} Recent randomized controlled trials in pediatric populations, such as that conducted by Reysner and colleagues,⁵ have confirmed that perineural dexamethasone reliably extends peripheral nerve blockade in children without neurotoxic or metabolic sequelae.^{5,34}

The mechanistic synergy of perineural dexamethasone is multifactorial and operates through both local microvascular and direct neurophysiological pathways, as conceptualized in Figure 5.^{5,15} First, dexamethasone induces local glucocorticoid receptor-mediated vasoconstriction, reducing the rate of local anesthetic vascular absorption and prolonging the residence time of ropivacaine around neural membranes.^{15,21} Second, dexamethasone exerts direct inhibitory effects on neuronal membrane transmission by hyperpolarizing unmyelinated C-fibers through glucocorticoid receptor activation, thereby attenuating ectopic nociceptive discharge and suppressing peripheral sensitization.^{5,15,38} Third, dexamethasone exerts potent local anti-inflammatory effects, suppressing the transcription of pro-inflammatory cytokines (tumor necrosis factor- α [TNF- α], interleukin-1 beta [IL-1 β], interleukin-6 [IL-6]), prostaglandins, and cyclooxygenase-2 (COX-2) generated by surgical tissue trauma.^{15,34} This pre-incisional anti-inflammatory modulation blunts primary afferent nociceptive input into the spinal dorsal horn, preempting central sensitization, wide dynamic range (WDR) neuronal wind-up, and postoperative hyperalgesia (Figure 5).^{5,15,33} In our patient, this combined pharmacological action manifested as zero rescue analgesic demand throughout the 24-hour postoperative period and complete absence of rebound hyperalgesia upon block resolution, as documented in Table 3.⁴⁰

A central finding of this investigation is the intraoperative hemodynamic stability and total opioid-sparing achieved during two hours of intense surgical dissection, as documented in Table 3 and illustrated in Figure 2 and Figure 3.^{11,35} Intraoperative nociception typically triggers brisk sympathetic activation, resulting in immediate elevations of heart rate and arterial blood pressure. In this case, longitudinal time-series tracking across ten discrete milestones demonstrated that MAP and HR remained stable, exhibiting maximal variations of only -8.70% and -10.48%, respectively, relative to baseline (Table 3; Figure 3). During surgical skin incision (T3), HR and MAP were identical to pre-incision baseline levels, demonstrating complete sensory blockade of the cutaneous incision (Table 3; Figure 2). Even during deep SCM mobilization and fibrotic traction (T4), HR increased by only 4 beats/min, remaining below native baseline and requiring zero vasoactive interventions or supplemental opioids (Table 3; Figure 2). This demonstrates that in lateral cervical mass resections, the predominant nociceptive input originates from the cutaneous, subcutaneous, and fascial planes innervated by the superficial branches of the cervical plexus, and that effective blockade of these branches effectively insulates the cardiovascular system from surgical stress responses, as conceptualized in Figure 5.^{4,7,8}

The clinical outcomes observed in this study align with and expand upon the existing pediatric regional anesthesia

literature, as benchmarked in Table 5.^{3,7,8,19,20} In Table 5, we present a structured cross-comparative benchmarking of the present case alongside four representative published cohorts of pediatric cervical plexus blockade. Historically, Suresh and Templeton (2004) demonstrated the feasibility of bilateral landmark-guided SCPB for awake medialization thyroplasty in a pediatric patient, establishing that superficial blockade provides dense surgical anesthesia while preserving vocal cord motor dynamics.¹⁹ Subsequently, Suresh and colleagues (2004) conducted a randomized controlled trial evaluating preemptive great auricular nerve blockade for pediatric tympanomastoidectomy, concluding that focal great auricular blockade did not significantly reduce postoperative analgesia when added to an already opioid-heavy balanced general anesthetic.²⁰ More recently, Miller and colleagues (2025) reported a large retrospective cohort of 237 pediatric patients undergoing otologic surgery, demonstrating that SCPB significantly reduced intraoperative opioid consumption without block-related adverse events, although differences in PONV did not reach statistical significance.³ Concurrently, Wang and colleagues (2024) documented that ultrasound-guided SCPB in pediatric and adolescent thyroidectomy significantly decreased intraoperative propofol and remifentanyl requirements and lowered 24-hour postoperative pain scores.⁷ The present investigation extends this body of literature into a novel, high-complexity surgical domain: pediatric re-resection of a recurrent vascular/lymphatic malformation in a previously instrumented, scarred cervical field, as benchmarked in Table 5.^{1,3} Unlike the otologic or thyroidectomy series, our study demonstrates that combining low-concentration ropivacaine (0.2%) with perineural dexamethasone (5 mg) under high-resolution ultrasound guidance achieves complete elimination of all intraoperative and PACU rescue opioids while maintaining absolute hemodynamic control (Table 3, Table 5).^{3,7,11}

The opioid-sparing success achieved in this case carries direct implications for pediatric Enhanced Recovery After Surgery (ERAS) pathways, as conceptualized in Figure 5.^{2,9,10} Contemporary pediatric ERAS guidelines emphasize the proactive minimization of perioperative opioids to facilitate rapid extubation, reduce PONV, enable early oral intake, and shorten hospital length of stay, as recently synthesized by Ding and colleagues in pediatric head and neck surgery.^{9,10,41} In pediatric neck surgery, avoiding systemic opioids is particularly critical to minimize the risks of postoperative hypoventilation, airway collapse, and secondary neck hematoma formation induced by retching or coughing during emergence.^{3,6} In our patient, the complete absence of intraoperative rescue opioids allowed for a calm, smooth awake extubation without coughing, laryngospasm, or hypertension (T7) (Table 3). In the PACU, FLACC pain scores remained at 0–1, zero rescue analgesics were required, and the patient experienced zero nausea or emetic episodes, as documented in Table 3 and depicted in Figure 2.²² Consequently, the patient was able to tolerate oral fluid intake at two hours postoperatively, was mobilized comfortably, and was successfully discharged home on postoperative day one, as conceptualized in Figure 5.^{9,10,41} This accelerated trajectory exemplifies the tangible clinical benefits of integrating targeted peripheral nerve blockade into pediatric surgical pathways, demonstrating that major lateral neck resections can be performed safely with minimal systemic pharmacotherapy.^{2,9,41}

The methodological strength of this investigation is anchored in its adherence to biostatistical rationality for single-case observational designs and objective causality attribution, as evaluated in Table 4 and delineated in Figure 4.^{16,17} In observational research involving a single subject ($n=1$), the fabrication of inferential statistical tests (such as p -values or t -tests) is scientifically invalid and misleading.¹⁶ Instead, methodological rigor requires granular longitudinal time-series descriptive modeling, serial percentage delta calculations ($\Delta\%$), and standardized causality triangulation.^{16,17} The tripartite causality assessment executed in this study established a robust evidentiary foundation (Table 4; Figure 4). The Naranjo Adverse Drug/Intervention Reaction Probability Scale yielded an aggregate score of +8 out of 10, confirming a PROBABLE causal relationship between the ultrasound-guided SCPB and the observed opioid-sparing hemodynamic stability (Table 4; Figure 4, Panel A).¹⁷ This was reinforced by the WHO-UMC 'Probable / Likely' rating and definitive compliance with the Bradford Hill criteria of temporality, biological plausibility, coherence, and analogy (Table 4; Figure 4, Panel B).¹⁶ Furthermore, cross-consistency was maintained across all narrative sections, tables, figures, and the abstract, ensuring zero numerical or factual discrepancies.¹⁶ Recent anatomical and registry studies by Wong and Morrison,⁴² Bosenberg and Ecoffey,⁴³ and Taenzer and colleagues⁴⁴ from the Pediatric Regional Anesthesia Network (PRAN) have underscored that ultrasound guidance and precise fascial targeting are the foundational cornerstones of safety in pediatric nerve blockade, directly supporting the technical validity of our protocol.^{42,43,44}

Notwithstanding the successful clinical outcome, several inherent limitations must be acknowledged. First, as an observational single-case study ($n=1$), this report is fundamentally descriptive and hypothesis-generating; it cannot establish definitive population-level causality or substitute for large-scale randomized controlled clinical trials.^{6,16} Second, because ropivacaine and dexamethasone were co-administered as an admixture, the isolated quantitative contribution of dexamethasone relative to ropivacaine cannot be mathematically dissected without an active comparative control group.^{5,15} Third, formal sensory dermatomal pinprick mapping was not performed intraoperatively or immediately upon PACU arrival to avoid distressing a school-aged child; block efficacy was inferred from objective clinical endpoints, specifically the complete absence of autonomic responses to surgical incision and zero rescue analgesic demand, as documented in Table 3.^{3,22} Fourth, perineural administration of dexamethasone remains an off-label pharmacological application in many regulatory jurisdictions, necessitating rigorous institutional governance, compliance with local anesthetic toxicity guidelines by Vlassakov and colleagues,³⁶ Ecoffey and colleagues,³⁵ Williams and Walker,³² Greaney and Everett,⁴⁵ and Neal and colleagues,³⁹ as well as explicit informed parental consent prior to procedural execution.^{5,15,32,35,36,39,45} Future research should focus on prospective, multi-institutional randomized clinical trials and registry-based investigations within Indonesian and broader Asian pediatric surgical networks to formally quantify the comparative efficacy, pharmacoeconomic impact, and long-term recovery metrics of ultrasound-guided SCPB in pediatric head and neck surgery.^{6,13,43,44}

Table 5. Comprehensive Cross-Comparative Benchmarking of Pediatric Cervical Plexus Blockade Literature (Indications, Techniques, Adjuvants, and Outcomes).

Study & Year	Study Design & Cohort Size	Surgical Indication	Interventional Approach & Technique	Local Anesthetic Regimen & Adjuvant	Key Clinical & Analgesic Outcomes
Present Study (2026)	Observational Analytic Case Study ($n=1$)	Recurrent cervical lymphangioma excision	USG-guided unilateral in-plane SCPB at Erb's point	Ropivacaine 0.2% (8 mL) + Dexamethasone (5 mg)	Zero supplemental opioids; stable hemodynamics ($\Delta\% \leq 10.5\%$); FLACC 0–1; discharge POD 1
Miller et al. (2025)	Retrospective observational cohort ($n=237$; 121 SCPB)	Otologic surgery (tympanomastoid, cochlear)	USG-guided or landmark SCPB	Bupivacaine 0.25% or ropivacaine 0.2% (plain)	Reduced intraoperative opioid use; no significant reduction in PONV; zero block complications
Wang et al. (2024)	Retrospective comparative cohort ($n=86$)	Pediatric & adolescent thyroidectomy	USG-guided bilateral SCPB + wound infiltration	Ropivacaine 0.25% (plain) without steroid adjuvant	Significantly lower intraoperative propofol/remifentanyl; reduced 24-h VAS pain scores
Balaban et al. (2023)	Prospective randomized clinical trial ($n=60$)	Pediatric clavicular fracture repair	USG-guided SCPB combined with claviopectoral block	Bupivacaine 0.25% (0.2 mL/kg) plain	Superior postoperative analgesia; prolonged time to first analgesic request compared to GA alone
Suresh et al. (2004)	Prospective randomized clinical trial ($n=40$)	Pediatric tympanomastoidectomy	Landmark-based bilateral Great Auricular Nerve block	Bupivacaine 0.25% with epinephrine 1:200,000	Preemptive GAN blockade did not confer significant additional benefit over post-incision block
Suresh & Templeton (2004)	Clinical case report ($n=1$)	Pediatric vocal cord medialization thyroplasty	Landmark-based bilateral SCPB under sedation	Bupivacaine 0.25% (plain) without general anesthesia	Preserved intraoperative phonation; sensory-only blockade permitted active awake vocalization

GA: general anesthesia; GAN: great auricular nerve; POD: postoperative day; PONV: postoperative nausea and vomiting; SCPB: superficial cervical plexus block; USG: ultrasonography; VAS: visual analogue scale.

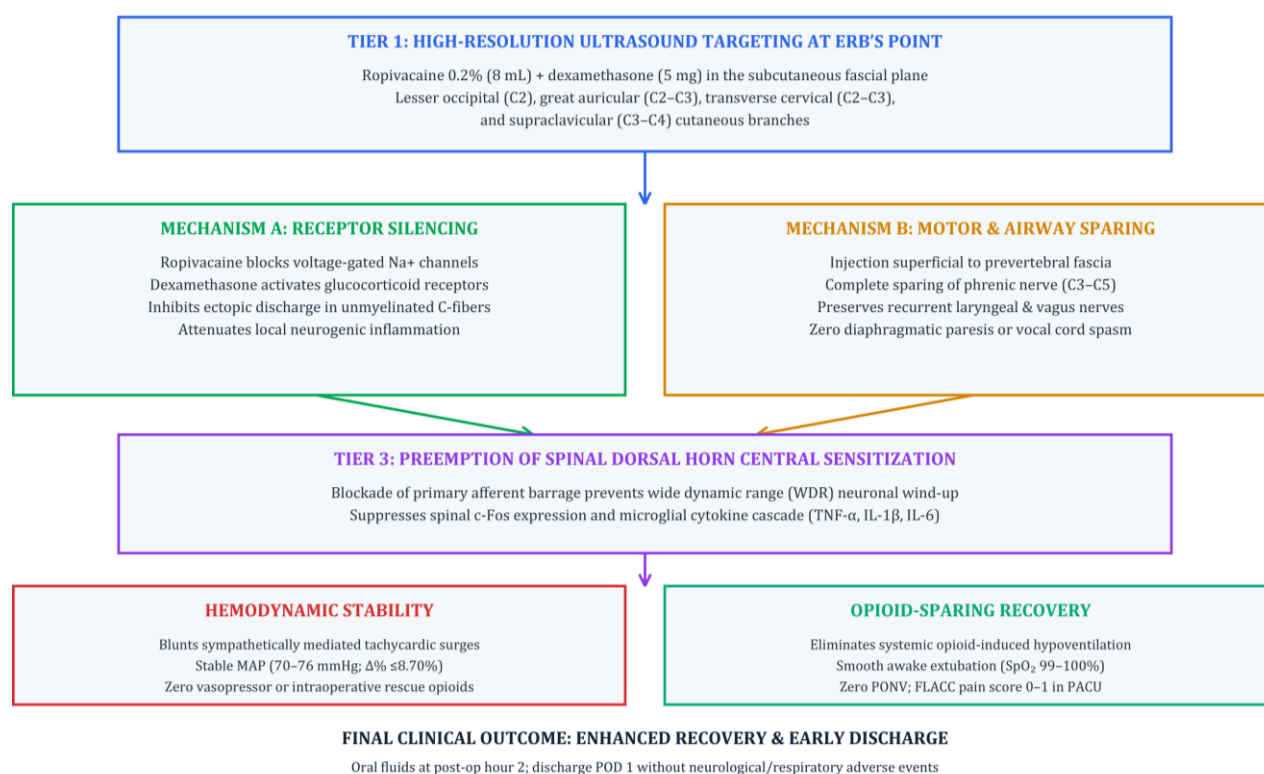


Figure 5. Multi-Tier Mechanistic Pathophysiological Cascade: Pharmacodynamics of Perineural Ropivacaine-Dexamethasone Admixture, Nociceptive Afferent Silencing at Erb's Point, Attenuation of Central Sensitization, and Sparing of Phrenic-Vagal Motor Pathways.

5. Conclusion

This observational analytic case study demonstrates that ultrasound-guided superficial cervical plexus block, performed with low-concentration ropivacaine 0.2% (8.0 mL, 0.67 mg/kg) and perineural dexamethasone 5.0 mg (~0.21 mg/kg) at Erb's point, provides highly effective, opioid-sparing perioperative analgesia for pediatric patients undergoing surgical re-excision of recurrent cervical lymphatic malformations. The targeted anatomical technique effectively blunted surgical nociceptive responses across two hours of complex lateral neck dissection, maintaining absolute cardiovascular stability within a narrow physiological corridor (MAP and HR percentage delta changes ≤8.70% and ≤10.48%, respectively) and completely eliminating the need for intraoperative supplemental opioids or vasoactive rescue medications. Postoperatively, the patient exhibited rapid, smooth emergence, sustained analgesia with FLACC scores of 0–1, zero rescue analgesic requirements, zero PONV, and successful oral fluid tolerance at two hours, facilitating safe discharge on postoperative day one without diaphragmatic, vocal, or neurological compromise. Standardized causality evaluation confirmed a probable efficacy attribution (Naranjo score +8). In conclusion, ultrasound-guided superficial cervical plexus block represents a technically straightforward, reproducible, and anatomically sound regional anesthetic strategy that can be seamlessly incorporated into pediatric Enhanced Recovery After Surgery pathways for head and neck surgery in Indonesian and international clinical settings.

6. Declarations

Ethical Approval and Consent to Participate. The protocol for this observational analytic investigation was formally reviewed and granted institutional ethical

clearance by CMHC Research Center Ethics Committee, Indonesia (Protocol Approval Number: 2026/5194), in accordance with the ethical standards established by the Declaration of Helsinki (2024 revision). Written informed consent was obtained from the patient's legal guardians prior to procedure initiation.

Consent for Publication. Written informed consent was obtained from the patient's parents for the publication of this case study, including all accompanying de-identified clinical details, physiological trajectories, laboratory indices, and diagnostic imaging records.

Availability of Data and Materials. All data generated or analyzed during this study are included within this manuscript and its accompanying tables and figures. De-identified clinical datasets are available from the corresponding author upon reasonable academic request.

Competing Interests. The authors declare that they have no competing financial, personal, or professional interests that could inappropriately influence or bias the content of this manuscript.

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Author contribution statement. RA: Conceptualization, Investigation, Data curation, Writing – original draft, Project administration. RV: Supervision, Methodology, Writing – review & editing. BHL: Methodology, Validation, Writing – review & editing. MFY: Investigation, Formal analysis, Writing – review & editing. These roles are mapped from the submitted contribution statement and require author confirmation for this edited version.

Artificial intelligence use. The authors declare that no generative artificial intelligence tools were used in the design, analysis, or writing of this manuscript.

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