Alqalam Journal of Medical and Applied Sciences. 2026;9(11):3964-3969
https://doi.org/10.54361/ajmas.261155

Review article

Ultrasound-Guided Supraclavicular Brachial Plexus Block in Upper-Limb Orthopedic Surgery: Efficacy, Respiratory Effects, Safety, and Adjuvants

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Abstract
Ultrasound-guided supraclavicular brachial plexus block (US-SCB) provides dense anesthesia for many elbow, forearm, wrist, and hand operations, but the target lies close to the pleura and phrenic nerve. To summarize contemporary evidence on the use, efficacy, respiratory effects, complications, adjuvants, and selection of US-SCB in upper-limb orthopedic surgery. Focused narrative review (not a registered systematic or scoping review) using PubMed/MEDLINE, Google Scholar, and open-access repositories, prioritizing randomized trials, meta-analyses, and practice guidance. No duplicate screening, formal risk-of-bias assessment, or pooling was performed. Observational series report high success and low major-complication rates (94.9% success in 565 pediatric trauma cases; 0.6% adverse events in 713 ambulatory hand procedures), although definitions of success vary. In a dose-escalation study (n = 21), hemidiaphragmatic paresis occurred at every volume studied, from 33% at 5 mL to 100% at 30–35 mL, so lower volumes may reduce but do not eliminate it. In a randomized trial using 25 mL, costoclavicular block caused less hemidiaphragmatic paresis (reported as paralysis) than US-SCB (11.4% vs 47.5%). Trials comparing perineural with intravenous dexamethasone are conflicting. US-SCB remains useful for selected distal upper-limb procedures. Selection should consider surgical territory, respiratory reserve, total local-anesthetic dose, and operator expertise; more distal approaches may be preferable when temporary hemidiaphragmatic paresis would be poorly tolerated. Most evidence is observational or from small trials, and adequately powered comparative studies are needed.
Keywords. Brachial Plexus, Regional Anesthesia, Supraclavicular Block, Orthopedic Surgery.

Introduction

Regional anesthesia is an important component of perioperative care for upper-limb orthopedic surgery. A brachial plexus block may provide surgical anesthesia or supplement general anesthesia, and it can reduce systemic opioid exposure while the block is active. The magnitude of benefit depends on the operation, the local-anesthetic regimen, patient characteristics, and the surrounding multimodal analgesic plan. The supraclavicular approach targets the plexus at the level of the trunks and divisions, where the neural elements are compact near the subclavian artery and first rib. This supports dense anesthesia of the distal two-thirds of the upper limb and makes the approach a common option for surgery at or below the elbow [1–3]. Because the pleural dome and phrenic nerve lie close to the target, pneumothorax and hemidiaphragmatic paresis have been the principal concerns. Historically, pneumothorax rates as high as 6.1% were reported without ultrasound monitoring [4]. Ultrasound improves visualization of the needle, pleura, first rib, vessels, and injectate spread, but it does not make complications impossible.

This review focuses on clinically meaningful distinctions: technical block success versus patient-centered recovery, sonographic hemidiaphragmatic paresis versus clinically important respiratory impairment, risk reduction versus risk elimination, and block Throughout this review, hemidiaphragmatic paresis denotes any ipsilateral reduction in diaphragmatic function, partial or complete; the term “paralysis” is retained only where a cited study used it to describe complete loss of movement; and respiratory impairment denotes clinically relevant effects such as dyspnea, hypoxemia, reduced pulmonary function, or need for intervention.

Review Approach

This is a focused narrative review updated through 8 November 2026. Targeted searches were conducted in PubMed/MEDLINE, Google Scholar, and open-access full-text repositories. Search concepts included supraclavicular brachial plexus block, ultrasound, hemidiaphragmatic paresis or paralysis, pneumothorax, corner-pocket injection, local-anesthetic volume, infraclavicular or costoclavicular block, dexamethasone, dexmedetomidine, rebound pain, and postoperative analgesia. Reference lists of key reviews and trials were also examined. Eligible evidence consisted of clinical studies, systematic reviews, meta-analyses, and professional guidance directly relevant to US-SCB or a closely related comparative approach; studies of neighboring blocks (infraclavicular, interscalene) are identified as such and were used only where SCB-specific data were lacking. The review is not registered and is not systematic. No exhaustive screening, independent duplicate selection, formal risk-of-bias assessment, or quantitative synthesis was performed. Study designs range from case reports to randomized trials, so findings are described by design and should be interpreted accordingly.

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Received*: 19-09-2026 -* ***Accepted****: 18-11-2026 -* ***Published****: 26-11-2026*

Anatomical and procedural considerations

At the supraclavicular fossa, the plexus is generally visualized posterolateral to the subclavian artery and superficial to the first rib. The first rib is an important bony boundary, and the pleural line should be identified before needle advancement. Relevant vessels should be assessed with Doppler when appropriate, and safe performance requires continuous needle-tip visualization and observation of extraneural injectate spread [1].

The "corner pocket" refers to the region between the subclavian artery and first rib near the inferior aspect of the plexus. In a randomized trial of 36 patients, predominantly corner-pocket deposition produced less hemidiaphragmatic paresis than predominantly intracluster injection (27.8% vs 66.7%), but hemidiaphragmatic paresis was not abolished [5]. Because injection volume, anesthetic mixture, needle trajectory, and definitions of hemidiaphragmatic paresis differ between studies, this result should not be generalized as a universal hemidiaphragm-sparing technique. US-SCB is most often considered for operations of the elbow, forearm, wrist, and hand. It is less attractive when the operation extends proximally toward the shoulder, when the incision or tourniquet falls outside the expected neural distribution, or when the patient cannot tolerate temporary ipsilateral hemidiaphragmatic paresis.

Efficacy and complication rates in clinical series

"Success" is not uniform across studies: it may mean complete sensory block, absence of supplemental analgesia, completion without conversion to general anesthesia, or a composite endpoint. A universal success rate should therefore not be quoted without defining the endpoint and population. (Table 1) summarizes the main clinical series.

Table 1. Efficacy and safety outcomes in clinical series of ultrasound-guided brachial plexus block.

Series	Population / design	Main findings	Ref.
Zadrazil 2020	565 children, upper-limb trauma surgery; retrospective, single trauma center; brachial plexus blocks of several approaches	Success 94.9%; failure rate 1.2% in the youngest children, rising to 12.5% at 15–18 years	[6]
Voskeridjian 2021	713 outpatient hand/upper-extremity cases, ambulatory surgery center; retrospective	4 adverse events (0.6%: 2 abnormal reactions, 2 incomplete blocks); no clinically significant pulmonary or neurovascular complications	[3]
Gamboa 2026	Prospective pilot of a training program, resource-limited hospital in Guatemala; all peripheral nerve blocks	Success 96.3% (180/187 blocks); no observed patient complications	[7]
Schöll 2025	35,443 orthopedic-trauma emergency patients over 6 years; retrospective, single center	Peripheral regional anesthesia used as an alternative to sedation, general anesthesia, or opioid analgesia; authors describe it as effective and low risk	[8]

These series suggest high success and few major complications, but they are retrospective or small, mix-block approaches in some cases, and cannot exclude rare serious events. Efficacy comparisons between approaches are discussed in section 6.

Local-anesthetic volume and hemidiaphragmatic paresis

There is no single minimum effective volume that applies across drugs, concentrations, injection sites, patient populations, and surgical endpoints. In a dose-escalation study of 21 patients, hemidiaphragmatic paresis was present at every dose studied, with an incidence of 33% at 5 mL and 100% at 30–35 mL; higher volumes produced denser sensory and motor block. Patients with hemidiaphragmatic paresis had small reductions in negative inspiratory force and room-air oxygen saturation, but dyspnea did not increase, and none required respiratory intervention [9]. Lower volume may therefore reduce the probability or extent of hemidiaphragmatic paresis in some protocols but cannot guarantee hemidiaphragm sparing, and low-volume techniques may increase incomplete coverage or the need for supplementation. Dose should be prescribed in milligrams as well as milliliters, and total exposure must include surgeon infiltration, additional blocks, and any repeat dosing.

Hemidiaphragmatic paresis is the main respiratory trade-off of US-SCB. Its frequency depends on volume, injection location, the timing and definition of ultrasound assessment, and the patient population. Sonographic hemidiaphragmatic paresis is not equivalent to clinically important respiratory impairment (e.g., dyspnea or hypoxemia), but it may matter in patients with severe lung disease, contralateral diaphragmatic dysfunction, neuromuscular weakness, or limited respiratory reserve.

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Received*: 19-09-2026 -* ***Accepted****: 18-11-2026 -* ***Published****: 26-11-2026*

Choosing between approaches

In a randomized trial of 80 patients using 25 mL of local anesthetic, hemidiaphragmatic paresis (reported as paralysis) occurred in 11.4% (4/35) after costoclavicular block versus 47.5% (19/40) after supraclavicular block, and pulmonary function was better preserved with the costoclavicular approach [10]. A propensity-matched retrospective cohort of 118 pairs showed the same direction (2.5% vs 39.8%), with both approach and injected volume associated with hemidiaphragmatic paresis (reported as paralysis) [11], and another randomized study also compared ipsilateral hemidiaphragmatic paresis after the two approaches [12]. These findings come from specific techniques and hemidiaphragmatic paresis definitions, so they support considering a more distal approach rather than a universal ranking of blocks. A related phrenic-sparing strategy for shoulder surgery, superior trunk block, reduced hemidiaphragmatic paresis (reported as paralysis) versus interscalene block in a meta-analysis of four randomized trials (359 patients; RR 0.07) with comparable block duration [13]; this concerns a different indication and is not directly transferable to the distal upper limb. Meta-analytic comparison of infraclavicular and supraclavicular blocks for distal arm surgery is limited. A 2024 meta-analysis of six randomized trials reported that the supraclavicular block was associated with less frequent complete sensory block (OR 0.41, 95% CI 0.19–0.88), and concluded that infraclavicular block may be superior for analgesia but needs longer performance time [14]. Heterogeneity in operations, anesthetics, and protocols prevents a universal conclusion.

Approach selection should integrate surgical territory, tourniquet location, respiratory risk, anatomy, anticoagulation and infection considerations, patient preference, operator experience, local-anesthetic dose, and the consequences of failure. The plan should include supplementation or conversion if surgical anesthesia is incomplete, and consent should address expected weakness or numbness, incomplete block, vascular puncture, systemic toxicity, pneumothorax, and respiratory effects.

Safety

Pneumothorax and vascular events

In a prospective observational study of 6366 ultrasound-guided periclavicular blocks, clinically symptomatic pneumothorax occurred in four patients (0.06%), three after a latency of two days [4], and the risk after ultrasound-guided supraclavicular block has been estimated at 0.4 per 1000 [15]. Delayed presentation means that discharge instructions should name respiratory symptoms and a local evaluation pathway. Prevention depends on identifying the pleural line and first rib, continuous needle-tip visualization, avoiding advancement when the tip is uncertain, and appropriate training and supervision [1,15]. Aspiration, incremental injection, total-dose accounting, and readiness to treat local-anesthetic systemic toxicity are prudent safeguards [16].

Intraneural injection and neurological complications

Ultrasound does not eliminate intraneural injection. In a prospective cohort of 257 patients receiving ultrasound-guided interscalene or supraclavicular blocks, blinded offline video review identified intraneural injection in 17% (95% CI 12–22%), yet no patient had a postoperative neurological complication (0%; 95% CI 0–1.6%) [17]. During supraclavicular block, a stimulation current of 0.2 mA or less reliably indicated intraneural needle placement, whereas currents of 0.2–0.5 mA could not exclude it [18]. Case reports document prolonged neurological recovery after ultrasound-guided brachial plexus block [19]. Persistent neurological symptoms should prompt consideration of surgical, positioning, tourniquet, and pre-existing causes alongside the block [20].

Adjuvants, diluents, and timing

Dexamethasone can prolong peripheral nerve block analgesia [21], but evidence on route is conflicting. One randomized trial reported that perineural dexamethasone shortened onset and prolonged sensory and motor block compared with the intravenous route in supraclavicular block [22]. In contrast, a 75-patient randomized trial found similar analgesia duration (about 25 h) with intravenous and perineural dexamethasone [23], and a network meta-analysis of supraclavicular trials found no clinically important difference between the routes [24]. A 2024 meta-analysis of interscalene block found only a low-quality advantage of about 2 hours for the perineural route, raised off-label and drug-crystallization concerns, and favored intravenous administration [25]; this is indirect evidence for US-SCB. Perineural dexamethasone remains off-label in many jurisdictions and should follow local policy, formulation compatibility, and consideration of glycemic effects.

In the same network meta-analysis, perineural but not intravenous dexmedetomidine prolonged block duration [24], while it can cause sedation, bradycardia, and hypotension. In an observational study of infraclavicular block, dexmedetomidine added to 0.75% ropivacaine produced longer sensory and motor blockade and analgesia than fentanyl, with slower onset [26]. Diluting ropivacaine with 5% dextrose shortened onset of analgesia compared with saline in supraclavicular block [27], and ropivacaine produced a faster onset but earlier motor regression than bupivacaine in below-elbow surgery [28]. Adjuvant effects should be quoted only with the drug, dose, local anesthetic, route, and endpoint specified.

Timing also matters. In 52 patients undergoing radial fracture fixation under general anesthesia, a pre-operative ultrasound-guided infraclavicular block delayed the first rescue analgesic compared with an identical block placed after surgery (mean 544 vs 343 min) [29]; this concerns an infraclavicular block and should not be assumed to apply to US-SCB.

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Received*: 19-09-2026 -* ***Accepted****: 18-11-2026 -* ***Published****: 26-11-2026*

Patient-centered recovery and rebound pain

An effective block may reduce pain and opioid use while active, but evidence for routine PACU savings, universal same-day discharge, or a fixed percentage reduction in opioid consumption should not be generalized across procedures. Rebound pain, the return of surgical nociception as sensory block resolves without adequate systemic analgesia, is best addressed with a scheduled systemic analgesic plan and written instructions on when to start analgesics, how to use rescue medication, expected sensory and motor changes, limb protection, and symptoms requiring review [30]. For fracture reduction, brachial plexus block may offer more complete analgesia and muscle relaxation distal to the elbow than hematoma or intravenous regional block, and the multicenter BLOCK trial is testing this in distal radius fractures [2].

Evidence summary

Table 2. Summary of key evidence questions, interpretation, and limitations.

Evidence question	Contemporary evidence	Clinical interpretation	Confidence/limitation
Volume and hemidiaphragmatic paresis	Hemidiaphragmatic paresis at every dose (n = 21); 33% at 5 mL to 100% at 30–35 mL [9]	Use the lowest dose consistent with the procedure; do not promise hemidiaphragm sparing	Small dose-escalation study
Injection location	Corner-pocket deposition reduced hemidiaphragmatic paresis vs intracluster injection (27.8% vs 66.7%), but hemidiaphragmatic paresis persisted [5]	May reduce proximal spread; does not eliminate phrenic involvement	Small randomized trial
Costoclavicular vs supraclavicular	Hemidiaphragmatic paresis (reported as paralysis) 11.4% vs 47.5% with 25 mL [10]; 2.5% vs 39.8% in matched cohort [11]	Consider a distal approach when respiratory preservation is important	Single randomized trial; technique-specific
Infraclavicular vs supraclavicular	Meta-analysis of six RCTs: complete sensory block less frequent with supraclavicular block (OR 0.41); infraclavicular needs longer performance time [14]	Both reasonable; choose by patient and procedure	Heterogeneous protocols
Dexamethasone route	Conflicting: perineural better in one trial [22]; similar in others [23,24]; ~2 h advantage in interscalene review [25]	Intravenous route is the more conservative choice	Evidence not entirely supraclavicular-specific
Pneumothorax	0.06% symptomatic in 6366 ultrasound-guided periclavicular blocks [4]; estimate 0.4 per 1000 [15]	Rare but possible, may present late	Observational data

Limitations and research priorities

The evidence base combines small single-center trials, observational cohorts, different definitions of hemidiaphragmatic paresis, varied local-anesthetic mixtures and volumes, and heterogeneous procedures. Sonographic hemidiaphragmatic paresis does not necessarily produce clinically important respiratory impairment, and small trials are not powered to identify uncommon serious events. Several adjuvant studies used different approaches, concentrations, and endpoints, and some evidence derives from neighboring blocks. This narrative review used targeted searching and did not perform formal risk-of-bias appraisal or quantitative synthesis, so selection bias is possible.

Future studies should standardize definitions of block success, hemidiaphragmatic paresis, clinically important respiratory impairment, rescue analgesia, rebound pain, and patient-reported recovery. Larger pragmatic comparisons should report local-anesthetic dose in milligrams, injection details, serious complications, time to functional recovery, opioid exposure, patient satisfaction, and cost. Patients with impaired pulmonary reserve deserve dedicated, carefully monitored studies.

Conclusion

US-SCB remains an established option for selected elbow, forearm, wrist, and hand procedures, with high success and few major complications in published series. Recent evidence reinforces three practical points: low volume does not guarantee

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Received*: 19-09-2026 -* ***Accepted****: 18-11-2026 -* ***Published****: 26-11-2026*

hemidiaphragm sparing; more distal approaches may reduce hemidiaphragmatic paresis in selected patients; and perineural dexamethasone should not be assumed to be superior to intravenous administration. Contemporary practice should prioritize visible needle-tip control, conservative dose accounting, individualized approach selection, realistic counselling, and a systemic analgesic plan that anticipates block resolution. Large comparative trials with patient-centered outcomes are needed.

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Received*: 19-09-2026 -* ***Accepted****: 18-11-2026 -* ***Published****: 26-11-2026*

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Received*: 19-09-2026 -* ***Accepted****: 18-11-2026 -* ***Published****: 26-11-2026*