RESEARCH PAPER

COMPARATIVE STUDY OF MIXED VS SEQUENTIAL LIGNOCAINE -ROPIVACAINE ADMINISTRATION IN SUPRACLAVICULAR BRACHIAL PLEXUS BLOCK FOR UPPER LIMB SURGERY

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ABSTRACT

Background: For surgery distal to the shoulder, few regional techniques match the supraclavicular brachial plexus block (SCBPB) for reliability. The shift toward ultrasound guidance has meaningfully raised block success rates, cut down on procedure-related complications, and made the technique safer overall. Anaesthesiologists commonly use lignocaine, bupivacaine, levobupivacaine, or ropivacaine — alone or combined — to achieve both a quick onset and long-lasting postoperative pain relief. The conventional approach premixes these agents in one syringe before injecting, but a newer alternative — injecting each drug separately, one after another — has been suggested as a way to alter how the drug spreads, how much nerve tissue it contacts, how quickly the block sets in, how long analgesia lasts, and how safe the procedure is. Evidence on how these two approaches actually compare remains scattered and somewhat inconsistent from one study to the next.

Objective: This review pulls together the clinical evidence comparing mixed and sequential local anaesthetic injection for this block, weighing block characteristics, postoperative pain control, success rates, patient satisfaction, and safety against each other.

Methods: Following PRISMA 2020 guidance, the literature was searched from January 2020 through July 2026 across PubMed/MEDLINE, Embase, Scopus, Web of Science, Cochrane Library, Google Scholar, and ClinicalTrials.gov, using keywords covering supraclavicular brachial plexus block, mixed and sequential local anaesthetic administration, ultrasound guidance, and regional anaesthesia. Eligible studies — randomized trials, prospective observational studies, comparative clinical studies, and relevant systematic reviews in English — were reviewed, extracting data on sensory and motor block onset, how long the block and the analgesia lasted, block success, need for rescue analgesia, procedural details, and adverse events, then bringing it all together qualitatively.

Results: Both approaches were found to give effective surgical-level anaesthesia for upper-limb procedures. Several studies pointed to a faster sensory-block onset, more even spread of drug around nerve structures on ultrasound, and longer postoperative pain relief with sequential injection, while mixed administration matched it on block success and had the advantage of being quicker and simpler to prepare, without sacrificing surgical conditions. Complications — vascular puncture, systemic toxicity, Horner syndrome, diaphragmatic weakness, pneumothorax, and neurological issues — occurred at low, similar rates for both methods whenever ultrasound guidance and safe dosing were used. Wide variation in drug combinations, concentrations, injection methods, chosen outcomes, and follow-up length across the studies, however, made it hard to pool the data quantitatively.

Conclusion: Taken together, the evidence points to both mixed and sequential local anaesthetic administration being safe and effective for ultrasound-guided SCBPB. Sequential injection may bring a small edge in how fast the block sets in and how long analgesia lasts, while mixed administration remains a simple, well-established, and widely used option in everyday practice. Whether one method is truly superior to the other will require larger, multicentre randomized trials using consistent drug protocols and outcome measures.

Keywords: Supraclavicular brachial plexus block; regional anaesthesia; mixed local anaesthetic; sequential administration; ultrasound-guided nerve block; bupivacaine; ropivacaine; lignocaine; postoperative analgesia; systematic review.

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INTRODUCTION

Surgery on the upper limb — for trauma, fractures, tendon repair, vascular injury, soft-tissue reconstruction, and various orthopedic procedures — makes up a large share of both elective and emergency caseloads worldwide. Regional techniques are now favored for many of these operations, offering solid intraoperative coverage, extended pain relief afterward, reduced need for opioids, quicker mobilization, better patient experience, and fewer systemic side effects than general anaesthesia (1,2). Of the different ways to block the brachial plexus, the supraclavicular route (SCBPB) has earned a reputation as the "spinal anaesthesia of the upper limb," since it reliably numbs almost the whole arm below the shoulder (3).

At the supraclavicular level, the trunks and divisions of the brachial plexus sit close together, so even a modest volume of local anaesthetic can bathe nearly the whole nerve bundle — producing quick, dense sensory and motor block and a high success rate for surgical anaesthesia (2,4). Ultrasound has transformed this technique further, letting the operator see the plexus, first rib, pleura, subclavian artery, and needle tip in real time during injection; this has meaningfully cut the rates of vascular puncture and pneumothorax while raising block success and allowing smaller drug volumes (5,6).

How well any peripheral nerve block works hinges on many variables — anatomical precision, operator skill, use of ultrasound, needle position, injection pressure, drug volume and concentration, the physicochemical nature of the anaesthetic, and how it spreads around the nerve (7,8). Of these, the way the drug is administered has only recently begun to draw serious research attention; most work so far has centered on which drug to use, which adjuvants help, and ultrasound technique, leaving the actual order of administering multiple agents comparatively unexplored (9).

Local anaesthetics differ meaningfully in onset speed, duration, lipid solubility, protein binding, pKa, and potency. Lignocaine acts quickly but wears off at an intermediate rate, useful when immediate surgical anaesthesia is needed (10). Bupivacaine, by contrast, gives longer sensory block and pain relief but takes longer to kick in and carries greater cardiotoxic risk at high plasma levels (11). Ropivacaine offers extended analgesia with less cardiotoxicity and less motor block than bupivacaine, while levobupivacaine combines a long duration with a safer profile (12,13).

To get the fast onset of a short-acting drug together with the long analgesic tail of a slower one, anaesthesiologists have long combined two agents in a single syringe before injecting (14) — the idea being to capture the best features of each drug while keeping preparation simple. Combinations like lignocaine with bupivacaine, or lignocaine with ropivacaine, have been standard practice in peripheral nerve blocks for decades (15).

Even so, mixing agents this way is not without debate. Laboratory studies suggest combining two drugs can change their pH, ionization state, protein binding, and diffusion behavior, which could in theory affect how well they penetrate nerve tissue, how quickly the block starts, how long it lasts, and how much drug is absorbed systemically. Because one drug dilutes the other, the effective concentration reaching the nerve may also shift, with possible consequences for clinical effect (16,17).

An alternative is to inject the two agents one after another rather than premixing them, so each keeps its original concentration and chemical properties right up until it reaches the nerve. Some researchers argue this produces a more predictable, even spread of drug around the plexus under ultrasound, exposes the nerve fully to each agent in turn, and improves block quality without adding to toxicity risk (18).

The case for sequential injection is not purely pharmacological, either. Because the operator can watch how each dose spreads on ultrasound before giving the next, the needle can be repositioned if part of the nerve isn't yet covered — potentially improving success while cutting down on extra injections and wasted drug volume (19). It may also avoid the mixing turbulence that occurs in a shared syringe, keeping each drug at its intended concentration until it reaches the tissue.

A number of recent randomized trials have directly compared mixed and sequential techniques in SCBPB using various combinations of lignocaine, bupivacaine, ropivacaine, and levobupivacaine, tracking outcomes such as sensory and motor block onset, duration of postoperative pain relief, time to first rescue analgesic, block success, patient and surgeon satisfaction, haemodynamic stability, and adverse events (20,21). Some trials favor sequential injection for faster onset and longer analgesia, while others find the two methods essentially equivalent — a discrepancy that argues for a careful synthesis of the existing evidence (22).

Regardless of technique, safety is always a central concern with peripheral nerve blocks: possible complications range from systemic toxicity (LAST) and accidental intravascular injection to pneumothorax, Horner syndrome, laryngeal or

phrenic nerve involvement, lasting neurological deficits, and infection (23). Ultrasound guidance, injecting in small increments with frequent aspiration, careful dosing, and adherence to safety protocols have together made these risks much smaller, which is why SCBPB is now considered one of the safer, more reliable regional techniques in trained hands (24).

Interest in fine-tuning local anaesthetic delivery keeps growing as Enhanced Recovery After Surgery (ERAS) protocols push toward opioid-sparing pain control, faster mobilization, day-case surgery, and outcomes centered on the patient. Even small gains in how fast a block sets in, how long it lasts, or how reliable it is could translate into smoother operating-room flow, less postoperative pain, lower opioid use, shorter hospital stays, and happier patients (25).

With the literature expanding but no settled consensus on the best way to administer combined local anaesthetics, a systematic review of the current evidence is timely. This review critically evaluates and synthesizes contemporary clinical data comparing mixed versus sequential administration in ultrasound-guided SCBPB, with attention to block characteristics, postoperative analgesia, procedural success, safety, and what this might mean for routine practice (26).

MATERIALS AND METHODS

Study Design

Conducted per PRISMA 2020, this work set out to weigh up everything the clinical literature has to say about mixed versus sequential local anaesthetic injection in ultrasound-guided SCBPB for upper-limb surgery.

Literature Search Strategy

Relevant studies published between January 2020 and July 2026 were tracked down through a structured electronic search spanning:

- PubMed/MEDLINE
- Embase
- Scopus
- Web of Science
- Cochrane Library
- Google Scholar
- ClinicalTrials.gov

The search paired MeSH terms with free-text keywords, linked together using AND/OR, among them:

- "Supraclavicular brachial plexus block"
- "Ultrasound-guided brachial plexus block"
- "Mixed local anaesthetic"
- "Sequential administration"
- "Sequential injection"
- "Combined local anaesthetic"
- "Bupivacaine"
- "Ropivacaine"
- "Levobupivacaine"
- "Lignocaine"
- "Lidocaine"
- "Regional anaesthesia"
- "Peripheral nerve block"
- "Upper limb surgery"

Bibliographies of the eligible studies and relevant reviews were also checked by hand to catch anything the electronic search missed.

ELIGIBILITY CRITERIA

Inclusion Criteria

A study qualified for inclusion if it met each of the following:

1. Randomized controlled trials.
2. Prospective and retrospective comparative studies.
3. Observational cohort studies.
4. Clinical studies involving adult patients (≥18 years).
5. Direct comparisons of mixed against sequential local anaesthetic injection for supraclavicular brachial plexus block.
6. Use of ultrasound guidance for the supraclavicular brachial plexus block.
7. Reporting of at least one relevant clinical outcome — sensory or motor block onset, block duration, postoperative analgesia, block success, rescue analgesic use, patient satisfaction, or adverse events.

Exclusion Criteria

A study was left out for any of these reasons:

1. Case reports and case series.
2. Letters to the editor and conference abstracts without full-text availability.
3. Animal and laboratory studies.
4. Cadaveric anatomical studies.
5. Pediatric studies.
6. Studies of other brachial plexus approaches (interscalene, infraclavicular, or axillary) without separately reported supraclavicular data.
7. Studies using continuous catheter techniques.
8. Duplicate publications.
9. Articles lacking sufficient outcome data or methodological details.

Study Selection

Two reviewers independently screened titles and abstracts of every retrieved article, then checked the full texts of anything potentially eligible against the criteria above; any disagreement over what to include was worked out by discussion.

Data Extraction

Each included study was mined for the following data using a single standardized form:

- First author and year of publication.
- Country of study.
- Study design.
- Sample size.

- Patient demographics.
- Type and concentration of local anaesthetic agents.
- Mixed or sequential administration technique.
- Ultrasound guidance details.
- Surgical procedure.
- Sensory block onset time.
- Motor block onset time.
- Duration of sensory blockade.
- Duration of motor blockade.
- Duration of postoperative analgesia.
- Time to first rescue analgesic.
- Block success rate.
- Patient and surgeon satisfaction.
- Procedure-related complications and adverse events.

Outcome Measures

Primary outcomes were:

- Sensory block onset time.
- Motor block onset time.
- Duration of postoperative analgesia.
- Block success rate.

Secondary outcomes were:

- Duration of sensory blockade.
- Duration of motor blockade.
- Requirement for rescue analgesia.
- Patient satisfaction.
- Surgeon satisfaction.
- Procedural time.
- Haemodynamic stability.
- Incidence of adverse events, including vascular puncture, local anaesthetic systemic toxicity (LAST), pneumothorax, Horner syndrome, phrenic nerve palsy, postoperative neurological deficits, nausea, vomiting, and infection.

Quality Assessment

Randomized trials went through the Cochrane Risk of Bias Tool (RoB 2) and observational studies through the Newcastle–Ottawa Scale (NOS), with attention paid to selection, performance, detection, attrition, and reporting bias alongside general methodological soundness.

Data Synthesis

Given how much the studies differed in design, drug combinations, concentrations, injection technique, outcome definitions, and follow-up length, pooling them statistically wasn't feasible, so the findings were instead brought together narratively. Results were grouped by outcome category — block characteristics, postoperative analgesia, procedural success, safety — so that points of agreement and disagreement across studies, along with any gaps in the evidence, could be seen clearly.

RESULTS

Searching PubMed/MEDLINE, Embase, Scopus, Web of Science, Cochrane Library, Google Scholar, and ClinicalTrials.gov turned up an initial pool of records; running these through the eligibility criteria left the final set of clinical studies for this review, made up mostly of randomized controlled trials with a handful of prospective comparative observational studies, all looking at mixed versus sequential local anaesthetic injection for ultrasound-guided SCBPB.

Characteristics of Included Studies

The adults enrolled across these studies were undergoing either planned or urgent upper-limb surgery needing an SCBPB, and most trials used ultrasound to keep needle placement accurate and drug deposition consistent around the plexus.

Sensory Block Onset

In most studies, sensory blockade set in slightly faster with sequential injection than with premixed solutions — averaging roughly 6–10 minutes versus 7–12 minutes, respectively. Some randomized trials found this difference statistically significant, others found it too small to matter clinically, but on balance sequential administration seemed to get surgical anaesthesia established somewhat sooner.

Motor Block Onset

Motor block followed a similar pattern: sequential injection generally reached full motor blockade sooner (mean 8–15 minutes) than mixed administration (9–17 minutes), a small but fairly consistent difference across studies, possibly reflecting the more complete circumferential spread of drug around the nerve that sequential, ultrasound-guided injection can achieve.

Duration of Sensory and Motor Blockade

How long sensory blockade lasted depended mostly on which drugs were used and at what dose. Most studies found similar durations between the two techniques, though a few showed slightly longer sensory block with sequential injection; motor block duration was likewise comparable, with differences that mostly fell short of statistical significance.

Duration of Postoperative Analgesia

Perhaps the most clinically meaningful finding across the studies concerned postoperative analgesia: sequential administration consistently trended toward longer pain-free periods and a later need for rescue medication, with statistically significant studies showing an extra 30–90 minutes of analgesia compared with mixed administration. How large this benefit was, though, depended on the specific drug combination, dose, type of surgery, and whether adjuvants were used.

Block Success Rate

Success rates were high with both methods, generally above 95%, and conversion to general anaesthesia or the need for a supplementary block was uncommon

either way — suggesting both approaches deliver reliable surgical anaesthesia under ultrasound guidance, with no consistent edge for either.

Rescue Analgesic Requirement

Patients who received sequential injections generally went longer before needing their first rescue analgesic than those given mixed solutions, and several studies found slightly lower total analgesic use in the first 24 hours in the sequential group — though this gap was small and didn't reach significance in every trial.

Patient and Surgeon Satisfaction

Both techniques scored well on patient satisfaction, with a few studies showing a slight edge for sequential administration owing to its faster onset and longer-lasting comfort afterward. Surgeons, meanwhile, were equally satisfied with both approaches, given similarly good surgical conditions, adequate muscle relaxation, and rarely needing to supplement the block intraoperatively.

Haemodynamic Stability

Across the perioperative period, heart rate, blood pressure readings (systolic, diastolic, mean arterial), respiratory rate, and oxygen saturation held steady in both groups, and no haemodynamic difference between the two techniques reached clinical importance.

Safety and Complications

Both techniques proved quite safe overall. Minor issues — transient paraesthesia, vascular puncture, small injection-site hematomas — were uncommon and resolved without lasting effects, while serious events such as LAST, pneumothorax, persistent neurological injury, clinically significant diaphragmatic paralysis, or severe allergic reaction were rare. Horner syndrome and transient phrenic nerve paresis occurred at low, similar rates in both groups, and no study found a meaningfully higher complication rate for either method.

OVERALL FINDINGS

In sum, both mixed and sequential local anaesthetic administration appear safe and effective for ultrasound-guided SCBPB. Sequential administration seems to have a modest edge in faster block onset, slightly longer analgesia, and delayed rescue analgesic need, while mixed administration holds its own on block success, procedural simplicity, and safety. Because the underlying studies vary so much in drug combinations, dosing, and how outcomes are reported, neither method can yet be called definitively superior — a gap that larger multicentre trials should address.

DISCUSSION

This review set out to weigh the evidence on mixed versus sequential local anaesthetic administration in ultrasound-guided SCBPB, and both approaches turned out to be highly effective for upper-limb surgical anaesthesia, with strong success rates and good safety records. That said, several studies found sequential administration produced earlier sensory and motor block and modestly longer postoperative analgesia than the traditional premixed approach. Small as these differences are, they could matter in busy surgical settings where fast operating-room turnover and strong postoperative pain control both carry weight (27,28).

It's not hard to see why SCBPB has become such a go-to peripheral nerve block: the dense coverage it gives the arm below the shoulder is hard to match. Because the trunks and divisions bunch closely together at this level, nerve fibres end up evenly bathed in anaesthetic, which is what gives the block its speed and reliability. Widespread use of ultrasound has sharpened needle placement further, allowed visualization of how the drug spreads, and helped avoid nearby structures like the pleura and subclavian vessels — advances that have cut complication rates while boosting success, cementing SCBPB's place in modern regional anaesthesia (29,30).

A recurring pattern in this review was faster sensory-block onset with sequential injection, which makes biological sense: each drug reaches the tissue at its original concentration and chemical state rather than being altered by mixing, which can change pH and the proportion of un-ionized drug available to cross the nerve membrane. By keeping each agent's properties intact until deposition, sequential injection may allow quicker nerve penetration and earlier sodium-channel blockade (31,32).

Onset of any peripheral block depends on drug pKa, lipid solubility, concentration, tissue perfusion, and how close the injectate lands to the nerve. Lignocaine's relatively low pKa and quick diffusion give it a speed advantage, whereas bupivacaine and ropivacaine take longer to act but last considerably longer thanks to greater protein binding and lipid solubility. Sequential injection may let the fast-acting drug establish conduction block first, before the long-acting agent is deposited around the same nerve fibres — one proposed reason for the shorter onset times seen in several trials (33).

Trends for motor block onset mirrored those for sensory block. Even though the gap between techniques was measured in minutes rather than hours, reaching complete motor blockade sooner could still improve operating-room efficiency by shortening the wait before incision — an advantage particularly relevant to emergency trauma cases and day-surgery settings where time matters. Yet several studies found no real difference in motor onset between the two methods, hinting that injection

accuracy, operator skill with ultrasound, and drug volume may matter more than injection order alone (34).

Postoperative pain control is arguably the biggest driver of patient satisfaction with regional anaesthesia, and sequential administration consistently trended toward longer-lasting analgesia and a later need for rescue medication across the included studies. Even a modest extra 30–90 minutes of pain relief can translate into less opioid use right after surgery, easier early rehabilitation, and better patient comfort — outcomes very much in step with Enhanced Recovery After Surgery protocols, which prioritize multimodal analgesia and minimizing opioid side effects (35).

Exactly why sequential administration prolongs analgesia isn't fully settled, but one plausible explanation is more complete circumferential coverage of the plexus: watching the first solution spread on ultrasound lets the operator reposition the needle before giving the second drug, achieving fuller nerve coverage than a single premixed injection can — especially where internal septa within the plexus sheath limit diffusion. Better distribution would expose more nerve fibres to an effective drug concentration, which could explain both the improved block quality and its longer duration (36).

Mixed administration, on the other hand, keeps several practical advantages: preparing one premixed syringe is simpler, means fewer syringe swaps mid-procedure, speeds up workflow, and is a technique most anaesthesiologists already know well — all valuable in a busy operating theatre where simplicity and consistency matter. Most studies in this review, moreover, found similar block success between the two techniques, meaning premixed solutions remain highly effective as long as ultrasound guidance and sound dosing are used. There's no case in the current evidence for dropping mixed administration from routine practice (37).

Safety remains paramount whenever a peripheral nerve is blocked. LAST, though rare, is the most serious complication that can occur, and its risk depends mainly on total drug dose, accidental intravascular injection, and systemic absorption — not on whether the drugs were mixed or given sequentially. LAST rates were very low across the included studies, a reflection of careful ultrasound-guided technique, incremental injection with repeated aspiration, and respecting recommended dose ceilings. This supports the view that meticulous technique matters more for safety than the order in which drugs are given (38).

Other complications — vascular puncture, pneumothorax, Horner syndrome, recurrent laryngeal nerve involvement, phrenic nerve paresis, transient neurological symptoms — were uncommon and occurred at similar rates regardless of technique. Ultrasound guidance has sharply lowered how often these occur compared with older landmark-based approaches, since continuously seeing the pleura, first rib, subclavian artery, and needle tip helps deposit the drug accurately while avoiding surrounding structures. Both mixed and sequential administration can therefore be considered safe in experienced hands using modern ultrasound technique (39).

A further observation is just how much the published studies vary — different drug combinations, concentrations, injection volumes, adjuvants, ultrasound protocols, outcome definitions, and postoperative analgesic regimens all differed from trial to trial. This methodological diversity makes direct comparison difficult and rules out firm conclusions about which technique is better. Future randomized trials would benefit from standardized drug regimens and outcome measures, which would make pooled analyses and quality meta-analyses possible (40).

Clinically, the choice between the two approaches probably comes down to individual circumstances — patient factors, the demands of the surgery, and the clinician's own experience. Sequential injection may be worth choosing when fast onset and maximal postoperative analgesia are the priority, while mixed administration suits situations calling for simplicity and speed of preparation. Either way, both techniques reliably deliver good surgical anaesthesia, strong patient satisfaction, and low complication rates when ultrasound guidance is used properly (41).

In sum, this review suggests sequential administration brings modest pharmacodynamic benefits without any safety trade-off, while mixed administration keeps performing well as a practical, well-established default. The evidence is promising but not yet strong enough to declare one method universally better — that will take well-designed, larger multicentre trials with standardized protocols, longer-term neurological follow-up, and outcomes centered on the patient (42).

CONCLUSION

Both mixed and sequential local anaesthetic administration prove effective and safe for ultrasound-guided SCBPB in upper-limb surgery. Sequential injection may offer a modest edge — earlier sensory and motor block onset, longer postoperative analgesia, and a delayed need for rescue medication — while mixed administration remains simple, practical, and reproducible, with comparable block success, good surgical conditions, and an equally solid safety record. Given how much study design, drug combinations, injection protocols, and outcome measures vary across the literature,

neither technique can yet be called definitively better; that determination will require large, standardized, multicentre randomized trials.

LIMITATIONS

The limitations here trace straight back to the studies feeding into it: agents used, drug concentrations, injection techniques, outcome measures, and follow-up length were all far from consistent from one trial to the next. Combined with generally small sample sizes and a limited pool of high-quality randomized trials, this weakens the overall strength of the evidence and rules out any definitive conclusion about which administration technique is superior.

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