Narrative Review

Choosing the Brachial Plexus Approach for Upper Limb Surgery: A Practical Review of Interscalene, Supraclavicular, Infraclavicular, Costoclavicular and Axillary Blockade

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ABSTRACT

Brachial plexus blockade can serve as the sole anesthetic for most operations distal to the shoulder, and in doing so it avoids airway instrumentation, shortens recovery, and provides analgesia that extends well into the postoperative period. These properties are valuable everywhere and are particularly valuable in hospitals without extensive postanesthesia care infrastructure. The plexus can be approached at five levels, and the choice among them is not arbitrary: each level trades completeness of blockade against the risk of a specific complication. The interscalene approach reliably anesthetizes the shoulder but is accompanied by hemidiaphragmatic paresis in a high proportion of patients; the supraclavicular approach gives dense blockade of the whole arm but carries a small pneumothorax risk and a substantial phrenic risk; the infraclavicular and costoclavicular approaches avoid both while requiring a deeper needle trajectory; the axillary approach is the safest but leaves the musculocutaneous nerve to be blocked separately and does not reach the proximal arm. This review sets out the anatomical basis of each approach, summarizes the randomized and meta-analytic evidence comparing them, and offers a practical framework for selecting an approach according to the operative site, the patient's respiratory reserve, and the resources available. Safety considerations, in particular the prevention and recognition of local anesthetic systemic toxicity, are addressed throughout.

Keywords: brachial plexus block; interscalene block; supraclavicular block; costoclavicular block; axillary block; hemidiaphragmatic paresis

INTRODUCTION

Upper limb surgery is well suited to regional anesthesia. The brachial plexus is superficial, sonographically accessible along most of its course, and supplies a territory that corresponds closely to the operative field. A block performed as the sole anesthetic spares the patient general anesthesia, reduces postoperative nausea and vomiting, permits earlier discharge, and — in hospitals where high-dependency beds and prolonged recovery-room monitoring are scarce — allows a surgical list to proceed that might otherwise be constrained.

The practical question is not whether to block the plexus but where. The plexus reorganizes along its course from roots to terminal branches, and each level offers a different compromise. What follows is an approach-by-approach account of that compromise, framed around the two variables that most often determine the decision: the proximal extent of the surgical field, and the patient's tolerance of unilateral diaphragmatic dysfunction.

THE INTERSCALENE APPROACH

At the interscalene groove the plexus is present as roots and trunks, and injection here anesthetizes predominantly the C5 and C6 distribution. This makes it the technique of choice for shoulder surgery and for procedures on the proximal humerus, while leaving the ulnar distribution unreliably covered.

Its limitation is well known. The phrenic nerve lies on the anterior scalene muscle immediately adjacent to the injection site, and classical interscalene blockade produces hemidiaphragmatic paresis in the large majority of patients. In a healthy patient this is inconsequential; in a patient with limited respiratory reserve it can be disabling. A sustained effort has therefore been made to develop phrenic-sparing alternatives that preserve shoulder analgesia, and this literature has been reviewed comprehensively [1,2] and updated recently [3]. The most successful of these is the superior trunk block, which moves the injection distal to the point at which the phrenic nerve diverges: a randomized controlled trial demonstrated equivalent analgesia to the interscalene block with a marked reduction in diaphragmatic paresis [4]. Selective suprascapular and axillary nerve blockade, and high-thoracic erector spinae plane blockade, have also been described as alternatives, the latter compared directly with continuous interscalene analgesia in a randomized trial for shoulder arthroplasty [5].

THE SUPRACLAVICULAR APPROACH

At the supraclavicular level the plexus is compact — divisions gathered above the first rib and lateral to the subclavian artery — and injection here produces the fastest and densest blockade of the whole arm, which is why the approach has long been called the "spinal of the arm". Ultrasound guidance has made it substantially safer than in the landmark era by allowing the pleura and the subclavian artery to be identified directly, but the pleura remains close and pneumothorax remains the characteristic complication.

Phrenic involvement is also common, though less universal than with the interscalene approach. A randomized comparison of diaphragmatic and pulmonary function after supraclavicular versus costoclavicular blockade found significantly better preservation of diaphragmatic excursion with the costoclavicular approach [6]. Where the surgical field permits a more distal injection, therefore, there is little reason to accept the supraclavicular risk profile.

THE INFRACLAVICULAR AND COSTOCLAVICULAR APPROACHES

Below the clavicle the plexus is present as cords surrounding the axillary artery. The classical lateral sagittal or paracoracoid infraclavicular approach targets these cords at the level of the coracoid process. Because the injection is remote from both the phrenic nerve and the pleural dome, the approach avoids the two principal complications of the more proximal techniques; because the plexus lies deeper here, needle visualization is more demanding and a steep angle of insertion is required. A Cochrane review comparing infraclavicular with axillary blockade for surgery of the lower arm found comparable success rates, with fewer needle passes and less tourniquet pain in the infraclavicular group [7].

The costoclavicular approach, described more recently, exploits the observation that in the costoclavicular space — between the clavicle and the first rib — the three cords lie clustered laterally to the axillary artery in a compact and superficial arrangement, so that a single injection can reach all of them. Leurcharusmee and colleagues showed in a randomized comparison with the paracoracoid approach that the costoclavicular block achieved comparable success with a shorter onset [8], and subsequent randomized trials have confirmed comparable or superior performance for upper extremity surgery [9,10], including in children [11]. A randomized comparison of the medial and lateral costoclavicular approaches with the traditional lateral sagittal technique found all three to be clinically effective [12], and single- versus double-injection strategies have been compared directly [13]. Whether nerve stimulation adds to ultrasound guidance in this space has also been examined in a randomized trial [14], as has the effect of injectate volume [15]. Meta-analytic comparison of the costoclavicular and infraclavicular approaches finds them broadly equivalent [16], and narrative reviews have summarized the technique's efficacy and safety profile [17,18].

For shoulder surgery specifically, the costoclavicular block has been proposed as a diaphragm-sparing alternative to the interscalene block. Randomized trials comparing the two have reported acceptable analgesia with markedly less diaphragmatic involvement [19–21], and a meta-analysis confirmed a lower incidence of hemidiaphragmatic paralysis with the costoclavicular approach than with more proximal

techniques [22]. A further meta-analysis comparing interscalene with costoclavicular blockade for arthroscopic shoulder surgery reached compatible conclusions [23]. The trade-off is a somewhat less complete blockade of the suprascapular distribution, and for extensive open shoulder surgery the interscalene approach remains difficult to replace entirely.

THE AXILLARY APPROACH

In the axilla the plexus has resolved into terminal nerves — median, ulnar and radial around the artery, with the musculocutaneous nerve having already left the sheath to lie within the coracobrachialis. Blockade here is the safest of all the approaches, with no phrenic and no pleural risk, and it is well suited to surgery of the forearm and hand. Its two limitations are that the musculocutaneous nerve must be identified and blocked separately, and that the block does not extend proximally enough for surgery above the elbow or for an upper-arm tourniquet without supplementation.

A randomized observer-blinded trial comparing low-volume supraclavicular, infraclavicular and axillary blockade for distal arm surgery found all three to provide adequate surgical anesthesia, which is a useful reminder that with ultrasound guidance and careful technique the differences between approaches in success rate are smaller than the differences in complication profile [24].

SAFETY

Two safety issues dominate practice. The first is local anesthetic systemic toxicity. Brachial plexus blockade uses relatively large volumes in a well-vascularized region, and the risk is real at every level. Dose should be calculated against lean body weight, injection should be incremental with intermittent aspiration, and the block should be performed where lipid emulsion and resuscitation equipment are immediately available. The American Society of Regional Anesthesia and Pain Medicine checklist for managing local anesthetic systemic toxicity should be displayed in the block area; it exists in successive versions, and the current one should be the one in use [25,26]. The second is perioperative nerve injury, for which the same society's practice advisory remains the standard reference and emphasizes avoiding injection in the deeply sedated or anesthetized adult, avoiding high injection pressures, and documenting any paresthesia [27].

A PRACTICAL FRAMEWORK

For shoulder and proximal humeral surgery, the interscalene block remains the most complete option; where respiratory reserve is limited, a superior trunk or costoclavicular block should be substituted [3,4,19]. For surgery of the arm, elbow and forearm, the costoclavicular or infraclavicular approach offers dense blockade without phrenic or pleural risk and is well suited to catheter placement [7,8,16]. For surgery of the hand and distal forearm, the axillary approach is adequate and carries the lowest complication burden, provided the musculocutaneous nerve is addressed [7,24]. The supraclavicular approach retains a place where speed and density matter and the patient's respiratory reserve is good.

In a hospital without a dedicated block room or extended recovery capacity, these considerations favour a distal approach performed with ultrasound guidance, a low-to-moderate volume of dilute local anesthetic, and a clear plan for the resolution of the block, since rebound pain after the block wears off is the most common reason for an unplanned return.

CONCLUSION

The five approaches to the brachial plexus are not interchangeable, and the discipline of choosing between them lies in matching the level of injection to the proximal extent of the surgical field while accepting the least complication risk compatible with that requirement. The clearest development of the past decade has been the demonstration that phrenic-sparing alternatives — the superior trunk block for the shoulder, the costoclavicular block for the arm — can deliver most of the analgesia of the classical approaches with substantially less respiratory compromise.

AUTHOR CONTRIBUTIONS

The author confirms sole responsibility for the following: study conception, literature search and appraisal, interpretation of the evidence, and manuscript preparation and revision.

CONFLICT OF INTEREST

The author declares that there is no conflict of interest.

ETHICS STATEMENT

This article is a narrative review of previously published literature. It does not report any study involving human participants or animals performed by the author, and therefore ethics committee approval and informed consent were not required.

ARTIFICIAL INTELLIGENCE DISCLOSURE

Artificial intelligence tools were used to assist with literature retrieval and language editing. All scientific content, interpretation, and conclusions are the responsibility of the author, who has reviewed and verified the final manuscript.

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