Awake Regional Anesthesia for Upper Limb Orthopedic Surgery During the COVID-19 Pandemic: Tips, Tricks, and Results

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Background: The severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), which causes COVID-19 illness, is mainly transmitted because of close contact with respiratory droplets and airborne particles. Aerosol-generating procedures during general anesthesia can increase the risk of COVID-19 transmission. An effective alternative to general anesthesia for upper limb orthopedic surgery is regional anesthesia (RA) using brachial plexus block.

Materials and Methods: Seventy-eight patients who received a brachial plexus block for upper limb trauma and elective operations before and during the COVID-19 pandemic, from 2017 to 2020, were included in this study. A protocol was devised for patient positioning, draping and equipment positioning for each location group—shoulder and upper arm; elbow and forearm; and distal extremities.

Results: RA was effective for upper limb surgery in 77 of 78 (98.7%) patients. Sixty-five patients (83.3%) were discharged the same day, with the average time from leaving the operating theater to discharge from hospital of 2.8 hours. No postoperative complications were recorded, and no patient nor staff member contracted COVID-19 infection 2 weeks after the operation.

Conclusion: We demonstrate the efficacy of awake RA for upper limb orthopedic procedures. We share our tips and tricks for implementing this into clinical practice and discuss the specific advantages of RA in the context of the COVID-19 global pandemic.

Key Words: shoulder—elbow—wrist—hand—regional anesthesia—trauma—COVID-19.

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COVID-19 illness, caused by the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), is transmitted because of contact with respiratory droplets and airborne particles. Aerosol-generating procedures (AGPs), such as airway suctioning, intubation and extubation during general anesthesia (GA), can increase the risk of COVID-19 transmission.[1,2] An effective alternative to GA for upper limb orthopedic surgery is regional anesthesia (RA) with brachial plexus block (BPB). Whilst wide awake local anesthetic no tourniquet technique (WALANT) has been commonly used for hand and wrist surgery, it may not be appropriate for more proximal upper limb surgery. Compared with GA alone, RA can offer superior analgesia, less systemic adverse effects and expedited postoperative recovery for discharge.

During the COVID-19 pandemic, to avoid AGPs during GA and reduce the risk of COVID-19 transmission, our team implemented a protocol to perform all upper limb trauma and elective surgery using RA with BPB. This was a new protocol for our hospital, through which we overcame surgical and practical challenges that led to valuable learning. The aim of this report is to share our tips and tricks for starting a service using RA for upper limb orthopedic procedures; to report our results for awake upper limb surgery under BPB; and to discuss how to avoid the complications that may arise.

MATERIALS AND METHODS

The study was approved by the local hospital trust review board. Patients who received BPB for upper limb trauma and elective operations before and during the COVID-19 pandemic, from November 2017 to December 2020, were included in this study. The inclusion criteria were surgery performed in the shoulder, arm, forearm, and hand. The exclusion criteria were surgery at a site proximal to the shoulder; patients with contraindications to RA, including active skin infection at needle insertion site; neurological deficits in area of distribution; local anesthesia (LA) allergy; simple hand surgery requiring only LA; high risk of compartment syndrome and patient refusal.

Using RA with BPB for upper limb surgery in the awake patient requires consideration of specific factors, including: patient positioning; surgical draping; position of image intensifier without compromising sterility; control of blood pressure (BP) and bleeding; and sufficient muscle relaxation.

Operations were divided according to location—shoulder and upper arm; elbow and forearm; and distal extremities. A protocol for patient positioning, draping and equipment positioning for each location group was devised. The study outcome measures were effectiveness of RA; conversion rate of RA to GA; rate of additional postoperative analgesia required; RA complication rate; surgical complication rate and incidence of COVID-19 infection postoperatively.

Shoulder and Upper Arm Surgery

Patient Positioning

The patient was placed in beach chair position, sat upright to 60 to 70 degrees. A nonsliding wedge placed below the leg was helpful in preventing the patient from sliding down when lightly sedated.

A gel-padded forehead strap was applied loosely to the head to maintain stability. In shoulder surgery lasting over an hour, commonly shoulder arthroplasty and superior capsular reconstruction, light sedation was given for comfort during a prolonged period of immobility.

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The authors declare that they have nothing to disclose.

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FIGURE 1. Draping for shoulder surgery. Sterile side with large drape separating patient's head and operative field.

Protocol for draping was devised using standard surgical drapes, without specialized transparent drapes to cover the face of the patient. One large drape was used to separate the head of the patient from the operating field. Two drip stands were used to secure both ends of the drape above and away from the patient's head—one drip stand was positioned behind the shoulder of the operated side and another at the level of the feet on the opposite side (Fig. 1).

Equipment Positioning

Normally, the image intensifier is brought across from the contralateral side of the patient under GA. However, because of our draping technique, it was not possible to maintain sterility if the image intensifier was brought across from the contralateral side. Instead, the image intensifier was brought in from the foot end of the bed and the C-arm was moved over the shoulder like a horse-shoe for anterior-posterior view and in neutral position (vertical) for axillary view. We were able to ask the awake patient to lean sideways for the axillary view. The anesthetic machine for monitoring was placed adjacent to the patient's head. The anesthetist was on the nonsterile side, with clear access to the anesthetic machine, patient's head and airway (Fig. 2).

Perioperative Medications

For arthroscopy procedures, adrenaline was not routinely used in arthroscopic fluid. Perioperatively patients received 10 mg/kg intravenous tranexamic acid (~1 g), with dose adjustments for patients with renal failure. BP control was achieved using titrated clonidine, with target systolic BP of 110 mm Hg for shoulder arthroplasty and 100 mm Hg for shoulder arthroscopy. As per standard practice, arthroscopic fluid inflow pressure is set at 50 mm Hg, which is 60 mm Hg below target systolic BP.

Elbow Surgery

Patient Positioning

Elbow surgery was normally performed in lateral decubitus position with the operated arm on an arm support, such as the Western arm holder (Smith & Nephew). The tourniquet was applied to the upper arm away from the sterile field. The nonoperated arm was supported on an arm extension board. The pelvis was gently supported with pelvis holders, such as ones commonly used during hip replacements, with gel pads for bony prominences. The patient's head was separated from the operative field with standard surgical drapes. An L-bar was placed at the head end of the bed to hold the drape away from the awake patient's head (Fig. 3).

Equipment Positioning

The image intensifier was covered with sterile drapes and brought in from the foot end of the bed to provide anterior-posterior and lateral images of the elbow. Monitoring equipment was next to patient's head of the nonsterile side, allowing the anesthetist clear access (Fig. 4).

Distal Extremities Surgery (Wrist, Hand, and Fingers)

Patient Positioning

The patient was placed supine with an arm table on the operated side and a tourniquet applied to the upper arm. The limb was prepared from the hand to the upper forearm, where a standard surgical drape was placed. A standard large drape was placed to separate the patient's head and the operative field. Two drip stands were used to secure both ends of the drape above and away from the patient's head, similar to the draping used in the shoulder surgery (Fig. 1).

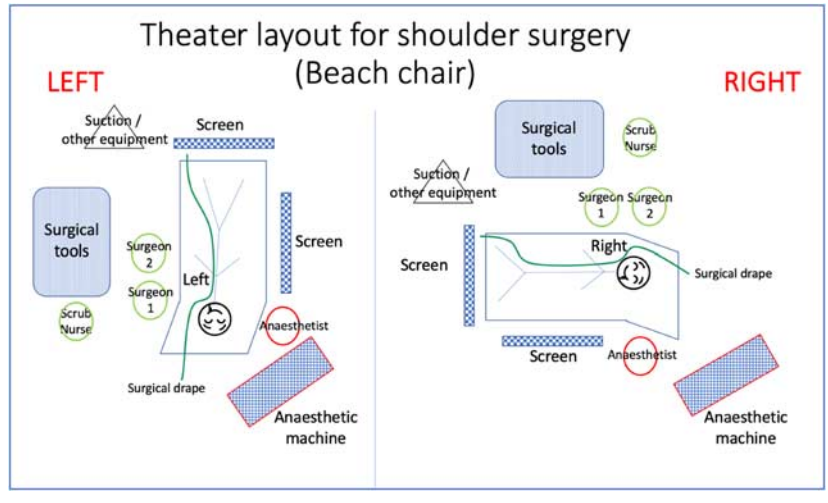

FIGURE 2. Bird's eye view of theater layout for shoulder surgery beach chair position.

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FIGURE 3. Patient in lateral decubitus position for elbow surgery with L-bar above patient's head to hold drape.

Equipment Positioning

The image intensifier was brought in at an angle opposite from the surgeon and the display screens placed at a short distance next to the surgeon, to allow clear view of the screens.

Anesthesia Technique for BPB

All patients gave informed consent for ultrasound (US)-guided BPB after benefits and risks of GA and RA were explained. The interscalene approach was used for shoulder surgery and the supraclavicular approach was used for surgery distal to the shoulder to ensure full blockade of C8 and T1 nerve roots. BPB was performed using aseptic technique with the patient in a semi-sitting position and head turned towards the contralateral side of the operation.

A flat US transducer probe (6 to 13 Hz, Sonosite S-Nerve) and an Ultraplex needle (22 G, 50 mm) were used. In the interscalene approach, the branches of the brachial plexus around the subclavian artery were identified and traced proximally to the roots of the plexus. Two injections of LA were made below the fifth and seventh cervical nerve root.

In the supraclavicular approach, the US probe was placed in the transverse plane, posterior to the middle of the clavicle. Two injections of LA were aimed superolateral to the subclavian artery to target the superior and middle trunks of the brachial plexus. A third injection was aimed inferolateral to the subclavian artery to target the inferior trunk of the brachial plexus. The objective was circumferential spread of LA around the nerves of the brachial plexus. For total shoulder arthroplasty, an additional 3 to 5 mL of LA was injected underneath the sternocleidomastoid muscle, outside the perivertebral fascia, to block the supraclavicular nerve.

The BPB block was assessed 15 minutes after administration and if anesthesia was not satisfactory, particularly on the medial aspect of the hand, an additional US-guided block was given at the level of mid-forearm.

Light sedation was administered at the beginning of surgery to help calm the patient. This was not a technical requirement but for patient comfort during long operations. Midazolam, a widely used sedative in spinal/epidural anesthesia for awake patients, or propofol target controlled infusion was administered. Supplementary sedation was given on patient request if the operation time exceeded 2 hours. Majority of the patients were "awake" and able to communicate. The patients always wore a surgical mask and oxygen was provided through nasal prongs under the mask.

Postoperatively the surgeon or resident medical officer assessed the compartments and neurovascular status of the upper limb. A compartment pressure measuring device was available if there was suspicion of raised intracompartmental pressures.

Data was prospectively collected and included patient demographics, type of operation, anesthetic drugs used, complications, and patient satisfaction. Patients were asked specifically, "If you were to have the same surgery again, would you have the same kind of anesthesia?". Follow up was by telephone call at 48 hours and in person at 2 weeks.

RESULTS

Seventy-eight patients planned for upper limb orthopedic surgery under RA using BPB were included in the study. Patient demographics are detailed in Table 1. Twenty-seven patients had elective surgery before the COVID-19 pandemic and 51 patients had upper limb elective and acute surgery during the COVID-19 pandemic (Table 1).

Types of Orthopedic Procedures

Surgical procedures included elective operations such as shoulder arthroscopy and arthroplasty and elbow arthroscopy; and expedited trauma operations including surgical fixation of proximal humerus fracture, radial head fracture and elbow fracture dislocation. All types of operations performed are presented in Table 2.

RA for BPB

The standard LA mixture used for the BPB was 2:1 of levobupivacaine 0.5% and lidocaine 2%. The interscalene approach was used for 24 cases of shoulder surgery. The supraclavicular approach was used for 54 operations distal to

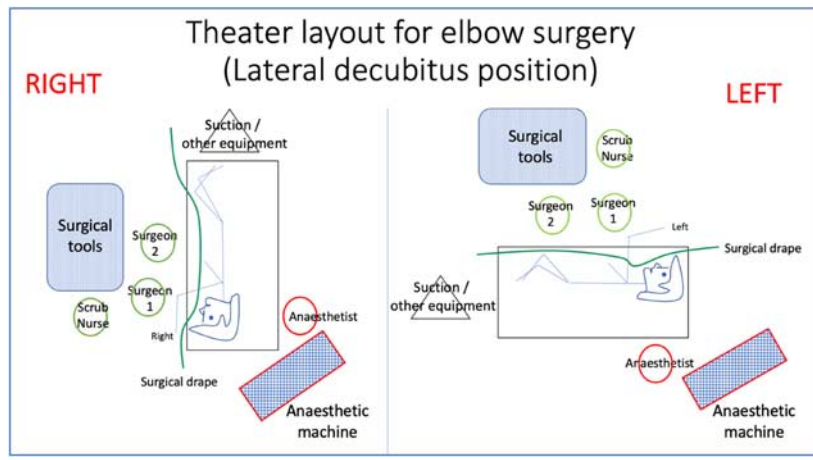

FIGURE 4. Bird's eye view of theater layout for elbow surgery in lateral decubitus position.

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TABLE 1. Patient Demographics

Patient Demographics	Mean (SD)	Median	Range
Age (y)	60.5 (15.9)	61	19-91
Sex			
Female	30	—	—
Male	48	—	—
Weight (kg)	83.2 (16.5)	78	58-130
Height (m)	1.67 (0.09)	1.68	1.45-1.87
BMI (kg/m^2)	29.4 (5.7)	28	21-44

BMI indicates body mass index.

the shoulder and 14 patients received supplementary mid-forearm blocks. Eight patients received an additional 3 mL LA infiltration by the surgeon, either at the operation site or posterior port site in shoulder arthroscopy. Satisfactory RA was achieved in all except 1 patient (98.7%) undergoing a palmar fasciectomy, for which anesthesia was subsequently converted to GA before skin incision.

Sixty-eight patients (88.3%) received perioperative light sedation and 9 patients had no sedation. Fifty-one patients received midazolam only (median 3 mg), 6 patients received intravenous propofol target controlled infusion at plasma concentration of 0.5 μg/mL, and 11 patients received midazolam and propofol. Propofol was preferred for elderly patients as it is associated with less postoperative confusion.

Postoperatively, 76 patients (98.7%) reported adequate analgesia without need for further analgesics with an average visual analog scale pain score of less than 3. One patient required additional paracetamol 1 g intravenously, following a palmar fasciectomy. All patients had complete return of neurological function of the upper limb.

TABLE 2. Types of Operation Performed

	Location	Operation Type	Pre-COVID-19	During COVID-19
Elective surgery	Shoulder	Shoulder arthroscopy	0	16
		Total shoulder replacement	0	6
		MUA shoulder	0	1
	Elbow	Elbow arthroscopy	0	2
		Cubital tunnel release	2	1
	Forearm	Excision biopsy	2	3
	Wrist	Wrist arthroscopy	0	1
		Trapeziectomy	4	5
	Hand	Palmar Fasciectomy	17	0
		Hand tendon release	1	0
		Finger amputation	0	1
		Removal of metal work	0	2
Acute surgery	Shoulder	Total shoulder replacement (proximal humerus fracture)	0	1
		ORIF proximal humerus fracture	0	1
	Elbow	ORIF olecranon fracture	0	3
	Forearm	Removal of metal work forearm	0	1
	Wrist	ORIF Hamate fracture	0	1
	Hand	ORIF metacarpal bones	0	3
		EUA+washout of wound	1	3
Total			27	51

EUA indicates exploration under anesthesia; MUA, manipulation under anesthesia; ORIF, open reduction internal fixation.

COVID-19 Infection Control

At the beginning of the pandemic, the return of COVID-19 test results was slow. To admit patients at our "green" zone to have acute trauma operations and prevent delay to surgery, we screened patients at presentation with blood results, chest x-ray and for COVID-19 symptoms. During the operation all theater staff were required to wear full personal protective equipment, including FFP3 masks and face shields. No patients or staff reported COVID-19 infection postoperatively.

Outcomes

Sixty-five patients (83.3%) were discharged the same day, with the average time from leaving the operating theater to discharge from hospital of 167.7 minutes, range 46 to 432 minutes. Thirteen patients (16.7%) stayed inpatient for one night for next day postoperative review. No perioperative or postoperative complications related to the BPB including pneumothorax, phrenic nerve palsy and vascular puncture were recorded. Seventy-six (96%) patients reported they would choose RA again for the same operation. All patients were able to recall their intra-operative experience at 48-hour telephone follow up. In fact, one patient had palmer fasciectomy in both hands, 8 months apart, under BPB. Results are presented in Tables 3 and 4.

DISCUSSION

RA for upper limb operations is an excellent option that offers benefits over GA.[3,4] Advantages include increased patient comfort; reduced pain and opioid consumption; less postoperative nausea and vomiting; decreased recovery time after surgery; early hospital discharge; and reduced costs incurred from anesthetic medications and hospital stay. RA in the awake patient also allows the anesthetist to be more

TABLE 3. Anaesthesia Outcomes

Anesthesia Outcomes	Results
Successful BPB	77/78 (98.7%)
Additional mid-forearm block	14/78 (17.9%)
Additional LA infiltration by surgeon	8/78 (10.2%)
Number of requiring additional analgesia in PACU	1/78 (1.3%)
Mean volume of LA injected (ml)	28.1 (range: 20-40)
Same day discharge	65/78 (83.3%)

BPB indicates brachial plexus block; LA, local anesthesia; PACU, post-anesthesia care unit.

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TABLE 4. Surgical Outcomes of Study

Surgical Outcomes	Mean (SD)	Median	Range
Duration of surgery* (min)	81.5 (60.5)	60	8-292
Same day discharge, time from leaving theater to hospital (min)	167.7 (78.3)	158	46-432

*Duration of surgery considered to be time from knife-to-skin to end of procedure.

available, as only routine monitoring is required perioperatively after complete onset of anesthesia. The anesthetist can begin preparation of RA administration for the next patient whilst the surgeon is operating, eliminating "down-time" between cases, and increasing surgical output.

In our practice, the administration of RA starts during wound closure of the preceding case. An average of 40 minutes is required from the administration of BPB till the onset of complete anesthesia. We start positioning, preparing and draping the patient at 30 minutes after administration of the BPB.

Our results demonstrate a high success rate of 98.6% of effective BPB for upper limb operations and high patient satisfaction rate of 96%. Sixty-five patients (83.3%) were discharged the same day, preventing hospital admission, and saving hospital beds.

Two patients reported dissatisfactory results: 1 patient required conversion of RA to GA because of failed block and 1 patient reported discomfort intra-operatively because of a full bladder. The recorded US video clip of the BPB administration of the failed RA was peer-reviewed in our local RA governance meeting, which concluded the failure of RA was likely because of inadequate spread of LA around the plexus.

Risks and Complications of RA

Although an excellent choice of anesthesia for upper limb orthopedic procedures, RA is not without risks and is associated with complications such as pulmonary function compromise secondary to hemidiaphragmatic paralysis, pneumothorax or masking of compartment symptoms after surgery.[3,5] The benefits of RA over GA must be balanced with the known risks.

A meta-analysis of randomized controlled trials comparing supraclavicular (SCBPB) and infraclavicular BPB reported that following a SCBPB, the incidence of hemidiaphragmatic paresis because of phrenic nerve palsy was as high as 34% and Horner's syndrome was 32.1%.[6] The advent of US-guided RA has dramatically improved the quality, duration and safety of upper limb nerve blocks.[3,5,7] In our study, there were no incidences of hemidiaphragmatic paresis, Horner's syndrome or pneumothorax.

The use of RA for trauma patients has been contentious because of the risk of masking acute compartment syndrome (ACS) with prolonged anesthesia. The risks of ACS after a distal radius fracture and forearm diaphyseal fracture are 0.25% and 3.1%, respectively.[8] A systematic review of case reports of RA and compartment syndrome in orthopedic procedures found no cases of RA masking ACS in upper limb trauma.[9] Fleming and Egeler[10] reported their military experience of safe and effective RA for extremity injuries in 287 trauma patients. The authors suggest that RA may aid detection of ACS, presenting as breakthrough pain in an otherwise fully functioning sensory and motor nerve block, or in territories of unblocked nerves.

Upper Limb RA During the COVID-19 Pandemic

In the context of the COVID-19 pandemic, RA presents additional advantages over GA. Firstly, RA avoids associated risk of virus transmission from AGPs during GA, reducing the potential spread of COVID-19 viral particles because of droplets and aerosols to medical staff perioperatively. An anesthesia review by Uppal et al[11] highlights the importance of RA for surgery to reduce risk of COVID-19 transmission with GA.

Secondly, with RA patients can maintain their own airway and respiratory function, meaning fewer effects on respiratory dynamics compared with GA. The international, multicentre cohort study by the COVIDSurg Collaborative investigating patients undergoing surgery with concurrent COVID-19 infection, found that in patients who had GA, pulmonary complications occurred in 53.5% and 30-day mortality was 24.8%.[12] In comparison, the rate of pulmonary complications and 30-day mortality was 48.3% and 21.2%, respectively, in patients who had RA. Patients who developed pulmonary complications had a higher 30-day mortality than those who did not, 38.0% versus 8.7% ($P < 0.0001$). The preservation of patient's own respiratory function can reduce postoperative pulmonary complications and 30-day mortality if patients have confirmed or suspected COVID-19 infection.

Third, RA can enable same-day discharge. In our study 94% of patients were discharged the same day, avoiding hospital admission and freeing bed space. A study by O'Donnell et al[13] comparing GA and RA for upper limb trauma found that patients who had US-guided axillary blocks had lower pain scores and attained earlier hospital discharge criteria.

Finally, with a scarcity of critical care capacity during the COVID-19 pandemic, awake RA for upper limb surgery can reduce need for postoperative high dependency unit admission for patients of high anesthetic risk, saving critical care beds for COVID-19 patients.

Wide Awake Local Anesthetic no Tourniquet (WALANT) Technique

WALANT technique for upper limb is commonly used for distal sites of the upper limb, mainly the hand and fingers. For more proximal sites of the forearm and humerus, complete field LA is challenging to achieve. RA also allows less soft tissue swelling from LA infiltration that is commonly associated with WALANT.

Lessons Learned

The BPB is a specialized RA technique that requires expert skills and sound knowledge of head, neck and upper limb anatomy. Upper limb surgery under RA requires not only a competent anesthetist, but also collaboration of the surgical, scrub and nursing team to deliver safe perioperative and postoperative patient care. Good preoperative preparation and multidisciplinary co-operation are paramount for success.

Awake patients generally do not tolerate the lateral decubitus position, used during elbow surgery, for an extended period of time. Indeed, one of our patients with fracture dislocation of the elbow had her surgery in the supine position. Whilst most upper limb surgeons perform elective shoulder surgery with RA, this may be a new experience for the general trauma surgeon. We hope our study promotes the advantages of RA with BPB for upper limb orthopedic surgery and encourages its uptake during the COVID-19 pandemic and beyond.

CONCLUSION

Our study has demonstrated the safe and effective use of RA, administered under US guidance, for elective and trauma upper limb orthopedic procedures. We hope the lessons learned described will aid the uptake of RA for orthopedic teams who plan to start this practice. In the context of the COVID-19 pandemic, we strongly advocate for the preferential safe use of RA for upper limb operations to reduce AGPs and the possible

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risk of COVID-19 transmission, reduce compromise of patients' respiratory function, enable same-day discharge and avoid bed occupancy during these critical times.

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