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Regional anaesthesia for upper limb trauma: a review

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Abstract

Trauma to the upper limb is extremely common. Many of these patients present for surgery and anaesthesia as an emergency case, often complicated by other injuries and requiring effective perioperative analgesia. Although the use of regional anaesthesia for elective upper limb surgery has greatly increased, there is a lack of readily available information on the use and potential benefits of regional anaesthesia, as well as the choice of block for upper limb trauma.

This review aims to provide a comprehensive overview of the role of regional anaesthesia for both anaesthesia and analgesia in the management of upper limb trauma. The review will also focus on the use of regional anaesthesia for paediatric patients with upper limb trauma, the choice of anaesthetic technique, acute compartment syndrome and upper limb blockade and the use of intravenous regional anaesthesia.

Key words: upper limb, regional anaesthesia, trauma, fracture

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Introduction

Trauma to the upper limb is very common. Annually an estimated 3 million people suffer upper limb fractures alone in the United States of America [1]. The financial cost of these injuries is enormous both in terms of direct medical costs and productivity losses [2].

The majority of these patients require medical attention, the management of which will inevitably require some form of anaesthesia, either performed in the emergency or operating room setting.

The benefits of performing regional anaesthesia for these patients, such as immediate analgesia and the avoidance of general anaesthesia in the non-fasted patient may appear self-evident. However, despite the high incidence of upper limb trauma and the increasing emphasis on the use of regional anaesthesia in modern anaesthetic practice, it is difficult to readily access information on the use of regional anaesthesia in the management of upper limb trauma.

This review aims to provide a comprehensive overview of the role of regional anaesthesia for both anaesthesia and analgesia in the management of upper limb trauma. This paper will describe the characteristics of the patient presenting with upper limb trauma, dealing with particular patient subgroups and their relationship to the performance of regional anaesthesia. It will also focus on the use of regional anaesthesia for paediatric patients with upper limb trauma, the choice of anaesthetic technique, acute compartment syndrome and upper limb blockade and the use of intravenous regional anaesthesia. The performance of regional anaesthesia for specific upper limb injuries will be discussed.

The patient presenting with upper limb trauma

There are numerous mechanisms of upper limb injury, including fracture, laceration, crush injury, burns, gunshot, dog bite, amputation or frostbite. Fractures are the commonest non- fatal injury requiring hospitalization in the United States of America followed by open wounds or lacerations. Trauma to the upper

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limb as a result of burns or gunshot injury is much less common, but patients are more likely to die and have multi-system injuries [3].

Patients will usually present as emergency or urgent cases in the non-fasted state. Unlike elective surgery, patients may present with sub-optimal care of pre-existing medical conditions or with undesirable drug effects such as anticoagulation secondary to coumarins or anti-platelet agents. Upper limb trauma involves the complete spectrum of age, including higher risk groups such as young children and the elderly.

Children aged 5 to 14 years account for the largest proportion (26%) of hand/forearm fractures and have the highest rate of radius/ulnar fracture followed by patients 75 years or older and children aged 0 to 4 years [1].

Based on the incidence of medically treated injuries in the United States of America, the greatest rate of injury is among males aged 15 to 24 years (27 per 100) followed by females over 75 years (24 per 100). Falls and motor vehicle or other road related accidents account for the majority of medically treated injuries [2]. Burns and gunshot injuries are relatively uncommon. These findings are also supported by data that falls and motor vehicle accidents are also the commonest causes of hand/forearm fractures [1]. White patients have a greater risk of hand/forearm fractures than Black or Asian patients. The lowest risk is among those of American Indian or Eskimo origin [1].

In about 40% of patients other system involvement is likely. The system involved will obviously depend on the mechanism of injury-a road traffic accident is more likely to result in head and chest trauma than a fall at home. Although any combination of injuries is possible with upper limb trauma, the following trauma subgroups are worth considering for the application of regional anaesthesia: traumatic brain injury, thoracic injury, patients requiring critical care management and burns.

Traumatic brain injury

The traumatic brain injured patient may present either unconscious requiring sedation and mechanical ventilation or in a state of varying levels of consciousness necessitating regular neurological observation. For mechanically ventilated patients, the use of an upper limb block may facilitate earlier weaning from analgesia and hence sedation allowing earlier neurological evaluation of the patient. The use of a peripheral block as sole anaesthesia for an upper limb injury allows for continuous neurological monitoring of the non-ventilated traumatic brain injury patient [4].

As a result of their mechanism of injury, patients presenting with traumatic brain injury often have or are suspected of having a cervical neck injury. The presence of a neck collar makes certain upper limb blocks such as interscalene or supraclavicular block impractical. The use of interscalene, supraclavicular or infraclavicular blocks may also complicate neurological evaluation as a result of pupillary changes (meiosis) from inadvertent Horner's syndrome [5].

Thoracic injury

Patients with thoracic injuries often present with fractured ribs, pulmonary contusions, and pneumothoraces. In these circumstances the use of regional anaesthesia techniques that may affect pulmonary function needs careful consideration.

Brachial plexus blocks with a risk of pneumothorax such as the supraclavicular block are best avoided if a contralateral pneumothorax is present [6]. This may also be advisable for the vertical infraclavicular block although it has a very low quoted incidence of pneumothorax [7]. The use of ultrasound guidance however, may permit the use of these blocks if necessary, as direct visualization of the needle, plexus and pulmonary structures is possible [8].

The effects of interscalene block on diaphragmatic function with reduced forced vital capacity and functional residual capacity as a result of phrenic nerve blockade (100% in some series), raise concerns of its use with both ipsilateral and contralateral pulmonary pathology. The use of lower volumes (20 mL) and distal digital pressure does not prevent phrenic nerve block, with similar effects on respiratory function as 40 mL [9]. Lateral infraclavicular or axillary brachial plexus blocks are useful in these circumstances, as they have no effect on respiratory function [10].

Critical care patient

Trauma patients requiring critical care management usually have multiple injuries often complicated by haemorrhagic shock or sepsis. These patients are usually mechanically ventilated and sedated.

The role of regional anaesthesia for upper limb trauma is reduced as most patients receive opioids as part of their sedation and general anaesthesia is necessary for surgery in patients who are mechanically ventilated. The only descriptions in the literature of upper limb blocks in critically ill patients are case reports. The placement of a catheter for continuous analgesia may be beneficial in patients where the main painful stimulus is the upper limb trauma and improved analgesia may facilitate a reduction in sedative requirements leading to earlier extubation with its associated advantages [11]. However this decision will have to be on a case-by-case basis taking into consideration concerns (although rare) regarding catheter related infection and the masking of compartment syndromes [12, 13]. The concurrent use of neuromuscular blocking agents, though seldom used in present critical care practice, will necessitate block performance using ultrasound guidance.

Burns

Burns to the hands and upper limbs are the commonest sites of burn injury but usually patients present with burns on average at two other anatomical sites [14]. Burns to the upper limb are more common in adults than children. Continuous axillary blocks have been described for repeated anaesthesia for skin grafting but unlike for the lower limb, there have been no clinical trials to date investigating the use of regional anaesthesia for upper limb burns [15, 16]. The use of a peripheral nerve block may be beneficial in reducing hyperalgesia, but not inflammation post burn injury as has been demonstrated in healthy volunteers who received a femoral nerve block followed by a superficial burn to the thigh (17).

Paediatric patients

Upper limb trauma is very common in paediatric patients (< 15 years). Taking fractures alone, the rate of hand/forearm is highest among children 0-14 years for radius/ulnar, metacarpal and multiple hand fractures [1].

The management of upper limb fractures in children is different than adults, as in general, manipulation and immobilisation are only required. As a result many children are treated in the emergency room setting. Sedation/analgesia is often provided using ketamine-midazolam, opioids (fentanyl or meperidine) or a 50:50 nitrous oxide/oxygen mix. While the use of sedation for these procedures is considered safe to be performed by non-anaesthesiologists, the practice is not universal [18]. The differences in practice are highlighted by the fact that the majority of children at a tertiary orthopaedic hospital in Dublin, Ireland undergo fracture manipulation under general anaesthesia with or without axillary block (S. Mannion, personal communication) while at a similar institute in Montpellier, France most children are managed in the emergency department using sedation (X. Capdevila, Hôpital Lapeyronie, Montpellier, France, personal communication). Sedation may not be the most cost-effective method however, with axillary plexus blocks less expensive than ketamine-midazolam or fentanyl-midazolam regimes [19]. Concerns have been raised regarding hypoxia (15% of children in one American tertiary hospital) and failure to provide analgesia – in one study over two-thirds of children with an extremity fracture and greater than one-third of children with a severe fracture did not receive pain medications in the emergency department [20].

Intravenous regional anaesthesia (IVRA) is also used in the emergency room for fracture manipulation and reduction in children. Colizza and Said prospectively followed 139 children (aged 4 to18 years) with unilateral closed fractures and dislocations of forearm or wrist over a 6 year period [21]. Children received premedication of meperidine-promethazine and IVRA with 0.5% lidocaine solution (3 mg/kg intravenously). All patients had complete relief of pain allowing successful closed reduction in 133 patients (96%) with tourniquet pain occurring in 10 patients (7%). There were no complications from lignocaine toxicity, neurovascular injury or compartment syndrome.

Axillary blocks in the emergency room setting are usually performed by orthopaedic surgeons or emergency physicians. In one study, axillary block was effective for fracture manipulation in 105 out of 111 blocks and the cost was one-third that of general anaesthesia in the operating room [22]. No serious complications occurred in this series. However although described as effective, a recent study indicated mean (+/- SD) Children's Hospital of Eastern Ontario Pain Scale (CHEOPS) scores of 6.4 +/- 2.8 with axillary plexus block and 7.5 +/- 1.6 with deep sedation with ketamine and midazolam during fracture manipulation, suggesting that block performance could be improved [23].

The decision therefore to bring a child to the operating room will depend both on local practice norms and extent/type of injury. However the above findings and those of a recent review of sedation and analgesia for fracture reduction in the emergency room in 1086 paediatric patients indicate that both analgesia and overall care can be improved [18].

Although upper limb blocks can be performed in children without general anaesthesia (usually from the age of 8 upwards), the concurrent use of general anaesthesia is common. There are no published studies comparing general anaesthesia to upper limb regional anaesthesia in paediatric patients or comparing analgesia with or without upper limb blockade.

Axillary blocks and infraclavicular blocks are the commonest upper limb blocks in children [24]. Axillary block is very safe and easy to perform in children, is a single neurostimulation technique (unless musculocutaneous nerve block is required) and is suitable for catheter placement for continuous analgesia. A volume of 0.5 mL/kg is used for single shot blocks and 2 to 5 mL/hour of ropivacaine 0.2% depending on the patient's weight for the continuous technique [25]. The increasing use of ultrasound permits lower volumes (0.2-0.3 mL/kg) to be used [26]. Single shot ropivacaine 0.2% is as effective as bupivacaine 0.25% in providing postoperative analgesia after upper limb surgery and may have advantages because of its lower cardiac toxicity. Axillary plexus blocks improve upper limb blood flow and may improve outcomes after microvascular reconstructions [27]. Continuous axillary block has been described in management of burns in a 3 year old girl as well as after major orthopaedic surgery [28].

The use of the infraclavicular block is relatively new in children but compared with axillary block is less painful to perform and results in a greater extent of brachial plexus blockade [24]. The infraclavicular approach also has the advantage of not requiring 90° arm abduction in a potentially painful upper limb. However both blocks provide similar postoperative analgesia [24]. The lateral approach to the infraclavicular block is recommended because of the possible increased risk of pneumothorax with the vertical technique.

Similar concerns of the risks of pneumothorax have been raised regarding the supraclavicular and interscalene blocks (smaller children)-however these blocks are rarely required as shoulder trauma is relatively rare in children.

As in adult practice, the increased use of ultrasonography for peripheral nerve blockade may improve block performance – no painful muscle contractions from neurostimulation, improved nerve identification and facilitates visualization of structures (pleura, vessels). In a study by Kapral et al., ultrasound guided infraclavicular block in children results in faster sensory and motor onset, a longer duration of sensory blockade and by avoiding muscle contractions, less pain during the procedure than nerve stimulation [8].

Choice of anaesthesia (general or regional)

The potential advantages of providing anaesthesia for upper limb trauma using regional as opposed to general anaesthesia may seem obvious-avoidance of general anaesthesia in the non-fasted patient, the increased risks from general anaesthesia performed "out-of-hours", early and improved analgesia, reduced postoperative nausea/vomiting, improved tissue perfusion during re-implantations and the ability to provide a continuous technique for repeated procedures. Despite these assertions, there has only been one study specifically comparing general and regional anaesthesia for upper limb trauma. O'Donnell et al. randomized patients to receive ultrasound guided axillary blocks or general anaesthesia following hand trauma. The ultrasound-guided axillary block group had lower visual analog scale pain scores (mean [SD]) in the recovery room (0.3 [1.3] vs. 55.8 [36.5], $P < 0.001$), and visual rating scale pain scores at 2 h (0.3 [1.3] vs. 45 [29.6], $P < 0.001$), and at 6 h (1.1 [2.7] vs. 4 [2.8], $P < 0.01$). All ultrasound-guided axillary block patients bypassed the recovery room and attained earlier hospital discharge criteria (30 min vs 120 min 30/240 $P < 0.0001$ median [range]) [29]. A further three randomized controlled trials have compared general with regional anaesthesia for patients undergoing non-urgent upper limb surgery.

McCartney et al. compared transarterial axillary block to general anaesthesia in 100 patients undergoing ambulatory hand surgery [30]. Patients who received axillary block reported a longer duration to first analgesic, had lower pain scores and opioid consumption, less nausea/vomiting and spent less time in the hospital than patients receiving general anesthesia. There was no difference in pain scores or opioid consumption on postoperative days 1, 7, and 14 however and the axillary block had a 10% failure rate necessitating general anaesthesia in these patients.

Hadzic et al. also compared regional anaesthesia to general anaesthesia for patients undergoing hand and wrist surgery in the ambulatory setting [31]. 52 patients received either infraclavicular block with chloroprocaine plus epinephrine and bicarbonate or general anaesthesia with propofol induction, desflurane maintenance and wound infiltration with bupivacaine. Infraclavicular block led to faster recovery times, lower pain scores (3% vs. 48% with pain scores > 3), four times less nausea/vomiting and earlier discharge from hospital.

More recently, Hadzic et al. also investigated the effects of interscalene block with 0.75% ropivacaine compared with general anaesthesia and wound infiltration for outpatient shoulder surgery [32]. Patients who received nerve block had less pain, ambulated earlier, could be discharged faster and had no unplanned hospital admissions compared with 4 of 25 patients who received general anaesthesia.

While the benefits of improved analgesia and reduced nausea/vomiting would also be likely in the trauma setting, the complexity and extent of surgery as well as the presence of other injuries may necessitate general anaesthesia. In these circumstances the main indication for upper limb blocks would be for postoperative analgesia especially if a continuous technique is used. Nevertheless it would seem that the advantages of upper limb blocks make them a sensible choice instead of general anaesthesia for upper limb trauma.

Acute compartment syndrome

Although the risk of acute compartment syndrome after upper limb trauma is rare (0.25% incidence for distal radius and 3.1% for forearm diaphyseal fracture), the consequences are significant [13]. As early detection is vital and pain is the first sign in the majority of patients (68%), prolonged analgesia from regional anaesthesia may prevent early recognition and management [33]. There are no cases described in the literature of regional anaesthesia masking compartment syndrome following upper limb trauma [34], therefore a clear discussion between the orthopaedic and anaesthetic teams is necessary as the use of an upper limb block may be required depending on the risk/benefit profile. Those at greatest risk are male, < 35 years, presenting with high impact distal radius or diaphyseal forearm fractures [13]. Other risk groups are crush injuries and hand fractures. Should an upper limb block be required, short acting local anaesthetics without adjuncts, compartment pressure monitoring and increased clinical vigilance are sensible precautions [34]. IVRA should be avoided as compartment syndrome secondary to the tourniquet placement and subsequent injection of large volumes of local anaesthetic has been described [35].

Intravenous regional anaesthesia (IVRA)

The use of intravenous regional anaesthesia (IVRA) was first described by Karl August Bier in Berlin, Germany in 1908, hence its name, Bier's Block [35]. The block is simple to perform – often by non-anaesthesiologists, effective and cheap. There have been a number of extensive reviews of the subject.

IVRA is suitable for forearm, hand and finger procedures. Problems include pain secondary to the tourniquet, short duration of anaesthesia (maximum 1 hour), toxicity if basic precautions are not followed and a lack of postoperative analgesia – it usually disappears in minutes and is not prolonged by longer acting local anaesthetics such as ropivacaine [35]. Tourniquet pain can be managed using a double tourniquet or adding clonidine (1 mcg/kg) or ketamine (0.1 mg/kg) to the local anaesthetic.

A recent Cochrane Review of anaesthetic techniques (IVRA, hematoma block, regional and general anaesthesia) for distal forearm fractures concluded that there was insufficient evidence available to establish the relative effectiveness of each technique [36]. IVRA was found to provide better analgesia and conditions than haematoma block for fracture manipulation with some evidence for a reduced risk of later re-dislocation. Compared to axillary plexus block in the emergency room, IVRA had a higher failure rate of anaesthesia, poorer analgesia and lower patient satisfaction but was quicker to perform (10 vs. 32.5 minutes) [37]. In a retrospective review, IVRA was 18 times cheaper than general anaesthesia for outpatient hand surgery with fewer side effects (nausea, dizziness) and faster discharge but with an 11% failure rate [38].

Despite some of the advantages of IVRA for upper limb trauma, its use is very limited. The involvement of the upper limb above the elbow, complex surgery and therefore increased procedure duration and the requirement for prolonged analgesia necessitate the use of peripheral nerve block techniques for upper limb regional anaesthesia (Table 1).

Table 1. Recommended upper limb nerve blocks with regard to surgical site

Site of injury	Upper limb block	Comments
Shoulder	Interscalene block	Supraclavicular block is an alternative but ultrasound guidance [47] is advised because of the increased risk of pneumothorax [6]. Continuous catheter beneficial for major surgery [42, 43].
Proximal humerus	Interscalene block	As for shoulder.
Mid to distal humerus	Lateral infraclavicular block	Other alternatives are vertical infraclavicular [7], interscalene [9] and supraclavicular [6, 47] blocks but these have a higher risk profile unless ultrasound guidance used.
Elbow	Lateral infraclavicular block	Other alternatives are vertical infraclavicular block but with an increased incidence of pneumothorax [7] or axillary plexus block (less radial and musculocutaneous nerve block unless multi-stimulation) [7] or ultrasound. Continuous catheter recommended for major surgery.
Forearm and wrist	Triple stimulation [49] or ultrasound guided [53] axillary block	Infraclavicular blocks should be used if a painful upper limb or difficulty with abduction [48]. IVRA is an alternative for short, minimally painful procedures [35]. Continuous catheter may be beneficial for major surgery.
Hand	Triple stimulation [49] or ultrasound guided [53] axillary block	As for forearm and wrist.
Fingers	Triple stimulation [49] or ultrasound guided [53] axillary block	As for forearm and wrist. For isolated finger surgery, digital intrathecal block is the block of choice [64, 65].

Shoulder and humeral trauma

Shoulder trauma usually results from high impact and most often presents with shoulder dislocation or acute rotator cuff tears following falls, motor vehicle accidents or from sports injuries [39].

There are a number of case series describing the successful manipulation of shoulder dislocation using interscalene block without general anaesthesia. Underhill et al. describe 30 cases of interscalene block in the emergency room with a success rate of 87% [39]. Blaivas and Lyons reported the successful use ultrasound guided interscalene block for 4 cases of shoulder dislocation presenting to their emergency department [40].

Acute rotator cuff tears are usually managed in a semi-elective manner, and as for other types of shoulder surgery (arthroplasty, fracture fixation or arthroscopic stabilization procedures) there are a number of studies demonstrating the benefits of interscalene block either alone, in combination with general anaesthesia or as a continuous technique. Bishop et al. report on a retrospective series of 547 patients in whom 478 had interscalene block intended as their sole anaesthetic technique with a further 34 patients receiving both interscalene block and planned general anaesthesia [41]. The block functioned as the sole anaesthetic in 462 (97%) of patients and there no major complications apart from 12 cases of sensory neuropathy, all of which resolved within 3 months. Hadzic et al. demonstrated that for outpatient shoulder surgery, interscalene block resulted in patients having less pain, earlier ambulation and discharge and no unplanned hospital admissions compared to patients who received general anaesthesia [32]. In a another randomized trial, comparing morphine patient controlled analgesia (PCA) with a continuous interscalene block of 0.2% ropivacaine (5 mL/hour) with a 3 or 4 mL bolus (lockout time-20 min) for 48 hours, the continuous block resulted in better analgesia at 12 and 24 hours, an incidence of nausea/vomiting of 5.5% versus 60% in the morphine PCA group and greater patient satisfaction [42]. Ekatodramis et al. investigated two infusion rates for a 48-hour continuous interscalene block with ropivacaine 0.2% commenced 6 hours after an initial interscalene block with 30 ml ropivacaine 0.75% [43]. They demonstrated that both an infusion of 6 or 9 mL/hour provided satisfactory postoperative analgesia after major shoulder surgery with unbound plasma concentrations of ropivacaine and its toxic metabolite 2.6-pipecoloxylidide (PPX) remaining well below threshold levels for systemic central nervous toxicity. Importantly, following the effects of the initial interscalene block on pulmonary function, there were no differences found in pulmonary function between the continuous infusion and morphine groups – in fact hemi-diaphragmatic function on the non-operated side was better in the continuous interscalene group at 24 and 48 hours [42].

Humeral trauma normally presents as a humeral fracture following a fall in elderly women. The commonest sites of injury are the proximal and middle thirds of the humerus and open fractures are rare (2% of cases) [44]. There have been no studies comparing interscalene with supra- or infraclavicular blocks for humeral surgery. However the failure of the interscalene block to consistently block the posterior elements (radial and ulnar nerves) of the brachial plexus suggests that supra- or infraclavicular blocks are more suitable for humeral surgery. The use of the lateral infraclavicular block for humeral fracture is effective, facilitates a continuous technique and has no effect on pulmonary function (66% incidence of complete or partial diaphragmatic paralysis following supraclavicular block) [6]. Ultrasound guided supraclavicular block may be an alternative as the incidence of pneumothorax is very low – there were no clinical cases reported in 510 blocks [45].

Finally it should also be remembered that axillary block is an effective block for surgery on the distal humerus. The use of bilateral blocks has also been described for the management of complicated multiple site upper limb fractures [46].

Elbow, forearm and wrist trauma

Regional anaesthesia for surgery involving the elbow, forearm and wrist has been described for numerous approaches to the brachial plexus. As there are few studies comparing various approaches to brachial plexus blockade for specific surgery, the choice of block is based on the anatomical knowledge of the extent of blockade, the site(s) of surgery and risk profile.

The common failure of the interscalene block to anesthetize the posterior elements of the brachial plexus makes it the least suitable block for surgery below the elbow. The supraclavicular block has a higher incidence of pneumothorax than other techniques and despite the use of ultrasound is only 85% effective for forearm or hand surgical anaesthesia [47] – compared with 95 to 98% with infraclavicular or axillary blocks [48, 49].

A rationale choice, in the absence of comparative studies, for surgery below and including the elbow is a peripheral nerve block below the clavicle. The four main blocks are the vertical and lateral infraclavicular approaches, axillary plexus and mid-humeral blocks.

Both the vertical and lateral approaches have high success rates generally blocking the median, radial, ulnar, and musculocutaneous nerves [7, 48]. Some of the potential advantages of these blocks in upper limb trauma include a single stimulation technique (lateral approaches may need a double stimulation if musculocutaneous nerve blockade is required), ease of catheter placement and fixation and not having to move or abduct the injured limb.

Infraclavicular blocks are more successful with single stimulation, have a faster onset and greater extent of anaesthesia (axillary and medial cutaneous nerves) than transarterial or single neurostimulation axillary blocks [7, 48].

Similar to axillary blocks, infraclavicular blocks have been performed successfully in the emergency room setting and can be performed equally well by resident anaesthesiologists (90% success rate vs. 93% senior staff). Likewise infraclavicular blocks have no effect on respiratory function [10].

However unlike axillary blocks, vertical infraclavicular approaches carry a risk of pneumothorax and neurological evaluation in traumatic brain injury may be difficult (meiosis in 4%) [5, 7]. The use of continuous axillary catheters is well described, safe and easy to perform.

Although infraclavicular approaches are more effective than transarterial or single neurostimulation axillary blocks [7], it is now generally accepted that the standard for axillary block is as a minimum a triple stimulation technique or ultrasound guided techniques [48, 49, 29]. Nerve stimulation techniques may cause discomfort to patients although in a study by Koscielniak-Nielsen et al. comparing lateral infraclavicular block to a quadruple stimulation technique, patient discomfort was 22 on a 100 scale for axillary plexus block and 10 for infraclavicular block with no difference found in the number of patients satisfied [48].

This study was not in trauma patients, however and ultrasound guided blocks may therefore reduce patient discomfort by avoiding stimulation of muscles supplying damaged tissues.

The mid-humeral block is a multiple stimulation block performed at the junction of the proximal and middle thirds of the arm. March et al. randomised 100 patients to triple stimulation axillary block or quadruple stimulation mid-humeral block [49].

Blockade of the peripheral nerves occurred in 94% of patients in the axillary group and 79% in the mid-humeral group. Time for block performance was shorter, onset time quicker and motor block more complete with the axillary group. However more vascular punctures occurred in the axillary group (22% vs 8%). Fuzier et al. reported similar findings with a double stimulation axillary block compared with mid-humeral block in 90 patients undergoing emergency upper limb surgery [50]. Minville et al., in a randomized study of 104 upper limb trauma patients, compared mid-humeral and infraclavicular blocks in terms of the pain caused by the block [51]. The severity of the pain during the procedure was recorded using a visual analog scale (VAS) – 0 to 100 mm. VAS scores were 35 +/- 27 mm with mid-humeral block versus 19 +/- 18 mm in the infraclavicular block group. Electrical stimulation was identified as the most unpleasant part of the block. Although time to perform the block was shorter with the infraclavicular block, onset was longer resulting in a similar mean regional anaesthesia time (19 min).

Potential advantages of the mid-humeral block are therefore the ability to selectively anaesthetise the individual nerves of the brachial plexus and a reduction in the incidence of vascular puncture compared with axillary and infraclavicular approaches. Finally mid-humeral block for elderly patients (> 70 years) with upper limb trauma results in a prolonged duration of motor and sensory block compared with younger patients (< 70 years). Paqueron et al. demonstrated that 20 mL ropivacaine 0.75% resulted in longer sensory (390 min vs 150 min) and motor (350 min vs 150 min) block in elderly compared to younger patients [52]. The duration of complete sensory block correlated significantly with increasing age. These findings have implications for post block monitoring and awareness of acute compartment syndromes.

The use of ultrasound guidance, where available facilitates block performance, improves success rates and reduces complications such as vascular puncture or pneumothorax. Ultrasound guided upper limb blocks are useful where neurostimulation is not possible or when avoidance of a particular structure is vital [8, 45].

In a prospective randomised study involving 56 patients, ultrasound guided axillary plexus block improved block success rates (29% failure in transarterial group vs. 0% with ultrasound) and reduced performance time (mean 4 minutes) compared to transarterial axillary block [53]. In a retrospective German study, ultrasound was superior to neurostimulation (number of stimulations was not specified) in terms of success (98.2 vs. 83.1%) [54].

Williams et al., in a randomised study of 80 patients, demonstrated that the use of ultrasonography with neurostimulation for supraclavicular block was superior to neurostimulation alone in terms of complete sensory blockade and performance time [47].

Hand and finger trauma

Trauma to the hand and/or fingers is extremely common and includes fractures, lacerations, amputations, crush injuries and burns. The number of possible techniques for regional anaesthesia for the hand and fingers is extensive and includes the blocks already mentioned (interscalene, supraclavicular, infraclavicular, axillary and midhumeral) as well as blocks at the elbow, forearm, wrist and fingers. As previously discussed, the interscalene and supraclavicular blocks are the least appropriate blocks for hand and finger surgery. The pros and cons of the other major brachial plexus blocks have also been presented. The major determinate will be whether a tourniquet is necessary and where on the upper limb it is to be placed. In general, tourniquet placement is on the arm necessitating an infraclavicular or axillary plexus block. It should be noted that the surgical anaesthesia provided by these blocks can with short-acting local anaesthetics (lignocaine, mepivacaine) with other blocks performed at a lower neural level with longer acting agents (levobupivacaine, ropivacaine) to provide selective longer duration postoperative analgesia.

Axillary plexus block results in sympathetic blockade of the upper limb with increased blood flow and skin perfusion [27, 55]. This has been postulated to be of benefit following finger re-implantation surgery or crush injury. Three small studies have investigated the effects of continuous upper limb neural blockade on digital re-implantation in adults. Kurt et al. found that in 9 of 16 patients undergoing digital re-implantations or toe-finger transplants who received continuous brachial plexus block with general anaesthesia, pain scores were less and Doppler measured blood flow was greater in transplanted or re-implanted digits as compared to the other 7 patients receiving general anaesthesia alone [56]. Taras and Behrman provided regional anaesthesia via a continuous forearm catheter in 55 patients undergoing digital replantation or revascularization [57]. 53 of 57 replanted digits (93%) and 25 of 26 revascularized digits (96%) survived. They concluded that this technique was a safe and effective adjunct in preventing neurogenically mediated vasospasm, however there were no case controls in their study. Finally Osada and colleagues placed continuous catheters the in the forearm in 22 patients with severe hand trauma. Pain scores were minimal and extrinsic hand motor function was maintained [58]. Axillary plexus blocks have also been recommended in small cases series to limit necrosis after high-pressure injection injuries of the hand and in the management of frostbite. If continuous axillary plexus blockade is performed, patient controlled boluses (1 mL/kg/hr of 0.25% bupivacaine) with a one-hour lockout time results in lower opioid and bupivacaine consumption with greater patient satisfaction [59].

The anatomical site of injury at the hand suggests that peripheral nerve blocks at the level of the elbow or forearm may be useful and therefore commonly employed. The requirement for a tourniquet and the need for injections at multiple sites (ulnar, median, radial and subcutaneous infiltration for medial and lateral cutaneous nerves of the forearm) for complete anaesthesia mean these blocks are rarely performed in practice. However the ability to perform these blocks is important in order to supplement partial higher blocks and target specific nerves for prolonged analgesic block. Blocks at the elbow and forearm may also be useful for providing analgesia in the pre-hospital trauma setting or in the emergency room and can be facilitated by ultrasonography [60, 61].

For minor hand trauma involving the fingers, a number of techniques for digital anaesthesia have been described. A digital block is simple to perform and provides a mean duration of anaesthesia of 24.9 hours with bupivacaine 0.5% compared with 10.4 hours for lignocaine 2% with epinephrine (1:100,000) and 4.9 hours for plain lignocaine 2% [62]. While the use of epinephrine has long been considered contraindicated in digital blocks, there is no evidence to support this view in the literature [63]. Epinephrine results in a temporary reduction in digital blood flow but with preservation of digital perfusion. Wilhelmi et al. demonstrated in a prospective randomized double-blinded study that the addition of epinephrine to lignocaine reduced the need to repeat blocks and the need for a digital tourniquet to control bleeding (20 of 29 with plain lignocaine vs. 9 of 31 using lignocaine with epinephrine) [63].

Two other commonly used blocks are the intrathecal digital block (injection of local anaesthetic into the flexor sheath) and the metacarpal block (local anaesthetic injected between and at the level of the metacarpal bones). An advantage of the intrathecal block is that it involves only a single injection, has a faster onset time (3.91 vs. 7.16 min) and better proximal and radial digital anaesthesia than metacarpal block [64]. Similar findings have also been reported for digital block compared to the metacarpal block [65].

Conclusion

Regional anaesthesia has a large role to play in the anaesthetic and analgesic management of upper limb trauma. A lack of clinical trials in this area makes it difficult to define its exact role – however with the data presently available it is possible to draw a number of conclusions.

Regional anaesthesia provides better analgesia than general anaesthesia following upper limb surgery and a continuous patient controlled technique may be the best method. Peripheral nerve blocks are a suitable alternative to general anaesthesia for upper limb anaesthesia but whether they improve outcomes after trauma surgery is not known. On an individual patient basis, regional anaesthesia and analgesia (especially continuous techniques) for upper limb trauma are beneficial in patients with concurrent traumatic brain or thoracic injury and may be of benefit in the management of upper limb burns. Upper limb nerve blocks have a definite role in the pain management of paediatric upper limb fractures [66].

Concerns regarding upper limb regional anaesthesia and acute compartment syndrome are largely unfounded and therefore upper limb single shot blocks or continuous techniques are not contraindicated in the majority of patients presenting with upper limb trauma – although an individualized risk assessment should be made, especially if known risk factors are present [34]. The placement of catheters for continuous peripheral nerve blockade in trauma patients is not a risk factor for catheter infection despite regular colonization [12].

As a result of recent military conflicts, there is increasing knowledge from case series of the use of and innovation in regional anaesthesia techniques for pre-hospital analgesia, medical transport, anaesthesia, postoperative analgesia and rehabilitation following trauma [67]. Some of these findings are likely to be of benefit in the civilian setting.

As regards the choice of block for upper limb trauma surgery, there are few comparative trials and any differences found between techniques have been of a minor nature. Therefore the decision to choose a particular block will be based on the site of surgery, the competences of the operator and particulars of a specific patient. Interscalene block appears to be the most appropriate for shoulder/humeral surgery followed by ultrasound guided supraclavicular block if effects on pulmonary function need to be reduced. Regional anaesthesia for trauma surgery at and below the elbow should be performed under triple stimulation or ultrasound guided axillary plexus block or lateral infraclavicular block. Infraclavicular block is more appropriate in cases of severe upper limb pain or inability to abduct the arm. These blocks can be supplemented if required at the elbow or forearm to complete partial blocks or provide prolonged targeted analgesia. Digital intrathecal block is the most effective block for digital anaesthesia.

Conflict of interest

Nothing to declare

References

1. Chung KC, Spilson SV. The frequency and epidemiology of hand and forearm fractures in the United States. J Hand Surg Am 2001; 26: 908-915
2. Corso P, Finkelstein E, Miller T, Fiebelkorn I, Zaloshnja E. Incidence and lifetime costs of injuries in the United States. Inj Prev 2006; 12: 212-218
3. National Center for Disease Statistics Injury Data. www.cdc.gov/nchs/injury.htm
4. Errando CL, Pallardó MA, Herranz A, Peiró CM, de Andrés JA. Bilateral axillary brachial plexus block guided by multiple nerve stimulation and ultrasound in a multiple trauma patient. Rev Esp Anestesiol Reanim 2006; 53: 383-386
5. Jandard C, Gentili ME, Girard F, et al. Infraclavicular block with lateral approach and nerve stimulation: extent of anesthesia and adverse effects. Reg Anesth Pain Med 2002; 27: 37-42
6. Mak PH, Irwin MG, Ooi CG, Chow BF. Incidence of diaphragmatic paralysis following supraclavicular brachial plexus block and its effect on pulmonary function. Anaesthesia 2001; 56: 352-356
7. Heid FM, Jage J, Guth M, Bauwe N, Brambrink AM. Efficacy of vertical infraclavicular plexus block vs. modified axillary plexus block: a prospective, randomized, observer-blinded study. Acta Anaesthesiol Scand 2005; 49: 677-682
8. Marhofer P, Sitzwohl C, Greher M, Kapral S. Ultrasound guidance for infraclavicular brachial plexus anaesthesia in children. Anaesthesia 2004; 59: 642-646
9. Sala-Blanch X, Lázaro JR, Correa J, Gómez-Fernandez M. Phrenic nerve block caused by interscalene brachial plexus block: effects of digital pressure and a low volume of local anesthetic. Reg Anesth Pain Med 1999; 24: 231-235
10. Rodríguez J, Bárcena M, Rodríguez V, Aneiros F, Alvarez J. Infraclavicular brachial plexus block effects on respiratory function and extent of the block. Reg Anesth Pain Med 1998; 23: 564-568
11. Schulz-Stübner S. The critically ill patient and regional anesthesia. Curr Opin Anaesthesiol 2006; 19: 538-544
12. Capdevila X, Pirat P, Bringuier S, et al.; French Study Group on Continuous Peripheral Nerve Blocks. Continuous peripheral nerve blocks in hospital wards after orthopedic surgery: a multicenter prospective analysis of the quality of postoperative analgesia and complications in 1,416 patients. Anesthesiology 2005; 103: 1035-1045
13. McQueen MM, Gaston P, Court-Brown CM. Acute compartment syndrome. Who is at risk? J Bone Joint Surg Br 2000; 82: 200-203
14. Chien WC, Pai L, Lin CC, Chen HC. Epidemiology of hospitalized burns patients in Taiwan. Burns 2003; 29: 582-588
15. Randalls B. Continuous brachial plexus blockade. A technique that uses an axillary catheter to allow successful skin grafting. Anaesthesia 1990; 45: 143-144
16. Cuignet O, Mbuyamba J, Pirson J. The long-term analgesic efficacy of a single-shot fascia iliaca compartment block in burn patients undergoing skin-grafting procedures. J Burn Care Rehabil 2005; 26: 409-415
17. Pedersen JL, Crawford ME, Dahl JB, Brennum J, Kehlet H. Effect of preemptive nerve block on inflammation and hyperalgesia after human thermal injury. Anesthesiology 1996; 84: 1020-1026
18. Migita RT, Klein EJ, Garrison MM. Sedation and analgesia for pediatric fracture reduction in the emergency department: a systematic review. Arch Pediatr Adolesc Med 2006; 160: 46-51
19. Pershad J, Todd K, Waters T. Cost-effectiveness analysis of sedation and analgesia regimens during fracture manipulation in the pediatric emergency department. Pediatr Emerg Care 2006; 22: 729-736
20. Cimpello LB, Khine H, Avner JR. Practice patterns of pediatric versus general emergency physicians for pain management of fractures in pediatric patients. Pediatr Emerg Care 2004; 20: 228-232

21. Colizza WA, Said E. Intravenous regional anesthesia in the treatment of forearm and wrist fractures and dislocations in children. Can J Surg 1993; 36: 225-228
22. Cramer KE, Glasson S, Mencio G, Green NE. Reduction of forearm fractures in children using axillary block anesthesia. J Orthop Trauma 1995; 9: 407-410
23. Kriwanek KL, Wan J, Beaty JH, Pershad J. Axillary block for analgesia during manipulation of forearm fractures in the pediatric emergency department a prospective randomized comparative trial. J Pediatr Orthop 2006; 26: 737-740
24. Fleischmann E, Marhofer P, Greher M, Waltl B, Sitzwohl C, Kapral S. Brachial plexus anaesthesia in children: lateral infraclavicular vs axillary approach. Paediatr Anaesth 2003; 13: 103-108
25. Dadure C, Pirat P, Raux O, et al. Perioperative continuous peripheral nerve blocks with disposable infusion pumps in children: a prospective descriptive study. Anesth Analg 2003; 97: 687-690
26. Marhofer P, Willschke H, Kettner SC. Ultrasound-guided upper extremity blocks – tips and tricks to improve the clinical practice. Paediatr Anaesth 2012; 22: 65-71
27. Inberg P, Kassila M, Vilkki S, Tarkkila P, Neuvonen P. Anaesthesia for microvascular surgery in children. A combination of general anaesthesia and axillary plexus block. Acta Anaesthesiol Scand 1995; 39: 518-522
28. Dadure C, Acosta C, Capdevila X. Perioperative pain management of a complex orthopedic surgical procedure with double continuous nerve blocks in a burned child. Anesth Analg 2004; 98: 1653-1655
29. O'Donnell BD, Ryan H, O'Sullivan O, Iohom G. Ultrasound-guided axillary brachial plexus block with 20 milliliters local anesthetic mixture versus general anesthesia for upper limb trauma surgery: an observer-blinded, prospective, randomized, controlled trial. Anesth Analg 2009; 109: 279-283
30. McCartney CJ, Brull R, Chan VW, et al. Early but no long-term benefit of regional compared with general anesthesia for ambulatory hand surgery. Anesthesiology 2004; 101: 461-467
31. Hadzic A, Arliss J, Kerimoglu B, et al. A comparison of infraclavicular nerve block versus general anesthesia for hand and wrist day-case surgeries. Anesthesiology 2004; 101: 127-132
32. Hadzic A, Williams BA, Karaca PE, et al. For outpatient rotator cuff surgery, nerve block anesthesia provides superior same-day recovery over general anesthesia. Anesthesiology 2005; 102: 1001-1007
33. Davis ET, Harris A, Keene D, Porter K, Manji M. The use of regional anaesthesia in patients at risk of acute compartment syndrome. Injury 2006; 37: 128-133
34. Mannion S, Capdevila X. Acute compartment syndrome and the role of regional anesthesia. Int Anesthesiol Clin 2010; 48: 85-105
35. Brill S, Middleton W, Brill G, Fisher A. Bier's block; 100 years old and still going strong! Acta Anaesthesiol Scand 2004; 48: 117-122
36. Handoll HHG, Madhok R, Dodds C. Anaesthesia for treating distal radial fracture in adults. Cochrane Database Syst Rev 2002; (3): CD003320
37. Mackay CA, Bowden DF. Axillary brachial plexus block – an underused technique in the accident and emergency department. J Accid Emerg Med 1997; 14: 226-229
38. Chilvers CR, Kinahan A, Vaghadia H, Merrick PM. Pharmacoeconomics of intravenous regional anaesthesia vs general anaesthesia for outpatient hand surgery. Can J Anaesth 1997; 44: 1152-1156
39. Underhill TJ, Wan A, Morrice M. Interscalene brachial plexus blocks in the management of shoulder dislocations. Arch Emerg Med 1989; 6: 199-204
40. Blaivas M, Lyon M. Ultrasound-guided interscalene block for shoulder dislocation reduction in the ED. Am J Emerg Med 2006; 24: 293-296
41. Bishop JY, Sprague M, Gelber J, et al. Interscalene regional anesthesia for shoulder surgery. J Bone Joint Surg Am 2005; 87: 974-979
42. Borgeat A, Perschak H, Bird P, Hodler J, Gerber C. Patient-controlled interscalene analgesia with ropivacaine 0.2% versus patient-controlled intravenous analgesia after major shoulder surgery: effects on diaphragmatic and respiratory function. Anesthesiology 2000; 92: 102-108
43. Ekatodramis G, Borgeat A, Huledal G, Jeppsson L, Westman L, Sjövall J. Continuous interscalene analgesia with ropivacaine 2 mg/ml after major shoulder surgery. Anesthesiology 2003; 98: 143-150
44. Ekholm R, Adami J, Tidermark J, Hansson K, Törnkvist H, Ponzer S. Fractures of the shaft of the humerus. An epidemiological study of 401 fractures. J Bone Joint Surg Br 2006; 88: 1469-1473
45. Perlas A, Lobo G, Lo N, Brull R, Chan VW, Karkhanis R. Ultrasound-guided supraclavicular block: outcome of 510 consecutive cases. Reg Anesth Pain Med 2009; 34: 171-176
46. Errando CL, Pallardó MA, Herranz A, Peiró CM, de Andrés JA. Bilateral axillary brachial plexus block guided by multiple nerve stimulation and ultrasound in a multiple trauma patient. Rev Esp Anestesiol Reanim 2006; 53: 383-386
47. Williams SR, Chouinard P, Arcand G, et al. Ultrasound guidance speeds execution and improves the quality of supraclavicular block. Anesth Analg 2003; 97: 1518-1523
48. Koscielniak-Nielsen ZJ, Rasmussen H, Hesselbjerg L, Nielsen TP, Gürkan Y. Infraclavicular block causes less discomfort than axillary block in ambulatory patients. Acta Anaesthesiol Scand 2005; 49: 1030-1034
49. March X, Pardina B, Torres-Bahí S, Navarro M, del Mar Garcia M, Villalonga A. A comparison of a triple-injection axillary brachial plexus block with the humeral approach. Reg Anesth Pain Med 2003; 28: 504-508
50. Fuzier R, Fourcade O, Pianezza A, Gilbert ML, Bounes V, Olivier M. A comparison between double-injection axillary brachial plexus block and midhumeral block for emergency upper limb surgery. Anesth Analg 2006; 102: 1856-1858
51. Minville V, Fourcade O, Idabouk L, et al. Infraclavicular brachial plexus block versus humeral block in trauma patients: a comparison of patient comfort. Anesth Analg 2006; 102: 912-915
52. Paqueron X, Boccara G, Bendahou M, Coriat P, Riou B. Brachial plexus nerve block exhibits prolonged duration in the elderly. Anesthesiology 2002; 97: 1245-1249
53. Sites BD, Beach ML, Spence BC, et al. Ultrasound guidance improves the success rate of a perivascular axillary plexus block. Acta Anaesthesiol Scand 2006; 50: 678-684
54. Schwemmer U, Schleppers A, Markus C, Kredel M, Kirschner S, Roewer N. Operative management in axillary brachial plexus blocks: comparison of ultrasound and nerve stimulation. Anaesthesist 2006; 55: 451-456
55. Chandran GJ, Chung B, Lalonde J, Lalonde DH. The hyperthermic effect of a distal volar forearm nerve block: a

possible treatment of acute digital frostbite injuries? Plast Reconstr Surg 2010; 126: 946-950
56. Kurt E, Ozturk S, Isik S, Zor F. Continuous brachial plexus blockade for digital replantations and toe-to-hand transfers. Ann Plast Surg 2005; 54: 24-27
57. Taras JS, Behrman MJ. Continuous peripheral nerve block in replantation and revascularization. J Reconstr Microsurg 1998; 14: 17-21
58. Osada R, Zukawa M, Seki E, Kimura T. Continuous peripheral nerve block in forearm for severe hand trauma. Hand Surg 2011; 16: 239-244
59. Mezzatesta JP, Scott DA, Schweitzer SA, Selander DE. Continuous axillary brachial plexus block for postoperative pain relief. Intermittent bolus versus continuous infusion. Reg Anesth 1997; 22: 357-362
60. Liebmann O, Price D, Mills C, et al. Feasibility of forearm ultrasonography-guided nerve blocks of the radial, ulnar, and median nerves for hand procedures in the emergency department. Ann Emerg Med 2006; 48: 558-562
61. De Buck F, Devroe S, Missant C, Van de Velde M. Regional anesthesia outside the operating room: indications and techniques. Curr Opin Anaesthesiol 2012; 25: 501-507
62. Thomson CJ, Lalonde DH. Randomized double-blind comparison of duration of anesthesia among three commonly used agents in digital nerve block. Plast Reconstr Surg 2006; 118: 429-432
63. Wilhelmi BJ, Blackwell SJ, Miller JH, et al. Do not use epinephrine in digital blocks: myth or truth? Plast Reconstr Surg 2001; 107: 393-397
64. Cummings AJ, Tisol WB, Meyer LE. Modified transthecal digital block versus traditional digital block for anesthesia of the finger. J Hand Surg Am 2004; 29: 44-48
65. Knoop K, Trott A, Syverud S. Comparison of digital versus metacarpal blocks for repair of finger injuries. Ann Emerg Med 1994; 23: 1296-1300
66. Saleh D, Nikkah D, Bhat W, Hopkins P. A retrospective survey of brachial plexus blockade in pediatric hand trauma patients. Paediatr Anaesth 2011; 21: 1166-1168
67. Hunter JG. Managing pain on the battlefield: an introduction to continuous peripheral nerve blocks. J R Army Med Corps 2010; 156: 230-232

Anestezia regională pentru traumatismele membrului superior: o actualizare

Rezumat

Accidentele traumatice ale membrului superior sunt extrem de frecvente. Numeroşi pacienţi se prezintă ca urgenţe anestezico-chirurgicale, deseori complicate cu alte leziuni şi necesitând o analgezie perioperatorie eficientă. Deşi utilizarea anesteziei regionale pentru intervenţiile de elecţie asupra membrului superior a crescut considerabil, se înregistrează totuşi un deficit de informaţie rapid disponibilă legat de utilizarea şi potenţialele beneficii oferite de anestezia regională, precum şi de opţiunile de alegere a blocurilor periferice pentru membrul superior traumatizat.

Această actualizare şi-a propus să ofere o privire de ansamblu asupra rolului anesteziei regionale privind anestezia şi analgezia utilizate în tratamentul membrului superior traumatizat. Această lucrare s-a concentrat de asemenea şi pe utilzarea anesteziei regionale în practica pediatrică, pe alegerea tehnicii anestezice, pe blocurile regionale în cadrul sindromului de compartiment acut şi pe utilizarea anesteziei intravenoase regionale.

Cuvinte cheie: membru superior, anestezie regională, traumă, fractură