Chapter 30
Regional Techniques: Role and Pitfalls

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Abstract Employing regional anesthesia outside of the operating room equips the clinician with another set of tools to optimally treat pain and allow for and improved patient recovery. Although regional anesthesia may not be appropriate in all situations, it is very effective in the right situation. When doing nerve blocks outside of the operating room setting, it is helpful to set up a portable block cart that can carry all equipment and medication necessary. The chapter outlines the instances when regional anesthesia may truly be beneficial to patient care, which nerve blocks should be employed, how to do the nerve blocks, and special considerations that should be thought of prior to placing a nerve block. The local anesthetic systemic toxicity algorithm is also placed in the chapter.

Keywords Interscalene Block • Supraclavicular Block • Infraclavicular Block • Axillary nerve block • Median nerve block • Radial nerve block • Ulnar Nerve block • Musculocutaneous Nerve block • IV regional block • Femoral Nerve block • Fascia Iliaca Block • Intercostal Nerve Block • Paravertebral Block • Neuraxial Anesthesia • Rib Fracture • Hip Fracture • Interstitial brachytherapy • Uterine Artery embolization

Upper Extremity Blocks

Brachial Plexus

Anatomy

The brachial plexus is formed from union of the anterior rami of C5-T1, with variable contributions of C4 and T2. Once the nerves leaves their intervertebral foramina, they course anterolaterally and inferiorly between the anterior and middle scalene muscles where the nerve roots unite to form three trunks, which lie posterior to the subclavian artery as it courses along the upper surface of the first rib [1–3]. The

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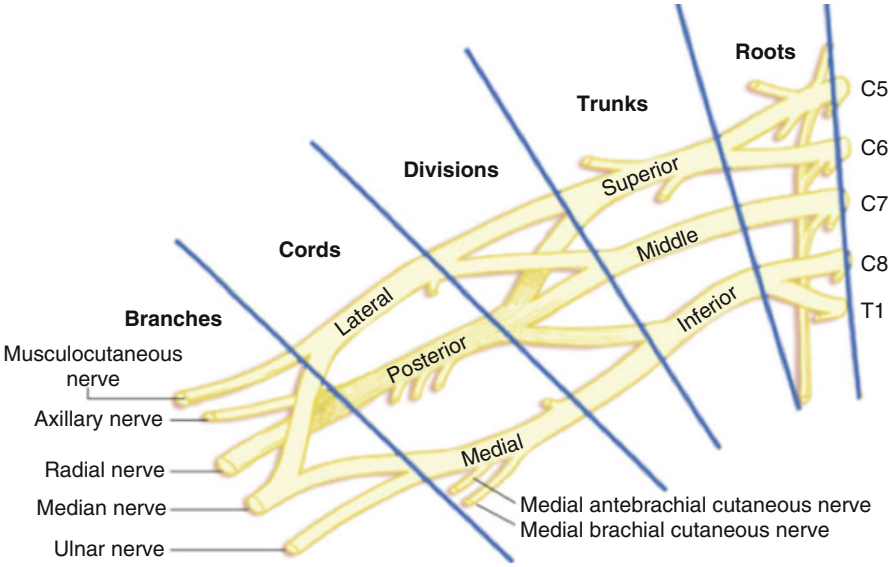

Fig. 30.1 Roots, trunks, divisions, cords, and branches of the brachial plexus (Reproduced from Elsevier, Miller's Anesthesia , Ronald D. Miller MD, MS , 2015, Ch 57, pp 1724–1724, Figure 57-3)

superior (C5 and C6), middle (C7), and inferior (C8 and T1) trunks are arranged accordingly and each trunk forms anterior and posterior divisions that pass posterior to the mid-portion of the clavicle to enter the axilla. Within the axilla, these divisions form the lateral, posterior, and medial cords, named according to their relationship with the second part of the axillary artery. At the border of the pectoralis minor muscle each cord gives off a large branch before ending as a major terminal nerve. The lateral cord gives rise to the lateral branch of the median nerve and terminate as the musculocutaneous nerve; the medial cord gives rise to the median nerve, and terminate as the ulnar nerve; and the posterior cord divides into the axillary and radial nerves (Fig. 30.1) [1]. Aside from the main terminal nerves several other branches arise from the roots of the brachial plexus including the suprascapular nerve, which arises from C5-C6 and supplies the muscles of the dorsal aspect of the scapula, and sensory supply of the shoulder joint. Local anesthetic may be applied along any point of the brachial plexus to provide a desired nerve block. Branches derived directly from cervical roots are usually blocked with the interscalene block approach.

Interscalene Block

Clinical Applications

An interscalene block is recommended for shoulder and proximal humerus surgical procedure therefore ideal for reduction of dislocated shoulder. When performed the roots of the brachial plexus (C5- C7) are most commonly blocked with this

technique. Due to location, blockage of the ulnar nerve, which originates from C8-T1, usually does not occur; and for complete surgical anesthesia of the shoulder, the C3-C4 cutaneous branches may need to be block with local infiltration or use of superficial cervical block. Interscalene blocks are appropriate in nearly all patients, even the obese due to ease of identifiable necessary landmarks [2–4]. However, Interscalene blocks should be avoided in patients with significant impaired pulmonary function due to blockage of the phrenic nerve and in patients with contralateral vocal cord paralysis [1]. Contraindication includes local infection, severe coagulopathy, local anesthetic allergy, and patient refusal.

Technique

Surface anatomy of importance includes the larynx, sternocleidomastoid muscle, and external jugular vein. This block can be performed with the arm in any position. The patient should be in the supine position, with the head turned away from the side to be blocked. The block is often performed at the level of the C6 vertebral body, which is at the level of the cricoid cartilage. The plexus courses between the anterior and middle scalene muscles, superior and posterior to the second and third parts of the subclavian artery. The interscalene groove can be palpated by rolling the fingers posterolaterally over the anterior scalene muscle into the groove. A line is extended laterally from the cricoid cartilage to intersect the interscalene groove, indicating the level of the transverse process of C6 [2]. Although the external jugular vein often overlies this point of intersection, it is not a constant or reliable landmark [2].

This block is well suited with ultrasound guidance as it is easy to obtain a supraclavicular view of the subclavian artery and brachial plexus; then trace the plexus up the neck with the ultrasound probe until the plexus are visualized as hypoechoic structures between the anterior and medial scalene muscles [4, 5]. A 22–25-gauge with 4-cm needle should be used. The needle is inserted perpendicular to the skin with a 45° caudad and slightly posterior angle [2, 5]. The needle is then advanced in an out-of-plane or an in-plane approach until a paresthesia or nerve stimulator response is elicited. After desired response is obtained and there is negative aspiration, local anesthetic solution is injected incrementally depending on the desired extent of blockade. This is one of the brachial plexus block in which large volume of local anesthetic allows effective anesthesia therefore large volumes up to 40 ml are typically used [1–4, 6].

Side Effects and Complications

Blockage of the ipsilateral phrenic nerve block is almost guaranteed with the interscalene block, which result in diaphragmatic paresis in majority of patients, even with dilute solutions of local anesthetics, and is associated with significant reduction in pulmonary function [2, 6]. Hemidiaphragmatic paresis may result in dyspnea,

hypercapnia, and hypoxemia. Techniques to decrease blockade of the phrenic nerve include using very small volumes of local anesthetic and localizing the brachial plexus at a lower level in the neck. Horner's syndrome may also result from blockage of sympathetic fibers to the cervicothoracic ganglion. The risk of pneumothorax is small when the needle is correctly placed at the C5 or C6 level because of the distance from the dome of the pleura. The proximity of significant neurovascular structures can increase the risk of serious neurologic complications when an interscalene block is performed in heavily sedated or anesthetized patients [4]. Therefore, an interscalene block should be placed with the patient awake or under light sedation.

Supraclavicular Block

Clinical Applications

The supraclavicular block is recommended for procedures of the upper arm, elbow, forearm, wrist, and hand. This technique blocks the divisions of the brachial plexus, at this level the distal trunk-proximal division of the brachial plexus is compact therefore the supraclavicular block result in faster onset and effective blockage of almost the entire upper extremity below the shoulder compared to other upper extremity blocks [5]. Studies have shown small volume of local anesthetic produces rapid onset of reliable blockade of the brachial plexus [4, 5, 7].

The neurovascular bundle of the brachial plexus lies midpoint inferior to the clavicle and the nerve bundles are located vertically over the first rib posterior to the subclavian artery, which can be palpated in some patients. The first rib which is short, broad, and flat, with an anteroposterior orientation at the site of the plexus typically prevents the needle's reaching the pleural. Contraindication includes local infection, severe coagulopathy, and patient refusal. This block is cautioned in patients who are uncooperative or cannot tolerate any degree of respiratory compromise.

Technique

The patient is positioned supine with the head turned away from the side to be blocked with then arm adducted and the hand extended along the side. The midpoint of the clavicle is typically identified and the posterior border of the sternocleidomastoid palpated over the anterior scalene muscle into the interscalene groove, identification of the subclavian artery at this point confirms the landmark. With the use of the ultrasound one can visualize the brachial plexus structures, as well as the subclavian artery and pleura, just below the first rib [8]. A 22-gauge, 4-cm needle is directed in a caudad, slightly medial to posterior direction until a paresthesia or motor response is elicited or the first rib is encountered. If the first rib is encountered without elicitation of a paresthesia, the needle can be systematically moved anteriorly or posteriorly along the rib with continuous visualization of the needle tip with

the ultrasound until the other landmarks are located such as the subclavian artery/vein and pleura. After localization of the brachial plexus, aspiration for blood should be performed before incremental injections of local anesthetic.

Side Effects and Complications

The supraclavicular block is more difficult to perform on obese patients, however there is no increased risk of complications documented [2]. The prevalence of pneumothorax after supraclavicular block is 0.5–6 % and diminishes with increased experience and use of ultrasound [1]. If pneumothorax occurs the onset of symptoms is usually delayed and it can take up to 24 h therefore a routine chest radiography post procedure is not recommended [4]. Other complications include phrenic nerve block, at a lesser degree than the interscalene block, Horner's syndrome, and neuropathy, which usually is self-limited.

Infraclavicular Block

Clinical Applications

The infraclavicular block is recommend for procedures at or distal to the elbow, arm, and hand. It provides blockage of the brachial plexus at the level of the cords. An ultrasound and nerve stimulator is required with this block because there are no palpable vascular landmarks to aid in directing the needle. This technique is distal from the neuraxial structures and the lungs, thus minimizing the complication of an interscalene or supraclavicular block.

Technique

The Patient is typically positioned supine but no special arm positioning is required. The ultrasound is placed below the midpoint of the inferior border of the clavicle near the palpable coracoid process and used to visualize the neurovascular bundle. The needle is inserted and advanced laterally until, the brachial plexus identified and confirmed by the nerve stimulator. An incremental local anesthetic is injected around the axillary artery.

Side Effects and Complications

Due to the proximity of the axillary artery there is risk of vascular puncture and systemic local anesthetic toxicity. It is recommended to avoid this approach on patient with catheters or pacemakers at this region [2].

Axillary Block

Clinical Applications

Among the brachial plexus blocks, the axillary approach is by far the most popular due to its ease, reliability, and safety [3, 4]. Blockade occurs at the level of the terminal nerves therefore it is suitable for procedure of the forearm and hand. The musculocutaneous nerve however is usually spared, at this level as it has already left the sheath and lies with the coracobrachialis muscle. This block is suited for outpatients and is easily adapted to the pediatric population [4, 7]. Arm position is very important therefore axillary blockade is unsuitable for patients who are unable to abduct the arm to perform the block.

Technique

The patient should be placed in supine position with the arm to be blocked placed at a right angle to the body, elbow flexed to 90°. The dorsum of the hand rests on a bed or pillow. The axillary artery can then be palpated and traced from the lower axilla to as proximal as possible. The artery is then fixed against the patient's humerus and the ultrasound is placed to visualize neurovascular bundle. Although anatomic variations exist the median nerve is typically found superior to the artery, the ulnar nerve is inferior, and the radial nerve is posterior to lateral. A short 22-gauge needle is then inserted and advanced until the axillary sheath is entered and desire (including muscular cutones) nerve stimulation is obtained. Local anesthetic is injected after negative aspiration. The ultrasound aids visualization of local anesthetic spread around the nerves. Proximal needle placement and maintenance of distal pressure facilitate proximal spread of the solution.

Side Effects and Complications

Nerve injury and systemic toxicity are the most significant complications associated with the axillary block [5, 9]. Hematoma and infection are rare complications.

Terminal Nerve Blocks

Clinical Applications

Peripheral nerve blocks are useful for procedures at the wrist and elbow requiring limited anesthesia or has contraindications to brachial plexus block such as infection, bilateral procedure, coagulopathy, or difficult anatomy [2, 8]. Peripheral blocks performed at the level of the elbow and wrist are typically performed as "field"

blocks without requiring the use of nerve stimulator or ultrasound. Benefits include ease of blocks and reduce complications.

Median Nerve Block

The median nerve originates from the lateral and medial cords of the brachial plexus. It travels medial to the brachial artery. In the antecubital space, it is medial to the insertion of the biceps tendon. It gives off multiple motor branches before it enters the carpal tunnel. Then it is located between the flexor carpi radialis and palmaris longus tendon in the carpal tunnel.

Blocking the median nerve provides anesthesia to the palmar surface of the first, second, third, and lateral half of the fourth digit, motor blockade causing Loss of pronation of forearm, weakness in flexion of the hand at the wrist, loss of flexion of radial half of digits and thumb, and loss of abduction and opposition of thumb. The median nerve block requires the patient's arm supine, the medial and lateral epicondyles of the humerus identified. The major landmark for this technique is the brachial artery, which is found medial to the biceps tendon at the intercondylar line.

To block the median nerve at the elbow, one identifies the brachial artery in the antecubital crease just medial to the biceps insertion and inserts a short 22-gauge needle just medial to the artery, and directed toward the medial epicondyle until desired wrist flexion and/or thumb opposition is obtained. A small amount of local anesthetic is then injected.

The median nerve is blocked at the wrist by identifying the palmaris longus tendon which can be discentered when the patient is instructed to flex at the way. A short 22-gauge needle is inserted just medial to the palmaris longus tendon at the carpal tunnel and small amount of local is injected.

Radial Nerve Block

The radial nerve originates from the terminal branch of the posterior cord of the brachial plexus and travels posterior to the humerus innervating the triceps and entering the spiral groove of the humerus. It then moves laterally at the elbow and travel thru the posterior lateral of the forearm.

Blockage of the radial nerve provides anesthesia to the lateral aspect of the dorsum of the hand and the proximal portion of the first, second, third and lateral half of the fourth digit. The Radial nerve can be block at the elbow or the wrist.

The radial nerve is blocked at the elbow by locating the biceps tendon and tracing it until it contacts the epicondyle. A small 22 gauge needle is inserted lateral to the biceps tendon near the epicondyle, a small local anesthetic is inject around the radial nerve as it passes over the anterior aspect of the lateral epicondyle.

The radial nerve is blocked at the wrist by identifying the palmaris longus and flexor carpi radialis tendon. A small needle is inserted over this tendon at the base of the first metacarpal; a small local anesthetic is injected proximally

along the tendon and a right angle across the anatomic snuffbox. This injection tends to be very superficial.

Ulnar Nerve Block

The ulnar nerve originated from the medial cords of the brachial plexus and travel alongside the axillary and brachial arteries. It is easily located in the ulnar groove, which is bony space between the medial epicondyle of the humerus and olecranon process. In the forearm the nerve travel between the flexor digitorum profundus and the flexor carpi ulnaris.

Blockade of the ulnar nerve provides anesthesia of the ulnar side of the hand, the fifth digit, the medial part of fourth digit, and all the small muscles of the hand, except the thenar eminence and the first and second lumbrical muscles.

At the elbow, the ulnar nerve is blocked by inserting a small needle proximal to the arcuate ligament and posterior to the medial epicondyle until desire the nerve stimulation is obtained. Due to the superficial location of this nerve at this site there is a high incidence of nerve injury.

At the wrist, the ulnar nerve is located beneath the flexor carpi ulnaris tendon between the ulnar artery and the pisiform bone. The nerve is blocked by placing the needle alongside the tendon until desire nerve stimulation is obtained. A small anesthetic is injected alongside the area.

Musculocutaneous Nerve Block

The musculocutaneous nerve originates as the terminal branch of the lateral cord. It innervates the biceps, brachialis muscles, and terminates as the lateral cutaneous nerve of the forearm providing sensory to the radial side of the forearm up to the radiocarpal joint.

The musculocutaneous nerve block is usually performed as a supplement block to the axillary block of the brachial plexus. The nerve is usually located superior and proximal to the brachial artery thru the coracobrachialis muscle. An ultrasound is helpful to visualize the nerve between the muscle tissues. A small amount of local anesthetic is then injected along the nerve.

Side Effects and Complications

In general, terminal peripheral nerve blocks have a less frequent risk of complications. However there is a higher risk of nerve injury due to the nerves being superficially placed between ligamentous and bony structures [8]. Intravascular injection can occur therefore injection after aspiration is recommended.

Intravenous Regional Blocks

Clinical Applications

Intravenous regional blocks also known as Bier block were first described in 1908 by a German surgeon, August Bier [1–3, 6]. The technique involves the patient resting supine an intravenous cannula placed. Proximal and distal tourniquets are then applied on the desired limb. The goal of the tourniquet is to contain the anesthetic injected locally therefore cuffs should have secure closures and reliable pressure gauges. The Bier block has multiple advantages, including ease of administration, and rapid onset and recovery; therefore it is excellent for short procedures.

Technique

Prior to the intravenous administration of local anesthetic the desired limb is first exsanguinated by either tightly wrapping the extremity with an Esmark elastic bandage from distal to proximal direction or elevating it for 3–4 min to allow gravity to exsanguinate it [2]. The proximal cuff is then inflated greater than the systolic pressure until the absence of a distal pulse. The local anesthetic is then injected slowly; the total dose is based on the patient's weight [6]. The onset of anesthesia is usually within 5 min. When the patient complains of tourniquet pain, the distal tourniquet, which overlies anesthetized skin, is inflated, and the proximal tourniquet is released. The tourniquet can be safely release slowly after 25 minutes and the patient monitored closely for local anesthetic toxicity. For very short duration procedure the tourniquet must be left inflated for at least 15–20 min to avoid rapid intravenous systemic bolus of local anesthetic resulting into toxicity.

Side Effects and Complications

Most common problems associated with bier blocks include tourniquet discomfort, painful exsanguination, and rapid recovery leading to postoperative pain [2, 6]. Early deflation of the tourniquet or excessive doses of local anesthetics can result in systemic anesthetic toxicity. Rare complications including development of compartment syndrome and limb loss have also been noted [2, 8].

Lower Extremity Blocks

The most common indication for regional anesthesia outside of the OR is hip fracture. Pain from hip fracture, both intracapsular and extracapsular, can be treated with a lower extremity nerve block [10]. These blocks include femoral nerve block, fascia

iliaca block, and lumbar plexus block. The femoral nerve block, sometimes called a 3-in-1 block, is an excellent block to treat pain from hip fracture and other injuries to the leg [11, 12]. A fascia iliaca block can also be used to treat hip and lower extremity pain, however, the efficacy of the femoral nerve block is greater than the fascia iliaca block [13]. A lumbar plexus block can also provide pain relief for hip fracture, however, the block is technically challenging, has a higher complication rate than the femoral block, and should only be performed by those with advanced training in nerve blocks [1, 14]. In addition, the femoral block is as effective as the lumbar plexus block in controlling pain after surgical repair of hip fractures [15].

Femoral Nerve Block [1, 16]

Anatomy

The femoral nerve innervates the leg- including the anterior and medial thigh distally to the knee and the medial aspect of the lower leg and foot. The femoral nerve also provides branches to the hip.

Indications

Hip fracture, injury to the anterior or medial thigh, femur, or knee

Procedure

The femoral nerve block is done adjacent to the femoral artery, in the inguinal crease. The block is usually done in the supine position, although some practitioners prefer Trendelenburg positioning of the table if the goal is analgesia to the hip [11]. The area should be prepped and draped in a sterile fashion. In the obese patient, tape can be used to secure the pannus out of the procedure field. The pulsation of the femoral artery can be used as a landmark in correct placement of the ultrasound transducer, although this can be difficult in the obese patient, and it is not necessary for the procedure. The ultrasound transducer should be placed in the inguinal crease in a transverse plane and adjusted until the femoral artery is identified. The femoral nerve can then be located lateral to the femoral artery, deep to the fascia illaca, superficial to the iliopsoas muscle. The femoral nerve is hyperechoic and can be oval or triangular in shape.

Once the femoral nerve is identified, the skin is anesthetized with a superficial infiltration of local anesthetic or skin wheal, 1 cm laterally to the ultrasound transducer. A 22-guage insulated stimulating needle is then inserted in-plane to the femoral nerve. A “pop” can often be felt as the needle moves deep to the fascia iliaca. A nerve stimulator is not necessary for a successful block, however, it can aid in

optimal positioning. To verify appropriate position of the needle, a patellar twitch should be present between 0.3 and 0.5 mA. After negative aspiration, 10–20 mL of local anesthetic is injected in divided doses adjacent to the femoral nerve, checking for negative aspiration between each dose. A finger can be used to apply pressure just distal to the point of injection to encourage proximal spread of the local anesthetic to improve analgesia to the hip. The Injection should be stopped if high injection pressures are noted or if the patient experiences pain during injection.

Complications

The complication rate for femoral blocks is low. Complications include failed block, nerve injury, intravascular injection of local anesthetic, local anesthetic systemic toxicity, bleeding, and infection [1].

Fascia Iliaca Block [17]

Anatomy

The fascia iliaca block relies on the location of the femoral nerve and the lateral femoral cutaneous nerve, coursing beneath the fascia iliacus and above the iliacus muscle. Spread of local anesthestic along this plane provides the block of the nerves.

Indications

Hip fracture, injury to the anterior, anterolateral, or medial thigh, femur, or knee

Procedure

As with the femoral block, the fascia iliaca block is done in the supine position, at the inguinal crease. After sterile prep and drape of the field, the transducer is placed in a transverse plane in the inguinal crease to identify the femoral artery. The hyperechoic femoral nerve is then located lateral to the femoral artery, deep to the fascia iliaca, superficial to the iliopsoas muscle. Once these structures are identified, the transducer is moved laterally to identify the sartorius muscle. Local anesthetic can be used to anesthetize the skin and subcutaneous tissue at the needle insertion point. Insert the needle in plane until the fascia iliaca is pierced. A “pop” may be felt as the needle moves deep to the fascia iliaca. After negative aspiration, 30–40 mL of local anesthetic is injected in divided doses. The transducer can be moved medically to confirm spread to the femoral nerve and laterally to confirm spread beneath the sartorius muscle.

Complications

The complications of the fascia iliaca block are similar to the femoral block, although the chance of intravascular injection is less as the block is not perivascular [1].

Thoracic Blocks

Regional anesthesia can be superior to systemic analgesia when a patient suffers from multiple rib fractures. There is often a possibility of coinciding lung injury. Regional analgesia will relieve the patient's pain and allow for improved breathing. The pain, otherwise, can impair ventilation and ability to clear secretions, which may progress. Up to 1/3 of patients with rib fractures develop nosocomial pneumonia [18]. Not only will epidural anesthesia decrease pain but it will double vital capacity and reduce flail chest [18]. While opioids may relieve the patient's pain, side effects such as sedation are common and may lead to further respiratory compromise. The pain management guidelines for blunt thoracic trauma recommend epidural analgesia as the preferred mode of pain relief unless contraindicated [18]. Reasons for inability to provide epidural anesthesia may include infection, coagulopathy, spinal fractures, hemodynamic instability [19, 20].

Intercostal Nerve Blocks

Indications

Pain relief from rib fractures, herpes zoster or cancer pain. Blockade of two dermatomes above and below the cause of pain is necessary.

Contraindications

Local Infection, Coagulatopathy, and if inadvertent pneumothorax would cause serious consequences.

Anatomy

The intercostal nerve runs with the intercostal artery and vein on the underside of corresponding rib. The nerve is formed from the dorsal and ventral rami of the thoracic spinal nerves. The nerve usually runs below both the vein and artery. The nerve block will anesthetize the sensory and motor fibers of that specific side.

Technique

Position: Put the patient in a supine or lateral decubitus position. Palpate and mark each rib at the mid and posterior axillary line to help visualize the length of the rib. Most commonly the block is placed 6–8 cm from (lateral to) the spinous process. Place a skin wheal at the inferior border of the rib and then place a 20–25 g needle needle at the inferior portion of the rib. Hit the rib and then walk off the rib inferiorly. Advance the needle 5 mm underneath the rib and aspirate. If aspiration for blood and air is negative inject 3–5 ml of local anesthetic. If a catheter is desired an 18–20 g Tuohy needle should be placed and a catheter can then be threaded through the Tuohy.

Complications

Intercostal nerve blocks have the highest levels of local anesthetic in the blood. Doses must be carefully titrated to avoid LAST.
Pneumothorax
Intravascular injection.
Spinal anesthesia
hematoma

Thoracic Paravertebral Nerve Block

Indications

The thoracic paravertebral block is an alternative to a thoracic epidural which is less complicated and has minimal hemodynamic changes.

Indications

Malignant and benign neuralgias
Post herpetic neuralgia
Multiple rib Fractures

Contraindications

Infection at the site
Empyema
Neoplasm
Coagulopathy
Deformed spine

Anatomy

The TPNB will anesthetize the spinal nerve as it emerges from the from the intervertebral foramina and divides into two rami. A larger anterior ramus, which innervates the muscles and the skin of the anterolateral body and limbs and a smaller posterior ramus which innervates the skin and muscles of the back and neck. This will create a unilateral, somatic and sympathetic block. The thoracic paravertebral space is defined as the parietal pleura as the anterolateral border, the base as the vertebral body. The posterior boundary is the transverse process and superior costotransverse ligament

Technique

Place the patient in the sitting or lateral decubitus position. Identify the midline. The C7 spinous process is the most prominent process when the neck is flexed. After identifying C7 continue to mark the thoracic spinous processes. T7 corresponds to the lower tip of the scapulae. Place a 22 g block needle 2.5 cm lateral to the midline (spinous process) of the side desired to be anesthetized. A 22 gauge block needle should enter perpendicular to the skin and contact the transverse process, approximately 3–4 cm. Because the thoracic spinous processes have an acute angle the middle of one spinous process correlates to the transverse process one level below. Eg. T5 spinous process and T6 transverse process. If the transverse process is not contacted at 4 cm, withdraw the needle and reinsert it caudad or cephalad. Once bone is contacted the needle should be withdrawn and redirected cauded 1 cm further. At this point a pop may be felt correlating with the costrotransverse ligament. This may correlate with a loss or resistance technique. After negative aspiration for air and blood 4 ml of local anesthetic may be administered. The nerve block must be redone at each level desired to be anesthetized. If placing for rib fractures a catheter may be placed at the halfway mark between the lowest and highest fracture. If placing a catheter it is common to feel resistance which can be overcome by creating a pocket with 5–10 ml of saline.

Dosing

If proceeding with multiple injections of 3–4 cc then 0.5–0.75 % ropivicaine may be bolused.

If placing a catheter an 18 g tuohy needle may be used to intraduce the gather then 0.2 % ropivicaine may be infused.

Complications

Pneumothorax
Intervascular injection
Inadvertant epidural injection and contralateral anesthetic spread

Intrathecal injection
Inadvertant intraplural catheter placemnt

Intrapleural Blocks

Intrapleural blocks are another option to give local anesthetic, but it runs a high risk of local anesthetic toxicity secondary to high absorption [21].

Neuraxial

Neuraxial anesthesia may be administered to the appropriate patient population. Thoracic epidural anesthesia may be appropriate for rib injury while lumbar neuraxial anesthesia may benefit the patient undergoing a gynecologic procedure in IR OR in offsite locate.

Anatomy

The epidural space is a potential space that is located between the ligamentum flavum and the dura mater. Its range is from the foramen magnum to the sacral hiatus and contains emerging nerve roots of the spinal cord, fat and veins. The spinal cord ends at L2L3.

An epidural can be placed in the sitting or lateral decubitus position. Landmarks used include the posterior superior iliac crests which coincide with L4L5. Then the midline is found by palpating the spine and feeling the finger come off of the spinous process into the interspace.

Once the location has been determined, administer a local anesthetic skin wheal and create a track.
Place the Tuohy needle through the skin wheel. The Tuohy needle will pass through the skin, superspinous, and interspinous ligaments before it reaches the ligamentum flavum. Engage the Tuohy needle at the ligamentum flavum.
Attach a fluid or air filled plastic or glass syringe. Advance the Tuohy needle in tiny increments and feel for a loss of resistance after each time the Tuohy is advanced.
If there is a positive loss of resistance without blood or csf, than an epidural catheter may be advanced
The catheter may be advanced 4–6 cm into the space.
Aspirate the catheter for blood or csf. If negative give a test dose of local anesthetic with epinephrine to verify once more that the catheter is not sitting in the csf or an epidural vessel.
Secure the epidural.

Thoracic Epidural Analgesia

Epidurals have been shown to reduce mechanical ventilation times and the incidence of pneumonia in patients with rib injury when the epidural corresponds with the level of the injury

Contraindications

Hypotension and hypovolemia, uncooperative patient, head or spinal injuries, systemic infection and hemostatic possibilities.

Anatomy

The thoracic spinous process are angled downward. This will affect the angle at which the Tuohy needle is introduced.

Technique

The needle will be inserted one fingerbreadth lateral to the desired interspace. The needle is inserted perpendicular to the skin until the lamina is met. Then the needle is angled 45° medially and 45° cephalad and walked to the ligamentum flavum

The loss of resistance technique is then employed to enter the epidural space

Gynecologic

Combined spinal epidural anesthesia or patient controlled epidural analgesia is a technique that allows for an anesthetic to be continued for post operative pain control after uterine artery embolizations. Uterine artery embolizations are an option for patients who do not wish to undergo hysterectomy for symptomatic uterine fibroids.

Combined Spinal Epidural: CSE

A CSE may be perfomed by finding the epidural space with a Tuohy needle and then advancing a spinal needle through the Tuohy needle, past the dura. Once CSF is confirmed, local anesthetic may be injected through the spinal needle to quickly achieve a spinal dose. Once the patient is dosed, the spinal needle is removed and an

epidural catheter is threaded through the Tuohy to leave an epidural for the rest of the case if needed or postoperative pain.

Interstitial Brachytherapy

Interstitial brachytherapy is associated with significant postoperative pain and PCEA is an effective method for post-operative pain

Sedation and Regional Anesthesia

Peripheral nerve blocks have been established since the early stages of anesthesia. It been performed since the 1880s, when Halsted and Hall described the injection of cocaine into peripheral nerves for minor surgical procedures [1]. To this day, regional anesthesia has grown significant popularity as it decreases the need for postoperative analgesics, incidence of nausea, shortens post-anesthesia care unit time, and increases patient satisfaction [1, 6]. Most importantly, peripheral nerve block can be performed in non-operative room settings.

The regional techniques are chosen depending on the surgical site, ambulation requirements, and the desired postoperative pain control. Anesthesia providers should have a detailed anatomic knowledge to choose the appropriate technique for the intended surgical procedure and avoid complications. Nerve blocks should be administered in areas with standard hemodynamic monitors, supplemental oxygen, and resuscitation medications including lipid emulsion readily available [1–3, 6]. Patients should be monitored with pulse-oximetry, Noninvasive blood pressure and electrocardiogram. Sedation for regional anesthesia is not a requirement. However sedation is readily used to reduce anxiety and minimize discomfort.

Goal, of sedation will depend on the technique being employed. Paresthesia seeking techniques are reliant on patient cooperation and participation to guide the local anesthetic injection accurately; therefore, only small doses of sedation medication are recommended [1]. Paresthesia techniques have been criticized for causing patient discomfort, although clinical studies have not shown a significant increase in neurologic complications with this technique [1, 2]. However the use of peripheral nerve stimulators allows for localization of a specific peripheral nerve without requiring the elicitation of a paresthesia, thus allowing patients to be more heavily sedated during block placement.

Short-acting benzodiazepine and opioids such as Midazolam and fentanyl respectively are widely used. Other well-documented drugs are Propofol, ketamine, or Etomidate. Regardless of drugs or techniques employed the most important goals are to titrate for comfort while ensuring the patient respond to verbal clues as well as patients' comorbidities [2].

The Benefits of Regional Anesthesia

One of the greatest benefits of regional anesthesia is the improved pain control and decreased need for opioids and sedation. Trauma patients are commonly undertreated for pain Reasons, include ongoing resuscitation, as well as concerns for the side-effects of systemic medications like NSAIDS and opioids [3]. Elderly patients with hip fractures are at high risk of delirium after injury. Practitioners are reluctant to prescribe opioid medications to elderly patients, and elderly patients receive less opioid medication when compared to younger patients with the same injuries [22]. Unfortunately, elderly patients who do not receive systemic pain medication are not protected from delirium. In fact, both inadequately treated pain and use of IV opioid medication increase the risk for delirium [23, 24]. Femoral nerve blocks provide better pain control when compared to opioid only pain control strategies [11]. In addition, regional anesthesia has been shown to decrease delirium in patients at intermediate-risk of developing delirium after hip fracture [25].

Peripheral nerve blocks can also replace the need for sedation for some procedures in the emergency department. This decreases complications related to sedation as well as staffing required to monitor patients after sedation, which can also reduce costs. Shoulder reductions performed under brachial plexus blocks had a decreased length of stay when compared to reductions performed under sedation, with no decrease in patient satisfaction [26].

Pain from rib fractures can lead to significant complications [12]. Pain often prevents patients from taking adequate breaths, leading to atelectasis, V/Q mismatch, hypoxemia, pneumonia, and respiratory failure. Opioid medications can worsen these symptoms. In treating rib fractures, epidural anesthesia has been shown to increase comfort, reduce incidence of pneumonia, reduce ICU length of stay, and reduce days on mechanical ventilation [19, 27]. When an epidural is contraindicated, a paravertebral nerve block catheter can also provide superior pain control and facilitated ambulation and return to normal activities [12].

Special Considerations

Compartment Syndrome

It has been debated if peripheral nerve blocks should be placed in patients at risk for acute compartment syndrome, because it could possibly mask pain. Pain is one of the most important symptoms in diagnosing the syndrome. Acute compartment syndrome occurs most often in men less than 35 years who have had a tibial or forearm fractures, and crush injuries, spare Femoral neck and ankle fractures are less susceptible to compartment syndrome [18]. The concern of using nerve blocks or continuous catheters is that the onset of ischemic pain may not be appreciated if the nerve block has anesthetized the area of injury. Failure to diagnose and treat

compartment syndrome early can lead to sequelae such as amputation, rhabdomyolysis, and cardiac arrhythmias [18]. Only a handful of case reports have been published describing nerve blocks with acute compartment syndrome. They describe either break through pain or a nerve block that was unable to resolve the pain. Thus new breakthrough pain or a failed nerve block may be a sign of early acute compartment syndrome. The risks and benefits of placing a peripheral nerve block on susceptible patients should be thoroughly discussed with the patient as well as the patient's perioperative care team. If choosing to do a regional nerve block one must keep a high index of suspicion, frequently assess the patient and monitor for compartmental pressures [21].

Elderly

The elderly pose several challenges to adequately treating pain. Opioids may have negative neurologic effects in a population that may already have diagnosed cognitive or vascular disorders [28]. Narcotics may also cause severe constipation and lead to nausea and vomiting in a population that may not be able to adequately protect their airway leading to aspiration pneumonia. Treating these patients with non-steroidal anti- inflammatory drugs (NSAIDS), poses issues of its own. NSAIDS can lead to gastrointestinal bleeds which may need further intervention, make the patient anemic and require transfusion. Yet inadequately treating these patients' pain especially after hip fracture, yields to delayed recovery.

Nerve blocks after hip surgery can decrease the need for systemic pain medications. While the femoral block and the fascia-iliaca block are helpful to control post operative pain, they may be also be considered in the ED setting for pre-operative analgesia. The fascia iliaca block has been found to be nearly as effective as parenteral NSAIDS after hip fracture. It has also been found to control patient pain without the need for additional narcotics [28].

Coagulation

The coagulation status of the patient must be taken into consideration when deciding if a peripheral nerve block would be appropriate. Spontaneous hematomas have been reported in patients who were on anticoagulants. A hematoma within the nerve sheath may increase the risk of ischemic nerve injury [6]. Of the cases that have been reported all patients with neuro deficits had neurologic recovery within 6–12 months [1]. Symptoms of bleeding that patients may present with include pain in the region of the peripheral nerve block, a drop in the hemoglobin, hypotension, and neurologic deficits. Diagnosis of a hematoma may be made via CT. Treatment includes surgical consultation and necessary supportive treatments.

ASRA guidelines recommend using the same neuraxial injection guidelines for peripheral nerve blocks. Patients who are to receive a peripheral nerve block while anticoagulated must be aware of the risks as well as be closely monitored after. An INR of ≤1.4 is considered acceptable for both neuraxial and peripheral nerve blocks [1].

Peripheral Nerve Injury PNI

There is conflicting information regarding whether the incidence of nerve injury has decreased with the use of ultrasound. The reported rate of long term injury is 2–4/10,000 blocks [28, 29]. There is usually resolution of sensory deficits that occur within the territory of the peripheral block within days to weeks [30] .

There is some evidence that suggests that proximal nerves may be at higher risk to injury than more distal [31, 32].

Get a neurologic consult to begin managing all treatable causes [33]. In the case that all treatable causes have been excluded a pain consultation can be useful to coordinate the patient's care and monitor the patient for chronic pain from the injury

Because of the various reporting mechanisms delineating the risk factors for PNI is difficult.

Infection

Infection in the blood is a relative contraindication for peripheral nerve blocks, but placing catheters may add another source of infection.

Local Anesthetic Toxicity

LAST is a known serious but rare complication of peripheral nerve blocks, The practitioner should be aware of signs and be prepared to treat the patient if necessary. This should be given even more careful consideration since these Religional blocks will be done outside of the operating room and necessary equipment may not be as readily available. It will be helpful to create a mobile cart with all equipment necessary to treat LAST, so there is no delay in treatment.

Absorption of Local Anesthetics (Most to Least)

Intravenous > Intercostal > Caudal epidural > Lumbar epidural > Brachial plexus > Subcutaneous

Checklist by ASRA [34] : Treatment:

Ventilate with 100 % FiO_2
Seizure suppression with benzodiazapenes (e.g., Midazolam IV), avoid Propofol if hemodynamically unstable.
Alert OR for possible need for Cardiopulmonary bypass

Management of Cardiac Dysrythmias

AVOID vasopressin, calcium channel blockers, beta blockers, or local anesthetic
Begin Lipid Emulsion Therapy (Intralipid)
Record LAST events at www.lipidrescue.org and report use of lipid to www.lipidregistry.org

Intralipid: 1.5 mL/kg IV bolus; Repeat 1–2 times for asystole

Start infusion 0.25–0.5 mL/kg/min for 30–60 mins for hypotension

Epinephrine: total dose: <1 mcg/kg

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