A simple guide to regional anaesthesia

ABSTRACT

Regional anaesthesia is widely used in modern anaesthetic practice for perioperative and postoperative analgesia. In the operating theatre, regional anaesthesia is used both on its own and in combination with other techniques (general anaesthesia and sedation). Regional anaesthesia is now a core skill set in anaesthetic training.

This article provides a basic outline of regional anaesthesia for surgeons and other non-anaesthetic staff working with anaesthetists, reviewing preparation, consent, basic and specialist equipment, central neuraxial blocks (spinal, epidural and caudal), trunk blocks, upper limb blocks (interscalene, supraclavicular, infraclavicular and axillary) and lower limb blocks (femoral, fascia iliaca, sciatic, popliteal and ankle). It also discusses the pharmacology of the agents used and common complications.

Regional anaesthesia is the infiltration of local anaesthetic around one or more nerves to cause temporary loss of sensation to a region of the body. For perioperative and postoperative analgesia, regional anaesthesia can be used as a standalone anaesthetic technique, or with sedation or general anaesthesia (Yentis et al, 2009; Tew and Norrish, 2014).

The advantages of regional anaesthesia are shown in *Table 1*. Adequate postoperative analgesia reduces the surgical stress response and postoperative organ dysfunction (Finnerty et al, 2013), particularly pulmonary complications (Kehlet and Holte, 2001). Adequate postoperative analgesia also allows earlier postoperative mobilization (Wade et al, 2014) and reduces the incidence of postoperative chronic pain (Kehlet et al, 2006).

For many surgical procedures (e.g. hand and foot surgery) regional anaesthesia is now the 'gold standard' anaesthetic technique: general anaesthesia is used only if regional anaesthesia is contraindicated (*Table 2*) (Hyndman, 2007; Harrop-Griffiths et al, 2013). Regional anaesthesia is a rapidly expanding subspecialty within anaesthetic practice and is now considered as a core skill set (Royal College of Anaesthetists, 2010).

Table 1. Advantages of regional anaesthesia

Anaesthetic	Awake patient. This helps patient positioning and perioperative neurological monitoring (e.g. carotid endarterectomy)
	Avoidance of general anaesthetic. Important in patients with severe respiratory or cardiovascular disease
	Better control of stress response to surgery
	Excellent perioperative and postoperative analgesia
Surgical	Reduced risk of bleeding and need for blood transfusion
	Improved surgical field
	Reduced complications (venous thromboembolism, respiratory complications, mental state)
Patient	Reduced postoperative analgesia and opiate requirement
	Reduced interruption of oral intake
	Earlier recovery from anaesthesia and earlier discharge in day-case surgery
	Patient participation (e.g. caesarean section)

This review outlines current techniques used for regional anaesthesia.

General preparation before regional anaesthesia

Checklists are used before regional anaesthesia to reduce morbidity and mortality (Haynes et al, 2009). Regional anaesthesia should only be attempted by anaesthetists with adequate training and skills. Generally, regional anaesthesia is given in an anaesthetic room with an operating department practitioner assisting and adequate monitoring and resuscitation equipment available. The patient must be properly consented, with appropriate intravenous access established. The toxic dose of local anaesthesia drug for that patient must be known.

Obtaining consent for regional anaesthesia

Written information concerning regional anaesthesia (a patient information leaflet or evidence-based online

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Table 2. Contraindications for central neuraxial and peripheral nerve blockade

Absolute contraindications	Patient refusal
	Local anaesthetic allergy
	Insurmountable technical difficulties
	Active infection at needle site
Relative contraindications	Bleeding diathesis international normalized ratio >1.2 or platelet count <80x10^9/litre
	Pharmacological anticoagulation
	Uncontrolled hypovolaemia
	Systemic sepsis
	Severe stenotic cardiac disease
	Some neurological conditions
	Raised intracranial pressure or previous back surgery

Table 3. Complication risks in central and peripheral neuraxial blockade

Side effect	Risk
Epidural not working perfectly	1 in 8
Hypotension	1 in 50
Headache	1 in 100
Nerve damage (temporary)	1 in 1000
Nerve damage (longer than 6 months)	1 in 13 000
Epidural abscess	1 in 50 000
Meningitis	1 in 100 000
Epidural haematoma	1 in 170 000
Reduced Glasgow Coma Score	1 in 100 000
Severe injury or paralysis	1 in 250 000

resource) should be given to patients before the day of surgery (Yentis et al, 2017). Informed consent must be obtained before the patient enters the anaesthetic room except in exceptional circumstances (Turner and Williams, 2002).

Consent should be obtained by the anaesthetist who will be undertaking the procedure. The benefits, risks, alternative options and process of the procedure should be discussed and documented (Yentis et al, 2017). Risks should be mentioned if they have an incidence of more than 1% or have serious effects. The current risk of permanent harm following spinal anaesthetic or epidural is lower than 1 in 20 000 (*Table 3*) (Cook et al, 2009).

Specialist equipment for regional anaesthesia

Needles

A spinal needle (25–27 G) with an introducer is used for central neuraxial blocks. An epidural pack contains a larger 16–18 G Tuohy needle, catheter guide, low resistance syringe, antimicrobial filter and catheter.

Most peripheral nerve blocks are performed using short bevelled insulated stimulating needles through which a small electrical current can be passed. Also used are echogenic needles that improve visibility under ultrasound.

Peripheral nerve stimulator

The peripheral nerve stimulator is set to the desired initial current (1–2 mA), pulse duration (0.1 ms) and frequency (2 Hz). The needle is connected to the cathode of the machine and the anode is connected to the patient via an electrocardiogram electrode. The needle is advanced until the desired motor twitch is elicited (Klein et al, 2012).

Ultrasound

Ultrasound permits visualization of the needle, target nerve and surrounding structures. Ultrasound transducers produce waves which reflect a proportion of their energy as they pass through tissues of different densities. A transducer converts this information to a two-dimensional image (Carty and Nicholls, 2007).

Central neuraxial blocks

Central neuraxial blocks (epidural, spinal and caudal) are commonly used to provide surgical anaesthesia.

Epidural

Local anaesthetic is injected into the epidural space, via an indwelling catheter in situ.

Indications

Epidural analgesia is often used to supplement general anaesthesia for surgical procedures in patients of all ages with moderate-to-severe comorbid disease to provide analgesia in the intraoperative, postoperative, peripartum and end-of-life settings, and can be used as the primary anaesthetic for surgical procedures from the mediastinum to the lower extremities. Thoracic epidural anaesthesia is commonly used in major intra-abdominal surgery.

It is safe to leave a catheter in situ and for an infusion to be given over time, e.g. during labour or after major surgery. Boluses or continuous infusions of drug are administered to prolong analgesia postoperatively. Catheters are removed after 72 hours to prevent catheter site infection.

Technique

The procedure may be performed with the patient awake or under light sedation. The patient should be sitting or lying on his/her side with the back flexed. The dermatomes which the anaesthetic is required to cover will dictate the level of the block. Surface anatomy is used to estimate the vertebral level to ensure the epidural is sited appropriately. The most common landmarks used are the iliac crests and a line drawn between them should correspond to L4.

A medial or paramedian approach is used. The skin is infiltrated with local anaesthetic. A 16G Tuohy needle is advanced into the interspinous ligament and a low resistance syringe filled with saline attached to the hub. The needle is then carefully advanced through the tough ligamentum flavum. A 'pop' is felt as the needle enters the epidural space. The epidural catheter is advanced through the needle leaving approximately 4–5 cm of catheter within the epidural space.

Spinal

Local anaesthetic is injected into the intrathecal space, providing a few hours of analgesia during surgical procedures.

Indications

Spinal blocks provide reliable anaesthesia for 2 hours and analgesia for 6–12 hours. They are commonly used for obstetric anaesthesia and lower limb arthroplasty. When combined with an epidural, the spinal block can be prolonged for complex surgery and to provide analgesia into the postoperative phase.

Technique

The procedure is performed with the patient awake or under light sedation. Positioning is as for epidural blocks. The spinal block must be performed below the termination of the spinal cord at L1. The L3/4 or L4/5 interspace is palpated and infiltrated with local anaesthetic. A 25G or 27G spinal needle is inserted in the midline, aiming slightly cranially. Resistance increases as the ligamentum flavum is entered and when the dura is encountered, with a sudden pop as the dura is pierced. Correct placement of the needle is confirmed by CSF emerging at the hub.

Caudal

Caudal anaesthesia is produced by injecting local anaesthetic into the caudal canal, blocking sacral and lumbar nerve roots.

Indication

This is used for surgical procedures below the umbilical region. This technique is popular for paediatric patients (Fingerman et al, 2009).

Technique

The patient is positioned in the left lateral position with the knees drawn up to the chest. In children a general anaesthesia is required. A 20–22 G cannula is introduced in a slightly cranial direction through the sacral hiatus. A click is felt as the needle pierces the sacrococcygeal membrane. The cannula is then directed cranially and advanced. Aspiration confirms the absence of blood or CSF and local anaesthetic is injected.

Peripheral nerve blocks

Infiltration of local anaesthetic around specific peripheral nerves can be used alone or as an adjunct to central neuraxial blockade. It can provide effective analgesia for up to 24 hours, enabling early postoperative rehabilitation (Stasiowska et al, 2015). An indwelling peripheral catheter can provide prolonged analgesia if required.

Trunk blocks

Transversus abdominis plane block

Indications

Analgesia for abdominal surgery below the level of the umbilicus. Unilateral for unilateral surgery (appendicectomy), bilateral for midline surgery (laparotomy).

Anatomy

The aim is to block the anterior rami of the T6–L1 nerve roots that supply sensation to the anterior abdominal wall and parietal peritoneum. The relevant intercostal nerves traverse the fascial plane between the internal oblique and transversus abdominis muscles, giving rise to anterior and lateral cutaneous branches supplying sensation to the abdominal wall.

Technique

Surface landmarks are the iliac crest, inferior costal margin and mid axillary line. Ultrasound shows the three characteristic muscle layers of the anterior abdominal wall: external oblique, internal oblique, transversus abdominis with peritoneum deep to these muscles. The transversus abdominis plane is seen as a single hyperechoic fascial line. The needle is inserted from anterior to posterior under ultrasound guidance. The needle tip should be visualized entering the transversus abdominal plane, then 20–30 ml 0.25% levobupivacaine is infiltrated.

Ilioinguinal or Iliohypogastric block

Indications

This is used for inguinal surgery, including orchidopexy (postoperative analgesia only). The aim is to block the superficial tissues and skin of the inguinal and pubic regions.

Technique

Mark a point 2 cm medial to the anterior superior iliac spine in adults. Ultrasound identifies the iliohypogastric and ilioinguinal nerves as they pass between the transversus abdominis and internal oblique muscles. Using an in-plane technique, anaesthetic is infiltrated around the nerves (Raju and Coventry, 2014).

Upper limb blocks

Brachial plexus blocks are often used, either alone or with general anaesthesia to target the appropriate dermatome (*Table 4*; *Figures 1* and *2*) (Raju and Coventry, 2014).

Interscalene block

Indications

This is used for surgery to shoulder and upper arm. The aim is to block the C5,6,7 nerve roots.

Technique

Ultrasound at the cricothyroid level is used to locate the relevant local structures: carotid artery, internal jugular

Table 4. Upper limb blocks

Block	Indication	Advantages	Risks
Interscalene	Surgery of the shoulder and upper arm	Anaesthesia of supraclavicular nerves	Hemidiaphragmatic paralysis Commonly spares inferior trunk (ulnar)
Supraclavicular	Surgery distal to the shoulder	Anaesthesia of the whole arm Technically simple to perform with ultrasound assistance	Pneumothorax
Infraclavicular	Any surgery distal to axilla	Anaesthesia whole arm distal to axilla	Technically demanding Uncomfortable
Axillary	Any surgery on elbow or below	No risk of pneumothorax or phrenic nerve paralysis	Haematoma Unsuitable for upper arm surgery

vein and sternocleidomastoid muscle. Posterior to these are the anterior scalene and medial scalene muscles. Within the scalene groove are hypoechoic circular structures ('traffic lights') – the C5, C6 and C7 nerve roots (adjacent to the C7 process). The C8 and T1 roots are deeper and more caudal so are often more difficult to visualize at this level.

The needle entry point is commonly at the C6 root level. Local anaesthetic should be seen to spread from anterior to posterior to cover all three nerve roots. Local anaesthetic spread over the scalenus anterior will consistently block the phrenic nerve.

Figure 1. The brachial plexus and surrounding anatomy.

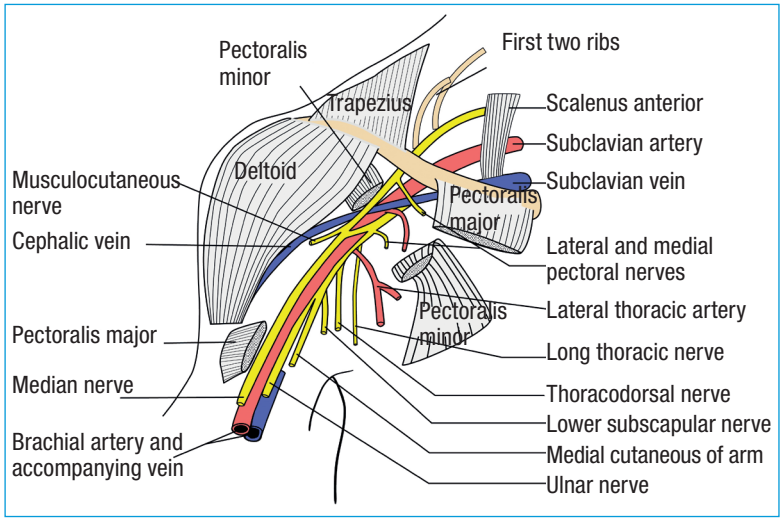
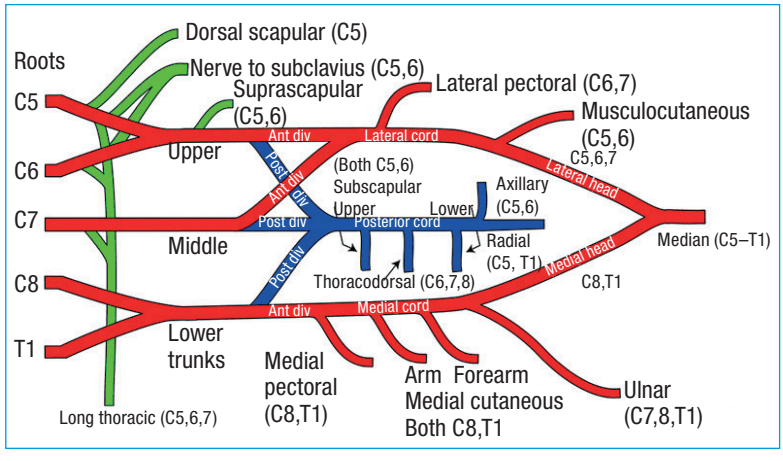


Figure 2. The brachial plexus. Note that there is usually some C7 in the ulnar nerve that gets there via a connection from the lateral cord or median nerve beyond the brachial plexus.



Supraclavicular block

Indications

This is used for surgery to arm and hand. The aim is to block the trunks and divisions of the brachial plexus that form in the lower neck near the first rib.

Technique

The ultrasound transducer is placed parallel to and behind the clavicle in the supraclavicular fossa. The subclavian artery, plexus, first rib and pleura are visualized.

The hypoechoic cluster of ovoid structures represents the trunks and divisions of the plexus which have a consistent relationship to the first rib. A superficial injection distends the plexus for further injections. Finally, local anaesthetic is injected to the lower part of the plexus (inferior trunk) between artery and first rib.

Infraclavicular block

A rarely used technique often combined with indwelling catheter placement.

Axillary block

Indications

This is used for surgery to the forearm and hand. The terminal branches of the plexus cords are blocked.

Technique

The ultrasound transducer is placed transversely across the axilla at the junction of the biceps and pectoralis muscles. The axillary artery and the median, ulnar and radial nerves are seen adjacent to the biceps, axillary vein and triceps respectively. The median and ulnar nerves are blocked first. The needle is then passed deep to the artery and local anaesthetic infiltrated around the radial nerve. The musculocutaneous nerve can often be approached from the same insertion point but will occasionally require a more distal injection site.

Lower limb blocks

The cutaneous innervation of the lower limb is shown in *Figure 3*.

Femoral block

Indications

This is used for surgery about the knee and lower limb surgery. Often combined with obturator and sciatic nerve blocks. The aim is to block the femoral nerve.

Technique
The ultrasound transducer is placed transversely across the upper thigh over the femoral artery just distal to the inguinal ligament. The nerve is found lateral to the femoral artery. Position the needle lateral to the nerve beneath fascia iliacus. A few millilitres of local anaesthetic are then injected observing infiltration around the nerve.

Fascia iliaca block
Indications
This is used for anterior thigh and knee surgery, including postoperative analgesia following hip and knee procedures (Nicholls, 2007). The femoral and lateral femoral cutaneous nerves are targeted.

Technique
The landmark technique involves placement of the needle at the lateral third of the line between the anterior superior iliac spine and the pubic tubercle. Ultrasound guidance places the needle tip under the fascia iliaca at the same anatomical point. The injection is made several centimetres lateral to the femoral artery and 30–40 ml of local anaesthetic is infiltrated until it is seen to spread laterally and medially.

Posterior sciatic (deep) block
Indications
The transgluteal approach is described here, which is used for foot and ankle surgery (in combination with saphenous nerve block) and for analgesia after lower limb surgery.

Anatomy
The sciatic nerve is formed from the sacral plexus (L4–S3 nerve roots), and emerges in front of the piriformis muscle, exiting the pelvis through the greater sciatic foramen.

Technique
The patient lies in the lateral position, block side uppermost. Using ultrasound, the nerve is located deep to the gluteus maximus muscle and superficial to the quadratus femoris. An in-plane technique is used to direct the needle to the lateral edge of the sciatic nerve where 2–3 ml of local anaesthetic are infiltrated. The plane between gluteus maximus and quadratus femoris should distend and the remainder of local anaesthetic can then be infiltrated.

Popliteal sciatic (superficial) block
Indications
This is used for foot and ankle surgery, and is often combined with saphenous and femoral nerve blocks.

Anatomy
The sciatic nerve descends into the posterior compartment of the thigh where it lies superficial to the adductor magnus, deep to the biceps femoris laterally and semitendinosus and semimembranosus muscles medially. It divides into the tibial nerve and the common peroneal nerve within 10 cm of the popliteal crease.

Technique
The patient is positioned prone. The ultrasound transducer is placed transversely across the popliteal fossa just above the crease. Using an in-plane technique and avoiding the biceps femoris tendon, the needle is inserted from the lateral aspect of the thigh and local anaesthetic is injected at the distal division of the sciatic nerve into the tibial and common peroneal nerves.

Ankle block
The terminal branches of the femoral and sciatic nerves and their blockade are described (*Figure 4*).

Saphenous nerve
The saphenous nerve can be blocked by infiltration on either side of the saphenous vein anterior to the medial malleolus at the ankle.

Deep peroneal nerve
About 2–3 cm distal to the inter-malleolar line, palpate the extensor hallucis longus tendon and the dorsalis pedis artery. Insert a needle just medial and lateral to the artery until bony contact is made. Withdraw slightly and inject 2 ml of local anaesthetic either side of the artery.

Figure 3. Cutaneous innervation of the lower limb.

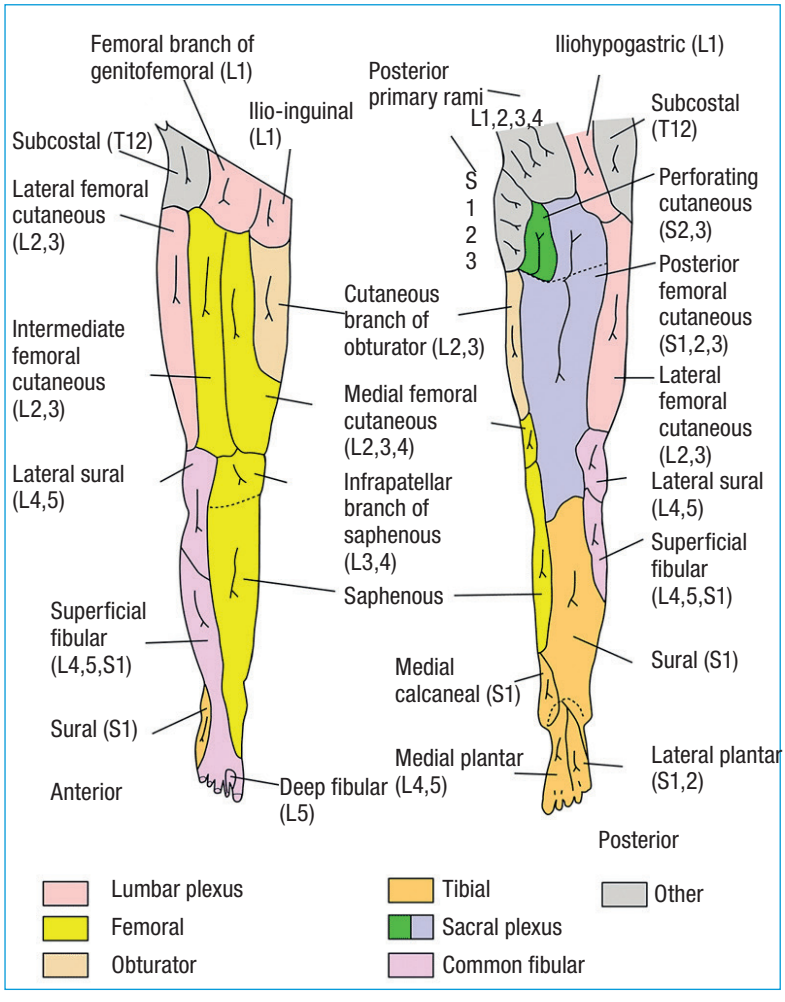
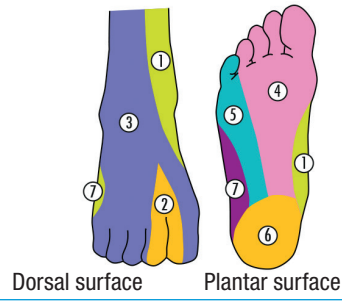


Figure 4. The cutaneous innervation of the foot. From Shearman et al (2013).

1 Saphenous nerve
2 Deep peroneal nerve
3 Superficial peroneal nerve
4 Medial plantar nerve
5 Lateral plantar nerve
6 Calcaneal branch (tibial nerve)
7 Sural nerve



Superficial peroneal nerves
After blocking the deep peroneal nerve, infiltrate 10 ml of local anaesthetic medially and laterally at the plantar junction of the foot to block the medial and lateral divisions.

Tibial nerve
Take a line from the medial malleolus to the posterior inferior calcaneus and palpate the posterior tibial artery. Insert needle just behind the artery, advance it until bone is encountered, withdraw slightly, injecting 6–10 ml of local anaesthetic.

Sural nerve
Inject 5 ml of local anaesthetic subcutaneously between the lateral malleolus and the lateral border of the Achilles tendon.

Laparoscopic surgery

There was evidence to support the use of regional and local anaesthesia for postoperative analgesia in patients undergoing laparoscopic surgery, but their effectiveness was unclear. Infiltration of port sites with local anaesthetic reduces postoperative pain but the evidence for reducing postoperative analgesic requirements was weak (Gupta, 2005). There was good evidence that a transversus abdominis plane block reduces postoperative pain and reduces analgesic requirements following laparoscopic cholecystectomy. Local anaesthetic infiltration alone may be just as effective (Keir et al, 2013). More evidence is required to establish the relative and additive contributions of regional and local anaesthesia (in port sites or intraperitoneally) for laparoscopic surgery.

Table 5. Clinical features of local anaesthetic toxicity

	Central nervous system	Cardiovascular system
Early – excitation phase	■ Tongue numbness and perioral tingling ■ Tinnitus or vertigo ■ Muscular twitching and tremors ■ Generalized convulsions	■ Hypertension and tachycardia
Late – depression phase	■ Generalized depression ■ Decreased Glasgow Coma Score ■ Apnoea	■ Sinus bradycardia ■ Intracardiac conduction defects (prolonged PR and widened QRS complex) ■ Ventricular arrhythmias ■ Cardiac arrest

Perianal surgery

There was evidence that local anaesthesia alone was safe, acceptable and cost-effective for perianal day case surgery (e.g. perianal abscess, pilonidal sinus, haemorrhoids) (Delikoukos and Gikas, 2007). The postoperative analgesic effect was similar to that provided by regional anaesthesia (Saranga Bharathi et al, 2010).

Although adrenaline is a useful adjunct to local anaesthetic in the notoriously vascular perianal region, it does not appear that regional anaesthesia alone causes increased postoperative bleeding (Singh et al, 2017), although more research is required to confirm this.

Pharmacology of local anaesthetic agents

Local anaesthetic agents cross the lipophilic nerve membrane in their un-ionized form. The relatively acidic intracellular pH generates the ionized form of the drug, which then reversibly binds to neuronal sodium channels. Once sufficient sodium channels are blocked, an action potential cannot occur, preventing impulse conduction along the nerve.

The speed of onset of local anaesthetic action depends on three principal properties: pKa (the pH at which both ionized and un-ionized forms exist in equal amounts), lipid solubility (high solubility allows a greater fraction of the drug to diffuse into the neuron) and protein binding (the percentage of agent binding to plasma proteins correlates with its duration of action) (Becker and Reed, 2006).

Toxicity

Systemic toxic reactions are caused by either injection of an inappropriately high dose of local anaesthetic or by inadvertent intravascular injection. The clinical features of local anaesthetic toxicity are given in *Table 5* (Association of Anaesthetists of Great Britain and Ireland, 2010). The treatment of toxicity is supportive with treatment of life-threatening arrhythmias and convulsions. In the event of circulatory arrest cardiopulmonary resuscitation with intravenous lipid emulsion is now mandatory and should continue for at least 1 hour (Association of Anaesthetists of Great Britain and Ireland, 2010).

Complications after regional anaesthesia

Haematomas can form in anticoagulated patients, most seriously in a non-expansile space in central neuraxial blocks. Providing regional anaesthesia in patients who are anticoagulated is complex and extensive guidance for anaesthetists has been provided (Fleming and Egeler, 2014).

Seizures can result from CNS and cardiovascular toxicity if local anaesthetic is inadvertently injected into a vessel (Zink and Graf, 2003). Following regional anaesthesia block, pain is no longer a sensitive or specific symptom to diagnose compartment syndrome, making this orthopaedic emergency harder to detect (Fleming and Egeler, 2014).

Another risk includes wrong-side blocks. Although the incidence of this complication is only 0.027%, there may be an element of under-reporting. In the majority of cases it was found that correct protocols were not followed

(Cohen et al, 2010). Completing a proposed 9-point checklist reduces such events (Mulroy et al, 2014).

Conclusions

All anaesthetists and surgeons will encounter regional anaesthesia in their practice. Both need to be aware of the risks involved and the steps necessary to address these. The practice of regional anaesthesia will continue to evolve. For some procedures (i.e. shoulder surgery) evidence is emerging that local anaesthetic infiltration is as good as regional anaesthesia (Bjørnholdt et al, 2015).

The future of regional anaesthesia will likely include more evidence-based and personalized treatment and formalizing clinical pathways and algorithms for operations such as total knee replacements (Rosenberg, 2005; Turnbull et al, 2017). **BJHM**

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Conflict of interest: none.

KEY POINTS

- Regional anaesthesia involves the temporary loss of sensation to a region of the body.
- Regional anaesthesia can be used standalone or as an adjunct to sedation or general anaesthesia.
- Surgeons need to be aware of the indications and risks associated with regional anaesthetic blocks.
- Adequate postoperative analgesia improves patient outcomes.
- In future, regional anaesthesia will likely involve more personalized treatment.

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