Complications of regional anaesthesia

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Abstract

Complications of regional anaesthesia can be divided into those specific to central neuraxial blockade, those specific to peripheral nerve blockade, and those that pertain to both. Fortunately, severe complications, namely spinal cord damage, vertebral cord haematoma and epidural abscess are rare. Here we have given an overview of these complications, with reference to incidences available following the 3rd National Audit Project of the Royal College of Anaesthetists. A thorough knowledge of anatomy and pharmacology, and a meticulous, unhurried technique are key to reducing the risk of such complications. When considering the use of a regional anaesthetic technique, the risks and benefits for the individual patient should be assessed on a case-by-case basis, and set against the risks and benefits of alternatives.

Keywords Central neuraxial block; complications; consent; nerve damage; peripheral nerve block; regional anaesthesia

Royal College of Anaesthetists CPD Matrix: 1F01, 2B04, 2G01, 2G04 and 3A09

Learning objectives

After reading this article, you should be able to:

- list the potential risks and complications of regional anaesthesia
- describe the mechanisms resulting in severe complications
- explain the risks of regional anaesthetic techniques to patients in order to inform consent.

Advances in local anaesthetic drugs and equipment have improved the safety of regional anaesthesia (RA). This, coupled with improved supervision and training in regional anaesthetic techniques, has helped to minimize complications. In particular, the rate of local anaesthetic systemic toxicity[1] and pneumothorax in supraclavicular and paravertebral blocks.[2] Reassuring data are available on major complications of central neuraxial blockade, following the Third National Audit Project (NAP3) of the Royal College of Anaesthetists. This audit estimated the risk of permanent nerve injury to be 4.2 per 100,000 and the risk of death or paraplegia 1.8 per 100,000 following central neuraxial blockade (CNB).[3] Szypula et al. analysed the extent, patterns and cost associated with litigation claims related to RA in England. RA was the largest clinical category within the NHS Litigation Authority database. Eighty-nine per cent of claims were related to CNB, with epidurals being disproportionately represented (81% of claims).[4] The rate of long-term nerve injury following peripheral nerve blockade (PNB) is 2–4 per 10,000. Disappointingly, this does not appear to have fallen with increased ultrasound use.[5]

Comprehensive knowledge of complications forms the cornerstone of robust consent. Much has changed in relation to the ethical and legal context of healthcare delivery since the landmark Montgomery ruling.[6] It is worth noting that this case related to an omission of a high risk (10% of shoulder dystocia), and the court report specifically councils against 'bombarding the patient' with information in the pursuit of rigorous consent. The AAGBI recommend that the amount and the nature of information that should be provided to the patient should be determined by the question: 'What would this particular patient regard as relevant when coming to a decision about which of the available options to accept?'[7] RA–UK provide information that relates specifically to consent for nerve blockade.[8]

This article details the complications of RA, which include those relating to CNB, PNB or both (Table 1).

Central neuraxial blockade

Post-dural puncture headache (PDPH)

This is the most common complication following CNB, during which the dura is breached whether intentionally or accidentally. The resultant cerebrospinal fluid leak causes sagging of intracranial structures, with traction and vasodilatation in the meninges. The onset of the headache is usually within 2–3 days following dural puncture, but can occur sooner or later. Patients may complain of a searing frontal or fronto-occipital headache, exacerbated by sitting up and relieved by lying down. Additional symptoms include neck stiffness, nausea and vomiting, hearing

The incidences of major complications of regional anaesthesia

Complication	Incidence
Central neuraxial blockade	
PDPH following spinal	1 in 500[9]
PDPH following epidural tap	66 in 100[9]
Epidural abscess	1 in 47,000[3]
Meningitis	<1 in 200,000[3]
Vertebral canal haematoma	1 in 118,000[3]
Spinal cord injury	1 in 100,000–243,000[3]
Peripheral nerve block	
Peripheral nerve injury	1 in 2,500-5,000[5]
Central or peripheral complications	
Local anaesthetic toxicity	Unknown
Total spinal	Unknown
Failed block (spinal)	1 in 100[12]

Table 1

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loss, visual disturbance, cranial nerve palsies, tinnitus, vertigo and paraesthesia. It is prudent to also consider the possibility of other diagnoses. These include viral, bacterial or chemical meningitis, intracranial haemorrhage, cerebral venous thrombosis, intracranial tumour, cerebral infarction and, in obstetric patients, pre-eclampsia.[2]

The risk of accidental dural puncture during an epidural procedure is about 1%. If the Tuohy needle breaches the dura, the incidence of headache is 66%.[9] The incidence of headache following spinal anaesthesia is much lower, at 0.2%. The reduction in incidence of PDPH over several years is due to advances in needle design; namely, smaller gauge needles (25–27 gauge) with pencil-point tips that separate as opposed to cut the dural fibres.

Profound hypotension

Profound hypotension can result as a consequence of sympathetic blockade. It is more likely in patients who are intravascularly deplete, have a fixed cardiac output, receive heavy rather than isobaric local anaesthetic, or experience a high spinal block. The precise incidence is not known as it is variably defined in the literature.

Infective complications

Epidural abscess is a rare but serious medical emergency, requiring prompt diagnosis and treatment.[3] Delay in treatment can result in permanent neurological injury and even death. Factors that may predispose to the development of an epidural abscess following CNB include: immune-compromise, systemic corticosteroid drugs, diabetes and systemic sepsis.[9] Strict adherence to aseptic technique to minimize the risk is mandatory. This includes wearing a mask, cap, sterile gown and gloves, and adequate hand washing. Technical difficulty with the block can result in localized haemorrhage, which may provide a focus of infection. The presence and duration of an in-dwelling epidural catheter increases the risk.

The incidence of spontaneous epidural abscess occurring in the population is between 1 in 8300 and 50,000.[3] The NAP3 report gives the incidence of spinal epidural abscess in patients following CNB as 1 in 47,000. This rises dramatically with duration of epidural catheter insertion, as demonstrated by an earlier Danish study that found 20 epidural abscesses in 17,000 epidurals, with a mean duration of catheter at 11 days in those who developed abscesses.[10] Permanent harm occurred in 1 in 88,000 cases and paraplegia occurred in 1 in 236,000.[3]

Meningitis, another major complication of CNB, more commonly follows spinal block. The same risk factors for epidural abscess apply to the risk of meningitis. This complication is rare (incidence in the UK is less than 1 per 200,000)[3] but potentially fatal if not promptly diagnosed and treated.

Vertebral canal haematoma

Vertebral canal haematoma is also a medical emergency: delay in diagnosis and treatment beyond 8 hours may result in permanent paraplegia. Patients at risk include those with disordered coagulation, patients on antiplatelet or anticoagulant drugs, and patients in whom the procedure proves technically difficult, resulting in multiple attempts. It is essential to seek expert advice when faced with less familiar novel antiplatelet agents and anticoagulants in the context of deranged hepatorenal function. Most case reports are associated with the use of epidural catheters, and often the only sign is abnormal lower limb motor deficit, or a progressive weakness and sensory disturbance. The incidence of vertebral canal haematoma is 1 in 118,000 for all CNBs, with permanent harm occurring in 1 in 140,000 patients.[3] However, the incidence of permanent harm in patients administered a perioperative thoracic epidural was estimated to be as high as 1 in 5,700 in the NAP3 Audit.[3]

Spinal cord injury

Traumatic injury of the spinal cord, nerve root or peripheral nerve may be caused by the block needle or by an indwelling catheter. These injuries need to be differentiated from neurological injury cause by cord compression (e.g. epidural abscess or haematoma). Early radiological imaging is essential. Establishing a causal link between procedural trauma and nerve damage is rarely straightforward. Confounding or contributing factors such as surgical positioning, the operation itself, the pathology under treatment and pre-existing conditions such as diabetes mellitus or spinal canal stenosis need to be considered.[3] Nerve injury from needle or catheter trauma is not reliably associated with pain or paraesthesia during the procedure, but it is still wise to perform CNBs on conscious or lightly sedated patients so that they may report these symptoms.[3]

There are three scenarios that increase the risk of injury to the spinal cord:

- Firstly, failure to identify the correct vertebral interspace. This is difficult to do when using surface anatomical landmarks such as Tuffier's line.
- Secondly, the spinal cord may terminate anywhere from T12 to L4. The combination of performing a subarachnoid block at a higher level than estimated, in a patient whose conus medullaris ends lower than usual may result in spinal cord puncture.
- Thirdly, the ligamentum flavum may not fuse in the midline, which can alter the customary 'feel' of performing a central neuraxial block, particularly an epidural block.

Permanent nerve injury is rare following CNB. NAP3 reported the incidence of permanent harm from nerve or spinal cord damage to be between 1 in 100,000 and 234,000.[3]

Transient neurological radiculopathy (TNR)

This is a symptom complex that may occur after spinal anaesthesia. Typically, there is complete recovery from the spinal block, followed by dysaesthesia in the back and buttocks, radiating to the thighs. Symptoms last up to 72 hours. It is unclear whether the pain is related to local anaesthetic toxicity or if it is musculoskeletal or myofascial in origin. The incidence appears to be influenced by the local anaesthetic used, with lidocaine carrying a higher risk. Another important aetiological factor is patient position, the lithotomy position in particular.

Adhesive arachnoiditis

This severe inflammatory condition is characterized by collagen band formation distorting tissue, disrupting blood and CSF circulation, and damaging nerves. Blood, local anaesthetics and chlorhexidine have been implicated in the aetiology, both in the epidural and subarachnoid spaces. The incidence is extremely low, with only seven cases identified in a literature review covering a 22-year period.

Peripheral nerve blockade

Peripheral nerve injury

Nerve injury is a complication of all types of anaesthetic. The risk of peripheral nerve injury following peripheral nerve block has disappointingly not fallen despite the widespread introduction of ultrasound guided blocks.[1] Munirama's meta-analysis gives an incidence of 9% of transient neurological symptoms lasting up to 28 days post operatively, regardless of whether ultrasound or electrical stimulation was used. Similarly, the rate of long-term nerve injury is 2–4 per 10,000 for both ultrasound and electrical stimulation guided blocks (Box 1).[5]

Ultrasound has demonstrated that neurostimulation thresholds below 0.5 mA are frequently sub-epineural.[5] The neurostimulation threshold may be further increased in patients with pre-existing peripheral neuropathy. However, ultrasound-guided techniques may be associated with more needle manipulation, potentially increasing the risk of direct needle-to-nerve trauma.

Improved reporting of complications and a more challenging patient population may offer some explanation as to why peripheral nerve injury rates have not decreased. It is also thought to relate to an incomplete understanding of the pathogenesis, and a predominance of surgical (e.g. tourniquet) and patient (e.g. diabetes) factors.

Mechanisms of peripheral nerve injury can be classified as follows:

- Direct needle trauma: Absence of pain and paraesthesia on injection is not a reliable indicator of extraneural needle placement.
- Toxic injury: Caused by subepineural local anaesthetic injection and neural exposure to high concentrations of local anaesthetics,
- Compressive injury: May be caused by a haematoma or abscess at the site of injection, by prolonged tourniquet use, or by poor positioning in theatre.
- Stretch injury: A result of excessive traction or improper positioning.
- Ischaemic injury: Rare, and can result from a number of factors. Impaired blood supply can result from vascular injury, or any combination of hypotension, pre-existing atherosclerosis, pre-existing neuropathy, and the use of vasoconstrictors.

Blunt trauma and toxic or ischaemic injuries all cause axonal loss or damage and carry a less favourable prognosis. Compressive and stretch injuries typically result in a neuropraxia, giving a better prognosis as the axon is left intact. Fortunately, the vast majority of peripheral nerve injuries are transient. A range of incidences are quoted in the literature, from 0 to 2.2% at 3 months, 0–0.8% at 6 months, falling to 0–0.2% at 12 months.[5]

The recommended management of a suspected peripheral nerve injury is outlined in an RA-UK guideline.[11]

Techniques employed to minimize nerve injury risk

- Perform block in the awake or lightly sedated patient where practicable
- Use short bevel regional block needle
- Maintain visualization of needle tip, preferably in-plane
- Immediate withdrawal and repositioning of needle if needle-to-nerve contact occurs
- Stop and reposition needle if high injection pressures are observed
- Minimize needle manipulation

Box 1

Postoperative care

Peripheral nerve blockade may last for several hours into the postoperative period. It is important that appropriate communication, in particular regarding limb blocks, is provided to both the patient and ward staff responsible for ongoing care. Lower limb blocks may increase the risk of falls due to residual motor or proprioceptive block. Pressure areas should be monitored, particularly the heel following sciatic nerve block to avoid pressure sores. Patients must also be advised to care for an insensate limb or anatomical area to avoid inadvertent trauma prior to return of full sensation.

Complications common to both central and peripheral nerve blockade

Local anaesthetic toxicity

This includes local and systemic effects of local anaesthetics.

Direct application of local anaesthetic to denuded axons can cause acute inflammatory reactions and neurotoxicity. These insults are magnified with prolonged exposure, high concentration of local anaesthetic and a disrupted perineurium.[5]

Systemic toxicity results from inadvertent intravascular injection or systemic absorption of toxic doses of local anaesthetic. It is characterized by neurological features including perioral tingling, tinnitus, slurred speech, confusion agitation, convulsions and coma. It is also associated with cardiovascular collapse and death. The incidence of intravascular injection in relation to PNB has been dramatically reduced (by eightfold) with ultrasound.[1] This relates to using lower doses of drug, and the ability to avoid vessels and visualize local anaesthetic spread. Additionally, the management of systemic toxicity has been improved by the inclusion of 20% intralipid.

Vasovagal reactions

This is a phenomenon seen mostly in young patients with a high resting vagal tone. The reported incidence is between 13 and 28%.[2] RA performed in an awake, sitting, fasted patient can reduce ventricular filling. This, in combination with anxiety and systemically absorbed exogenous adrenaline, results in vigorous ventricular contraction. This can stimulate the ventricular wall pressure receptors and massive vagal outflow results, causing profound bradycardia or even asystole (Bezold-Jarisch reflex).[2]

Respiratory complications

Hemidiaphragmatic paresis was historically reported to occur in close to 100% of patients receiving interscalene blocks, and in 50% of patients receiving supraclavicular blocks.[2] This complication is a key consideration in patients with concurrent (particularly contralateral) respiratory pathology. Improved precision

with ultrasound, enabling smaller volumes of local anaesthetic, has decreased this risk.

Pneumothorax: this is a potential complication of supraclavicular and paravertebral blocks, as a result of the close proximity of pleura to the nerves. Ultrasound guidance gives a degree of safety, and is now thought to occur at a clinically insignificant rate.[2] As for hemidiaphragmatic paresis, this low risk becomes important in patients with concurrent respiratory pathology.

High spinal block: this can occur after deliberate or inadvertent placement of subarachnoid local anaesthetic. Pregnant women are particularly susceptible, because of compression of the thecal sac by engorged epidural veins. The high spinal block compromises intercostal muscle function with dyspnoea, poor cough and somnolence.[2] Hypotension is also common because of sympatholysis. Symptomatic treatment, supplemental oxygen, optimizing position and reassurance are all that is required for the majority of cases. As it is relatively rare, with variable definition, accurate incidence figures are not known.

Total spinal block

This is the extreme of a high spinal block: anaesthesia of the brainstem, resulting in loss of consciousness, respiratory arrest and profound hypotension. This can occur during an intentional subarachnoid block with excessive spread of local anaesthetic. For example, following a failed epidural top-up with conversion to spinal anaesthesia, it is conceivable that the thecal sac can be compressed by the epidural contents.[2] A total spinal block may also occur if a large volume of local anaesthetic intended for an epidural or plexus block, is inadvertently placed subarachnoid. This is associated particularly with lumbar plexus, interscalene brachial plexus and paravertebral blocks. Regarding interscalene blocks, epidural and subarachnoid needle placement have been reported using the lateral or Winnie approach as well as the posterior approach. Nerve roots may have a cuff of dura for several centimetres from the neuraxis, making direct intrathecal injection of local anaesthetic a possibility. Although rare, it is also possible for an epidural catheter to migrate into the subarachnoid space.

Failure of block

A review by Fettes et al. found the failure rate of spinal blocks to be about 1%.[12] Reasons for a failed central neuraxial block are multifactorial, including problems with lumbar puncture, errors in preparation and injection of solutions, inadequate spread, and difficulties more related to patient management than the block itself.

Peripheral nerve blocks have a failure rate that is influenced by a number of factors including target nerve, operator expertise and equipment used. If a nerve stimulator is used a motor response can be misinterpreted.[2] Additionally, it is possible to stimulate a nerve through a fascial plane, but if the needle does not pass through that plane, spread of the local anaesthetic will be impeded and not reach the target nerve. Misinterpretation of sonoanatomy may occur when using ultrasound. The improved success rate of ultrasound guidance (92% versus 83% with electrical stimulation)[1] requires robust sonoanatomy knowledge and clinical experience.

Wrong site block

This persists as a never event, as it is wholly preventable and has the potential to cause serious patient harm where systemic barriers exist (Stop before you block campaign). It was reported four times in NHS England in April and May 2018. Comparison with data from recent years is less useful as the never event definition has regularly changed. The risks include asleep patients and prone or lateral positioning.

Drug error

The possibility of catastrophic drug error applies to both CNB and PNB, and the incidence appears to be rising.[5] The harm caused by inadvertent administration of a neurotoxic drug is clearly greater where this drug is administered centrally. This has recently been the subject of legislation and substantial investment in order to develop incompatible connectors (ISO 80369-6).

Until the widespread introduction of this new equipment occurs particular risks remain. For example, intravenous (IV) tranexamic acid has recently gained popularity in post-partum haemorrhage; an emergency setting where many patients have an epidural already sited. A simple error of injecting into the epidural catheter rather than the IV line is a real risk. Although no data was found on the prevalence, case reports describe the catastrophic effects.

The implementation of ISO 80369-6 is an important step to reducing the risk of catastrophic drug error. However, as a drawing up needle will be required, this risk of error remains.

Conclusion

Severe complications associated with RA are reassuringly rare. Substantial progress has been made in improving the safety profile reducing these rates through the widespread adoption of ultrasound and procedural checklists.

The benefits including superior analgesia in the postoperative period, suppression of the stress response to surgery and avoidance of alternatives may outweigh the risks, but RA must always be considered on a case-by-case basis.

In the context of an increasingly litigious working environment an in-depth knowledge of complications is essential in order to appropriately consent patients and to aid in diagnosis when they occur. Understanding the underlying mechanisms is important in order to mitigate the risks. Application of a meticulous, unhurried technique and sound knowledge of anatomy and pharmacology are crucial. Safe practice extends into the postoperative period with ward involvement of the anaesthetist or acute pain team. ◆

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