

# HOW TO AVOID NEUROLOGICAL DAMAGE – ESRA RECOMMENDATIONS FOR GOOD CLINICAL PRACTICE

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## INTRODUCTION

Serious neurological damage associated with regional anaesthesia is extremely rare; the mean incidence of permanent damage is approximately 1:10,000, although the range varies from 0.1:10,000 for damage after obstetric epidural nerve damage [1] to 7.6:10,000 in a high risk surgical group [2] with a difference between the risks for spinal and epidural techniques. Spinal anaesthesia is associated with a higher risk of persistent nerve damage than epidural injection although the relative risks vary in different reviews. Because of the rarity of serious damage, it is not possible to study the incidence in an evidence-based manner, using large prospective randomised studies or systematic reviews of such studies. The published evidence is limited to reviews of the major risk factors leading to neurological damage from both spinal and epidural anaesthesia [3], editorials [4,5,6], case reports and case series [7,0]. Two large retrospective, closed claims analyses of nerve injury associated with both general and regional anaesthesia have provided a large database of information about the types of injury and their association with regional or general anaesthesia [9,10]. These studies provide great insight into the changing trends of nerve injury over a twenty-year period of growth in the use of regional anaesthesia but provide very limited information about the mechanisms of injury and give no recommendations as to how we can minimise risks.

Permanent, severe damage to major peripheral nerves is also very rare. Auroy recorded an incidence of 0.019% for nerve damage in a large prospective survey [11]. The published data for paediatric injury is even lower [12], although quoted incidences vary as some studies include transient nerve root or peripheral nerve damage, which is more common but invariably recovers spontaneously within a matter of weeks or months [13]. Smaller studies of nerve injury following peripheral nerve block reveal a range of up to 5% depending on the type of peripheral block studied although there is usually no distinction between temporary and permanent symptoms. However, the increase in the use of peripheral nerve blocks has been associated with an increase in the reported complications of peripheral nerve blocks [14,15,16]. There is a debate about whether this rise is just a reflection of the increased use of these techniques or due to a general increase in reporting rates and a decreased threshold of resorting to medico-legal action. There remains a lack of objective data about both the numerator (the number of complications) and denominator (the total number of blocks performed). **If regional anaesthesia is to retain its current popularity, it is important to ensure that**

**peripheral nerve blockade is practiced to the highest standards of safety and best practice.**

Without graded evidence and recommendations, ESRA can only publish advice in the form of Good Practice Guidelines and advice to help reduce the risk of nerve damage has already been presented at the 2003 and 2004 ESRA Annual Congress [17,18,19].

## Causes of neurological damage

General causes of peripheral neurological injury are listed in figure 1. Peri-operative nerve injury may occur in patients who have a general anaesthetic only, as a consequence of surgical nerve injury or due to postural compression or traction [9,10,20]. It is important therefore to establish what role, if any, a regional anaesthetic technique may have played in the direct causation of the nerve injury to avoid blame being apportioned to regional anaesthesia when the damage is actually due to another cause.

- **Failure of technique**
  - Primary (multiple attempts)
  - Secondary (apparent successful location of nerve but no clinical effect)
- **Poor patient management**
  - Failure to manage side effects may convert them to complications
- **Direct nerve trauma**
  - Needle damage to spinal cord, major peripheral nerve or plexus
  - Intraneural injection
  - Surgical injury
  - Compression
  - Traction
- **Infection**
  - Viral/bacterial
  - Epidural/intrathecal
  - Perineural – risk of central spread (paravertebral/psoas compartment)
- **Haematoma**
  - Epidural
  - Psoas sheath/brachial plexus

- **Drug toxicity**
  - TNS – transient neurological symptoms
  - Drug error
  - Systemic overdose
  - Intravascular injection
- **Miscellaneous**
  - Anterior spinal artery syndrome
  - Spinal cord infarction
  - Pre-existing co-morbidity
    - Spinal arteriovenous malformation, meningioma,
    - Prolapsed disc,
    - Multiple sclerosis, Guillain-Barré Syndrome

**Figure 1. The main causes of peri-operative neurological damage**

There are three elements to developing safe practice for peripheral nerve blockade and minimising the risk of nerve injury.

1. The Patient

Patients expect to be involved more closely in their medical care than in previous years. Detailed but easy to understand patient information leaflets about regional anaesthesia, including the risks, are now available [12] to enable balanced preoperative discussions and properly informed consent. Informed consent is an essential prerequisite to safe practice; the amount of detail of risk and benefit that patients expect will vary between individuals but each must have the opportunity and relevant information to be able to make a rational decision.

Performing and documenting the block

The doctor performing the block must possess the requisite theoretical and practical knowledge and competence to minimize the risks of neurological damage.

- Careful patient selection
- Sound anatomical knowledge of the block in question
- Proper supervised training
- Regular practice
- Careful, subtle technique
- Familiarity with equipment and needles
- High index of suspicion with difficulties and a readiness to avoid repeated attempts
- Careful patient selection and assessment of pre-existing neurological, endocrine microvascular co-morbidity
- Appropriate modification of any accompanying anaesthetic
- Careful management of block during and after surgery

**Figure 2. Criteria for minimising risks of neurological damage**

There is a mandatory requirement to record all the important facts relating to the performance and management of a block. The amount of information recorded will vary according to the com-

plexity of the block but the minimum data set for all major techniques should include the parameters listed in figure 3

- Named technique and approach
- Needle insertion site (where relevant)
- Number of attempts
- Type of needle
- Use of nerve stimulator (or not)
- Use of catheter
- The agent, its concentration and volume (including vasoconstrictor or other additives)
- Onset times for motor and sensory block (bilateral or unilateral)
- Extent of dermatomal block and degree of motor block
- The occurrence of any paraesthesiae or pain on needle or catheter insertion
- Bleeding or other sequelae of the injection
- If a catheter is inserted, the time and date of its removal + any adverse sequelae noted

**Figure 3. Documenting the regional block**

**Figure 4. lists specific advice for the safe conduct of peripheral nerve blockade**

- Use a peripheral nerve stimulator for all motor or mixed nerve blocks but remain vigilant
- Avoid paraesthesiae and pain when inserting the needle; remove the needle if they occur!
- Heavy sedation/light GA will prevent patient feedback – be aware
- Avoid stimulus threshold of <0.3mA
- Do not inject against resistance (ensure needle is patent and understand what low resistance injection feels like)
- Slow incremental injection with regular aspiration
- Respect maximum recommended doses

**Figure 4. Recommendations for safe peripheral block techniques**

2. Risk Management Issues

Safe practice requires a formal, systematic approach to managing clinical risk; the care and management of the patient for the entire duration of the block must also be planned to ensure safety. A properly organized, integrated care pathway should ensure that patients will be safely managed in hospital, in a step down unit or at home for the duration of the block (up to 48 – 72 hours, if a catheter infusion is used). All staff involved in caring for this group of patients should be aware of the importance of:–

- Management of the insensate limb [22,23]
- Provision of adequate sequential analgesia as the block wears off.
- Risk awareness of potential complications of the block (nerve damage)
- Risk awareness of potential surgical complications (ischaemia, compartment syndrome, infection)

- Adequate hospital back-up for patient contract re: pain problems following discharge
- Proper documentation of the procedure [24]
- Standardised paperwork, drug combinations and delivery hardware
- Pre-filled syringes/infusions
- Clear lines of communication for all staff
- Effective monitoring and audit systems

#### Managing nerve damage

Permanent serious morbidity is extremely rare and it is difficult to make general assumptions about the factors involved and how they can be reduced even further. One of the features of nerve damage from regional anaesthesia is that it is usually impossible to determine the mechanism of damage in the majority of cases [10]. In 1961, Greene suggested a criteria system for establishing whether a spinal anaesthesia was directly implicated in any neurological damage [25].

- Is the lesion intradural?
- Did the onset of symptoms coincide with the block?
- Were there previous symptoms antecedent to the block?
- Is the pathological change consistent with those due to spinal anaesthesia?
- Is the pathological damage actually due to the anaesthesia?

These criteria remain valid today and if used early enough can direct neurological and radiological investigation in a targeted way so that early intervention may be appropriate and therapeutic (surgical exploration of spinal haematoma or abscess for example).

- Ensure that the pharmacological effects of any local anaesthetic drug or adjuvant agent have fully regressed. Assess the area for the return of motor, sensory, proprioceptive and autonomic nerve function
- Involve an experienced regional anaesthetist in the review of any potential nerve injuries
- Take a careful history especially looking for any pre-existing neurological problems. Spinal stenosis may be sub-clinical unless careful assessment is made
- Obtain an early, formal neurological examination by a neurologist who understands the practice of regional anaesthesia
- Exclude other causes (Surgical injury, Ischaemia, Compression)
- Define the anatomical basis of the damage
  - Motor, sensory, autonomic, proprioceptive, mixed
  - Upper motor neurone, lower motor neurone
  - Root, plexus, trunk, branch
  - Dermatomal or discrete nerve distribution
- Does the pattern of nerve damage match the territory of the regional anaesthetic technique used?

- Is the damage spatially related to the needle insertion site?
- Is it within the surgical site?
- Could compression or traction match the site of injury?
- Early electrophysiological testing and radiological imaging
  - Sensory nerve conduction, somatosensory evoked potentials, motor nerve conduction, electromyography (EMG), sudomotor test of sympathetic function
- Imaging
  - Ultrasonography
  - CT
  - MRI
- Ensure the colleagues know what you are looking for
- Be patient, the great majority resolve in time
- Treatment options are limited

#### Figure 5. A task list for investigating, diagnosing and treating peripheral nerve damage

##### Diagnosis of Neurological Injury

The options for treating or alleviating major nerve damage following injury from any cause are limited. It is therefore important to develop and use strategies and guidelines to prevent or minimize the risk of nerve damage from all causes for patients undergoing surgery. It is also important to recognize that nerve damage may have occurred and to diagnose the likely mechanism as early as possible as well as the level at which the damage to the central or peripheral nervous system has occurred. While few causes of damage are amenable to surgical intervention, it is vital to diagnose these with the minimum of delay as prompt surgery may restore most, if not all, function.

##### Investigation of Neurological Damage

As outline in the task list, after obtaining a detailed history and performing a thorough and detailed examination, early and appropriate electrophysiological and radiological examination is essential. Detailed explanation of the role of these tests is beyond the scope of this presentation but they reviewed in some detail by Hogan et al [26]. The timing of these tests is important however. Early MRI scan will detect haematoma or abscess formation and is the most appropriate imaging modality for soft tissue compression or injury to the spinal cord or nerve plexuses. CT imaging is more appropriate for bony abnormalities of the spinal canal and intervertebral foraminae.

Motor conduction studies, sensory conduction (or somatosensory evoked potentials) should be performed immediately (1-3 days post injury) to assess the early degree of damage and then repeated at intervals of up to 6 months, depending on the rate of recovery. After 6 months the chances of further significant recovery are small and patients should be followed up by observation only after this time, if necessary.

If electromyography (EMG) is used too soon in the investigation of nerve damage, no abnormality will be detected, unless one predated the apparent injury, because they are diagnostic for denervation rather than acute injury and therefore will not become abnormal for several days. Some authorities recommend a baseline EMG as soon as the injury is suspected just in case there is pre-existing damage, with repeated EMG at 3 weeks and then monthly to 3 months to track the degree of damage and any subsequent recovery.

Surgery has a limited role in the delayed treatment of scarring to the brachial plexus and other major neurological structures where significant scarring from trauma or haemorrhage is involved. Nerve grafting may also have a limited role where damage is limited to a single nerve.

Most treatment is supportive only and aimed at alleviating the effects of the damage and limiting any further extension of the damage. It is important to prevent indirect disability and injury due to lack of motor, sensory and proprioceptive awareness. Joints and limbs need protection from contractures, hyperextension injury, thermal or pressure injury. Long term rehabilitation and physiotherapy support is the mainstay of treatment for many of these patients; in addition autonomic disruption to bladder, bowel and other visceral function often necessitates additional long-term treatment for these organs.

#### Treatment of neurological damage

There are few indications for active interventional treatment. The major indications are the early relief of spinal cord compression due to vertebral canal haemotoma or epidural abscess. However, even with early surgery recovery may only be partial – only about 20% of cases have complete recovery – and emergency laminectomy in high risk patients carries a significant risk of morbidity and mortality. Surgery has a limited role in the delayed treatment of scarring to the brachial plexus and other major neurological structures where significant scarring from trauma or haemorrhage is involved. Nerve grafting may also have a limited role where damage is limited to a single nerve.

#### Conclusions

Regional anaesthesia, by its very nature, is an invasive practical procedure which involves placing needle tips in close proximity to delicate nerve structures and then injecting potent local anaesthetic and other adjuvant drugs around the nerves. Complications are an inevitable consequence of medical practice and it is unrealistic to assume that nerve damage can be completely avoided. However, by developing a comprehensive, consistent and practical approach to the teaching and practice of regional anaesthesia, every anaesthetic department should ensure that all its members adopt high standards of practice and use appropriate levels of care when performing regional anaesthesia.

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**CONTRA-INDICATIONS:** Hypersensitivity to local anaesthetics of the amide type. Intravenous regional anaesthesia (Bier's block). Obstetric paracervical anaesthesia. Local anaesthetics: contra-indicated for epidural and spinal anaesthesia in patients with uncorrected hypotension. Local anaesthetic techniques must not be used when there is inflammation and/or sepsis in the region of the proposed injection and/or in the presence of septicaemia.

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**DOSAGE AND DIRECTIONS FOR USE:** For dosage and directions for use see package insert.

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INJECTION SHOULD ALWAYS BE MADE SLOWLY WITH FREQUENT ASPIRATIONS TO AVOID INADVERTENT INTRAVASCULAR INJECTION, WHICH CAN PRODUCE TOXIC EFFECTS.

When neuraxial anaesthesia is employed patients who are to be anticoagulated using low molecular weight heparin and heparinoids are at risk of developing an epidural or spinal haematoma, which can result in long-term or permanent paralysis. Safety and efficacy depends on proper dosage, correct technique and adequate precautions. Lowest dosage that results in efficacious anaesthesia should be used. Elderly, young and debilitated patients, including those with partial or complete heart conduction block, advanced liver disease or severe renal dysfunction should be given reduced doses commensurate with their age and physical condition. Children between 1-12 should be given doses commensurate with their weight and clinical status. NAROPIN is not recommended in children under the age of one year. No dose modification is necessary in patients with impaired renal function when used for single dose of short-term treatment. Acidosis and reduced plasma protein concentration may increase the risk of systemic toxicity. Possibility of hypotension and bradycardia following epidural blockade should be anticipated and precautions taken. Partial or complete heart block. Certain local anaesthetic procedures such as injection in the head and neck region, including retrobulbar, dental and stellate ganglion block may be associated with a higher frequency of serious adverse reactions regardless of the local anaesthetic used. Ropivacaine should be used with caution in patients with known drug sensitivities. Careful and constant monitoring of cardiovascular and respiratory vital signs and the patient's state of consciousness should be accomplished after each local anaesthetic injection. It should be kept in mind that at such times restlessness, anxiety, tinnitus, dizziness, blurred vision, tremors, depression or drowsiness may be early warning signs of CNS toxicity. Local anaesthetics should be given with great caution (if at all) to patients with pre-existing abnormal neurological pathology, e.g. myasthenia gravis. Use with extreme caution in epidural, caudal and spinal anaesthesia when there are serious diseases of the CNS or of the spinal cord, e.g. meningitis, spinal fluid block, cranial or spinal haemorrhage, tumours and poliomyelitis, syphilis, tuberculosis or metastatic lesions of the spinal cord. Due to NAROPIN being metabolised in the liver it should be used with caution in patients with severe liver disease and repeated doses may need to be reduced due to delayed elimination. The risk should also be considered in patients suffering from malnutrition or patients with hypovolaemia.

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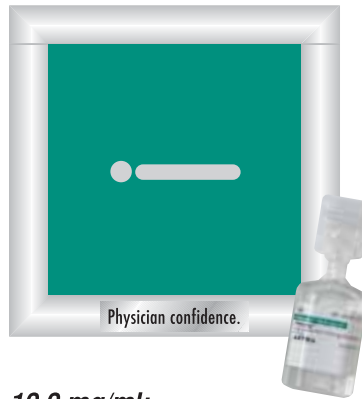
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