The popularity of peripheral nerve blockade has increased rapidly over recent years. The analgesia provided by a nerve block is advantageous after operation, reduces nurse intervention and opioid administration, and, in the day case setting, allows patients to go home pain free. Peripheral nerve blockade, when used alone or with a small amount of sedation, may avoid the need for general anaesthesia with its potential adverse effects. After the block is established, physiological disturbance is minimal, and time in the recovery room is markedly reduced. However, patients and some professionals may have exaggerated fears and misconceptions about regional anaesthetic techniques. It is therefore important that the anaesthetist has an understanding of risk and potential complications, so that patients can be given accurate information in order to make an informed choice over the most appropriate anaesthetic technique. This article describes the risks of neurological impairment after local anaesthesia; complications such as pneumothorax, and intrathecal or intravascular injections are not considered.

Pathological classification of nerve damage

Neuropraxia is a physiological interruption of an anatomically intact nerve. There is minimal damage and the axons are intact; however, conduction is lost because of segmental demyelination. This is a transient lesion with spontaneous recovery occurring after a few days or weeks.

Axonotmesis indicates separation of a peripheral nerve. In this condition, there is severe damage of the axon and the distal portions of the axon degenerate. The investing sheaths of the nerve remain intact and recovery although delayed, is likely.

Neurotmesis is complete division of the nerve; spontaneous recovery is not possible.

Incidence

In the last decade, there have been a number of studies looking at the incidence of nerve damage associated with regional anaesthesia (Table 1). It is currently not possible to give an accurate risk of rare events for an individual anaesthetist, because, assuming a high power is utilized, a large sample size would be required. Multi-centred prospective audits of patients have suggested an approximate indication of risk because they have included tens of thousands of patients. However, these large studies relied upon voluntary reporting by anaesthetists and, as a result, may have significantly underestimated complication rates.

The two largest studies of regional anaesthesia which included peripheral nerve blockade, were performed by Auroy and colleagues1 2 in France. The number of anaesthetists participating in the studies was 736 and 487, respectively. In the first study, 103 730 regional anaesthetics were reported; 21 278 involved peripheral nerve blockade. Four procedures resulted in neurological injury attributable to the block technique, all of which became apparent within 48 h and were subsequently confirmed by a neurologist. Interestingly, the incidence of neurological injury was reported to be greater after spinal anaesthesia (6 in 10 000) than peripheral nerve blockade (2 in 10 000). The second survey3 provided data on more than 43 000 limb blocks. Neuropathy was reported in 12 patients, 7 of whom remained symptomatic 6 months later. A nerve stimulator was used in 9 of the 12 cases, illustrating that its use does not guarantee avoidance of nerve damage. The paper does not indicate whether patients were awake or anaesthetized when the blocks were performed.

Table 1 Nerve injury evident after 6 months. It should be noted that risk of nerve damage after general anaesthesia (without nerve block) is estimated at 1 in 300 for the ulnar nerve and 1 in 1000 for other nerves

<table>
<thead>
<tr>
<th>Study</th>
<th>Patients</th>
<th>Nerve Block</th>
<th>General Anaesthesia</th>
<th>Nerve Injury</th>
</tr>
</thead>
<tbody>
<tr>
<td>Auroy et al. (1)</td>
<td>21 278</td>
<td>71%</td>
<td>29%</td>
<td>4 (1:5000)</td>
</tr>
<tr>
<td>Auroy et al. (2)</td>
<td>43 000</td>
<td>71%</td>
<td>29%</td>
<td>7 (1:6000)</td>
</tr>
<tr>
<td>Giaufre et al. (3)</td>
<td>1400</td>
<td>50%</td>
<td>50%</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Borgeat et al. (4)</td>
<td>520</td>
<td>100%</td>
<td>0%</td>
<td>5 (1:100)</td>
</tr>
<tr>
<td>Franco et al. (5)</td>
<td>1001</td>
<td>100%</td>
<td>0%</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Stan et al. (6)</td>
<td>1000</td>
<td>100%</td>
<td>0%</td>
<td>5 (1:200)</td>
</tr>
</tbody>
</table>

Key points

Temporary postoperative paraesthesia is not uncommon.

The incidence of permanent nerve damage approximates to 1 in 5000.

A nerve stimulator will not necessarily prevent nerve damage.

Patient positioning and surgery is often implicated in perioperative nerve damage.

Stephen Ridgway FRCA
Clinical Fellow in Regional Anaesthesia
Addenbrooke’s Hospital
Hills Road
Cambridge CB2 2QQ
UK

Martin Herrick FRCA
Consultant Anaesthetist
Department of Anaesthetics
Box 93
Addenbrooke’s Hospital
Hills Road
Cambridge CB2 2QQ
UK
Tel: 01223 217434
Fax: 01223 217223
E-mail: martin.herrick@addenbrookes.nhs.uk
(for correspondence)
In a paediatric anaesthetic survey based on more than 24,000 regional blocks, of which around 1400 were peripheral limb blocks, the vast majority (89%) were performed in anaesthetized patients. There were no cases of nerve damage reported in those children who had peripheral nerve blockade, but the article does not state whether follow-up involved active review of children or depended on passive reporting of complications. Franco and colleagues studied the subclavian perivascular block prospectively in >1000 patients. They followed up patients for only 24 h and then relied on surgical reporting of any subsequent complications. No case of neurological deficit was reported. Another large upper limb study was performed by Stan and colleagues who prospectively surveyed 1000 patients undergoing axillary brachial plexus block for shoulder surgery, either by single injection or plexus catheter. Patients were reviewed daily until the fifth postoperative day and were questioned for neurological symptoms until the third week after operation. EMG was performed on any symptomatic patients. They found that, after day 10, 14% had paraesthesia, dysaesthesia or pain apparently unrelated to surgery. The incidence fell to 0.2% had sensory paraesthesia after operation, all of which resolved within 1 month.

Probably the most comprehensive prospective study to date was performed by Borgeat and colleagues who reported on 520 patients receiving interscalene brachial plexus block for shoulder surgery, either by single injection or plexus catheter. Patients were reviewed daily until the fifth postoperative day and were questioned for neurological symptoms until the third week after operation. EMG was performed on any symptomatic patients. They found that, after day 10, 14% had paraesthesia, dysaesthesia or pain apparently unrelated to surgery. The incidence fell to <8% at 1 month and to 0.9–0.2% 6–9 months after surgery. No muscle weakness was recorded at any time in any patient. Of those who had EMG examinations, only two showed plexus damage; it should be remembered that brachial plexus damage is a well recognized complication of shoulder surgery per se. From these studies, there is an implication that the more closely patients are reviewed, the greater the incidence of temporary neurological symptoms. The study by Borgeat and colleagues, although involving only 520 patients, gives us what is likely to be the most accurate current insight into the incidence of temporary neurological deficit.

### Risk vs hazard

Risk and hazard are two different concepts; they are often confused. Broadly speaking, hazard expresses the severity of a complication; it does not specify the incidence. Risk quantifies the frequency of an undesirable outcome. For example, the risks of failed intubation in the general and obstetric populations are 1 in 3000 and 1 in 300, respectively. Therefore, the risk is increased 10-fold in the obstetric population. However, there is no difference in hazard, that is, potential hypoxia.

### Reducing the risk of neurological damage

#### Training

It seems logical to assume that operator experience, knowledge of anatomy and equipment and an increased awareness of potential problems will minimize the risks. The ability to locate nerves with fewer attempts should reduce the risks; however, as yet, there is no strong evidence to support this.

### Nerve location techniques

Nerves may be located either by using a peripheral nerve stimulator, eliciting paraesthesia or, more recently, ultrasonic imaging. Debate has raged for more than 20 years over the association between paraesthesia and nerve damage. This is still unresolved. With a paraesthesia technique, there is no advance warning that the nerve is being approached, in theory increasing the potential for damaging the nerve with the advancing needle. However, many anaesthetists have successfully used this technique for many years with no apparent problem.

Electrical nerve stimulation delivers impulses at a frequency of 1 or 2 Hz. At 1 Hz, a twitch is sought every second, whereas at 2 Hz, this occurs every half-second. In theory, this technique decreases the likelihood of impaling the nerve. Current teaching holds that, if a current of 0.2 mA or less produces a twitch, then the needle may be intraneural, and injection of local anaesthetic could cause damage. It is therefore recommended that the needle is withdrawn slightly before injecting. At present, there is no conclusive proof of this. However, it is a prudent guideline. Factors considered to reduce the risk of intraneural injection are summarized in Table 2.

Slow advancement of the needle is essential no matter what technique is used. Ultrasound guided techniques to aid nerve location are developing; however, presently, they are used in a few centres only. It is possible that, as with central venous cannulation, the use of these techniques will become widespread.

### Table 2: Criteria considered to minimize risk of intraneural injection

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loss of twitch at or above 0.2 mA</td>
<td>(if using nerve stimulator, with 0.1 ms pulse width)</td>
</tr>
<tr>
<td>Instant loss of twitch with initial 0.5 ml injected</td>
<td></td>
</tr>
<tr>
<td>Low resistance to injection</td>
<td></td>
</tr>
<tr>
<td>Painless injection</td>
<td></td>
</tr>
</tbody>
</table>

### Asleep vs awake

There is much debate as to whether regional anaesthesia in adults should be performed in the awake or anaesthetized patient. There is concern that, under general anaesthesia, the patient cannot report the severe pain generated by intraneural injection, increasing the risk of inadvertent nerve damage. In addition, the ability to appreciate early signs of toxicity related to inadvertent i.v. administration is abolished.

Neurological damage has been highlighted in four cases of interscalene blockade performed under general anaesthesia. After injection of the local anaesthetic, all patients became apnoeic, and three patients were noted to have dilated pupils. There was subsequent evidence of cervical spinal cord damage. Magnetic resonance imaging showed syrinx-like pathology in the substance of the cord. It was therefore concluded that the
injections were made into the spinal cord itself and the anaestheticized patients were unable to communicate the experience of pain. It should be noted that three of the four anaesthetists used nerve stimulators when performing the block; one documented the appropriate upper extremity twitch. It could be argued that the use of the peripheral nerve stimulator could increase the risk of nerve damage by facilitating the performance of the block in the anaesthetized patient and giving clinicians a false sense of security regarding needle position. Interestingly, patients who undergo awake cordotomy for relief of chronic pain report a painful sensation when the cord is pierced and a sensation of paraesthesia, or a hot or cold feeling, on the contra-lateral side of their body on electrical stimulation. We believe serious consideration should be given to performing brachial plexus blockade in the awake or lightly sedated patient. In addition to a perceived reduction in risk of spinal cord and peripheral nerve damage, this reduces the intensity of observation required for the patient at a time when the anaesthetist is occupied with other matters. Furthermore, complications such as i.v. injection should be detected at an earlier stage.

Type of needle

There are three needle types that can be used for nerve blockade: the short bevelled, long bevelled and pencil point (Fig. 1). The most commonly used, and most widely manufactured, is the short bevelled insulated needle, which has a bevel angle of 30° at the tip. Currently, it is believed that the short bevelled needle is advantageous because the operator has a greater feel of the tissue planes and is less likely to penetrate the nerve and more likely to displace it. A long bevelled needle (with an angle of 15° e.g. Quincke hypodermic needle) gives less indication of tissue planes and may penetrate nerves more easily. However, any damage may be less, attributable to the ‘clean cut’. The insulated pencil point needle is not widely used in the UK, although it is popular in other European countries. It is not clear whether the larger needles used for catheter insertion, notably the insulated Tuohy needle, pose a different risk to the nerve.

Additional factors

Additives

Local anaesthetics containing epinephrine are often used to increase the duration of local anaesthetic block, reduce systemic absorption or highlight inadvertent i.v. administration. The resulting vasoconstriction may impair neural blood supply and cause ischaemic nerve damage. It is suggested that epinephrine-containing solutions should be used with caution in patients with a pre-existing reduction in the neural blood supply, for example diabetics. Most long acting local anaesthetics provide over 12 h of analgesia when used for blockade of large peripheral nerves. Epinephrine does not increase the duration of action of bupivacaine or ropivacaine. Consequently, if a further increase in block duration is required, a catheter based technique is preferable. Clearly, injection of the incorrect solution because of a drug error may potentially damage the nerve.

Surgery

Just as there is controversy as to the incidence of nerve damage after local anaesthesia, the same is true after surgery. The incidence of peroneal nerve palsy after total knee arthroplasty is reported as 1%, rheumatoid arthritis and prolonged use of the tourniquet being particular risk factors. In arthroscopic shoulder surgery, nerve injury has been reported with large traction weights >7 kg and excessive fluid extravasation, which may cause excessive joint distension. Incorrect portal placement can damage surrounding nerves. Oedema caused by trauma or surgery may cause local ischaemia or compression of the nerve giving paraesthesia or pain. It should be remembered that the incidence of nerve damage occurring whilst under general anaesthesia, most frequently to the ulnar nerve, is estimated to be as high as 1:300.

Patient pathology

Patients with pre-existing disease such as diabetes often make excellent candidates for surgery under local anaesthesia. Fasting is minimized, oral intake more easily established and conscious level easily monitored. However, these patients may already have neuropathy, and any deterioration may be attributed to the block. Patients with pre-existing neurological disease present a dilemma to the regional anaesthetist. Multiple sclerosis is a degenerative disorder of the central nervous system which does not affect peripheral nerves. The condition should not therefore be worsened by peripheral nerve blockade. However, it should be remembered that the stress of trauma or surgery may exacerbate the disease and appear to have a temporal relationship to the nerve block. A decision on the appropriateness of the technique for each individual patient should be determined after a full discussion of the risks and benefits.

Patient positioning

This topic was comprehensively discussed in a previous article in this journal, it is potentially the most significant cause of
perioperative nerve damage, either through direct pressure or unnatural traction forces applied across joints.

References


Please see multiple choice questions 21–23.