Spinal anaesthesia is now practised widely. This article is not intended to be an exhaustive review; it will focus on some new developments and techniques.

Equipment and needle design

Developments in needle design have been driven largely by the need to reduce the incidence of post-dural puncture headache (PDPH). Reduction in needle size reduced significantly the incidence of PDPH, but technical difficulties leading to failure of spinal anaesthesia are common when needles of 29G or smaller are used. However, development of atraumatic ‘pencil-point’ needles also led to a reduction in the incidence of PDPH (0–2%).

Although atraumatic needles reduce the incidence of PDPH, they have been shown to increase the likelihood of neurological deficit because of contact with either the spinal cord or the nerve roots of the cauda equina. The blunt nature of the needle tip and the increased distance that these needles have to be inserted into the subarachnoid space before CSF flow is appreciated are reasons suggested for the increased risk to central nervous system tissue.

The introduction of a new 26G Atraucan® spinal needle with a cutting point and a double bevel (Fig. 1) has been shown to be associated with a higher rate of successful identification of the subarachnoid space at the first attempt, faster CSF backflow and fewer neurological symptoms than a 25G Whitacre needle.

Further work is needed to determine whether the incidences of failed spinal anaesthesia and PDPH are less with the new needle design.

Drugs for spinal anaesthesia

Only preservative-free agents should be used for spinal anaesthesia, and the agents currently available in the UK are lidocaine, bupivacaine, levobupivacaine and ropivacaine. It should be noted that only hyperbaric (heavy) bupivacaine and plain levobupivacaine are licensed for intrathecal use. Preservative-free lidocaine 1% or 2% cannot be recommended for intrathecal use because of the high incidence of transient neurological symptoms (TNS)—see later. Data on the incidence with ropivacaine and levobupivacaine are limited so far, but would appear to be similar to that of bupivacaine.

Ropivacaine

Ropivacaine is an amino-amide local anaesthetic agent that is structurally related to bupivacaine and mepivacaine. Currently, it is not licensed for intrathecal use, but a number of clinical studies have been published. Early evaluation of the drug using glucose-free solutions demonstrated that sensory block of variable extent and intermediate duration was produced. Such findings are consistent with data published for glucose-free solutions of bupivacaine.

A number of studies of intrathecal ropivacaine have questioned its suitability for spinal anaesthesia in comparison with bupivacaine. These studies used plain, glucose-free preparations, but in larger volumes of less concentrated solutions than are normally used in clinical practice. When equal doses of ropivacaine and bupivacaine were compared, the onset and extent of sensory block were similar, but the duration of that sensory block and the degree of motor block produced were both less with ropivacaine. These findings, particularly the shorter duration of action, led a number of authors to claim that ropivacaine is less potent than bupivacaine such that it offers no significant advantage, even though the patients who received ropivacaine passed urine and mobilized more rapidly than those who received bupivacaine. If the potency of a drug is defined as the degree of effect of a drug relative to the dose administered, then it is the clinical profile of the block produced that defines potency and not duration of action.

More recent work has shown that glucose (10 mg ml⁻¹ and 50 mg ml⁻¹) containing solutions of ropivacaine, hyperbaric relative to CSF, can be used to provide reliable spinal anaesthesia of intermediate duration (Fig. 2).
Where hyperbaric solutions of ropivacaine and bupivacaine have been compared in a clinical setting, the onset and extent of sensory block were similar, but the duration of that sensory block and the degree of motor block produced were both less with ropivacaine. Patients receiving ropivacaine were also able to mobilize and micturate earlier than those receiving bupivacaine. This recovery profile may be of interest in the day-case setting.

Levobupivacaine

Levobupivacaine is the S(-) enantiomer of bupivacaine and, although it is licensed for intrathecal use, experience is relatively limited. As with bupivacaine, plain solutions of levobupivacaine were shown to produce variable spread of analgesia, which was occasionally unsatisfactory for surgery. These findings can largely be attributed to the baricity of plain levobupivacaine, which at 37°C is hypobaric relative to CSF.

Fig. 1 Graphical representations of epidural (D) and spinal needle tip design. (a) 26G Atraucan® double bevel design; (b) 26G Sprotte® style pencil point; (c) 22G Whitacre style pencil point; (d) 16G Tuohy needle. Reprinted with permission from reference 1.

A number of direct comparisons of levobupivacaine with racemic bupivacaine have demonstrated that the two drugs produce spinal blocks with similar clinical profiles. However, one important point that must be noted by clinicians using the commercial preparation of levobupivacaine relates to a change in the regulations governing the presentation of hydrates and salts. As a new drug, levobupivacaine is bound by the directive of the European Economic Community which states that concentrations of hydrates and salts must be expressed in terms of milligrams of active moiety. Thus, an ampoule of 0.5% levobupivacaine contains 5 mg ml⁻¹ of free base, whereas ampoules of the same concentration of both racemic bupivacaine and ropivacaine, because registration of these drugs predates the directive, contain 5 mg ml⁻¹ of the hydrochloride salt. Thus an ampoule of levobupivacaine contains 11% more molecules of local anaesthetic than an ampoule of racemic bupivacaine of apparently the same percentage concentration. The relevance of this to spinal anaesthesia has yet to be established.

The very little published work on the clinical profile of hyperbaric (glucose-containing) solutions of levobupivacaine suggests that block characteristics are similar to those produced by hyperbaric bupivacaine.

Translational neurological symptoms

First described in 1993, TNS are defined as pain and dysaesthesia in the buttocks and/or lower extremities after apparently uncomplicated spinal anaesthesia. TNS should not be confused with the neurotoxic cauda equina syndrome seen after the administration of 5% hyperbaric lidocaine through microcatheters.

Initially TNS were described after the administration of hyperbaric 5% lidocaine, but subsequent studies have suggested an equally high incidence with lower concentrations of plain lidocaine. These symptoms have also been associated with mepivacaine, but are rare with prilocaine and bupivacaine. The duration of TNS is widely variable, with the majority patients having resolution of their symptoms within 72 h. However, a small number of patients will continue to have symptoms at 1 week and beyond.

One other factor which has been implicated in the pathophysiology of TNS is flexion of the hips and knees during surgery under spinal anaesthesia (e.g. lithotomy position). The stretching of the ligaments, fasciae and muscles, but not the lumbosacral nerve roots, has been postulated as a possible mechanism for these findings. The supine position results in flattening of the lumbar lordosis, and this is even more pronounced in the lithotomy position leading to hyperflexion of longitudinal ligaments, tendons, muscles and fasciae in the area.

Studies have suggested that the incidence of TNS can approach 25% in patients receiving lidocaine spinal anaesthesia for surgery performed in the lithotomy position. A more profound motor block produced by lidocaine than that seen with bupivacaine, leading to supramaximal flattening of the lordotic arch has been used to explain the absence of TNS after spinal anaesthesia with the latter.

Fig. 2 Upper levels of sensory block in individual patients with solutions of 0.5% ropivacaine. Horizontal bars represent the median maximum block height.4

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There is little evidence that the TNS syndrome is of a neurological or neurotoxic nature and that the clinical picture strongly indicates that it is a myofascial pain condition. This has led some authors to suggest that a more suitable description would be transient lumbar pain (TLP).\(^7\)

**Day-case spinal anaesthesia**

Spinal anaesthesia represents an attractive proposition for day-case anaesthesia, being associated with less postoperative nausea and vomiting (PONV) and better postoperative pain relief than general anaesthesia. However, significant concerns restrict the more widespread use of spinal anaesthesia for day-case procedures: the risk of PDPH; the effect on bladder function; and delay in recovery of motor function. The use of smaller, atraumatic spinal needles has greatly reduced the incidence of PDPH and the incidence has not been shown to increase when spinal anaesthesia is used in the day-case setting.

Voiding is usually a prerequisite before discharge after spinal anaesthesia to avoid overdistension of the bladder secondary to sympathetic blockade. However, some authors would advocate that this is not strictly necessary if patients are carefully selected (i.e. patients younger than 70 yr, without a history of voiding problems, and not having hernia, rectal or urological procedures). This view is not widely held and therefore cannot be advocated.

Complete recovery of motor block after spinal anaesthesia is required before discharge. The ability to flex the ankle, knee and hip joints is usually taken as a sign of complete regression of motor block, but it must be stressed that functional balance may remain impaired for longer so that a controlled assessment of independent ambulation is also necessary before discharge.

Therefore, both the drug and dose used for day-case spinal anaesthesia must be chosen carefully to allow successful ambulation, but maintain block efficacy. In the UK, the choice of drug is limited to low-dose bupivacaine/levobupivacaine or ropivacaine. Glucose-containing solutions have been shown to provide more reliable blocks than plain solutions and would seem the logical choice for this technique. The only commercially available glucose-containing preparation is ‘heavy’ bupivacaine, and this preparation has been used successfully in doses as low as 6–8 mg. When using very low doses of bupivacaine many authors found it necessary to add small doses of opioid to achieve satisfactory analgesia.

However, recent work with hyperbaric solutions of ropivacaine has demonstrated a more favourable recovery profile when compared with ‘heavy’ bupivacaine. A more rapid regression of sensory and motor block, earlier mobilization and shorter time to first micturition were all demonstrated using doses more commonly employed for spinal anaesthesia (Table 1).\(^5\)

An agent with a similar recovery profile to lidocaine 5% without neurological complications would be of benefit. Further work with hyperbaric solutions of ropivacaine in the day-case setting is required to demonstrate if this would be a suitable alternative to lidocaine.

**Unilateral spinal anaesthesia**

The suggested aims of limiting the spread of a spinal block are twofold. Firstly, a desire to reduce the cardiovascular side-effects of an extensive block and secondly to achieve earlier patient mobilization.

The distance between the right and left spinal nerve roots is very small and should therefore prevent the production of unilateral spinal anaesthesia. Early work in the 1980s demonstrated that gravity had no effect on the spread of isobaric solutions and that, while hyperbaric solutions did indeed spread under the effect of gravity, it was found that posture could not be used to control spread effectively. Clinically relevant migration of spinal block has also been demonstrated up to 1 h after injection of hyperbaric solutions into patients remaining in the lateral decubitus position. Some authors have therefore suggested that the use of much smaller doses of either hypo- or hyperbaric solutions than originally studied, injected in patients lying in the lateral decubitus position for 15–30 min, may result in preferential distribution of spinal block.

Studies using as little as 6 mg of either hypo- or hyperbaric bupivacaine have demonstrated successful anaesthesia and analgesia, with minimal haemodynamic changes for knee arthroscopy. However, they have failed to demonstrate convincing lack of spread to the non-operative side. Also, there remains no

<table>
<thead>
<tr>
<th>Sensory block</th>
<th>Bupivacaine</th>
<th>Ropivacaine</th>
<th>(P) value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Onset at T10 (min)</td>
<td>2 (2–10)</td>
<td>5 (2–25)</td>
<td>0.0046</td>
</tr>
<tr>
<td>Maximum cephalad spread (dermatome)</td>
<td>T5 (T3–T11)</td>
<td>T7 (T4/5–T11)</td>
<td>0.0007</td>
</tr>
<tr>
<td>Time to maximum cephalad spread (min)</td>
<td>20 (5–30)</td>
<td>20 (10–30)</td>
<td>n.s.</td>
</tr>
<tr>
<td>Block height at 90 min (dermatome)</td>
<td>T7/8 (T6–L1)</td>
<td>T8/9 (T6–S2)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Duration at T10 (min)</td>
<td>118 (80–238)</td>
<td>56.5 (28–145)</td>
<td>0.001</td>
</tr>
<tr>
<td>Total duration (min)</td>
<td>255 (150–420)</td>
<td>180 (120–270)</td>
<td>0.0001</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Motor block</th>
<th>Grade 3 block, n (%)</th>
<th>Grade 3 block, n (%)</th>
<th>(P) value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time to maximum degree (min)</td>
<td>10 (2–15)</td>
<td>15 (10–25)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Total duration (min)</td>
<td>180 (120–210)</td>
<td>90 (60–180)</td>
<td>&lt;0.0001</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Adverse events</th>
<th>Hypotension</th>
<th>Mild back tenderness</th>
<th>Post-dural puncture headache</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade 3 block, n (%)</td>
<td>14 (70%)</td>
<td>3 (15%)</td>
<td>n.s.</td>
</tr>
<tr>
<td>Time to maximum degree (min)</td>
<td>10 (2–15)</td>
<td>15 (10–25)</td>
<td>n.s.</td>
</tr>
<tr>
<td>Total duration (min)</td>
<td>180 (120–210)</td>
<td>90 (60–180)</td>
<td>n.s.</td>
</tr>
</tbody>
</table>

| Transient neurological symptoms | 0 | 0 | n.s. |
| Other factors | Time to first mobilize (min) | 331 (219–475) | 253.5 (151–359) | 0.0019 |
| Time to first micturate (min) | 340.5 (268–497) | 276 (177–494) | 0.01 |
convincing data to support claims of earlier mobilization and discharge after using this technique.

**Other developments**

Continuous spinal anaesthesia and the role of spinal anaesthesia in deep venous thrombosis prophylaxis have been discussed recently in previous issues of the journal.

**Summary**

Spinal anaesthesia remains a popular technique for surgery to the abdomen, pelvis and lower limbs. Complications after spinal anaesthesia are minimal and these have been further reduced by advances in needle design. Also, the introduction of the newer local anaesthetic agents has reconfirmed the need for hyperbaric, glucose-containing solutions in order to provide predictably reliable clinical block patterns. Hyperbaric solutions of ropivacaine may represent an agent with a similar recovery profile to 5% lidocaine without the neurological complications and be of interest to those performing spinal anaesthesia in the day-case setting. However, there remains no conclusive evidence that the use of small doses of hyperbaric solutions of local anaesthetic can be used to provide spinal anaesthesia that is exclusively unilateral.

**References**

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See multiple choice questions 27–29.