Spinal anaesthesia: comparison of plain ropivacaine 5 mg ml\(^{-1}\) with bupivacaine 5 mg ml\(^{-1}\) for major orthopaedic surgery

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**Background.** Ropivacaine provides effective spinal anaesthesia for total hip arthroplasty. This study was designed to compare the efficacy and safety of plain ropivacaine with plain bupivacaine for spinal anaesthesia in patients undergoing total hip arthroplasty.

**Methods.** Sixty-six patients, ASA I or II, were randomized to receive an intrathecal injection of one of two local anaesthetic solutions. Group R (\(n=32\)) received 3.5 ml of ropivacaine 5 mg ml\(^{-1}\) (17.5 mg). Group B (\(n=34\)) received 3.5 ml of bupivacaine 5 mg ml\(^{-1}\) (17.5 mg). The onset and duration of sensory block at dermatome level T10, maximum upper and lower spread of sensory block and the onset, intensity and duration of motor block were recorded, as were safety data.

**Results.** Onset of motor and sensory block was rapid with no significant differences between the two groups. The median time of onset of sensory block at the T10 dermatome was 2 min (range 2–5 min) in Group R and 2 min in Group B (range 2–9 min). The median duration of sensory block at the T10 dermatome was 3.0 h (range 1.5–4.6 h) in Group R and 3.5 h (2.7–5.2 h) in Group B (\(P<0.0001\)). The median duration of complete motor block (modified Bromage Scale 3) was significantly shorter in the ropivacaine group compared with the bupivacaine group (2.1 vs 3.9 h, \(P<0.001\)).

**Conclusions.** Intrathecal administration of either 17.5 mg plain ropivacaine or 17.5 mg plain bupivacaine was well tolerated and an adequate block for total hip arthroplasty was achieved in all patients. A more rapid postoperative recovery of sensory and motor function was seen in Group R compared with Group B.

**Keywords:** anaesthetic techniques, regional; anaesthetic techniques, subarachnoid; anaesthetics, local, ropivacaine; anaesthetics local, bupivacaine; surgery, total hip replacement

Accepted for publication: May 30, 2002

Ropivacaine is an amide local anaesthetic with local anaesthetic properties similar to those of bupivacaine.\(^1\)\(^2\) It is presented as a single-enantiomer and has been used extensively for local infiltration, epidural, and peripheral nerve block. Extensive clinical data have shown that ropivacaine is effective and safe for regional anaesthetic techniques such as epidural and brachial plexus block.\(^3\) However, experience of intrathecal anaesthesia with ropivacaine is not as well documented.

In a previous study we have demonstrated that intrathecal administration of ropivacaine (plain 18.75 and 25 mg) is well tolerated and provides effective anaesthesia for total hip arthroplasty surgery.\(^4\) To our knowledge, no studies have compared intrathecal ropivacaine with bupivacaine, the standard agent, in patients undergoing major surgery. This study was designed to compare the safety and efficacy of intrathecal plain ropivacaine 17.5 mg (baricity 0.9988 at 37°C) and plain bupivacaine 17.5 mg (baricity 0.9988 at 37°C) in patients undergoing primary total hip arthroplasty.

**Methods**

A Clinical Trials Exemption Certificate was obtained from the Medicines Control Agency and approval for this
randomized, double-blind study was granted by the Research Ethics Committee of the Queen’s University of Belfast. Written informed consent was obtained from 66 patients who fulfilled the following inclusion criteria: undergoing primary unilateral total hip arthroplasty (cemented prosthesis) under intrathecal anaesthesia, ASA I–III, age 18–80 yr, height ≥160 cm, and weight 60–110 kg. Patients who had contraindications to spinal anaesthesia, allergy to amide local anaesthetics, a significant history of substance abuse, who had participated in clinical trials in the preceding 3 months, had been enrolled previously in this study or had significant derangement of laboratory values and women of child bearing potential were excluded.

Oral premedication consisted of diazepam 10 mg and ranitidine 150 mg. Following arrival in the anaesthetic room, i.v. access was established, full non-invasive monitoring applied and the patient placed in the lateral position with the affected hip uppermost. Following skin infiltration with 1% lidocaine a 20 G introducer needle was inserted at the L2/3 or the L3/4 interspace through which a 25 G pencil point needle with its opening uppermost was passed. Correct needle placement was identified by free flow of cerebrospinal fluid and 3.5 ml (17.5 mg) study drug was injected over 10 s. Group R received plain 0.5% ropivacaine, Group B received plain 0.5% bupivacaine. The local anaesthetic solutions were presented in identical numbered ampoules to ensure blinding. The spinal needle was removed and the patient placed supine to carry out the initial assessments. Following completion of these and before the commencement of surgery, patients were returned to the lateral position and a continuous i.v. infusion of 1% propofol was started. The rate of this infusion was adjusted to render the patients drowsy but rousable. Surgery was commenced once normal motor function returned. Heart rate and arterial pressure were recorded using standard non-invasive monitors before intrathecal injection and thereafter at 5, 10, 15, 20, 25, 30, 45, and 60 min, then hourly until 8 h post-injection.

The time to first request for postoperative analgesia and the total morphine consumption in the first 24 h following surgery were noted, as well as intraoperative blood loss. The quality of anaesthesia as judged by the anaesthetist, the quality of muscle relaxation as judged by the surgeon, the degree of intraoperative comfort as judged by the patient were recorded as excellent, satisfactory, or unsatisfactory. Patients were followed up daily for adverse events for the duration of their hospital stay and again by telephone 14–21 days post-surgery.

A difference of 60 min in the duration of motor block (modified Bromage score ≥1) was taken to be clinically significant. An estimated 26 patients per group were necessary to detect a 60-min difference in the duration of motor block with an 80% power, based on a simple unstratified two-sample 95% $t$-based confidence interval for group comparison. The Stratified Wilcoxon (mid) rank sum test was used for comparison between the two groups. A $P$ value of <0.05 was considered statistically significant.

**Results**

The characteristics of the two groups were comparable in terms of age, height, weight, gender, and ASA classification. There was no significant difference in the duration of surgery (see Table 1). Sixty-eight patients were randomized to the two treatment groups. Two of these patients were excluded from the study, both from the ropivacaine 5 mg ml$^{-1}$ group: one due to withdrawal of consent before arrival in the anaesthetic room, the other due to spillage of the study drug before commencement of intrathecal injection. All patients were able to co-operate fully with the subsequent assessments.

There was no significant difference in the median time of onset of sensory block at the T10 dermatome, which was 2 min (range 2–5 min) in the ropivacaine group and 2 min (range 2–9 min) in the bupivacaine group. The median duration of sensory block at the T10 dermatome was significantly longer in the bupivacaine group: 3.5 h (range 2.7–5.2 h) compared with 3.0 h (range 1.5–4.6 h) in the ropivacaine group ($P<0.0001$).

There was a trend for patients in the bupivacaine group to achieve a higher upper dermatome level of sensory block but this difference was not significant (Fig. 1). The lower distribution of spread of sensory block was similar in both groups.

| Table 1 Patient characteristics and duration of surgery (median (range)) |
|-----------------------------|-----------------------------|
|                            | Ropivacaine 17.5 mg         | Bupivacaine 17.5 mg       |
| Age (yr)                    | 66 (33–78)                  | 67 (34–77)                |
| Height (cm)                 | 170 (161–189)               | 168 (160–184)             |
| Weight (kg)                 | 79 (64–97)                  | 80 (60–106)               |
| Gender (M/F)                | 21/11                       | 22/12                      |
| ASA I/II/III                | 8/24/0                      | 12/22/0                    |
| Duration of surgery (h)     | 1.0 (0.7–2.6)               | 0.9 (0.7–2.1)             |

Whilst there was an overall trend towards a longer duration of sensory block at dermatome levels other than T10 in the bupivacaine group, this difference was not
statistically significant. The duration of sensory block in each group is shown in Figure 2.

The onset of motor block was rapid in both groups with a median onset time of 2 min to achieve a Bromage score of 1 for both groups and a median onset time of 4 min to achieve a Bromage score of 2 for both groups. All patients in the bupivacaine group and all but one in the ropivacaine group achieved Bromage of at least 1. Onset of motor block was prolonged in some patients in both groups who failed to report any degree of motor block until after surgery. As no assessments were carried out during surgery, this delay was probably exaggerated.

The median time of onset to achieve a Bromage score of 3 was 10 min in the ropivacaine group and 8 min in the bupivacaine group. This difference was not significant. The median duration of complete motor block (modified Bromage Scale 3) was significantly shorter in the ropivacaine group compared with the bupivacaine group (2.1 vs 3.9 h, \( P < 0.001 \)). After surgery, the degree of motor block was lower in the ropivacaine patients compared with patients receiving bupivacaine (Fig. 3). At 2 h after intrathecal injection, 69% of the patients in the ropivacaine group, and 97% of the patients in the bupivacaine group, had a Bromage score of 3. At 4 h after injection 56% of the ropivacaine patients had no detectable motor block (Bromage score 0), whereas the corresponding figure in the bupivacaine patients was 12%.

Anaesthesia was judged to be excellent in all patients, except for one patient in the ropivacaine group in whom it was judged to be satisfactory. No patients required supplemental analgesia intraoperatively. Excellent muscle relaxation was reported in all but one patient in each group. The median time to first analgesic request was significantly shorter in the ropivacaine group than in the bupivacaine group (3.4 vs 4.9 h, \( P < 0.001 \)). There was a trend towards higher morphine requirements in the ropivacaine group (median 54 mg, range 12–86 mg) than in the bupivacaine group (median 44 mg, range 7–99 mg) although this difference was not statistically significant.

Both intrathecal ropivacaine and bupivacaine produced an initial moderate fall in arterial pressure in keeping with the expected sympathetic block produced by spinal anaesthesia. Intraoperative hypotension requiring treatment with i.v. ephedrine occurred in 12% of patients in ropivacaine groups (range 5–35 mg) and in 26% of patients in the bupivacaine group (range 5–35 mg). Two patients in the ropivacaine group also required atropine 0.6 mg for the treatment of bradycardia compared with none in the bupivacaine group. The most commonly reported adverse events during the first 24 h were oliguria, nausea, pyrexia, hypotension, and vomiting. These events were equally distributed between groups. There was no difference in the blood loss between the two groups (median blood loss was 350 ml for both groups).

**Discussion**

This study shows that intrathecal administration of either 17.5 mg ropivacaine or 17.5 mg bupivacaine was well
tolerated and an adequate block for total hip arthroplasty was achieved in all patients.

Intrathecal ropivacaine does not produce any signs of neurotoxicity following administration to rats. In dogs intrathecal ropivacaine has been shown to produce effective local anaesthesia with an equipotent sensory block but shorter duration of motor block than intrathecal bupivacaine. In humans, ropivacaine has been shown to be effective in providing intrathecal anaesthesia for patients undergoing total hip replacement, transurethral resection of the prostate, and lower abdominal or limb surgery. The present study is the first, to our knowledge, to compare intrathecal ropivacaine with bupivacaine as a sole anaesthetic agent in patients undergoing major orthopaedic surgery. The efficacy and safety of two glucose-free solutions, ropivacaine 5 mg ml$^{-1}$ and bupivacaine 5 mg ml$^{-1}$, were assessed.

In the present study, both solutions produced similar results in terms of onset and spread of analgesia. Both the ropivacaine and bupivacaine solutions exhibited variation in the degree of spread of sensory block, which may be attributed to the use of a plain solution.

Gautier and colleagues compared 4 ml of intrathecal hyperbaric 0.2% bupivacaine (8 mg) with 4 ml of 0.2, 0.25, 0.3, or 0.35% hyperbaric ropivacaine (8, 10, 12, or 14 mg) in patients undergoing knee arthroscopy. They estimated that the 12 mg dose of ropivacaine was approximately equivalent to bupivacaine 8 mg. Although the duration of both sensory and motor block was significantly shorter in the ropivacaine group in our study, these differences were not as pronounced as those seen in the above-mentioned study. This may reflect a difference in the dosage use, the baricity of the solution used, the patient position and the population studied. Whiteside and others compared equal doses (15 mg) of intrathecal 0.5% ropivacaine in 10 mg ml$^{-1}$ or 50 mg ml$^{-1}$ glucose in two groups of patients undergoing a variety of minor surgical procedures. They showed that the onset of sensory block to T10 was significantly faster in the glucose 50 mg ml$^{-1}$ group but that maximum extent of sensory block, time to block regression and quality and duration of motor block were similar in both groups. In keeping with our findings, all patients demonstrated sensory block adequate for surgery.

In another recent study, in patients undergoing transurethral resection of the bladder or prostate, patients were randomized to receive either 5 ml of 0.2% isobaric bupivacaine (10 mg) or 5 ml 0.3% isobaric ropivacaine (15 mg) for spinal anaesthesia. Despite the fact that a lower dose of bupivacaine was used in comparison with ropivacaine, there was a significant increase in the cephalad spread of the sensory block in the bupivacaine group. The degree of motor block was similar which is in accordance with our study, where a lower intensity of motor block was seen with ropivacaine than with bupivacaine with the same dose.

Polley and colleagues investigated the minimum concentration of a fixed volume of an epidurally administered local anaesthetic required to abolish the pain of the first stage of labour. They ascertained that ropivacaine is approximately 40% less potent than bupivacaine in this situation. However other investigators have failed to demonstrate any differences between these two agents for epidural analgesia in labour. Whilst there has been no evaluation of the differences in potency of these two agents following intrathecal administration, the difference in the duration of motor and sensory block seen in our study may be due to differences in potency. However these differences were not of the same order as those detected by Polley and co-workers.

Twenty-two per cent of patients in the ropivacaine group and 41% of patients in the bupivacaine group had sensory anaesthesia in the cervical dermatomes. This is higher than recorded in studies using similar doses of ropivacaine carried out by van Kleef and colleagues and by Malinovsky and co-workers, but is similar to work carried out by McNamee and colleagues. This may be due to a difference in the characteristics of the populations studied, or a difference in the position of the patient during the institution.
of intrathecal anaesthesia. Sensory block in our study was tested using loss of sensation to ice rather than loss of sensation to pin-prick as used by others.9 This difference in the method of assessment of sensory block readily accounts for the discrepancy between the degree of sensory block achieved in these two studies.14 The subgroup of patients with sensory anaesthesia in the cervical dermatomes did not demonstrate any upper limb motor weakness, respiratory distress, decrease in oxygen saturation, or cardiovascular compromise. This suggests a significant separation in the extent of motor and sensory block when loss of sensation to ice is used. Cervical sensory block to ice was not associated with any clinically significant adverse events. Although the upper extent of loss of sensation to ice only reached the T10 dermatome in two patients in the ropivacaine group this was not associated with any discomfort during or immediately following surgery.

Although previous studies have linked intrathecal ropivacaine with an increased incidence of post-dural puncture headache3 and low back pain,15 no patient in the present study reported symptoms in keeping with these two complications. This is in agreement with the findings of others.4 8 11 The headache reported in the study by van Kleef and colleagues9 is probably due to the fact that a Quinke type of spinal needle was used, compared with a Whitacre-needle in the present study. Furthermore, hip replacement is commonly performed in elderly patients in whom post-dural puncture headache is rare.

In terms of safety, both intrathecal ropivacaine and bupivacaine provided a high degree of cardiovascular stability with a low incidence of bradycardia. The degree of hypotension was felt to be predictable in an elderly population undergoing an operative procedure under a combination of spinal anaesthesia and propofol sedation. The hypotension seen was associated with the commencement of the i.v. infusion of 1% propofol rather than the institution of spinal anaesthesia.16 The most commonly reported adverse events, oliguria, pyrexia, hypotension, nausea, and vomiting, were those commonly seen in connection with this type of surgery and there were no reports of postoperative neurological problems. Postoperative fever is commonly seen following total hip arthroplasty, and bone cement may also cause fever.17 No serious problems were associated with these adverse effects and they were treated according to hospital routine.

In conclusion, intrathecal administration of either 17.5 mg ropivacaine or 17.5 mg bupivacaine was well-tolerated and provided similar, effective anaesthesia for total hip arthroplasty. In an equal milligram dose, bupivacaine produced a more prolonged sensory and motor block. Intrathecal ropivacaine may prove useful when surgical anaesthesia of a similar quality but of a shorter duration than that of bupivacaine is desired. Thus, ropivacaine offers a reliable motor block for major orthopaedic surgery, with a predictable and rapid return of motor function after surgery.

Acknowledgements
We would like to thank Mr D. Beverland and the other consultant orthopaedic surgeons for their patience and assistance with the scheduling of suitable cases and the nursing staff of Musgrave Park Hospital for their help in carrying out the observations. This research was supported by a grant from AstraZeneca Pharmaceuticals Ltd.

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