COMPARISON OF BUPIVACAINE HYDROCHLORIDE AND CARBONATED BUPIVACAINE IN BRACHIAL PLEXUS BLOCK BY THE INTERSCALENE TECHNIQUE

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SUMMARY
A double-blind comparison of carbonated bupivacaine and bupivacaine hydrochloride in brachial plexus anaesthesia produced by the interscalene technique was made in 20 patients. A more widespread and more intense nerve block was demonstrated using the carbonated solution.

Carbonated local anaesthetics may have shorter latency and greater spread than equivalent hydrochloride salts when used for regional anaesthesia. In brachial plexus anaesthesia produced by the supraclavicular technique, Bromage and Gertel (1970) using 1% lignocaine and Schulte-Steinberg, Hartmuth and Schütt (1970) using 2% lignocaine, reported a marked decrease in the time of onset of anaesthesia using the carbonated solution compared with the hydrochloride.

Bupivacaine is a longer acting agent, but has a slow onset of action: 23 min on average for 0.25% bupivacaine hydrochloride compared with 14 min for 1% lignocaine hydrochloride in brachial plexus anaesthesia by the supraclavicular technique (Bromage and Gertel, 1970).

Carbonation of bupivacaine has been reported to decrease the time of onset of extradural anaesthesia (Eckstein et al., 1978) although Brown and others (1980) failed to verify this in a double-blind trial.

This study was undertaken to compare carbonated bupivacaine with the hydrochloride salt in interscalene brachial plexus block.

METHODS
Twenty patients undergoing elective and emergency forearm or hand surgery were studied. The patients were premedicated with diazepam 10 mg orally 1.5–2 h before anaesthesia. The brachial plexus was blocked in each patient using the interscalene technique originally described by Winnie (1970). The interscalene groove was entered at the level of the cricoid cartilage (6th cervical vertebra) in a direction perpendicular to the skin in all planes using a Venflon i.v. cannula 47 mm long and 1 mm e.d. (Viggo). Paraesthesia was elicited in all patients, whereupon the stylet was held firm and the cannula advanced over the needle tip by 1–2 mm. The brachial plexus sheath was then considered cannulated.

After aspiration, an extension tubing was connected and a standard volume of 40 ml of anaesthetic solution was injected over 2 min. Aspiration was repeated twice during injection. All patients lay supine during the injection with the head turned to the opposite side and supported by one pillow. The sheath was not compressed above the cannula.

The patients were allocated randomly to two groups which were similar in age, height and weight. One group received 0.5% bupivacaine hydrochloride 40 ml (Marcaïn plain, Duncan, Flockhart and Co. Ltd, U.K.) containing 0.44% bupivacaine base and the second group received 0.5% bupivacaine CO$_2$ 40 ml (Meaverin-Ultra CO$_2$, Woelm Pharma, Germany) containing 0.42% bupivacaine base.

All the blocks were performed by the same anaesthetist.

The onset and spread of sensory and motor block were assessed every 5 min for 30 min after the injection of bupivacaine but before start of surgery. The heart rate and arterial pressure were measured at intervals of 5 min.

All assessments were performed by the same anaesthetist who performed the blocks. He was unaware of the local anaesthetic solution used. The ampoules were opened and the solutions drawn up

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in a taped syringe by a different anaesthetist in another room. This ensured that the study remained double-blind, since occasionally bubbles of carbon dioxide were seen in the carbonated solution.

The sensory block was assessed by pin-prick, analgesia being defined as loss of sensation of sharpness. The extent of sensory block was assessed by the number of dermatomes blocked. A total of seven dermatomes was tested (C4–T2) (fig. 1). Motor block was scored on a scale 0–3: 0 = no motor block; 1 = inability to abduct the shoulder or flex the elbow against resistance; 2 = inability to abduct the shoulder or flex the elbow against gravity; 3 = inability to abduct the shoulder or flex the elbow and wrist against gravity.

Surgery was not begun until at least 30 min after injection when the patient was given additional local anaesthesia if necessary (usually an ulnar nerve block at the elbow or wrist) or further sedation if requested. The statistical significance of differences between the data of the two groups was determined using Student’s t test.

**RESULTS**

The mean age, height and weight of the two groups of patients are shown in table I. There is no statistically significant difference between the two groups.

<table>
<thead>
<tr>
<th></th>
<th>n</th>
<th>Age (yr)</th>
<th>Height (cm)</th>
<th>Weight (kg)</th>
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<tr>
<td>Bupivacaine</td>
<td>10</td>
<td>41.9±5.5</td>
<td>171.0±3.3</td>
<td>70.0±5.4</td>
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<td>HCI</td>
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<tr>
<td>Bupivacaine</td>
<td>10</td>
<td>44.3±5.9</td>
<td>173.3±2.6</td>
<td>66.5±4.2</td>
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<tr>
<td>CO₂</td>
<td></td>
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The spread of analgesia is illustrated in figure 2, which shows the mean number (±SEM) of dermatomes blocked at 5-min intervals in each group of 10 patients. More than five dermatomes were analgesic in the group receiving the carbonated solution at 20 min whereas this spread was not reached until after 30 min in the group receiving the hydrochloride solution. Analgesia of five dermatomes permits most surgical procedures to be performed on the arm. The two groups are significantly different at 20, 25 and 30 min.
In the group receiving the carbonated solution, six of 10 patients had analgesia of the 8th cervical dermatome within 30 min compared with none of the 10 patients receiving the hydrochloride solution.

Table II shows the mean (± SEM) time of onset for each grade of motor block and the number of patients in whom the grade was achieved.

Table II. Motor block: mean time of onset (min) (± SEM) for each grade. n = no. of patients in whom the grade was achieved

<table>
<thead>
<tr>
<th></th>
<th>Grade 1</th>
<th>Grade 2</th>
<th>Grade 3</th>
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<tbody>
<tr>
<td>Bupivacaine HCl</td>
<td>Mean</td>
<td>7.5</td>
<td>15.6</td>
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<td></td>
<td>SEM</td>
<td>1.12</td>
<td>2.27</td>
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<td></td>
<td>n</td>
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<td>9</td>
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<tr>
<td>Bupivacaine CO₂</td>
<td>Mean</td>
<td>6.5</td>
<td>9.4</td>
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<tr>
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<td>SEM</td>
<td>0.76</td>
<td>1.00</td>
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<tr>
<td></td>
<td>n</td>
<td>10</td>
<td>9</td>
</tr>
<tr>
<td>Difference</td>
<td>n.s.</td>
<td>P &lt; 0.025</td>
<td>n.s.</td>
</tr>
<tr>
<td>between groups</td>
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</table>

DISCUSSION

This study shows that carbonated bupivacaine has distinct advantages over bupivacaine hydrochloride for interscalene block.

Local anaesthetics are available usually as the water-soluble hydrochloride salt. Carbonated local anaesthetics are rendered soluble by combining the free base with carbon dioxide in equilibrium with carbonic acid within pressurized ampoules.

Carbonated solutions are less acidic than the hydrochlorides and require less buffering by the tissues. Rapid buffering and diffusion of the carbon dioxide enables free base to be deposited rapidly in high concentration on the nerve fibres. In addition, carbon dioxide is thought to increase the intracellular hydrogen ion concentration, thus increasing the amount of active cation available at the receptor sites on the sodium channels inside the nerve membrane (Catchlove, 1972).

The results suggest there is a more rapid onset of sensory and motor block with carbonated bupivacaine. However, this may be caused by carbonated bupivacaine producing more widespread and complete block. There is little difference between the time taken by each agent to achieve its maximal spread.

The study also demonstrates the relative unsuitability of 0.5% bupivacaine hydrochloride for interscalene block to produce adequate sensory blockade for hand surgery since the 8th cervical dermatome was unaffected up to 30 min after injection. This may represent poor blockade of “core” bundles (Winnie et al., 1977) within the nerve trunks in the brachial plexus. Core bundles are the nerve bundles occupying the centre of the brachial plexus trunks and are distributed distally. Failure to achieve distal motor block in five of 10 patients within 30 min using the hydrochloride salt may also have been caused by poor core blockade.

Carbonated bupivacaine is clinically more useful in interscalene brachial plexus block, therefore, and usually surgery may begin 20 min after injection.

A dose of 40 ml was used in the study in the expectation that it would be supramaximal for most patients and exceeds Winnie’s dose recommendations (1970). No patient suffered systemic toxic side-effects, which reflects the slow absorption of local anaesthetics from the brachial plexus sheath. Wildsmith and others (1977) showed a maximum concentration of 2.0 μg ml⁻¹ at 25 min following 30 ml of 0.5% bupivacaine hydrochloride without adrenaline. Concentrations greater than 4.0 μg ml⁻¹ are thought to be convulsive (Jorfeldt et al., 1968).

Although no systemic effects were noted in the series, two patients who were excluded showed extradural spread of the local anaesthetic (bupivacaine hydrochloride in each case). Both patients were of small stature and developed bilateral thoracic analgesia with depression of breathing and coughing, though this was not sufficiently marked to require assistance. The weakness was explained to them and they underwent surgery uneventfully following administration of fluid i.v. and a pressor agent to counteract arterial hypotension. This complication has been described previously by Kumar and others (1971) and should be considered when large volumes are used in patients of small stature. A dose related to height (0.5 ml per inch of height) has been recommended by Winnie (1970).
Cervical sympathetic block was assessed by the development of Horner's syndrome and was present in 75% of patients. No other complication was encountered, although phrenic nerve paralysis was not assessed. Extradural and cephalad spread may be limited by using compression of the brachial plexus sheath above the site of the injection.

The catheter technique originally described by Selander (1977) for axillary plexus block has been applied to the interscalene route and is no more difficult than the standard needle technique. It offers the possibility of a continuous block in prolonged surgery or for postoperative analgesia and it may reduce trauma to the nerve trunks by reducing the length of time a sharp needle is within the brachial plexus sheath.

ACKNOWLEDGEMENTS
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REFERENCES