HYPOXAEMIA AND PAIN RELIEF AFTER UPPER ABDOMINAL SURGERY: COMPARISON OF I.M. AND PATIENT-CONTROLLED ANALGESIA

R. G. WHEATLEY, D. SHEPHERD, I. J. B. JACKSON, T. H. MADEJ AND D. HUNTER

SUMMARY

Forty patients recovering from upper abdominal surgery were allocated randomly to receive i.m. morphine 0.15 mg kg⁻¹ as required or patient-controlled analgesia (PCA), with i.v. morphine 1 mg and a 5-min lock out time. Arterial oxygen saturation (SpO₂) was measured continuously the night before and for 24 h immediately after surgery. A significantly greater proportion of patients in the PCA group (nine of 19) rated their analgesia as excellent compared with the i.m. group (two of 20) (P < 0.05). There was no significant difference in the incidence of postoperative hypoxaemia in the two treatment groups. Severe postoperative hypoxaemia (SpO₂ < 85% for more than 6 min h⁻¹) was seen in three patients receiving i.m. analgesia and one patient in the PCA group.

KEY WORDS

A major factor limiting the use of patient-controlled analgesia (PCA) is the fear of respiratory depression. In a recent survey of postoperative analgesic practice in Anaesthetic departments in England and Wales, PCA was felt by 58% of respondents to be the ideal method of analgesia where there were no limitations in staffing or equipment [1]. However, only 18% rated it as the safest technique on normally staffed wards. In contrast, 63% of departments felt that on-demand i.m. analgesia was the safest form of analgesia. These fears about the safety of PCA are based on isolated reports of equipment failure [2] and the potential of the patient to administer an overdose of i.v. opioid drug. The aim of this study was to compare the efficacy and respiratory effects of PCA and i.m. analgesia after elective upper abdominal surgery using a bedside, computerized system of analysis and display of continuous SpO₂ monitoring described previously [3].

PATIENTS AND METHODS

We studied 40 patients (aged 20–80 yr; ASA I or II) undergoing elective upper abdominal surgery. All gave written, informed consent to the study, which was approved by the Hospital Ethics Committee.

The patients were anaesthetized after oral temazepam premedication, with a standardized general anaesthetic technique comprising propofol 2 mg kg⁻¹, vecuronium 0.1 mg kg⁻¹ and nitrous oxide and enflurane in oxygen. Intraoperative analgesia was provided with fentanyl 2–4 µg kg⁻¹. Both groups of patients were made comfortable in the recovery room, when necessary, by administration of i.v. morphine. The patients were then allocated randomly to receive either i.m. analgesia or PCA after operation.

In the i.m. group, 20 patients received morphine 0.15 mg kg⁻¹ i.m. 4-hourly on request. In the PCA group, 20 patients self-administered i.v. morphine at a maximum rate of 1 mg every 5 min using a Graseby Patient Controlled Analgesia system (PCAS). All patients were able to use the device within 1 h of the end of surgery.

The total dose of morphine administered to each patient in the first 24 h was noted.

Pulse oximetry

Continuous monitoring of arterial oxygen saturation (SpO₂) was performed on the night before surgery and for the first 24 h after operation whilst the patient breathed air. The SpO₂ monitoring was carried out using a Nellcor N-100 pulse oximeter interfaced with an Opus IBM-compatible microcomputer.

Recordings of SpO₂ were made every 10 s and stored on the computer. The data were analysed by the computer and displayed in three ways:

1. Percentage and distribution of recorded SpO₂.

The values recorded during the whole observation period were displayed as min h⁻¹ within a range of SpO₂ values: < 85%; ≥ 85 < 90%; ≥ 90 < 94%; ≥ 94%.

2. Grades of hypoxaemia were defined as: mild = SpO₂ < 94% for more than 12 min h⁻¹ [4]; moderate = SpO₂ < 90% for more than 12 min h⁻¹; severe = SpO₂ < 85% for more than 6 min h⁻¹.

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MS-DOS 3.2). Unpaired statistics package on an IBM-compatible computer excellent.

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Postoperative assessment period.

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Distribution.

Hypoxaemic episodes. The number and duration of episodes of severe hypoxaemia (SpO₂ < 85 % for more than 6 min h⁻¹) were noted during each observation period.

Postoperative assessment

Pain scores were obtained 4-hourly using a 10-cm visual analogue scale (VAS). In addition, patients were asked to rate their postoperative pain relief using a verbal rating score: poor, fair, adequate and excellent.

Statistical analysis

Data were analysed using the Northwick Park statistics package on an IBM-compatible computer (MS-DOS 3.2). Unpaired t tests and Welch's test were used for parametric data. Non-parametric data was analysed using chi-square with Yates' correction.

RESULTS

The two treatment groups did not differ in age, sex distribution, degree of obesity or total dose of morphine used (table I). Surgery and anesthesia were uncomplicated, with similar duration of surgery and blood loss in the two groups (table I). Operations performed were cholecystectomy (35), vagotomy and pyloroplasty (three) and anti-reflux operations (two).

Seventeen i.m. patients and 16 PCA patients were monitored on the night before surgery from approximately 22:00 to 07:00. The six patients with incomplete monitoring before operation had normal postoperative results and it is assumed that preoperative monitoring would not have revealed any major degree of hypoxaemia.

Six of the i.m. group and three of the PCA group were mildly hypoxaemic during the preoperative monitoring period. Severe hypoxaemia (SpO₂ < 85 % for more than 6 min h⁻¹) was not seen in any patient before operation, but one patient in each group had transient episodes of desaturation to less than 85 % before surgery.

One patient in the PCA group had insufficient data collected for technical reasons and was excluded from the study. The remaining 39 patients were monitored for 20-24 h immediately after surgery.

There were no significant differences between the two groups in the duration of hypoxaemia either before or after operation (table II). However, it is interesting to note that the i.m. group spent a mean of 25.7 (SD 4.9) min h⁻¹ with SpO₂ less than 94 %—an increase compared with preoperative mean values of 12.5 (3.9) min h⁻¹ which just reached statistical significance (P = 0.042).

Table III shows the number of patients in each treatment group with mild, moderate or severe hypoxaemia. Severe hypoxaemia was seen in three i.m. patients and one patient receiving PCA. The preoperative status, age, degree of obesity, 24-h pain scores and dose of morphine used in these severely hypoxaemic patients are shown in table IV. The three i.m. patients with severe hypoxaemia had no

(2) Graphic representation of the pattern of SpO₂ distribution. The computer was programmed to produce a curve of SpO₂ distribution vs percentage of each hour. An array of curves was produced, "stacked" to show the whole observation period hour by hour as a compressed array of curves.

(3) Hypoxaemic episodes. The number and duration of episodes of severe hypoxaemia (SpO₂ < 85 % for longer than 20 s) were noted during each observation period.

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After major surgery, it continues to be used because it is felt to be the safest form of analgesia. Numerous reports of the inadequacy of this technique have been found in patients recovering from abdominal vascular surgery. Increased experience of studying older patients undergoing major surgery suggests that it is not uncommon for patients in this category to spend more than 6 min h⁻¹ with an \( \text{Sp}_{\text{o}2} \) less than 94%. This was based on observations the night before minor surgery in young, healthy patients who spent 0.6 min h⁻¹ with an \( \text{Sp}_{\text{o}2} \) less than 94%. Increasing experience of studying older patients undergoing major surgery suggests that it is not uncommon for patients in this category to spend more than 6 min h⁻¹ with an \( \text{Sp}_{\text{o}2} \) less than 94%. For this reason, we have defined severe hypoxaemia as \( \text{Sp}_{\text{o}2} \) less than 85% for more than 6 min h⁻¹ during the observation period and, in addition, we have determined the number and maximum duration of continuous episodes of \( \text{Sp}_{\text{o}2} \) less than 85%.

In previous studies [7] we have examined the effect of different forms of analgesia on the pattern of hypoxaemia in patients recovering from lower abdominal surgery. I.m. analgesia in this group of patients was associated with a low incidence of hypoxaemia. Severe hypoxaemia was rare, but moderate hypoxaemia occurred most commonly in those patients receiving excellent pain relief with extradural infusion analgesia. However, in upper abdominal surgery the degree of pain and the respiratory consequences of poorly relieved pain are more marked and effective pain control is more difficult to achieve.

The four patients with severe hypoxaemia in this study were all characterized by poor pain relief. The obese patient receiving PCA had poor pain relief despite self-administering morphine 65 mg in the first 24 h. The three i.m. patients with severe hypoxaemia had poor pain control with significantly greater pain scores, despite receiving significantly larger doses of morphine than the non-hypoxaemic i.m. patients. The limitations of i.m. analgesia are attributed usually to the patients receiving inadequate doses of analgesia. In this study, patients received frequent i.m. dosing, but had ineffective pain control and subsequently became hypoxaemic.

The intermittent i.m. administration of opioid drugs remains the mainstay of postoperative pain relief, being used routinely by 87% of anaesthetic departments sampled in a recent survey [1]. Despite numerous reports of the inadequacy of this technique after major surgery, it continues to be used because it is felt to be the safest form of analgesia on normally staffed surgical wards.

### Table VI. Episodes of severe hypoxaemia

<table>
<thead>
<tr>
<th>Group</th>
<th>( \text{op.} &lt; 85% ) (min h⁻¹)</th>
<th>No. episodes</th>
<th>Maximum duration (min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I.m.</td>
<td>13.8</td>
<td>52</td>
<td>54.8</td>
</tr>
<tr>
<td>I.m.</td>
<td>11.4</td>
<td>232</td>
<td>7.6</td>
</tr>
<tr>
<td>I.m.</td>
<td>12</td>
<td>129</td>
<td>35.8</td>
</tr>
<tr>
<td>PCA</td>
<td>6.6</td>
<td>29</td>
<td>71.5</td>
</tr>
</tbody>
</table>

Fig. 1. Mean (SEM) VAS pain scores in the two treatment groups 4–24 h after operation. --- = I.m. group; --- = PCA group. * \( P < 0.05 \) compared with i.m.

**Discussion**

The intermittent i.m. administration of opioid drugs remains the mainstay of postoperative pain relief, being used routinely by 87% of anaesthetic departments sampled in a recent survey [1]. Despite numerous reports of the inadequacy of this technique after major surgery, it continues to be used because it is felt to be the safest form of analgesia on normally staffed surgical wards.

In this study, PCA was associated with significantly better pain control, measured by VAS pain scores and patient satisfaction, than i.m. analgesia, without any evidence of increased hypoxaemia. In an earlier study [5] we defined mild hypoxaemia as occurring when the patient spent more than 6 min h⁻¹ with an \( \text{Sp}_{\text{o}2} \) less than 94%. This was based on observations the night before minor surgery in young, healthy patients who spent 0.6 min h⁻¹ with an \( \text{Sp}_{\text{o}2} \) less than 94%. Increasing experience of studying older patients undergoing major surgery suggests that it is not uncommon for patients in this category to spend more than 6 min h⁻¹ with an \( \text{Sp}_{\text{o}2} \) less than 94%. Despite numerous studies, it is still unclear what level of hypoxaemia is severe and what duration is critical and likely to cause harm in the postoperative period. Reeder and his colleagues [6] have shown that ST segment changes on Holter monitoring in patients recovering from abdominal vascular surgery are maximal on the third day and occur in those patients who have had desaturations to less than 85%. For this reason, we have defined severe hypoxaemia as \( \text{Sp}_{\text{o}2} \) less than 85% for more than 6 min h⁻¹ during the observation period and, in addition, we have determined the number and maximum duration of continuous episodes of \( \text{Sp}_{\text{o}2} \) less than 85%.

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suggest that PCA is not associated with an increased risk of severe hypoxaemia compared with i.m. analgesia, and that severe hypoxaemia can occur in upper abdominal surgery in patients with poor pain relief.

In view of the clinical significance of persistent postoperative hypoxaemia in the development of myocardial ischaemia [6], and the experimental evidence about the role of oxygen lack in cerebral dysfunction [8], wound healing [9] and infections [10], further investigation is required into the use of pulse oximetry in the prediction and detection of severe hypoxaemia, the value and duration of supplementary oxygen therapy and the use of balanced analgesia and opioid sparing analgesic techniques.

REFERENCES