POSTOPERATIVE ANALGESIA AND LUNG FUNCTION: A COMPARISON OF MORPHINE WITH EXTRADURAL BLOCK

BY

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SUMMARY

Twenty-one patients for vagotomy with gastroenterostomy or pyloroplasty were allocated randomly to postoperative analgesia with either morphine by injection or continuous extradural nerve block. In terms of clinical assessment and A—a Po₂ difference measured before and after operation, extradural nerve block was found to reduce the degree of postoperative lung dysfunction. It is concluded that the conventional use of narcotics for postoperative analgesia increases the risk of lung morbidity.

Postoperative hypoxaemia in the absence of hypoventilation has been observed by many investigators and is most marked following upper abdominal and thoracic surgery (Diament and Palmer, 1966). In the first few hours after operation, hypoxaemia is thought to be due chiefly to regional misalignment of ventilation and perfusion (Nunn and Payne, 1962; Conway and Payne, 1963). Diament and Palmer (1967) have shown that, by the end of 24 hours, frank shunting of blood past closed alveoli is the dominant factor, although a ventilation/perfusion component may be demonstrated (Georg, Hornum and Mellemgaard, 1967). It is known that these derangements need not be accompanied by radiological changes in the lung (Bendixen, Hedley-Whyte and Laver, 1963; Hamilton et al., 1964).

Although the factors which produce postoperative alveolar collapse are not fully evaluated, it is widely assumed that pain plays an important role by impairing coughing, limiting lung expansion (Beecher, 1933; Schwartz, Dale and Rahn, 1957; Mead and Collier, 1959) and reducing functional residual capacity (Anscombe, 1957). It is a matter of everyday observation that opiate analgesia, although administratively simple and therefore commonly used, may not produce complete pain relief. Continuous extradural nerve block has been shown to produce complete analgesia (Simpson et al., 1961) and to facilitate better lung expansion (Bromage, 1955), but is time-consuming and demands special skill. This study was designed to compare the effect of these two approaches to postoperative pain relief on lung function with special reference to arterial oxygenation.

PATIENTS AND METHODS

Investigations were made on 21 male patients in the age range 21–50 years, scheduled for vagotomy with gastroenterostomy or pyloroplasty, but otherwise in good health and within ± 10 per cent of the expected body weight.

The patients were given morphine 10 mg, atropine 0.6 mg and droperidol 5 mg, 1 hour before operation. Anaesthesia was induced with thiopentone followed by suxamethonium and, after orotracheal intubation, maintained with nitrous oxide, supplemented by morphine 10 mg and tubocurarine. At the end of anaesthesia, the tubocurarine was reversed with neostigmine combined with atropine. Extubation was preceded by bronchial and pharyngeal suction using a Pinkerton catheter.

The operation was performed through a standard right paramedian incision. All patients came from the same surgical unit and were nursed in the same ward. At the end of each operation, the patient was allocated randomly to one of two postoperative analgesic regimes:

1. Morphine 10 mg by intramuscular injection given on demand by the Sister or Senior Ward Staff Nurse. [The mean dose of morphine was 26 mg (range 20–30 mg) on day 1 and 18 mg (range 10–20 mg) on day 2.]
(2) Continuous extradural spinal nerve block administered by investigators.

At the completion of the operation, but before the end of anaesthesia, a catheter was inserted in the thoracic extradural space through the T7–8 interspace. For 48 hours after operation, bupivacaine 0.5 per cent (with adrenaline 1:300,030) was injected intermittently to achieve a block of the wound segments. In practice, the blocks achieved loss of pinprick sensation from segments T4 to T12. The volume of each injection was usually in the range 5–7 ml and repeat injections were made every 2 hours approximately. Criteria for repeat injections were subjective discomfort or the return of pinprick sensation.

All patients had routine chest physiotherapy once per day after operation. This consisted of diaphragmatic breathing, lower costal breathing, percussion-assisted drainage and assisted coughing. The whole procedure lasted for about 20 minutes. If on clinical grounds those in charge of the patient considered that postoperative pneumonia had occurred, physiotherapy was increased in frequency and antibiotics were administered. In this context, chest infection was defined as:

(a) pyrexia of more than 5 hours duration accompanied by progressive auscultatory changes, or
(b) radiological changes, or
(c) purulent sputum plus pyrexia.

In fact, where such a decision was reached, more than one of the prearranged criteria were present.

INVESTIGATIONS OF PULMONARY FUNCTION

Pre-operatively and on days 1, 2 and 5 after operation, the following were carried out:

(1) Chest X-ray.
(2) Arterial blood analysis: \( P_{\text{aO}_2}, P_{\text{aCO}_2} \) and pH.
(3) Expired gas analysis; volume (VE), respiratory frequency (f), fractional concentration of oxygen and carbon dioxide.
(4) Spirometry: vital capacity and timed forced vital capacity.

Blood sampling and gas collection were performed simultaneously. All patients breathed room air at all times. Alveolar-arterial \( P_{\text{aO}_2} \) difference [A–a \( D_{\text{O}_2} \) (mm Hg)] was calculated as follows:

\[
A-a \ D_{\text{O}_2} = P_{\text{aO}_2} - P_{\text{aO}_2} \]

where \( P_{\text{aO}_2} = P_{\text{tO}_2} - P_{\text{aCO}_2} \left( \frac{F_{\text{tO}_2} - F_{\text{CO}_2}}{F_{\text{CO}_2}} \right) \)

(Filley, MacIntosh and Wright, 1954)

Physiological deadspace (\( V_d \)) was calculated using the Bohr equation and was expressed as a fraction of tidal volume (\( V_t \)). All blood-gas values were corrected, where necessary, for temperature using the nomograms of Kelman and Nunn (1966). Pulmonary function tests were performed in an identical order and manner for all patients studied. All tests were made by the investigators. During tests, the patients were in the sitting position.

RESULTS

Table I presents details of the patients studied. At 48 hours after operation, 7 of the 10 patients in the morphine group and 2 of 11 in the extradural group had a postoperative pneumonia.

Table II shows the results of the blood gas measurements together with calculated values for A–a \( D_{\text{O}_2} \), oxygen consumption (\( V_{\text{O}_2} \)) and carbon dioxide output (\( V_{\text{CO}_2} \)). In terms of A–a \( D_{\text{O}_2} \), there is a significant difference between the two groups on day 1 (\( P<0.02 \)), day 2 (\( P<0.01 \)) and day 5 (\( P=0.01 \)) after operation. By day 5, the mean value of the extradural group had returned to the pre-operative level, whereas the morphine group still showed evidence of hypoxaemia (mean A–a \( D_{\text{O}_2} = 25 \) mm Hg). Parallel changes occurred in arterial \( P_{\text{aO}_2} \) measurements. There was no important difference between the groups in arterial \( P_{\text{CO}_2} \) measurements in the first two postoperative days, although the mean values after operation were lower than before operation. On day 5, the mean value for the extradural group was significantly higher than the mean value for the morphine group (\( P<0.05 \)).

An apparent fall in mean \( V_{\text{O}_2} \) and \( V_{\text{CO}_2} \) in the extradural group on postoperative days 1 and 2 (i.e. during the period of the block) was not statistically significant when compared with the pre-operative mean for that group or the corresponding values for the morphine group.

Table III lists the results of spirometry together with calculated \( V_d/V_t \) ratios and FEV\(_1\)/FVC per cent. The first two postoperative days were characterized by a fall in tidal volume with an
TABLE I

Mean age, height and weight, smoking habits and incidence of postoperative pneumonia for the two
patient groups studied. Standard errors of the mean are given where appropriate.

<table>
<thead>
<tr>
<th>Treatment group</th>
<th>Number</th>
<th>Age (yr)</th>
<th>Height (cm)</th>
<th>Weight (kg)</th>
<th>Ratio smokers : non-smokers</th>
<th>Postoperative pneumonia</th>
</tr>
</thead>
<tbody>
<tr>
<td>Morphine</td>
<td>10</td>
<td>37 ± 3.4</td>
<td>175 ± 1.1</td>
<td>62 ± 3.5</td>
<td>9 : 1</td>
<td>7</td>
</tr>
<tr>
<td>Extradural</td>
<td>11</td>
<td>42 ± 3.7</td>
<td>176 ± 1.4</td>
<td>66 ± 2.3</td>
<td>10 : 1</td>
<td>2</td>
</tr>
</tbody>
</table>

TABLE II

Arterial Po₂ and Pco₂, alveolar-arterial Po₂ difference, oxygen consumption and carbon dioxide output.
Mean values and standard errors of the mean for morphine (M) and extradural (E) patient groups.

<table>
<thead>
<tr>
<th>Time of measurement</th>
<th>PaO₂ (mm Hg)</th>
<th>PaCO₂ (mm Hg)</th>
<th>A-a Do₂ (mm Hg)</th>
<th>V̇O₂ (ml STPD/ min)</th>
<th>V̇CO₂ (ml STPD/ min)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M E</td>
<td>M E</td>
<td>M E</td>
<td>M E</td>
<td>M E</td>
</tr>
<tr>
<td>Before operation</td>
<td>93.0 ± 3.0</td>
<td>94.8 ± 4.0</td>
<td>37.1 ± 1.0</td>
<td>38.3 ± 0.9</td>
<td>7.8 ± 2.9</td>
</tr>
<tr>
<td>Postop. day 1</td>
<td>69.3 ± 4.4</td>
<td>82.8 ± 2.3</td>
<td>35.2 ± 1.0</td>
<td>34.1 ± 0.9</td>
<td>33.3 ± 4.9</td>
</tr>
<tr>
<td>Postop. day 2</td>
<td>68.0 ± 3.2</td>
<td>81.6 ± 3.4</td>
<td>35.1 ± 1.0</td>
<td>33.7 ± 0.9</td>
<td>35.7 ± 3.3</td>
</tr>
<tr>
<td>Postop. day 5</td>
<td>83.5 ± 5.4</td>
<td>92.3 ± 3.3</td>
<td>33.1 ± 1.2</td>
<td>36.3 ± 0.3</td>
<td>25.3 ± 6.6</td>
</tr>
</tbody>
</table>

increase in minute volume and respiratory frequency which were similar in magnitude for both
groups. The mean frequency of 20.7 in the morphine group on day 2 was significantly higher than
the corresponding mean of 16.5 in the extradural group (0.05>P>0.025). There was no significant
change in Vd/Vt throughout the study.

Both groups had a marked reduction in vital
capacity following operation which, although im-
proving, had not returned to the pre-operative
values by day 5. There was no significant dif-
ference between the groups for any vital capacity
measurement. The mean values for FEV₁/FVC
per cent decreased following operation in the
morphine group but increased slightly in the
extradural group. The difference between the
groups was significantly different on day 2
(P<0.01).

X-ray appearances of the lungs did not relate
to the degree of hypoxaemia, although evidence of
consolidation was found in some of the patients
with clinical evidence of pneumonia. After opera-
tion, all patients showed radiological evidence of
gas under the diaphragm which was absorbed
slowly, although still detectable on X-ray at
day 5.

DISCUSSION

In this study, we have compared a conventional
method of therapy for postoperative pain (mor-
phine 10 mg by injection) with extradural block—
a method known to abolish pain. We chose
patients having upper abdominal incisions because
earlier unpublished observations by one of us
(A.A.S.) had established that this group had the
highest incidence of postoperative pain and that
pain was more or less continuous throughout 48
hours following operation. We attempted to
standardize as far as possible all other factors
which might influence postoperative lung morbidity: weight, age, medical history, smoking habits
and abdominal incision.

The patients who had extradural analgesia were
significantly better in terms of clinical assessment
and arterial oxygenation than those who had mor-
phine. In 1968 Muneyuki and his colleagues also
studying patients for upper abdominal surgery, compared the effect of extradural nerve block with intravenous pethidine carefully “titrated” against the patients’ pain state. Although their study ended at 15 hours after operation, their results may be compared with our findings on day 1. They found no significant difference between extradural block and pethidine in terms of $PAO_2$ and $A-a Do_2$. The mean values for $PAO_2$ (86.6 mm Hg) and $A-a Do_2$ (17.9 mm Hg) in their extradural group are very close to the findings which we report (table II). On an equipotent basis, the dose of narcotic employed by us was approximately nine times that of Muneyuki and his colleagues. Therefore, we conclude that our study highlights the unsatisfactory consequences of the conventional large doses of narcotics in the postoperative period.

By the use of intravenous isotonic solutions, we were able to ensure that the extradural patients did not become hypotensive as a consequence of the technique. There exists the possibility that disturbance of the ventilation perfusion relationship in the lung may be aggravated in patients who have a partial sympathetic block. Although there is no evidence that this is an important factor in the supine patient (de Jong, 1965), it should be pointed out that our patients were sitting up after operation. The absence of a significant change in $Vd/Vt$ during the period of the block is not in keeping with this hypothesis.

We were surprised to find that the postoperative changes in vital capacity were similar in both groups. The order of the changes which we found in the morphine group have been reported previously (Anscombe, 1957). Other workers have described a sparing effect of extradural analgesia on the vital capacity (Bromage, 1955; Simpson et al., 1961), although in both of these studies the selection of patients was less rigorous than in the present study. A possible explanation of our findings is that extradural block may produce considerable, if not complete, motor function loss in the affected segments. Since the lower intercostal and upper abdominal muscles are expiratory in function, there must have been a considerable reduction in expiratory reserve volume. Unfortunately, this was not measured.

Our investigations ended on the 5th postoperative day, by which time most of the patients were regarded as being sufficiently recovered for transfer to convalescence. It is disturbing that the morphine group, at this stage, still exhibited hypoxaemia sufficient to suggest an approximate 10 per cent increase in intrapulmonary shunting. We consider that this prolonged hypoxaemia and the possibility of long-term morbidity arising from such postoperative lung changes merit further attention.

Our radiological studies have confirmed the findings of previous workers that considerable hypoxaemia may exist without detectable X-ray changes. The presence of gas under the diaphragm was an incidental finding and was so consistent that we cannot at present assess its effect. Bevan

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**TABLE III**

Tidal and minute volumes, respiratory frequency, deadspace/tidal volume ratio, vital capacity and $FEV_1/FVC$ per cent. Mean values and standard errors of the mean for morphine (M) and extradural (E) patient groups. All gas volumes at BTPS.

<table>
<thead>
<tr>
<th>Time of measurement</th>
<th>$V_t$ (ml)</th>
<th>$V_e$ (ml)</th>
<th>Frequency (b.p.m.)</th>
<th>$Vd/Vt$</th>
<th>Vital capacity (ml)</th>
<th>$FEV_1/FVC$ per cent</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>E</td>
<td>M</td>
<td>E</td>
<td>M</td>
<td>E</td>
</tr>
<tr>
<td>Before operation</td>
<td>630 ± 56</td>
<td>667 ± 125</td>
<td>6221 ± 561</td>
<td>7140 ± 799</td>
<td>13.5 ± 0.9</td>
<td>14.0 ± 1.2</td>
</tr>
<tr>
<td>Postop. day 1</td>
<td>478 ± 32</td>
<td>559 ± 75</td>
<td>9976 ± 972</td>
<td>8423 ± 600</td>
<td>21.1 ± 1.9</td>
<td>16.9 ± 1.6</td>
</tr>
<tr>
<td>Postop. day 2</td>
<td>519 ± 40</td>
<td>542 ± 64</td>
<td>10345 ± 803</td>
<td>8146 ± 546</td>
<td>20.7 ± 1.6</td>
<td>16.5 ± 1.6</td>
</tr>
<tr>
<td>Postop. day 5</td>
<td>659 ± 68</td>
<td>642 ± 102</td>
<td>9165 ± 704</td>
<td>7598 ± 360</td>
<td>15.2 ± 1.5</td>
<td>13.6 ± 1.3</td>
</tr>
</tbody>
</table>
concluded that pneumoperitoneum may be a cause of postoperative pneumonia.

In conclusion, we have shown that the analgesic regime may influence the pattern of postoperative hypoxaemia. Although we accept that the widespread use of continuous extradural nerve block in routine practice is not always feasible, we would advocate that analgesic techniques should be assessed not only in terms of the subjective relief which the patient experiences but also their effect in reducing lung morbidity.

REFERENCES


