RANDOMIZED CONTROLLED TRIAL OF PHYSIOTHERAPY FOR POSTOPERATIVE PULMONARY COMPLICATIONS

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SUMMARY

A prospective randomized controlled trial was conducted in patients undergoing elective cholecystectomy to assess the value of routine chest physiotherapy. One hundred and two patients entered the study: 47 patients developed no pulmonary complications, 29 had pulmonary atelectasis and a further 26 developed chest infection. The pattern of changes in arterial oxygen tension in the period after operation supported the clinical allocation of the patients. Of 51 patients not receiving physiotherapy, 11 developed atelectasis and 19 chest infection. Of 51 treated patients, 18 developed atelectasis and seven chest infection. Routine prophylactic postoperative chest physiotherapy decreased significantly the frequency of chest infection \((P < 0.02)\).

Pulmonary complications occur in the period after operation in 30–70\% of patients undergoing upper abdominal surgery (Wightman, 1968; Hansen, Drablos and Steinert, 1977; Morran and McArdle, 1980). Inability to cough because of wound pain, elevation of the diaphragm and retention of secretions may lead to patchy atelectasis, particularly in smokers, the obese and those with a history of respiratory disease. Chest infection by \textit{Haemophilus influenzae} and \textit{Streptococcus pneumoniae} may supervene (Philp and Spencer, 1974; Wilkinson et al., 1977).

Although chest physiotherapy is advocated widely to prevent the development of pulmonary complications, its value remains unproven (Leading Article, 1977, 1978; Jones, 1974) and those trials which have been conducted have been either uncontrolled (Thoren, 1954) or have failed to demonstrate clinical benefit (Palmer and Sellick, 1952; Nichols and Howell, 1970; Lord, Hiebert and Francis, 1972).

We report the results of a prospective randomized clinical trial designed to evaluate the effect of routine chest physiotherapy on the frequency of pulmonary complications following upper abdominal surgery.

PATIENTS AND METHODS

Consecutive patients undergoing elective cholecystectomy were included in the study. Respiratory status was established before operation using a questionnaire based on the MRC Respiratory Assessment Protocol (Medical Research Council, 1976), clinical examination and chest radiography. Samples of arterial blood were obtained and blood-gas analysis performed within 30 min (Radiometer ABL2).

Anaesthesia was induced in all patients with thiopentone and intermittent positive pressure ventilation instituted. Anaesthesia was maintained with inhalation agents supplemented by narcotic analgesia i.v. as required. The choice of incision and operative technique were at the discretion of the surgeon. Drainage of the gall-bladder bed was performed in all patients following surgery. The choice of postoperative analgesia was at the discretion of the anaesthetist. Patients were allocated randomly to receive either no prophylactic physiotherapy or routine chest physiotherapy in the period after operation. Chest physiotherapy consisted of 15 min breathing exercises (6 min diaphragmatic, 6 min lateral costal and 3 min apical) with assisted coughing and vibration of the chest wall. Therapy was instituted on the 1st day after operation and continued for a minimum of 2 days or until clinical signs had resolved. Both groups were encouraged to breathe deeply and cough by nursing and medical staff.

Patients were assessed daily during the postoperative period by a single observer and allocated to one of three clinical groups—no pulmonary complications, pulmonary atelectasis or chest infection. Pulmonary atelectasis was defined as pyrexia, production of sputum, clinical and radiological evidence of collapse. Chest infection was defined as pyrexia, production of purulent sputum, clinical signs of infection and radiological evidence of collapse per-
sisting for more than 72 h. Arterial blood-gas analysis was performed in the morning, before any physiotherapy, on the first 4 days following operation and the results recorded separately. Sputum was obtained when available for bacteriological culture. Patients in the control group who developed chest infection were given physiotherapy. Antibiotics were given at the discretion of the surgeon involved.

Comparison of the results of blood-gas analysis within the groups and between the groups was performed using paired and unpaired t tests respectively. Age and duration of surgery were compared using Mann–Whitney U test. Analysis of differences in qualitative factors was performed using Chi square test with Yates correction. The study was approved by the hospital Ethics committee and informed consent was obtained from all patients.

RESULTS

One hundred and two patients were included in the study. As judged by the clinical criteria described, 47 patients had no pulmonary complications after operation, 29 developed pulmonary atelectasis and a further 26 developed chest infection.

The mean arterial oxygen tensions in the three groups were not significantly different before surgery (table I). In patients with no pulmonary complications following surgery, mean arterial oxygen tension decreased from 11.6±0.3 kPa (mean ± SEM) to 9.9±0.3 kPa on the 1st day after operation (P<0.001) and remained significantly lower throughout the 4 days of study (P<0.001). Comparison of patients with and without postoperative pulmonary complications showed that the mean arterial oxygen tensions in patients with complications decreased further during the first 2 days after operation (P<0.001). In patients who developed chest infection, mean arterial oxygen tension remained significantly less than in the uncomplicated group throughout the period of study (P<0.001).

In patients with no pulmonary complications after operation and those who developed pulmonary atelectasis, bacteriological culture of sputum yielded only upper respiratory tract commensals (table II). Haemophilus influenzae or Streptococcus pneumoniae were obtained from the sputum of 15 of the 16 patients with chest infection in whom sputum cultures were available.

There was no significant difference between the treated and untreated groups in terms of age, clinical evidence of obesity, smoking habits, respiratory status and arterial oxygen tensions before operation, type of incision and duration of surgery (table III). Two patients in each group received prophylactic antibiotics. There were no major differences between the groups in the choice and amount of analgesia after surgery. Thirteen patients in the control group and six in the treated group received antibiotics in the postoperative period.

Of 51 patients in the untreated group, 11 developed pulmonary atelectasis and 19 chest infection (table IV). Of 51 patients receiving routine postoperative chest physiotherapy, 18 developed pulmonary atelectasis and seven chest infection. The decrease in the frequency of chest infection was significant (P<0.02).

There was no significant difference in the mean arterial oxygen tensions between the control and treated group on the first 4 days after operation. In the control group, nine of 20 obese patients developed a chest infection as opposed to one of 17 in the physiotherapy group (P<0.05). In the control group 13 of 29 smokers developed a chest infection compared with six out of 28 in the treated group.

### Table I. Arterial oxygen tensions (kPa) (mean±SEM). *P<0.001, unpaired Student's t test comparing no pulmonary complications with chest infection

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<th>Before operation</th>
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</thead>
<tbody>
<tr>
<td>No pulmonary complication (n=47)</td>
<td>11.6±0.3</td>
<td>9.9±0.3*</td>
<td>10.1±0.3*</td>
<td>10.5±0.3*</td>
<td>10.9±0.3*</td>
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<tr>
<td>Pulmonary atelectasis (n=29)</td>
<td>10.8±0.3</td>
<td>8.1±0.3</td>
<td>8.1±0.3</td>
<td>9.1±0.3</td>
<td>9.7±0.3</td>
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<tr>
<td>Chest infection (n=26)</td>
<td>11.2±0.3</td>
<td>8.0±0.3*</td>
<td>8.3±0.3*</td>
<td>8.5±0.3*</td>
<td>8.7±0.3*</td>
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DISCUSSION

Routine prophylactic chest physiotherapy has been considered important in the prevention and management of pulmonary complications after abdominal surgery. The evidence to support this belief remains unconvincing and the value of chest physiotherapy in this context has been challenged (Leading Article, 1977; 1978; Jones, 1974).

A number of prospective randomized studies have assessed the effect of routine postoperative physiotherapy on the frequency of pulmonary complications. Palmer and Sellick (1952) found that routine chest physiotherapy conferred no benefit to patients undergoing lower abdominal surgery, conclusions in keeping with those of Nichols and Howell (1970). In patients undergoing upper abdominal surgery, Lord, Hiebert and Francis (1972) found that physiotherapy was not of value despite a small but not significant decrease in chest complications after lower abdominal surgery. In a study of two groups of patients undergoing elective cholecystectomy, one of which received chest physiotherapy, postural drainage and hourly breathing exercises, Thoren (1954) found that the frequency of pulmonary complications was 30% in patients not receiving physiotherapy and 12% in the treated group and concluded that frequent physiotherapy decreased pulmonary complications following surgery. However, the study was not randomized, there was no indication whether the groups were comparable for known risk factors, and the patients were drawn from two different populations. Subsequent randomized prospective studies confirmed that intensive physiotherapy, including postural drainage and bronchodilator therapy, decreased the frequency of pulmonary complications and improved respiratory function in patients undergoing lower abdominal surgery (Palmer and Sellick, 1953; Spence, 1980). However, intensive chest physiotherapy is seldom utilized in clinical practice.

The results of the present study support the widely held clinical belief that routine prophylactic physiotherapy decreases the frequency of postoperative chest infection. Previous studies may have failed to demonstrate benefit because of the low frequency of postoperative pulmonary complications after lower abdominal surgery and because investigators failed to distinguishatelectasis from chest infection. In our study of patients undergoing cholecystectomy, the high frequency of pulmonary complications and allocation of patients to three clinical groups allowed us to differentiate between the nature and severity of pulmonary complications after operation.

Hypoxaemia as a result of ventilation-perfusion

<table>
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<th>TABLE IV. Pulmonary complications. ( P &lt; 0.02 )</th>
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<td>No. of patients</td>
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<td>No. of patients</td>
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<td>No pulmonary complication</td>
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<td>Pulmonary atelectasis</td>
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<td>Chest infection</td>
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inequality and shunting of blood through un aerated alveoli is a feature of the postoperative period. Significant atelectasis or infection is likely to produce increased shunting and accentuate further the decrease in arterial oxygen tension. In this study, mean arterial oxygen tensions further decreased significantly on the 1st and 2nd days after operation in patients who were considered, on the basis of clinical criteria, to have developed post-operative pulmonary complications. In patients with chest infection, significant arterial hypoxaemia persisted until the 4th day following surgery. Thus, the pattern of blood-gas changes in the period after operation supported the clinical allocation of the patients to three groups. The presence of *Haemophilus influenzae* and *Streptococcus pneumoniae* in the sputum of patients with chest infection provided further confirmation of the clinical assessment.

Bronchial secretions are removed continuously from the lung periphery by ciliary action. The cough mechanism can mobilize sputum from the large airways down to the sixth generation of bronchi. Using radio-labelled microspheres, Bateman and colleagues (1979) demonstrated that physiotherapy resulted in improved clearance of bronchial secretions from the lung periphery to more proximal bronchi, thus aiding expectoration. In patients with bronchiectasis, Cochrane, Webber and Clarke (1977) showed that, following physiotherapy, patients produced large amounts of sputum, removal of which resulted in improvement in pulmonary function.

In this study the frequency of postoperative pulmonary complications was similar in both groups. Anaesthesia, elevation of the diaphragm, wound pain and restricted coughing, and small airway closure may initiate changes leading to atelectasis. It would be unrealistic to expect routine postoperative physiotherapy to influence these changes. Nevertheless, the frequency of chest infection was decreased in the treated group, suggesting that routine physiotherapy prevented progression of atelectasis to chest infection.

ACKNOWLEDGEMENTS

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REFERENCES


Medical Research Council (1976). Committee on research into chronic bronchitis. Questionnaire on respiratory symptoms and instructions for its use. London: Medical Research Council.


ESSAI ALEATOIRE CONTROLE DE KINESITHERAPIE RESPIRATOIRE POUR LES COMPLICATIONS PULMONAIRES POST-OPERATOIRES

RESUME
Un essai aléatoire prospectif contrôlé a été conduit chez des patients subissant une cholecystectomie en chirurgie réglée pour étudier la valeur de la kinésithérapie respiratoire de principe. Cent deux patients sont entrés dans l’étude: 47 patients n’ont eu aucune complication respiratoire, 29 ont eu une atélectasie pulmonaire et 26 autres ont fait une pneumopathie infectieuse. Les variations de la pression partielle en oxygène artériel dans la période post-opératoire concordaient avec l’état clinique des patients. Sur 51 patients qui n’avaient pas reçu de kinésithérapie respiratoire, 11 ont développé une atélectasie et 19 une pneumopathie infectieuse. Sur 51 patients traités, 18 ont développé une atélectasie et sept une pneumopathie infectieuse. La kinésithérapie respiratoire prophylactique systématique dans la période post-opératoire a diminué de façon significative la fréquence des pneumopathies infectieuses (P<0,02).

RANDOMISIERTER KONTROLLIERTER VERSUCH MIT PHYSIOTHERAPIE GEGEN POSTOPERATIVE PULMONALE KOMPLIKATIONEN

ZUSAMMENFASSUNG

ENSAYO CONTROLADO AL AZAR DE FISIOTERAPIA PARA COMPLICACIONES PULMONARIAS POSTOPERATORIAS

SUMARIO
En pacientes sometidos a una colecistectomía electiva, se llevó a cabo un ensayo controlado al azar en perspectiva con el objeto de evaluar la fisioterapia pulmonar de rutina. El estudio incluía ciento y dos pacientes: 47 pacientes no sufrieron complicación pulmonar alguna, 29 tuvieron atelectasias pulmonares y unos 26 desarrollaron una infección pulmonar. La forma de los cambios de tensión de oxígeno arterial durante el periodo postoperatorio después de la operación correspondió a la asignación clínica de los pacientes. De los 51 pacientes que no fueron sometidos a fisioterapia, 11 tuvieron atelectasias y 19 una infección pulmonar. De los 51 pacientes sometidos al tratamiento, 18 sufrieron de atelectasia y siete una infección pulmonar. La fisioterapia pulmonar postoperatoria profiláctica de rutina redujo de manera significante la frecuencia e incidencia de la infección pulmonar (P<0,02).