Acute Lobar Atelectasis
A Comparison of Two Chest Physiotherapy Regimens


Fourteen cases of acute lobar atelectasis were alternately allocated to one of two chest physiotherapy regimens for treatment. Treatment in group 1 comprised positioning, vibrations, hyperinflation, and suction, and in group 2, treatment consisted of hyperinflation and suction alone. Treatment in either group was given hourly for six hours. Patients in group 1 had a significantly higher mean percentage resolution of their atelectasis (mean value, 60.1 percent), as seen on chest roentgenogram, after one treatment intervention than patients in group 2 (mean value, 7.6 percent; p<.006). After the intensive six-hour treatment period, the difference between the groups was marginally statistically significant, still favoring group 1 over group 2 (p<.055). Follow-up roentgenograms at 24 and 48 hours revealed no significant difference between the treatment groups (p>.10 and >.20, respectively). These results suggest that, at least initially in the course of acute lobar atelectasis, positioning and vibrations add to the efficacy of a treatment of hyperinflation and suction alone.

(Chest 1990; 98:1336-40)

Acute lobar atelectasis is frequently encountered in the critically ill patient. Because of the potential complications of persistent atelectasis, including hypoxemia, bronchopulmonary infection, and pulmonary fibrosis, an aggressive approach toward its treatment has been advocated.\(^1\)\(^2\)

Marini et al\(^3\) found that initial fiberoptic bronchoscopy with suction did not add to the efficacy of chest physiotherapy in the treatment of acute lobar atelectasis. The physiotherapy treatment used by these authors incorporated postural drainage, percussion, hyperinflation or deep breathing, and suction or coughing. An important question that follows is which components of physiotherapy are effective in the treatment of acute lobar atelectasis. Preliminary investigations by Johnson et al\(^4\) found that postural drainage and percussion did not add to the efficacy of a treatment of deep breathing and coughing.\(^4\) We decided to investigate this question with other critically ill patients, who were either spontaneously ventilating or mechanically ventilated, to see if a multimodality physiotherapy treatment was more effective than a simple physiotherapy treatment.

**Materials and Methods**

**Patients**

Any patient admitted with or who had developed acute lobar atelectasis while in the Intensive Care Unit or High Dependency Unit of the Royal Adelaide Hospital was included in the study. Acute lobar atelectasis, which was diagnosed by two radiologists from chest roentgenograms, was defined as "volume loss conforming to a characteristic pattern (radiographic density, fissure displacement, mediastinal shift, diaphragmatic elevation, and compensatory hyperinflation).\(^5\)\(^6\) Patients were excluded if they had any condition that prevented them lying supine, if any pathologic process on the involved side of the lung prevented reading of the chest roentgenogram, or if lung collapse was secondary to incorrect placement of endotracheal tube or tracheostomy tube. As the treatment for nonintubated patients required their cooperation, nonintubated patients with a decreased conscious state were excluded.

Patients who satisfied the inclusion criteria were allocated in an alternate fashion to one of two treatment groups to ensure equal numbers in either group. The study was approved by the Human Ethics Committee of the Royal Adelaide Hospital.

**Treatment Groups**

**Group 1:** Treatment for this group incorporated positioning, vibrations, hyperinflation (or deep breathing), and suction (or coughing).

Positioning involved placing the patient in flat side lying with the involved lung uppermost (or supine to avoid prolonged lying in one position). This position was maintained for at least 20 minutes. With the patient in this position, manual vibrations to the chest wall overlying the involved area were performed during expiration for five minutes prior to suction. For intubated patients, hyperinflation, in groups of six to eight inflations using a 2-L anesthesia bag (FIO\(_2\) = 1.0) was given for approximately two minutes prior to and between each suction procedure, with each hyperinflation held at full inflation for up to 5 s. Nonintubated patients were encouraged to breathe to their maximal volume (in a pattern similar to the hyperinflation procedure) prior to and between each coughing and huffing procedure. Suction or coughing continued until all secretions were cleared at any one time. Nasotracheal suction was performed by an Intensive Care staff specialist on nonintubated patients whose cough was ineffective.

**Group 2:** Treatment for this group consisted of hyperinflation (or deep breathing) and suction (or coughing). These techniques were performed in a similar manner to those techniques described for group 1.

Treatment in either group was begun as soon as possible after diagnosis of acute lobar atelectasis and was given hourly for six
hours. If more than two hours had elapsed since the initial chest roentgenogram, another was obtained to ensure the atelectasis had not resolved spontaneously. One physiotherapist (K.S.) supervised the positioning, hyperinflation, deep breathing and coughing and performed the vibrations and suction (except nasotracheal suction) throughout the 6-h period for all patients.

Poststudy Treatment: Following this intensive 6-h treatment period, therapy reverted to that routinely used. For intubated patients, this comprised two hourly suction after approximately 20 minutes of flat-side lying (right or left side alternately uppermost from one suction session to the next). Routine treatment for nonintubated patients involved deep breathing and coughing exercises every 2 h, with no specific positioning employed.

Measurement

Portable chest roentgenograms were obtained following the first treatment intervention and the 6 h intensive treatment period. In addition, whenever possible, roentgenograms were taken at 24 and 48 hours. Roentgenograms were evaluated by two radiologists who were blind to the patient's identity, general condition, and treatment group, in the manner described by Marini et al.6

Arterial blood gases were taken at entry into the study, at the end of the 6-h intensive treatment period, and at 24 and 48 hours. The maximal lung volume (to the nearest 50 ml) achieved during the hyperinflation procedure or deep breathing was recorded using a Wright's spirometer during the first and last treatments in the 6-h period. Other observations made during the 6-h treatment period were the intubation/ventilation status, volume of sputum obtained (to the nearest 5 ml), patient temperature, medical and surgical status, conscious state, and drugs administered. White blood cell count was measured on the day of entry into the study and at 24 and 48 hours. A sample of sputum was cultured. All of these measurements and tests were taken by appropriately qualified staff not directly involved in the study and were analyzed in the routine manner.

Statistical Analysis

All analyses were made using the analysis of variance (ANOVA).

As the usual assumptions underlying standard ANOVA calculations did not hold for many of the measurements (eg, normal distribution), the p values quoted are approximate.

Examiner Reliability Study

To investigate intraexaminer and interexaminer reliability, the two radiologists independently assigned scores to a series of 30 chest roentgenograms with evidence of complete or resolving acute lobar atelectasis and repeated this procedure two weeks later with the same roentgenograms. Acceptable intraexaminer agreement (within 10 percent of each other) was found on 89 percent of occasions for radiologist 1 and 87 percent of occasions for radiologist 2. Interexaminer agreement was 88 percent.

RESULTS

Fourteen cases of acute lobar atelectasis (three women, 11 men) were studied between November 13, 1987 and June 14, 1989, seven in each group. Two patients were included in the study twice, each occasion separated from the other by a period of days. In all cases, the lobar atelectasis was not present on a roentgenogram taken within the previous 48 hours. In one case, the initial diagnostic roentgenogram was taken for investigation of clinical deterioration (hypoxemia, fever). In the other 13 cases, the atelectasis was detected on a routine daily chest roentgenogram, although there was associated clinical deterioration in eight of these cases (hypoxemia, fever, or raised white blood cell count). Ten patients had to be excluded from the study because positioning in flat-side lying was contraindicated owing to spinal or head injury.

Descriptive data for patients included in the study can be found in Table 1. The mean patient age was 36.9 years (range, 18 to 66 years). Eleven of the 14

<table>
<thead>
<tr>
<th>Patient No./ Sex/Age, yr</th>
<th>Primary Diagnosis</th>
<th>Medical History</th>
<th>Treatment Group</th>
<th>Area Involved</th>
<th>Air Bronchogram</th>
<th>Intubation/ Ventilation Status</th>
<th>Sputum</th>
<th>Improvement at 6 h, %</th>
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<tbody>
<tr>
<td>1/F/22</td>
<td>Post upper abdominal surgery</td>
<td>Smoker</td>
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<td>ni/sv</td>
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<td>ii/ippv</td>
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<td>100</td>
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<td>–</td>
<td>ii/ippv</td>
<td>5</td>
<td>100</td>
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<td>ii/ippv</td>
<td>0</td>
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<td>10/A/18</td>
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<td>L LL</td>
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</table>

MVA = motor vehicle accident; SAH = subarachnoid hemorrhage; R lung = right lung; L lung = left lung; RUL = right upper lobe; RLL = right lower lobe; LLL = left lower lobe; ni = not intubated; i = intubated; sv = spontaneous ventilation; ippv = intermittent positive pressure ventilation.
patients were intubated, nine of these receiving intermittent positive pressure ventilation. The two groups were similar with respect to age, sex, and intubation/ventilation status, although group 2 patients were somewhat younger than group 1 patients (mean age, 45.3 and 28.4 years for group 1 and 2, respectively, p>.07). Two patients were not followed up for the entire 48-h period—one patient in group 1 died of nonrespiratory complications at 24 hours, one patient in group 2 did not have a roentgenogram at 48 hours. Their data prior to these times have been included in the analysis of results. Of the three nonintubated patients (Table 1), two required nasotracheal suction at least once during the intensive 6-h treatment period as they were deemed to have an ineffective cough.

Figure 1 compares the mean percentage of resolution in patients allocated to groups 1 and 2. Patients in group 1 had a significantly greater resolution of atelectasis (mean value, 60.1 percent) than patients in group 2 (mean value, 7.6 percent) after one treatment intervention (p<.006). After the 6-h intensive treatment period, the difference between the two groups was marginally statistically significant (p<.055), favoring group 1 over group 2. The difference between the groups became less apparent at 24 and 48 hours (p>.10 and >.20, respectively) (Fig 1).

As the sample group was small, individual results of patients have been included (Fig 2). Although it can be seen that there was some variability in the response of patients, it is still evident that the majority of patients in group 1 achieved most of their improvement after one treatment, whereas patients in group 2 were somewhat more variable over the entire 48 hour period.

The effect of the intubation status on the rate of resolution of atelectasis is shown in Figure 3. Statistical analysis was not performed on these data owing to lack of numbers.
Lung volume measured during hyperinflation (or deep breathing) increased significantly from the first treatment intervention to the end of the 6-h treatment period when all patients were considered together (p<.01; mean increase, 230 ml). There was no significant difference between groups in this measurement. Although patient temperature was not significantly different between the two groups at entry into the study (group 1 mean, 37.9°C; group 2 mean, 37.6°C; p>.40), the change in patient temperature from the first to last treatment in the 6-h treatment period did differ significantly between group 1 and 2 (−0.18°C and +0.37°C, respectively; p<.05).

For all the other data collected, no significant differences were detected either for the patients as a whole or between the two treatment groups. In particular, arterial blood gas levels did not show a consistent change in either treatment group over the 6-h treatment period (mean change in PaO_2 for group 1: +25 mm Hg; group 2: −31 mm Hg; p>.07; mean change in PaCO_2 for group 1: −2 mm Hg; group 2: −3 mm Hg; p>.70). Results of sputum cultures and white blood cell count (group 1 mean, 15.6×10^9/cu mm; group 2 mean, 13.7×10^9/cu mm; p>.40) were not significantly different between the two treatment groups. Factors such as age, conscious state, ventilation status, medical status, and volume of sputum cleared did not appear to affect the response to treatment.

When clinical status at 48 hours was examined, of the five patients with less than 60 percent resolution, three had development of, or continuation of, clinical signs compatible with persisting atelectasis (hypoxemia, raised white blood cell count, or bacterial contamination of sputum). Of the seven patients with more than 60 percent resolution at 48 hours, six showed improvement in clinical status. The remaining two patients did not have roentgenograms at 48 hours.

**Discussion**

Although chest physiotherapy is widely used in the treatment of atelectasis, only five studies could be found that investigated the use of physiotherapy in this condition.\(^5\)\(^6\)\(^7\)\(^8\) All concluded that chest physiotherapy was effective in the treatment of acute lobar atelectasis. However, as none of these studies included control groups, it is not possible to exclude spontaneous resolution of atelectasis as an explanation for the improvements that were observed. The use of a control group that received no treatment for atelectasis would allow analysis of this variable, but clearly this is unethical. We believe that the present study, by incorporating a basic treatment regimen as the “control” group (group 2), used the most appropriate design possible in such circumstances. While spontaneous resolution cannot be entirely excluded from being responsible for any improvement seen, the present study design allowed at least the possibility of comparing one treatment regimen with another.

The present study demonstrated a significantly better rate of resolution of acute lobar atelectasis after one treatment intervention in patients who received positioning, vibrations, hyperinflation, and suction (group 1) than patients who received hyperinflation and suction alone (group 2). At the conclusion of the six hours of intensive treatment, this difference was marginally statistically significant. Although the two groups were not significantly different at 24 and 48 hours, it can be seen that their mean percentage of resolution differed by approximately 25 percent from the 6-h treatment period onwards (Fig 1). Clinicians involved in the treatment of acute lobar atelectasis generally advocate a vigorous treatment regimen to achieve prompt results. On this basis, the differences between groups 1 and 2 after the initial treatment and perhaps also after the six hours of treatment would be considered to be clinically significant. However, if clinicians are content to achieve a satisfactory resolution of the atelectasis over 24 or 48 hours, it may well be that this might be achieved regardless of whether a basic or more involved treatment was given initially. Whether this alters associated morbidity or justifies the use of a basic treatment regimen throughout is a point that cannot be answered with certainty from the results of the present study.

When the present study is compared to the earlier one by Marini and associates,\(^3\) there are some important differences in study design that should be highlighted. First, we used positioning rather than postural drainage and chest vibrations rather than percussion. Secondly, our treatment was more frequent, during both the initial 6-h treatment period and the subsequent 48 h. Despite these differences, the overall results are comparable to those of Marini.\(^3\) However, unlike Johnson et al,\(^4\) we found that initially in the course of acute lobar atelectasis, a treatment of hyperinflation and suction (or deep breathing and coughing) was enhanced by the addition to it of positioning and vibrations. The reason for this contradiction in results is unclear. Like Johnson et al\(^4\) we found there was no difference between treatment groups at 24 and 48 h.

Marini et al\(^3\) reported that an air bronchogram was a predictor of delayed resolution of atelectasis. Although resolution of more than 50 percent was delayed to at least the 24-h point for the two patients with air bronchograms in this study (Fig 2), the results do not allow any conclusion to be drawn because of the limited data. A factor that appeared to alter the response of patients to the intensive 6-h treatment period was the intubation status. All three nonintubated patients were slower to achieve resolution than their intubated counterparts (Fig 3). Two required nasotracheal suction to remove secretions they were
unable to clear on their own. This suggests, in agreement with our clinical impression, that the presence of an effective cough appears to be critical for secretion clearance and prevention of acute lobar atelectasis. On the other hand, the ability to perform regular hyperinflation and suction with the intubated patient for treatment of acute lobar atelectasis seems to be beneficial.

Although chest physiotherapy has been reported to produce a number of deleterious effects with the acutely ill patient,10-15 there were no significant complications associated with its use in the present study.

This study, although restricted in patient numbers, provides new evidence that at least initially in the course of acute lobar atelectasis, a basic physiotherapy treatment of hyperinflation and suction is enhanced by the addition to it of positioning and vibrations. Assuming this to be so, a number of questions require investigation. First, was the positioning or the vibrations (or the combination) the effective additional component? Would the inclusion of traditional postural drainage positions, some of which involve tipping the patient head down, further enhance the response to treatment? Do patients receiving positioning, vibrations, hyperinflation, and suction require hourly treatment for six hours, or could the same result be achieved and sustained with only one treatment? Do patients with persistent lobar atelectasis for more than 48 hours have an increased mortality or morbidity? These questions are being addressed by the current authors, but further investigation to verify the results of this study is still required with larger patient samples, perhaps by the use of multicentered trials.

ACKNOWLEDGMENT: This study was funded by the Research Review Committee of the Royal Adelaide Hospital. We wish to thank the Intensive Care staff specialists and nursing staff for their cooperation, and Naomi Haensel, Physiotherapy Department, for her help in editing this article.

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