Effect of Body Position on Gas Exchange in Patients With Unilateral Central Airway Lesions*
Down With the Good Lung?
Shi-Chuan Chang, M.D., Ph.D., F.C.C.P.; Huei-Ing Chang, B.S.; Guang-Ming Shiao, M.B., F.C.C.P.; and Ruey-Perng Perng, M.D., Ph.D., F.C.C.P.

In this study, we evaluated the effect of body position (erect, supine, and two decubitus positions) on gas exchange (alveolar-arterial Po$_2$ difference [AaPO$_2$]) in 35 patients who had various degrees of lung collapse roentgenographically caused by unilateral central airway lesions, with special reference to the difference in AaPO$_2$ between two lateral decubitus positions. The patients were divided into two groups. Group 1 was composed of 23 patients with FEV$_1$/FVC $>$ 70 percent. In group 2, there were 12 patients with FEV$_1$/FVC $<$ 70 percent. Our results showed that the mean AaPO$_2$ of group 1 patients was least in the lateral decubitus position with normal lung down (AaPO$_2$N), followed by those in the supine position (AaPO$_2$S), in the lateral decubitus position with lesioned lung down (AaPO$_2$L), and in the erect position (AaPO$_2$E). There was no significant difference in AaPO$_2$ obtained in four positions. However, a significantly negative correlation was found between AaPO$_2$NL (AaPO$_2$N minus AaPO$_2$L) and patient’s FEV$_1$ (p $<$ 0.05). In group 2 patients, the mean AaPO$_2$E was least, followed by AaPO$_2$L, AaPO$_2$N, and AaPO$_2$S. The changes of body position did not significantly affect gas exchange in group 2 patients. Unlike previous reports, the present study showed that AaPO$_2$N was not exclusively less than AaPO$_2$L in our patients. AaPO$_2$N was higher than AaPO$_2$L in 11 of 23 in group 1 and in 5 of 12 in group 2 patients. In summary, our results indicated that positional changes did not significantly affect gas exchange in the patients with lung collapse roentgenographically caused by unilateral central airway lesions and the dogma “Down with the good lung” could not be applied to these patients flawlessly.

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Body position may affect lung volume and gas exchange by altering the matching of ventilation to perfusion within the lung.$^{15}$ In normal subjects breathing normally, both blood flow and ventilation are greater in the dependent lung zones. However, there is no significant change in gas exchange between right and left decubitus positions in normal subjects.$^{6,7}$

Previous reports stated that a higher PaO$_2$ (arterial oxygen tension) or SaO$_2$ (arterial oxygen saturation) was obtained in the patients with unilateral lung disorders$^{5-11}$ or unilateral pleural effusions$^{12,13}$ when they lay in the lateral decubitus position with normal side down than in the lateral decubitus position with lesioned side down. At variance with the results of previous reports,$^{12,13}$ our previous study demonstrated that gas exchange improved when the lesioned side was placed in the dependent position in 8 of 21 patients with unilateral pleural effusions.$^{14}$ Subsequent reports showed that in one patient with centrally located lung cancer and in two patients with unilateral pulmonary embolism, oxygenation improved when the “sick” lung was dependent and deteriorated when the “good” lung was in the dependent position.$^{15,16}$

Based on the results of aforementioned studies, it is uncertain that the dogma “Down with the good lung” can also be applied to the patients with unilateral central airway lesions. Thus, in the present study, we intended to evaluate the effect of body position on gas exchange in the patients with various degrees of lung collapse roentgenographically caused by unilateral central airway lesions and to examine the relationship between this postural effect and the patient's pulmonary function, with special reference to the difference in alveolar-arterial Po$_2$ difference (AaPO$_2$) between two lateral decubitus positions.

MATERIALS AND METHODS

Thirty-five consecutive patients who had various degrees of lung collapse roentgenographically caused by unilateral central airway lesions were enrolled in this study. All the patients underwent fiberoptic bronchoscopy and were proved to have an endobronchial lesion in a large airway such as a main bronchus, an intermediate bronchus, or a lobar bronchus of the lesioned lung. None had a pleural effusion that was evidenced by chest roentgenography and/or chest sonography. All the patients denied cardiac disease and had a normal electrocardiogram. The patients were divided into two groups based on FEV$_1$/FVC. Group 1 was composed of 23 patients with FEV$_1$/FVC greater than 70 percent. In group 2, there

*From the Chest Department, Veterans General Hospital-Taipei, and the Institute of Clinical Medicine, National Yang-Ming Medical College, Taipei, Taiwan, Republic of China. Manuscript received May 1; revision accepted July 9. Reprint requests: Dr. Chang, Veterans General Hospital, Taipei, Shih-Pai, Taipei, Taiwan 112, Republic of China.
were 12 patients with FEV/FVC less than 70 percent.

Spirometry was performed on the standard erect (seated) position in all patients with a minimum of three times (using a CPI 5000 IV, Gould, Houston, Tex). The best values of FVC and FEV, were selected for analysis.

Erect, supine, and two lateral decubitus positions were studied in random order. Samples of arterial blood were drawn anaerobically 20 min after assumption of a new position with the patients breathing room air. Blood samples for PaO, PCO, and pH values were analyzed immediately (using ABL III, Radiometer, Copenhagen, Denmark).

PaO, (alveolar oxygen tension) is calculated by the following equation. PaO,=(barometric pressure - 47) x FiO2 + PaCO/R, R, an exchange ratio, is assumed as 0.8 in this study. The alveolararterial PaO, difference (AaPaO) is calculated by subtraction of PaO, from PaO,.

Statistical comparison of the data, including arterial blood gas and AaPaO, values obtained in four positions are shown in Table 1. The mean PaO, (79.4±10.0 mm Hg, mean±SD) was highest in the lateral decubitus position with normal lung down (PaO,L), followed by 79.0±10.9 mm Hg in the supine position (PaO,S), 78.6±11.0 mm Hg in the erect position (PaO,E), and 77.8±9.4 mm Hg in the lateral decubitus position with lesioned lung down (PaO,L). Similar to the PaO, data, the mean AaPaO, (28.37±13.86 mm Hg, mean±SD) was least in the lateral decubitus position with normal lung down (AaPaO,N), followed by 28.95±14.94 mm Hg in the supine position (AaPaO,S), 29.20±13.20 mm Hg in the lateral decubitus position with lesioned lung down (AaPaO,L), and 29.21±14.18 mm Hg in the erect position (AaPaO,E). However, there was no significant difference in the arterial blood gas and AaPaO, values obtained in the four positions.

In group 2 patients, the arterial blood gas and AaPaO, values obtained in four positions in group 1 patients are shown in Table 3. The mean PaO, (79.4±10.0 mm Hg, mean±SD) was highest in the lateral decubitus position with normal lung down (PaO,N), followed by 79.0±10.9 mm Hg in the supine position (PaO,S), 78.6±11.0 mm Hg in the erect position (PaO,E), and 77.8±9.4 mm Hg in the lateral decubitus position with lesioned lung down (PaO,L). Similar to the PaO, data, the mean AaPaO, (28.37±13.86 mm Hg, mean±SD) was least in the lateral decubitus position with normal lung down (AaPaO,N), followed by 28.95±14.94 mm Hg in the supine position (AaPaO,S), 29.20±13.20 mm Hg in the lateral decubitus position with lesioned lung down (AaPaO,L), and 29.21±14.18 mm Hg in the erect position (AaPaO,E). However, there was no significant difference in the arterial blood gas and AaPaO, values obtained in the four positions.

In group 2 patients, the arterial blood gas and AaPaO, values obtained in the four positions are shown in Table 4. The mean PaO, (80.4±14.5 mm Hg, mean±SD) was highest, followed by PaO,L (75.9±14.0 mm Hg), PaO,N (75.9±13.0 mm Hg), and PaO,S (75.0 mm Hg).
Our results showed that changes of body position did not significantly affect gas exchange in the patients with various degrees of lung collapse roentgenographically caused by unilateral central airway lesions. Although mean PaO\textsubscript{2} was higher than mean PaO\textsubscript{2}L and mean AaPO\textsubscript{2}N was less than AaPO\textsubscript{2}L in group 1 patients who had no obstructive ventilatory defect, the difference in the values of PaO\textsubscript{2} and AaPO\textsubscript{2} between two lateral decubitus positions showed no statistical significance. The PaO\textsubscript{2} and AaPO\textsubscript{2} values obtained in two lateral decubitus positions were quite similar in group 2 patients who had various degrees of obstructive ventilatory impairment. As in group 1 patients, there were no significant differences in the PaO\textsubscript{2} and AaPO\textsubscript{2} values obtained in two lateral decubitus positions.

Furthermore, our results demonstrated that a favorable gas exchange was not exclusively present when the patients lay in the lateral decubitus position with normal lung down. PaO\textsubscript{2}N was less than PaO\textsubscript{2}L in 10 of 23 in group 1 and 5 of 12 in group 2. AaPO\textsubscript{2}N was higher than AaPO\textsubscript{2}L in 11 of 23 patients in group 1 and 5 of 12 patients in group 2. These findings were not correlated with FEV\textsubscript{i}, FVC, and severity of gas exchange impairment.

**Table 5—PaO\textsubscript{2}NL and AaPO\textsubscript{2}NL in 35 Patients With Unilateral Central Airway Lesions***

<table>
<thead>
<tr>
<th></th>
<th>Group 1, N = 23 (FEV\textsubscript{i}/FVC &gt;70%)</th>
<th>Group 2, N = 12 (FEV\textsubscript{i}/FVC &lt;70%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PaO\textsubscript{2}NL, mm Hg</td>
<td>Mean ± SD</td>
<td>Range</td>
</tr>
<tr>
<td>&gt;0</td>
<td>n = 13</td>
<td>1.68 ± 6.56</td>
</tr>
<tr>
<td>&lt;0</td>
<td>n = 10</td>
<td>12.5 to 13.85</td>
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</tbody>
</table>

**Table 4—Arterial Blood Gas and AaPO\textsubscript{2} Values in 12 Patients With Unilateral Central Airway Lesions*** (FEV\textsubscript{i}/FVC <70%)

<table>
<thead>
<tr>
<th></th>
<th>E</th>
<th>S</th>
<th>L</th>
<th>N</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>PaO\textsubscript{2}, mm Hg</td>
<td>80.4 ± 14.5</td>
<td>75.0 ± 12.9</td>
<td>75.9 ± 14.0</td>
<td>75.9 ± 13.0</td>
<td>53.0-99.3</td>
</tr>
<tr>
<td>PaCO\textsubscript{2}, mm Hg</td>
<td>34.0 ± 3.3</td>
<td>34.9 ± 4.4</td>
<td>27.9-42.7</td>
<td>29.0 ± 4.0</td>
<td>35.1 ± 5.1</td>
</tr>
<tr>
<td>pH</td>
<td>7.448 ± 0.054</td>
<td>7.454 ± 0.048</td>
<td>7.448 ± 0.051</td>
<td>7.450 ± 0.047</td>
<td>(7.388-7.590)</td>
</tr>
<tr>
<td>AaPO\textsubscript{2}, mm Hg</td>
<td>12.54 ± 1.25</td>
<td>13.85 ± 1.50</td>
<td>13.26 to 9.37</td>
<td>12.50 to 13.85</td>
<td>7.40-15.0</td>
</tr>
</tbody>
</table>

*Values of mean and SD are given. The data in parentheses are range. E = erect position; S = supine position; L = lateral decubitus position with lesioned lung down; N = lateral decubitus position with normal lung down; NS = not significant.

PaO\textsubscript{2}NL did not correlate well with FVC or severity of gas exchange impairment. In group 2 patients, AaPO\textsubscript{2}NL did not significantly correlate with FEV\textsubscript{i}, FVC, and severity of gas exchange impairment.

**Discussion**

Our results showed that the changes of body position did not significantly affect gas exchange in the patients with various degrees of lung collapse roentgenographically caused by unilateral central airway lesions. Although mean PaO\textsubscript{2} was higher than mean PaO\textsubscript{2}L and mean AaPO\textsubscript{2}N was less than AaPO\textsubscript{2}L in group 1 patients who had no obstructive ventilatory defect, the difference in the values of PaO\textsubscript{2} and AaPO\textsubscript{2} between two lateral decubitus positions showed no statistical significance. The PaO\textsubscript{2} and AaPO\textsubscript{2} values obtained in two lateral decubitus positions were quite similar in group 2 patients who had various degrees of obstructive ventilatory impairment. As in group 1 patients, there were no significant differences in the PaO\textsubscript{2} and AaPO\textsubscript{2} values obtained in two lateral decubitus positions.

Furthermore, our results demonstrated that a favorable gas exchange was not exclusively present when the patients lay in the lateral decubitus position with normal lung down. PaO\textsubscript{2}N was less than PaO\textsubscript{2}L in 10 of 23 in group 1 and 5 of 12 in group 2. AaPO\textsubscript{2}N was higher than AaPO\textsubscript{2}L in 11 of 23 patients in group 1 and 5 of 12 patients in group 2. These findings were

![Figure 1. The AaPO\textsubscript{2} difference (AaPO\textsubscript{2}NL = AaPO\textsubscript{2}N - AaPO\textsubscript{2}L) between two lateral decubitus positions was significantly correlated with FEV\textsubscript{i}. N = lateral decubitus position with normal lung down; L = lateral decubitus position with lesioned lung down.](http://journal.publications.chestnet.org/pdfaccess.ashx?url=/data/journals/chest/21667/ on 04/02/2017)
at variance with the results of previous workers who stated that a favorable gas exchange could be obtained exclusively in the patients with unilateral lung disorders when they were positioned in the lateral decubitus position with normal lung down.\textsuperscript{7-11} The reasons for these discrepancies may be explained by the following: (1) the aforementioned studies included a heterogeneous group of patients with different pulmonary pathologic processes and the cases of unilateral lung collapse were limited; (2) the impairment of gas exchange seemed more severe in the reported patients than ours; and (3) most of the reported-on patients required supplementary oxygen therapy and this may more or less mask and correct ventilation-perfusion mismatch and interfere with the effect of body position on gas exchange.

Interestingly, our results showed that a significantly negative correlation was found between AaPO\(_2\)NL and FEV\(_1\), in group 1 patients (Fig 1). AaPO\(_2\)N was higher than AaPO\(_2\)L in the patients with moderate to severe reduction of FEV\(_1\), whereas the reverse applied in the patients with rather normal or mild-to-moderate reduction of FEV\(_1\).

The most likely mechanism for the observed phenomenon involved positionally induced changes in the matching of ventilation to perfusion and/or shunting of venous blood between the two lateral decubitus positions. Lung collapse decreases lung volume, and thus, decreases ventilation to the lesioned lung. It may also relatively increase closing volume due to a decrease in expiratory reserve volume. The above effects of lung collapse may lower the overall ventilation-perfusion ratios in the lesioned lung and cause widening of AaPO\(_2\). When the patients with lung collapse caused by unilateral central airway lesions lie in the lateral decubitus position with lesioned lung down, one may anticipate that a worsening of ventilation-perfusion inequality will ensue because gravity increases the perfusion to the lesioned lung in which there is a low ventilation-perfusion ratio. However, when the patients are positioned in the lateral decubitus position with normal lung down, blood is shifted away from these areas to the better ventilated lung with an improvement in oxygenation.

When lung collapse becomes more severe (reflected by FEV\(_1\)), lung collapse may begin to have an impact on perfusion and decrease blood flow to the lesioned lung. The mechanisms responsible for this decrease in blood flow may be mechanical and/or due to hypoxic vasoconstriction resulting from local hypoxia in the lesioned lung. This effect may be more profound when the lesioned lung is in a dependent position. The above effects may shift both ventilation and perfusion to the contralateral normal lung. Accordingly, when the patients lie in the lesioned-lung-dependent position, there is no further worsening of gas exchange.

It is unclear why gas exchange deteriorated in group 1 patients who had moderate to severe reduction of FEV\(_1\), when they lay in the lateral decubitus position with normal lung down. Possibly obstruction of the lesioned airway might become more severe when the patients were positioned in the lateral decubitus position with normal lung down. This will decrease ventilation to the lesioned lung and cause ventilation-perfusion mismatch in the lesioned lung. Another reason may be movement of airway secretions from the lesioned lung to the normal lung when the patients lie in the normal-lung-dependent position. This may cause less ventilation to the normal lung and result in hypoxemia through ventilation-perfusion mismatch and/or shunting of venous blood.

In conclusion, the present study demonstrated that positional changes did not significantly affect gas exchange in the patients with various degrees of lung collapse roentgenographically caused by unilateral central airway lesions. The dogma "Down with the good lung" could not be applied to these patients flawlessly. In addition, we found that there was a significantly negative correlation between AaPO\(_2\)NL and FEV\(_1\) in group 1 patients who had no obstructive ventilatory defect. AaPO\(_2\)N was less than AaPO\(_2\)L in the patients with almost normal and mild-to-moderate reduction of FEV\(_1\). The reverse applied in the patients with moderate-to-severe reduction in FEV\(_1\). The above findings may provide a guide for selecting the more favorable lateral decubitus position that maximizes gas exchange and adjusting the adequate inspired oxygen concentration if supplementary oxygen supply is needed.

References

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