The Validity of Determinations of Pulmonary Wedge Pressure during Mechanical Ventilation

Richard Davison, M.D.,** Michele Parker, R.N.;† and Ronald A. Harrison, M.D., F.C.C.P.‡

Changes in the mean pulmonary wedge pressure were measured during temporary disconnection from a ventilator in 29 patients to assess the effects of therapy with controlled-volume ventilation on determinations of pulmonary wedge pressure. In 16 observations performed during therapy with intermittent positive-pressure ventilation, the mean value for the pulmonary wedge pressure was the same (10.3 mm Hg) with the patients connected to or disconnected from the ventilator. Thirteen of the patients were also maintained on therapy with positive end-expiratory pressure (PEEP); the mean (± SD) of 17 measurements of pulmonary wedge pressure did not show a significant variation on cessation of mechanical ventilation (12.5 ± 6.7 mm Hg vs 11.7 ± 6.9 mm Hg; P > 0.05). We conclude that pulmonary wedge pressure can be measured accurately at the end of exhalation during the administration of positive-pressure ventilation with 10 cm H2O of PEEP. The suggested practice of discontinuing mechanical ventilation in order to obtain a more exact measurement is not warranted.

The continuous monitoring of pulmonary vascular pressures is now considered standard practice in the management of critically ill patients. Many of these patients also require mechanical ventilatory support, often with the concomitant use of positive end-expiratory pressure (PEEP). In this setting the measurement of pulmonary wedge pressure is potentially susceptible to distortion, due to the increased intrathoracic pressure. Based upon the assumption that such interference results in spurious hemodynamic values, several authors have advocated the temporary discontinuation of mechanical ventilation in order to obtain "true" readings for pulmonary wedge pressure.14

The purpose of this study is to document the changes in pulmonary wedge pressure that occurred when mechanical ventilation was temporarily interrupted during routine care of the seriously ill. The findings reported herein show that the alterations induced by therapy with positive-pressure ventilation are minor and do not significantly affect the validity of the measurement of pulmonary wedge pressure.

MATERIALS AND METHODS

Thirty-three observations were performed on 29 patients admitted to a medical intensive care unit for a variety of conditions (Table 1). All subjects were maintained on therapy with volume ventilators, spontaneous respiratory efforts being either absent or suppressed by sedatives or muscular relaxant drugs (or by both). Thirteen of the patients were also receiving therapy with PEEP. Of the 17 observations performed in the latter subgroup, seven were with the patient receiving therapy with PEEP at 10 cm H2O, one at 9 cm H2O, two at 8 cm H2O, and the rest at 5 cm H2O.

Mean pulmonary wedge pressures were measured with transducers (Statham P23db) via a No. 5 or 7 French Swan-Ganz catheter. The transducers were positioned 10 cm from the dorsal surface of the patient. Atmospheric pressure was used as the zero reference point. Tracings of pressures were obtained on a recorder (Electronics for Medicine VR6). During mechanical ventilation, values for pulmonary wedge pressure were measured at the end of exhalation.

The changes induced by therapy with positive-pressure

Table 1—Diagnosis and Mode of Ventilation in 29 Patients Studied

<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>IPPV</th>
<th>IPPV and PEEP</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Postoperative complications</td>
<td>2</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Pulmonary disease</td>
<td>6</td>
<td>8</td>
<td>14</td>
</tr>
<tr>
<td>Neurologic disease</td>
<td>4</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>Cardiovascular disease</td>
<td>4</td>
<td>3</td>
<td>7</td>
</tr>
</tbody>
</table>

*From the Medical Intensive Care Facilities and Respiratory Care Services, Northwestern Memorial Hospital, and the Departments of Medicine and Anesthesia, Northwestern University Medical School, Chicago.
**Director, Medical Intensive Care Facilities, and Assistant Professor of Medicine.
†Research Nurse Clinician, Medical Intensive Care Area.
‡Associate Medical Director of Respiratory Care Services and Assistant Professor of Anesthesia.
Manuscript received May 23; revision accepted July 13
Reprint requests: Dr. Davison, 250 East Superior Street, Chicago 60611

352 DAVISON, PARKER, HARRISON

CHEST, 73: 3, MARCH, 1978
ventilation were investigated by obtaining continuous recordings of the pulmonary wedge pressure during the time when patients were transiently disconnected from the ventilator as part of their routine care. Recordings were considered acceptable if the following three criteria were met: (1) the presence of a stable pulmonary wedge pressure prior to disconnection; (2) a time of disconnection from the ventilator of 10 to 15 seconds; and (3) absence of artifacts caused by spontaneous respiratory efforts, coughing, etc.

In each observation the following three measurements were obtained: (1) the lowest pulmonary wedge pressure during the last end-expiratory period prior to disconnection; (2) the lowest pulmonary wedge pressure during disconnection; and (3) the highest pulmonary wedge pressure whenever a rise occurred during the recording. A representative recording is reproduced in Figure 1.

Statistical comparisons of the means were made using the t-test for paired samples. The coefficient of correlation was analyzed using the correlated t-test.

RESULTS

Intermittent Positive-Pressure Ventilation

Sixteen observations were performed on 16 patients. When intermittent positive-pressure ventilation (IPPV) was temporarily suspended, changes in pulmonary wedge pressure were recorded in five instances. In only two observations were the pressures noted to vary by more than 1 mm Hg (an increment of 4 mm Hg in one case and a drop of 2 mm Hg in another). The mean value for pulmonary wedge pressure with the patients connected to the ventilator was 10.3 ± 6.1 mm Hg (± SD), identical to the mean value noted with the patients disconnected from the ventilator (10.3 ± 6.3 mm Hg; P > 0.5).

IPPV and PEEP

Upon disconnection from the ventilator, a fall in pulmonary wedge pressure occurred in nine of 17 observations. In four instances the decrease was in excess of 1 mm Hg. The magnitude of the variation in these four observations was 2 mm Hg in three cases and 3 mm Hg in one. The mean value for pulmonary wedge pressure in patients receiving IPPV and PEEP was 12.5 ± 6.7 mm Hg, not significantly different from the mean value of 11.7 ± 6.9 mm Hg obtained with the patients not receiving mechanical ventilation (P > 0.05). Figure 2 shows...
the correlation between pulmonary wedge pressures with the patients connected to or disconnected from the ventilator for all of the determinations performed.

Late Rise in Pulmonary Wedge Pressure

In six of the patients (three receiving IPPV and three receiving IPPV and PEEP), the pulmonary wedge pressure was noted to gradually rise throughout the period of disconnection from the ventilator to a final value that was 2 or more mm Hg greater than that noted immediately upon disconnection (Fig 3). This finding was quite distinct from the usual pattern observed, where after the immediate change on disconnection, the pulmonary wedge pressure remained stable. A summary of the results is presented in Table 2.

Discussion

Pulmonary wedge pressure, as measured with balloon-tipped catheters, has been shown to accurately reflect left ventricular filling pressure. Several articles in the literature challenged the validity of such measurements when obtained during therapy with positive-pressure ventilation. Simultaneous determination of the pulmonary wedge pressure and left atrial pressure during mechanical ventilation reportedly demonstrated sufficient disparity to invalidate the clinical usefulness of such measurements, especially when levels of PEEP of 10 cm H2O or greater were applied.

Many explanations have been offered for this phenomenon, including the possibility that, in the presence of PEEP, the increased intra-alveolar pressure results in occlusion of pulmonary capillaries. At this point the pulmonary wedge pressure would more closely reflect alveolar pressure than left atrial pressure. The actual import of such influence should become readily apparent when the patient is disconnected from the ventilator and when intrathoracic pressure is allowed to drop to atmospheric levels. The present series indicates that although minor changes in pulmonary wedge pressure do occur, especially if PEEP is applied, they are not statistically significant. Furthermore, in no instance was the observed variation of sufficient magnitude to suggest that the values for pulmonary wedge pressure obtained during mechanical ventilation would have led to an erroneous appraisal of the hemodynamic status.

A recent publication suggests that measurements of pulmonary wedge pressure recorded in the presence of positive alveolar pressures are only valid in the setting of severe acute respiratory failure. The group of patients included in the present study exhibited a variety of clinical conditions; and in them, positive-pressure ventilation failed to notably alter the pulmonary wedge pressure, regardless of the underlying pathologic abnormalities. Therefore, we find it unjustified to purposely discontinue positive-pressure ventilation in order to measure pulmonary wedge pressure.

In most instances where the pulmonary wedge pressure was modified by the cessation of mechani-
cal ventilation, the change occurred immediately following disconnection. Conversely, in six (21 percent) of the 29 patients, instead of the usual sudden initial change, we observed a delayed progressive elevation of the pulmonary wedge pressure throughout the recording. In our experience, this pattern was observed in the setting of underlying heart disease. The pattern presumably reflects the higher filling pressures required by a failing left ventricle in order to accommodate the increased venous return that results from a restoration of intrathoracic pressures to atmospheric levels.

REFERENCES
6 Roy RS, Powers SR, Dutton RE: Pulmonary wedge catheterization during positive end expiratory pressure (PEEP) ventilation. Physiologist 17:323, 1974