The Interrelations of the Pulmonary Arterial and Venous Wedge Pressures

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Pulmonary venous wedge pressure closely reflects the pulmonary arterial mean pressure. Pulmonary arterial wedge pressure is not significantly different from the left atrial mean pressure. Neither the former nor the latter is an approximation of the pulmonary capillary pressure.

A pressure recorded through a cardiac catheter wedged tightly in a small pulmonary artery has been referred to as a "capillary," "venous" or "wedge" pressure. On the other hand, a pressure recorded through a cardiac catheter wedged into a pulmonary vein during thoracotomy and in intact animals has been referred to as a pulmonary venous wedge pressure. Some investigators have found good correlation between the mean pulmonary arterial wedge pressure and the mean left atrial pressure in man and other animals; others have found great variability. A thorough analysis of the data and methods of each group of investigators reveals differences in techniques with which the data were obtained, and in methods of statistical analyses.

The purpose of this study was to show the relationship between pulmonary arterial wedge pressure and mean left atrial pressure on the one hand, and the pulmonary venous wedge pressure and mean pulmonary arterial pressure on the other. Determinations were made in normal dogs with the thorax open so that catheters could be placed precisely in the desired position.

Method

This study was done in 24 normal dogs. Pulmonary arterial wedge pressures were obtained by wedging into a small pulmonary arterial branch a 7 F cardiac catheter with one hole in the tip and pulmonary venous wedge pressures by wedging a catheter into a small branch of a pulmonary vein in the same lobe of the lung (fig. 1). Seven-F catheters with three holes in the tips were placed into the left atrium through a small pulmonary vein and into the pulmonary artery through a small pulmonary arterial branch (fig. 1). The catheters were attached to Lundy stopcocks so that pressures from the different vascular and cardiac chambers could be recorded simultaneously or in rapid sequence. Pressures were recorded with the chest closed and open by calibrated Statham strain gauges on a 4-channel Sanborn recorder. The superior surface of the presenting left atrium was taken as the zero level.

Results

Pulmonary arterial wedge pressures ranged from 0.2 to 14.8 mm. Hg. and left atrial pressures from 0.6 to 15.4 mm. Hg. There was a highly significant correlation between the means of the pulmonary arterial wedge and left atrial pressures (fig. 2); r = 0.9577, p < 0.01. There was no significant difference in the difference between the means of the left atrial and pulmonary arterial wedge pressure; t = 0.7700 and p > 0.4. A lobar pulmonary venous branch was ligated and the pressure recorded in the pulmonary arterial wedge was of the same order of magnitude as the pulmonary arterial mean pressure (table 1). These data indicate correlation of these pressures at high as well as low levels.

Pulmonary venous wedge pressures ranged from 3.3 to 19.7 mm. Hg. The range of the pulmonary arterial mean pressure was from 4.0 to 19.6 mm. Hg. There was a high degree of correlation between the levels of pressure in the two vascular chambers; r = 0.9400, p < 0.01 (fig. 3). There was no significant difference in the difference between the mean pulmonary venous wedge and the pulmonary arterial pressures; t = 1.39; p > 0.1. The bronchial arteries of the right lung were ligated in a dog and there...
PULMONARY WEDGE PRESSURES

Table 1.—Effect of Ligating a Lobar Pulmonary Vein on Pulmonary Arterial Wedge Pressure in a Dog

<table>
<thead>
<tr>
<th>Experiment No.</th>
<th>Mean Control Pressures</th>
<th>Mean Pressures Measured</th>
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<tbody>
<tr>
<td></td>
<td>Left Atrium</td>
<td>Pulmonary Arterial Wedge</td>
</tr>
<tr>
<td></td>
<td>Pulmonary Venous Lumen Patent</td>
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<tr>
<td></td>
<td>mm. Hg</td>
<td>mm. Hg</td>
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<tr>
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<td>2.6</td>
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<tr>
<td>2</td>
<td>4.6</td>
<td>4.5</td>
</tr>
<tr>
<td>3</td>
<td>4.9</td>
<td>5.7</td>
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</tbody>
</table>

FIG. 1. Schematic representation of a lobule of the lung and the heart showing catheters in position: a, catheter inserted into a branch of the pulmonary artery and extended into the trunk; b, catheter inserted into a pulmonary vein and extended into the left atrium; c, catheter inserted into small branch of pulmonary artery and wedged at d; e, catheter inserted into a small pulmonary vein and wedged at f.

Fig. 2. Interrelation of the Left Atrial and Pulmonary Arterial Wedge Pressures.

was neither change in the pulmonary arterial mean pressure nor in the pulmonary venous wedge pressure.

In order to show clearly the relationship between the pulmonary arterial wedge pressure and left atrial pressure, the two pressures were recorded through a Lundy stopcock (fig. 4). The

left atrial mean pressure was 3.1 mm. Hg. and the pulmonary arterial wedge pressure was 3.3 mm. Hg. Further, to remove any doubt about the relationship between the pulmonary venous wedge and arterial mean pressures, the tracing shown in fig. 5 was recorded. The pressures were 17.0 and 15.0 mm. Hg. in the respective chambers. The differences shown in fig. 4 and 5 are well within experimental error.

DISCUSSION

When a catheter is wedged in a pulmonary vein or artery, the flow of blood is interrupted in the segment of the lung supplied by the occluded vessel. The lumen of the catheter communicates through the arterioles, venules and
capillary plexus, with a volume of blood which extends to the mitral valve or to the pulmonic valve, depending on which side the catheter is wedged. The pressure recorded in either position is the pressure in the vascular compartment beyond that in which the flow of blood has been interrupted. The small arteries, veins and capillary plexus serve as an extension of the catheter into these vascular compartments. The pressure recorded through a catheter wedged in a small artery is undoubtedly the pressure in the small pulmonary veins which closely reflects the pressure in the left atrium (fig. 4). The pressure recorded through a catheter wedged in a small vein is no doubt a close estimate of the mean pressure in the pulmonary artery (fig. 5).

The wedge pressures correlate with the pressure in the left atrium and the pressure in the arterial trunk respectively, because the pressure gradient in the large pulmonary arteries and veins is small with respect to the degree in which a particular pressure measurement may be in error. Neither the arterial nor the venous wedge pressure is a measurement of the pressure in the pulmonary capillaries in which the flow of blood has not been interrupted.

The data presented indicate that the difference between these pulmonary arterial and wedge pressures is approximately equal to the pressure gradient across the entire lesser circulation. It is evident that pulmonary "arteriolar" resistance cannot be calculated if the dynamic capillary pressure is not known. Resistance in the capillaries is a factor in the total pulmonary vascular resistance. The data in the literature referred to as "total pulmonary resistance" includes all factors of resistance to flow from the pulmonic valve to the mitral valve.

A few technical expedients were discovered during the course of these experiments: catheters with single openings in the tips facilitate optimal wedging and accurate recording of pressure. In the open chest, wedge pressures may be obtained with the catheter inserted into a pulmonary vessel under direct control,
rather than through the right heart. In the latter instance, one should wedge the catheter repeatedly in different sections of the lung. Unwedging the catheter should produce a definite “snap.” In certain instances, insertion of a stainless steel stylus into the lumen of the catheter facilitates wedging.

SUMMARY

Pulmonary venous wedge pressure accurately reflects high and low levels of pulmonary arterial mean pressure.

Pulmonary arterial wedge pressure accurately reflects left atrial mean pressure. However, neither the pulmonary venous wedge nor the arterial wedge is equal to the pressure in pulmonary capillaries through which blood is flowing.

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