The Influence of the Pulmonary Arterial Pressure on the Pulmonary Capillary Venous Pressure in Man

By LARS WERKÖ, M.D., E. VARNIAUSKAS, M.D., H. ELIASCH, M.D., AND B. THOMASSON, M.D.

In two cases with a well-defined pulmonary capillary venous pressure pulse, the lobular pulmonary artery was occluded with a balloon while the pulmonary capillary venous pressure was registered. There was no change in the tracing obtained. In two other cases positive pressure respiration almost completely dampened out the pulmonary capillary venous pressure variations, but the mean pressure remained virtually unchanged. It is concluded that the pulmonary arterial pulse wave usually does not cause artefacts in the pulmonary capillary venous tracing. Cyclic changes in pulmonary capillary venous pressure cannot be studied while the subject is on positive pressure respiration.

If a heart catheter is wedged in the pulmonary arterial tree occluding one of its smaller branches, it is possible to record a pressure pulse with all the characteristics of a venous pulse (PCV). In cases with mitral valvular disease or left heart failure, typical changes occur in mean pressure height as well as pulse contour.

Since the introduction of this method of investigation it has been applied in many laboratories when estimating the pulmonary venous pressure in man. It has been pointed out, however, that the pulmonary arterial pressure pulse most decidedly influences the pulmonary capillary venous tracing.

The object of the present study has been to elucidate the role of the pulmonary arterial pressure pulse in the production of the pulmonary capillary venous tracing by using a special technic.

METHODS

The pulmonary artery was catheterized with the usual technic. The catheter was then pushed further out into the pulmonary arterial tree until complete occlusion of a small branch. The pressure was then recorded using a Tybjaerg-Hansen electrical manometer. Subsequently, in two of the cases, a second catheter with an inflatable rubber balloon at the tip was placed in the main stem of the lobular artery corresponding to the position of the first catheter (right lower lobe). During continuous recording of the pulmonary capillary venous pressure pulse and under fluoroscopic control the balloon was gradually inflated with 30 per cent Diodrast. It initially assumed the same round shape as when tested, but on further filling its outline resembled that of a 3 to 4 cm. long sausage, indicating that it was pressed against the walls of the artery. It then contained 8 to 10 ml. of Diodrast. After two to three minutes the balloon was deflated again. The continuous recording was interrupted briefly in order to check the transmitting system and the pressure standards. Several observers controlled the size of the balloon on the fluoroscope during the whole procedure, which was repeated at least three times in both patients. The recording catheter was withdrawn to the pulmonary artery and again moved out into the pulmonary capillary venous position between each experiment.

In the third case the catheter with the balloon was not used; two standard catheters were placed in the same positions as described above. The effect of positive pressure breathing with a pneumatic balance resuscitator (M.S.A. Pneulator) using 100 per cent oxygen was studied.

MATERIAL

One of the cases (505) showed mitral stenosis with almost normal pulmonary pressures, the other (588) had a patent ductus arteriosus, mitral insufficiency, and elevated pulmonary pressures. Mitral insufficiency was also the diagnosis in case 590 studied during positive pressure breathing. The hemodynamic data of the three cases are given in table 1.

RESULTS

Figure 1 shows the pulmonary capillary venous pressure curve in case 505 before and
during complete occlusion of the corresponding lobar artery. As can be seen, there is no essential change in the pulse contour on occlusion, but the extraneous vibrations in the recording catheter diminish. The pulmonary capillary venous pressure curve clearly shows the pre-systolic pressure peak typical of mitral stenosis with regular rhythm and a good functioning case 588. The systolic pressure rose to 30 mm. Hg. When the corresponding pulmonary arterial branch was occluded there was no change either in shape or height of the pulmonary capillary venous pressure. Likewise, no change occurred when the balloon was deflated. The same result was obtained in three tests. The patients had no subjective sensations

During complete occlusion of the corresponding lobar artery. As can be seen, there is no essential change in the pulse contour on occlusion, but the extraneous vibrations in the recording catheter diminish. The pulmonary capillary venous pressure curve clearly shows the pre-systolic pressure peak typical of mitral stenosis with regular rhythm and a good functioning case 588. The systolic pressure rose to 30 mm. Hg. When the corresponding pulmonary arterial branch was occluded there was no change either in shape or height of the pulmonary capillary venous pressure. Likewise, no change occurred when the balloon was deflated. The same result was obtained in three tests. The patients had no subjective sensations

auricular myocardium. The mean pulmonary capillary venous pressure was slightly higher during the first and second occlusions than before and after, remaining the same during the third and fourth occlusions. Otherwise the result was similar every time the balloon was inflated.

Figure 2 shows the tracing obtained in during these manipulations. The electrocardiogram was unchanged, except for a few extrasystoles in the first case.

Figure 3 shows tracings obtained in the patient in whom positive pressure breathing was performed. During ambient breathing, before and after the experiment, the characteristic pulse waves in the pulmonary capillary venous

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>505</td>
<td>Sinus</td>
<td>465</td>
<td>62</td>
<td>3,75</td>
<td>5,28</td>
<td>7</td>
<td>36</td>
<td>13</td>
<td>18</td>
<td>-</td>
<td>74</td>
</tr>
<tr>
<td>588</td>
<td>Sinus</td>
<td>600</td>
<td>70</td>
<td>3,34</td>
<td>7,9*</td>
<td>17</td>
<td>61</td>
<td>35</td>
<td>43</td>
<td>2</td>
<td>100</td>
</tr>
<tr>
<td>590</td>
<td>Aur. Fibrill.</td>
<td>800</td>
<td>61</td>
<td>5,70</td>
<td>3,78</td>
<td>17</td>
<td>47</td>
<td>20</td>
<td>33</td>
<td>-</td>
<td>87</td>
</tr>
</tbody>
</table>

* Peripheral CO; BA-PA O₂ diff. 9.8 ml/L.
Fig. 2. Simultaneous tracings of pulmonary capillary venous pressure and electrocardiogram in a case of patent ductus arteriosus; markedly increased pulmonary blood flow combined with mitral incompetence (high "systolic" pulmonary capillary venous pressure peak). Upper curves, pulmonary capillary venous pressure pulse before, on, and immediately after complete occlusion of the corresponding pulmonary arterial branch. Lower curves, pulmonary capillary venous pressure pulse after two minutes' occlusion. The pulmonary capillary venous pressure pulse is not influenced at all by the occlusion (case 588).

Fig. 3. Upper curves: Simultaneous recordings of electrocardiogram, pulmonary capillary venous and pulmonary arterial pressures at the moment when the patient reverts from positive balanced pressure breathing to ambient breathing. The pulmonary arterial recording is unchanged. The pulse waves in the pulmonary capillary venous recording are damped during positive balanced pressure breathing, but clearly seen during ambient breathing. Lower curves: Same except pulmonary capillary venous recording was electrically filtered. Note the steady mean pressure throughout the test (case 590).

tracing were clearly recorded. During pressure breathing they were almost extinguished, while the pulmonary arterial pressure pulse remained essentially unaltered.

DISCUSSION

The obvious venous type of pulse obtained in the pulmonary capillary venous pressure tracings was one of the reasons which led us to
believe that it was a transmission of left atrial pressure. Also this type is found to be much more pronounced in cases with heart disease affecting the left heart and leading to increased pressure and/or blood filling of the pulmonary vascular tree. The circumstances created by a long lasting disease with gradual changes in the pulmonary vessels cannot be duplicated in "acute" animal experiments.

When the pulmonary artery or one of its major branches is occluded by such a large and tense object as the balloon used in the present experiments, the blood flow stops, the pressure falls, and the arterial pulse wave is no longer transmitted as before. However, the pulmonary capillary venous pressure pulse obtained in the lung lobe corresponding to the occluded main artery remains unchanged. This conclusively shows that neither the height nor the shape of the pulmonary capillary venous pressure is influenced by the pulmonary artery. It must consequently be a true transmitted wave from the pulmonary veins and the left atrium.

The size of the systolic wave obtained cannot, however, on its own be relied upon in diagnosing mitral insufficiency on account of the lack of correspondence between mitral regurgitation and systolic pressure increase. Likewise, the size of a presystolic wave is not conclusive when diagnosing mitral stenosis. In a critical study of the pulmonary capillary venous pressure pulse in dogs it was concluded that pulmonary capillary venous pressure was a measure of left atrial pressure only when it did not contain any detailed, pulsating contour. Furthermore, it was believed that pulse waves must be transmitted from the pulmonary artery and that only "enthusiastic investigators" could see any resemblance to a true venous curve. The present report conclusively shows that in cases with heart disease the pulmonary capillary venous pressure pulse is not transmitted from the pulmonary artery.

In case 590 it could be shown that the pulmonary capillary venous pulse wave was extinguished during positive pressure breathing; the mean pressure, however, remaining unaltered. This perhaps explains why satisfactory pulmonary capillary venous tracings were not obtained in the anesthetized dog, with open chest and subject to positive pressure breathing as in the report mentioned above.

**SUMMARY AND CONCLUSIONS**

1. In one case of mitral stenosis and one case of patent ductus arteriosus with mitral incompetence the pulmonary capillary venous pressure pulse was recorded while the corresponding lobar artery was totally occluded by a rubber balloon placed in the tip of a second catheter and inflated with 30 per cent Diodrast under fluoroscopic control.

2. The mean height and shape of the pulmonary capillary venous pressure curve did not change in either case when the balloon was inflated or deflated.

3. It is concluded that the pulmonary arterial pulse does not influence the shape of the pulmonary capillary venous curve and that the latter gives a true picture of events in the pulmonary veins.

4. The pulse wave obtained with the catheter in the pulmonary capillary venous position is damped out completely during positive pressure respiration, but the mean pressure is essentially unchanged.

**REFERENCES**


- Further experimental evidence that pulmonary capillary pressures do not reflect cyclic changes in left atrial pressure (mitral lesions and pulmonary embolism). Circulation Research 1: 58, 1953.


The Influence of the Pulmonary Arterial Pressure on the Pulmonary Capillary Venous Pressure in Man

LARS WERKÖ, E. VARNAUSKAS, H. ELIASCH and B. THOMASSON

doi: 10.1161/01.RES.1.4.340

_Circulation Research_ is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231
Copyright © 1953 American Heart Association, Inc. All rights reserved.
Print ISSN: 0009-7330. Online ISSN: 1524-4571

The online version of this article, along with updated information and services, is located on the World Wide Web at:
http://circres.ahajournals.org/content/1/4/340

Permissions: Requests for permissions to reproduce figures, tables, or portions of articles originally published in _Circulation Research_ can be obtained via RightsLink, a service of the Copyright Clearance Center, not the Editorial Office. Once the online version of the published article for which permission is being requested is located, click Request Permissions in the middle column of the Web page under Services. Further information about this process is available in the Permissions and Rights Question and Answer document.

Reprints: Information about reprints can be found online at:
http://www.lww.com/reprints

Subscriptions: Information about subscribing to _Circulation Research_ is online at:
http://circres.ahajournals.org/subscriptions/