Direct Flowmetry of the Mitral Valve
A Simple Approach in the Experimental Study

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SUMMARY
A flow probe for direct measurement of blood flow of the mitral valve was devised. It was useful for acute experiment, particularly concerning pathophysiology of the mitral valve function. Insertion of the probe into the left atrium and fixation to the left atrial wall and thus to the mitral orifice were readily and satisfactorily performed without disturbance of blood flow and valvular function. It must also be emphasized that support with cardiopulmonary bypass was not necessary at the time of insertion of the probe. Effectiveness of the procedure has been confirmed through simultaneous observation of echocardiogram and mitral blood flow of the dog's heart with ruptured chordae tendineae.

Additional Indexing Words: Flow probe Direct flowmetry Mitral valve

FLOWMETRY is one of the fundamental approaches in the study of circulation. This paper deals with a devised flow probe and its insertion technique into the left atrium. Support of cardiopulmonary bypass was not necessary. Measurement of blood flow through the mitral valve was easy with this method. The device and the procedure were useful in acute experiments necessitating measurement of mitral blood flow.

MATERIALS AND METHODS
A flow probe has been devised in collaboration with Nihon Kohden Co. (Fig. 1). It has a thickness of 7 mm, slight inclination in connection with a cable (15 degrees), and 2 holes for fixation. The characteristics of the probe are presented in the table (Table I). An electromagnetic flow meter of MF-27 (Nihon Kohden) was available for this probe.

Mongrel dogs weighing over 15 Kg were anesthetized with 25 mg/Kg of in-
Fig. 1. Pictures of devised probe show a thickness of 7 mm and an angle between cable and probe (15 degrees). The probe has 2 holes on the body to be snared to the atrial wall. They are located at angles of 120 degrees from the point of cable attachment and are bored obliquely to make an angle of 45 degrees with the plane of circular probe. These holes are used for fixation of the probe on the mitral orifice.

Table I. Characteristics of the Probe

<table>
<thead>
<tr>
<th>Designs</th>
<th>Inner diameter (mm)</th>
<th>Outer diameter (mm)</th>
<th>Sensitivity (μV/l/min)</th>
<th>Flux density (gauss)</th>
<th>Inductance (mH)</th>
</tr>
</thead>
<tbody>
<tr>
<td>FM-200 T</td>
<td>20</td>
<td>30</td>
<td>3.5</td>
<td>28</td>
<td>1.72</td>
</tr>
<tr>
<td>FM-180 T</td>
<td>18</td>
<td>28</td>
<td>4.9</td>
<td>33</td>
<td>1.45</td>
</tr>
<tr>
<td>FM-160 T</td>
<td>16</td>
<td>26</td>
<td>6.5</td>
<td>40</td>
<td>1.74</td>
</tr>
</tbody>
</table>
Fig. 2. Two stitches are placed on the atrium passing the points closely superior to the atrioventricular sulcus and the points around the root of the left atrial appendage.

Fig. 3. The holes are snared by the threads. The threads are stitched back into the atrial cavity parallel with the previous course, avoiding tangle, and withdrawn near the initial stitches.

travenous pentothal sodium, intubated, and ventilated with a Harvard’s respirator. A left thoracotomy was performed in the fourth intercostal space. The pericardium was widely opened, pulled up, and fixed to the chest wall. A couple of stitches were placed on the left atrium passing through the cavity from the points superior to the atrioventricular sulcus to the points around the root of the left atrial ap-
Fig. 4. A purse-string suture is placed around the threads on the atrial wall. This is used for control of bleeding at the time of probe insertion.

Fig. 5. A Satinsky type vascular clamp is placed on the top of the left atrium, clamping the threads and a purse-string suture. Blood flow of the pulmonary veins and the left atrium must be maintained.

pendage. The points of initial stitches must be selected to correspond with the holes of the probe for snaring. Withdrawal points of the threads from the left atrium were placed very closely (Fig. 2). The threads were then passed through the holes of the probe and were stitched back into the left atrium parallel with previous stitches (Fig. 3). Needle was a special, having 60–70 mm length with 1/2 or 3/8 circle, atraumatic with 2/0 thread. A purse-string suture for safety insertion of the probe was placed around the threads at the root of the appendage (Fig. 4). Then a vascular clamp of Satinsky type was placed to include the threads and the purse-string suture, together in a clamp (Fig. 5). The atrial wall under the clamping was incised to allow probe insertion. Four threads in the incision wound must be set free from the atrial wall for quick and accurate
Fig. 6. The threads must be set free in an incision wound for quick insertion of the probe.

Fig. 7. After insertion of the probe, the threads snaring the holes are pulled at the lateral wall and tied. An adequate fixation of the probe to the left atrial wall in this way provides an appropriate fitting of the probe to the mitral orifice.

insertion of the probe (Fig. 6). The purse-string suture was tied after insertion of the probe. Each couple of double threads were pulled and were tied at the portion of initial stitch. Tight fixation of the threads provided appropriate positioning of the probe (Fig. 7). No air embolism occurred. Bleeding was minimal and no blood transfusion was necessary.

Comment

Direct flowmetry of the mitral valve provides important data for pathophysiological study of circulation. There were several reports concerned
with direct flowmetry of the atrioventricular valves.\textsuperscript{1}\textendash 3) They were, however, performed with a support by cardiopulmonary bypass at the time of probe insertion. Exceptionally, a report by Flotz\textsuperscript{4} in 1967 abandoned support by cardiopulmonary bypass. He devised a C-figure probe and insertion was accomplished through a small hole on the atrial wall, sliding the probe gradually into the left atrium while bleeding was controlled by means of a purse-string suture. Fixation of the probe in place was carried out through adequate positioning of the cable with manipulation from outside of the atrial wall. Snaring sutures of the probe were placed blindly from outside of the atrial wall, too. In our method, insertion of a probe with appropriate fixation in place was readily, accurately, and satisfactorily carried out. An angle between cable and probe offered a good position in fixation. The holes on the probe play important role in snaring and fixation of the probe in a correct position. The figure (Fig. 8) represents simultaneous recording of echocardiogram (above) and blood flow across the mitral orifice (below) of an experimental chordal rupture of the mitral valve in a dog. In this study, a probe of MF-180 T was used.

Our method is a promising procedure for hemodynamic study of the mitral valve. An additional benefit is reduced expense because of absent cardiopulmonary bypass support. This method is preferably useful for acute

![Fig. 8. The picture shows a simultaneous recording of the echocardiogram (above) and the flow pattern of the mitral orifice (below) in a dog with experimental chordal rupture.](image-url)
experiment. Insertion for chronic observation is also possible.

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REFERENCES