A Study of Duroziez's Murmur of Aortic Insufficiency in Man Utilizing an Electromagnetic Flowmeter

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SUMMARY

Femoral arterial blood flow was recorded with an electromagnetic flowmeter at the time of open heart surgery on subjects with and without aortic insufficiency. The records demonstrated that subjects with severe aortic insufficiency and Duroziez's murmur had a large amount of retrograde flow in the femoral artery. Those subjects without significant aortic insufficiency and no Duroziez's murmur had little or no backflow. When only a moderate amount of aortic insufficiency was present, the correlation was less satisfactory. In some subjects who had femoral backflow, a second recording was made from the femoral artery after the aortic valve had been replaced, and in these instances there was no longer any measurable backflow. Postoperatively these patients did not have Duroziez's murmur.

It is concluded that Duroziez's crural murmur in subjects with aortic insufficiency is associated with retrograde diastolic femoral arterial blood flow.

Additional Indexing Words: Femoral artery flow, Openheart surgery, Hemodynamics, Physical diagnosis

Since the middle of the nineteenth century, it has been postulated that the double crural murmur of Duroziez associated with aortic insufficiency is produced by forward flow during systole and retrograde flow during diastole.1,2 While this would seem to be a reasonable explanation, a considerable amount of investigation has been undertaken and conclusions have been drawn which both support3,4 and deny5,6 this contention. A recent report presented cineangiographic evidence that contrast material infused at a constant rate into the femoral artery was swept sharply backward during diastole in subjects with Duroziez's murmur.7 Most of the previous attempts to investigate this condition have been indirect, inferential, and somewhat subjective.

It would seem that a device such as an electromagnetic flowmeter, which records forward flow as a positive deflection and retrograde flow as a negative deflection, should be ideal to measure the flow direction in a subject with Duroziez's murmur, and thus to establish the presence or absence of backflow. While some investigators are not willing to accept the quantitative nature of data from electromagnetic flowmeters, most will accept their qualitative recording of forward and backward flow. Furthermore, there is considerable precedent for the present technique since other investigators have reported results of flow studied acutely during surgical procedures on the carotid,8 hepatic,9 pulmonary,10 femoral,11 popliteal,12 and other arteries.13

Methods

For this study a Medicon K2000 electromagnetic flowmeter was used. The electrical output...
of the flowmeter was recorded on a Sanborn model 296 two-channel portable recorder. Electromagnetic flowmeter probes were constructed in 1-mm increments for the range from 5 to 10 mm. Each probe was calibrated prior to use, using a segment of dog abdominal aorta of appropriate size. Blood was passed through the vessel at various rates, into a graduated cylinder, and the corresponding deflection recorded. The blood flow in milliliters per minute was plotted against the output of the flowmeter. A calibration curve, as shown in figure 1, was prepared for each probe.

The probe was applied to the femoral artery after it had been exposed but prior to its use for the arterial inflow during cardiopulmonary bypass. Zero flow was recorded by temporarily clamping the vessel. The forward flow of blood into the extremity was represented in the pulsatile flow profile as the area under the curve and above the zero line, whereas backflow was indicated by the curve below the zero line. Since the response of the flowmeter is linear, the ratio of the areas below to those above the zero line was converted simply into the percentage of backflow.

A variety of subjects were studied, but for purposes of this communication they were divided into those with and without aortic insufficiency. The criteria for the amount of aortic insufficiency were those of cardiac catheterization and surgical exploration. At catheterization aortic insufficiency was estimated by injecting indocyanine-green dye into the aortic root and withdrawing blood continuously through equisensitive cuvette densitometers from the left ventricle and the femoral artery. The estimate of insufficiency related the amount of dye which appeared in the left ventricle to that which appeared in the femoral artery. Aortic insufficiency was also estimated from cineangiograms taken during aortic root injection. Direct observation of aortic insufficiency was made at operation when, during

Figure 1

Calibration curve showing blood flow plotted against output of the flowmeter.
bypass, the left ventricle was opened. Utilizing the composite of information obtained by the indicator-dilution curves, cineangiograms, and observations made at operation, the aortic insufficiency was categorized as none, moderate, or severe. The group with aortic insufficiency was further divided into those who exhibited Duroziez's murmur and those who did not. The criteria for Duroziez's murmur were strictly clinical. It was recorded as present or absent after auscultation for the diastolic murmur during varying degrees of compression over the femoral artery.

Cardiac index was determined at catheterization by the Fick principle. Expired air was analyzed for oxygen and carbon dioxide by the

**Figure 2**
Example of phasic flow pattern in a case of aortic stenosis without significant aortic insufficiency.

**Figure 3**
Flow pattern in severe aortic stenosis and moderate aortic insufficiency.
Scholander apparatus, and blood gases were determined by the Van Slyke-Neill method.

Results

An example of the phasic flow pattern of a subject with aortic stenosis and no significant insufficiency is shown in figure 2. As can be seen there is considerable flow into the extremity and very little, if any, backflow. The magnitude of forward flow recorded immediately after removal from the cardiopulmonary bypass is greater than one would expect for a lower limb under normal circumstances. This is probably due to reactive hyperemia secondary to ischemia in the extremity during the bypass. A subject with severe aortic stenosis and moderate aortic insufficiency produced the flow pattern presented in figure 3. This subject has a small amount of femoral backflow but apparently not enough to produce an audible Duroziez's murmur. Figure 4 presents the flow pattern of a subject with very severe aortic insufficiency and a ventricular septal defect. This individual had a very loud Duroziez's murmur and showed a considerable amount of retrograde femoral flow. Indeed the integrated area below zero exceeds that above and must be attributed to instrumental error. Clearly more blood cannot flow out of the femoral artery during diastole than enters during systole unless this occurs only transiently. The second record in figure 4 was taken 45 minutes after discontinuing cardiopulmonary bypass with a normally functioning aortic valve. The flow into the femoral artery is in a normal range and no backflow is evident.

Further results are summarized in table 1. As can be seen on all occasions but one, when Duroziez's murmur was observed, a significant amount of femoral arterial backflow was measured at operation. In the one discrepant case Duroziez's murmur was considered to be slight. Two patients, O.H. and P.M., who had moderate aortic insufficiency showed some femoral arterial backflow, but did not exhibit Duroziez's murmur. It is to be expected that subjects with moderate aortic insufficiency and a small amount of backflow may well have a borderline condition that may not produce an audible crural murmur.

Discussion

Some observers think that an electromagnetic flowmeter probe should be left in place
Table 1
Duroziez’s Murmur of Aortic Insufficiency

<table>
<thead>
<tr>
<th>Subject</th>
<th>Diagnosis</th>
<th>Duroziez’s murmur</th>
<th>Cardiac index (L/min/m²)</th>
<th>Mean femoral flow (ml/min)</th>
<th>Backflow before valve repair (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>P.C.</td>
<td>VSD</td>
<td>No</td>
<td>No</td>
<td>2.3</td>
<td>300</td>
</tr>
<tr>
<td>G.P.</td>
<td>AS</td>
<td>No</td>
<td>No</td>
<td>3.8</td>
<td>380</td>
</tr>
<tr>
<td>H.D.</td>
<td>Severe MS, moderate AI</td>
<td>No</td>
<td>No</td>
<td>2.9</td>
<td>320</td>
</tr>
<tr>
<td>J.P.</td>
<td>Moderate AI, AS</td>
<td>No</td>
<td>No</td>
<td>3.5</td>
<td>340</td>
</tr>
<tr>
<td>C.M.</td>
<td>MS, MI, AI</td>
<td>Slight</td>
<td>No</td>
<td>3.1</td>
<td>350</td>
</tr>
<tr>
<td>O.H.</td>
<td>Severe AS, moderate AI</td>
<td>No</td>
<td>No</td>
<td>2.5</td>
<td>320</td>
</tr>
<tr>
<td>P.M.</td>
<td>Mild MI, moderate TI, AI</td>
<td>No</td>
<td>No</td>
<td>3.9</td>
<td>310</td>
</tr>
<tr>
<td>R.B.</td>
<td>Mild MI, severe AI</td>
<td>Yes</td>
<td>No</td>
<td>3.4</td>
<td>220</td>
</tr>
<tr>
<td>D.S.</td>
<td>Severe AI</td>
<td>Yes</td>
<td>No</td>
<td>3.0</td>
<td>270</td>
</tr>
<tr>
<td>W.J.</td>
<td>Severe AI</td>
<td>Yes</td>
<td>No</td>
<td>2.8</td>
<td>180</td>
</tr>
<tr>
<td>D.S.</td>
<td>Severe AI, VSD</td>
<td>Yes</td>
<td>No</td>
<td>3.0</td>
<td>50</td>
</tr>
</tbody>
</table>

*Coarctation of the aorta had been repaired at a previous operation. Subsequently the bicuspid aortic valve became incompetent.
†See text for discussion of this figure.

for several days to ensure complete welding of the probe to the arterial surface before truly objective measurements of flow can be made. Whereas this is no doubt ideal, it is not practicable for the present type of study, and in our experience if a good fit is obtained and movement of the probe on the vessel is minimal, a reasonably accurate measurement can be achieved. Additional features of the present probe, such as graphite coating and slightly elevated contact electrodes, may enhance the accuracy of the acute measurement, for clearly there was some error as indicated in figure 4 and in table 1.

In two recent studies human ascending aortic blood flow was measured with an electromagnetic flowmeter.14,15 The investigators observed that during an open chest operation a normal aortic valve prevented diastolic backflow into the left ventricle as did a prosthetic valve.14,15 However, in subjects with aortic insufficiency as much as 43%14 to 75%15 of the left ventricular stroke volume regurgitated into the left ventricle through the incompetent aortic valve. It seems inevitable that if 75% of the blood ejected into the aorta reverses its direction and re-enters the ventricle during diastole, some of the blood in the more distal arterial tree would also have to reverse its direction of flow. This is consistent with the present observations that in some subjects with severe aortic insufficiency large amounts of femoral arterial diastolic backflow occurred. In addition, the present results demonstrate that, after the valve was repaired, backflow at the level of the femoral artery was reduced essentially to zero, as has been reported in the ascending aorta.14,15

It is believed that the overall correlation presented in this study is reasonably good; that is, a subject with severe aortic insufficiency and a readily audible Duroziez’s crural murmur has considerable diastolic backflow in the femoral artery. A patient with a moderate amount of aortic insufficiency and with an equivocal Duroziez’s murmur may or may not show femoral backflow at operation;
and a patient clearly without aortic insufficiency and without Duroziez's murmur shows no significant backflow. It is not surprising that there are some discrepancies in the middle ground. Duroziez's murmur is not easily elicited in all subjects, particularly in those who are overweight and in whom retrograde flow is small. The degree of compression required to elicit the murmur is critical and may be difficult to achieve. Furthermore, it may be possible to confuse the murmur created by blood passing out of the extremity through the vein with that caused by blood passing out of the extremity in the artery. The murmur attributed to venous outflow is thought to be a continuous rumbling murmur; but only its diastolic portion may be heard if the degree of compression in the femoral artery is sufficient to produce a loud systolic murmur overwhelming the lower pitched and softer continuous component. We have no objective evidence that this rumbling murmur is produced in the venous system, but such a murmur was described by Duroziez and has long been presumed to be venous in origin. Finally, backflow from a vascular bed as large as that of the femoral artery must depend on resistance to runoff through its periphery as opposed to diastolic resistance in the more proximal vascular beds. Thus if, for example, the femoral resistance is high owing to chilling the extremity and the visceral resistance is low, it would be expected that the elastic femoral vascular bed would give up blood to the lower resistance system during diastole. This was demonstrated to occur in a previous study of Duroziez's murmur and may explain some of the discrepancies in the present study.

References


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