CRITICAL REVIEW

The Anatomic Variability of Coronary Arterial Fistulae Termination in the Right and Left Atria

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Ten cases of fistulae between a coronary artery and either the right or left atrium have been studied. Pertinent material from a review of the literature supplements the clinical analysis. The major finding is the anatomic variability of the fistula site, with three primary patterns of communication evident for both right and left atrial termination. These anatomic findings become relevant to (a) the proper diagnostic interpretation of arteriography, and (b) the proper selection of a surgical approach.

The diagnosis and adequate surgical correction of fistulae between the coronary arterial system and a cardiac chamber can present difficulties, especially with regard to a precise definition of the involved pathologic anatomy. Because of the scattered nature by which these fistulae are described, an appreciation as to how a particular group or subgroup varies in anatomy, ease of diagnosis and response to operation is difficult to obtain.

Coronary fistulae terminating in either the right or left atrium, since a low pressure cardiac chamber is involved, are physiologically different from those terminating in the higher pressure ventricles. The thin wall of the atrium has little effect on the fistula opening, while the thick-walled ventricles narrow or close the fistula opening during systole.

Anatomically, there is considerable variability of the site of fistula termination within either involved atrium. An appreciation of this variability would certainly improve interpretation of catheterization/arteriography studies and make the choice of a surgical approach easier.

This material was derived from a larger study of congenital abnormalities of the coronary arteries,469 patients subsequently studied and treated, and a review of the literature.

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CLINICAL MATERIAL

The pertinent findings in the current case series are summarized in Table 1. Representative arteriograms are shown in Figures 1 through 4.

Anatomy

Case 1 appeared to be a confluent termination of both the left circumflex and anterior descending branches adjacent to the ostium of the coronary sinus into the right atrium. Since the atrium was not opened during the surgical repair, it was not possible to ascertain the final point of communication. Cases 2, 3 and 5 involved right or left sinus node branches terminating near the junction of the superior vena cava with the right atrium. Cases 4 and 6 involved branches from the main right coronary artery terminating in the right atrial appendage. The patient in case 7 had a unique double fistula, to the right atrium near the tricuspid valve and to the right ventricular outflow tract. Cases 8 and 9 involved a branch of the left circumflex artery terminating in the left atrial appendage. Case 10 involved a small communication of the terminal right coronary artery with the posterior surface of the left atrium.

Operation

Distal ligation of the fistula was undertaken in seven cases, and similar surgical repair is planned in the eighth. Two patients were placed on cardiopulmonary bypass, but the atrium was not explored in either case. The course after operation was uneventful in all of these patients, with observation ranging from three months to four years. The patient in case 6 has had cardiac catheterization since operation, with no residual shunt being found.

DISCUSSION

Combining the current cases and those adequate-
### Table 1—Coronary Artery-Atrial Fistulae in the Current Study

<table>
<thead>
<tr>
<th>Case, No.</th>
<th>Age, Yrs.</th>
<th>Sex</th>
<th>Artery</th>
<th>Termination</th>
<th>Symptoms</th>
<th>Electrocardiographic Findings</th>
<th>Catheterization Data</th>
<th>Surgery Performed</th>
<th>Follow-up</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>55</td>
<td>F</td>
<td>LCIRC, LADCA</td>
<td>RA-3 or CS</td>
<td>DOE, URI, CHF</td>
<td>RBBB, AF</td>
<td>small shunt to RA</td>
<td>distal ligation, bypass</td>
<td>3 mos., asymptomatic</td>
</tr>
<tr>
<td>2</td>
<td>5</td>
<td>M</td>
<td>LSNA</td>
<td>RA-2</td>
<td>none</td>
<td>R axis deviation</td>
<td>shunt to RA</td>
<td>distal ligation, bypass</td>
<td>4 yrs., asymptomatic</td>
</tr>
<tr>
<td>3</td>
<td>40</td>
<td>F</td>
<td>RSNA</td>
<td>RA-2</td>
<td>DOE, URI, CHF</td>
<td>LVH</td>
<td>shunt to RA</td>
<td>distal ligation</td>
<td>3 yrs., asymptomatic</td>
</tr>
<tr>
<td>4</td>
<td>35</td>
<td>F</td>
<td>RCA</td>
<td>RA-1</td>
<td>DOE, URI, CHF</td>
<td>normal</td>
<td>shunt to RA</td>
<td>distal ligation</td>
<td>2 yrs., asymptomatic</td>
</tr>
<tr>
<td>5</td>
<td>5</td>
<td>F</td>
<td>RSNA</td>
<td>RA-2</td>
<td>none</td>
<td>LVH</td>
<td>shunt to RA</td>
<td>distal ligation</td>
<td>3 yrs., asymptomatic</td>
</tr>
<tr>
<td>6</td>
<td>10</td>
<td>F</td>
<td>RCA</td>
<td>RA</td>
<td>none</td>
<td>normal</td>
<td>no shunt by O2 saturation levels, small RA shunt by ascorbate indicator</td>
<td>distal ligation</td>
<td>1 yr., asymptomatic, no shunt by repeat catheterization</td>
</tr>
<tr>
<td>7</td>
<td>11</td>
<td>M</td>
<td>RCA</td>
<td>RA-1, RV-O</td>
<td>DOE</td>
<td>bigeminy</td>
<td>probable RV shunt</td>
<td>planned</td>
<td>—</td>
</tr>
<tr>
<td>8</td>
<td>46</td>
<td>M</td>
<td>LCIRC</td>
<td>LA-1</td>
<td>none</td>
<td>none</td>
<td>none</td>
<td>none</td>
<td>found at autopsy</td>
</tr>
<tr>
<td>9</td>
<td>7</td>
<td>F</td>
<td>LCIRC</td>
<td>LA-1</td>
<td>none</td>
<td>normal</td>
<td>no detectable shunt</td>
<td>distal ligation</td>
<td>3 yrs., asymptomatic</td>
</tr>
<tr>
<td>10</td>
<td>66</td>
<td>M</td>
<td>LCIRC</td>
<td>LA-3</td>
<td>DOE</td>
<td>none</td>
<td>none</td>
<td>none</td>
<td>found at autopsy</td>
</tr>
</tbody>
</table>

RCA = right coronary artery.  
RSNA = sinus node branch of right coronary artery.  
LCIRC = left circumflex artery.  
LADCA = left anterior descending artery.  
LSNA = sinus node branch of left coronary artery.  
1, 2, 3 = types of termination, see text for details.  
RA = right atrium.  
LA = left atrium.  
DOE = exertional dyspnea.  
URI = frequent upper respiratory infections.  
CHF = congestive heart failure.  
RBBB = right bundle branch block.  
LVH = left ventricular hypertrophy.  
AF = atrial fibrillation.  
AO = aorta.

**FIGURE 1.** Serial aortic root injection in case 1, demonstrating enlargement of left circumflex artery. Third frame shows opacification of anterior descending artery near fistula termination.
ly described in the literature, there were 72 cases terminating in the right atrium,469,471a3 and 16 cases terminating in the left atrium.469,484 Three cases of termination in the superior vena cava will also be included in the "right atrial termination" category, since the only real difference is a distance of a few millimeters along the course of two convergent structures.

There are three characteristic regions of termination of fistulae within the right atrium. These are depicted schematically in Figure 5. In type I a short, dilated arterial branch extends from the main right coronary artery to a termination in either the right atrial appendage (auricle) or the anterior right

Figure 2. Schematic and radiographic depictions of fistulae in case 2, case 4. See text and Table 1 for details.

Figure 3. Schematic and radiographic depictions of fistulae in case 3, case 5. See text and Table 1 for details.
atrium near the tricuspid valve. Only the right coronary artery appears to be involved in this type. Type 2 is more variable. The sinus node (sinoatrial) branch of either the right or left coronary artery may be involved. This branch courses posteriorly between the atria, then either terminates anterior to the superior vena cava or courses around the superior vena cava to terminate on the posterior atrial surface. Included in type 2 are those fistulae that terminate in the superior vena cava, all of which involve the sinus node branch. In type 3 the site of termination is the posterior surface of the right atrium, along the atrioventricular groove; either the right or left coronary artery may be involved.

Utilizing this classification scheme, there were 19 cases of type 1. All involved a right atrial branch, with termination in the atrial appendage or anterior atrial wall just above the tricuspid valve. The most frequently encountered variety was type 2. There were 39 cases, 19 involving the right sinus node branch and 20 involving the left sinus node branch. In ten cases the fistula terminated in the posterior right atrium (type 3). Six cases involved the terminal right coronary artery, three cases the terminal left circumflex branch, and one case both the left circumflex and anterior descending branches.

The types of termination in the left atrium are depicted in Figure 6. They are analogous to right atrial termination, except that the left coronary artery is involved in type 1; no cases of a right coronary branch have been described.

In six cases, a branch arising from the left main stem or circumflex branch entered the left atrial appendage. In a seventh case involving a circumflex-left atrial communication, the circumflex artery arose from the pulmonary artery, rather than the aorta. In one case, the left anterior descending branch communicated with the left atrial appendage. Three cases had a communication between the right sinus node branch and the left atrium. Sloman described a dilated left circumflex artery that formed a side-to-side fistula with the left atrial appendage, then continued to a terminal fistula in the pulmonary artery. Char reported a case with a fistula from the left circumflex branch to the left atrial appendage; however, the right coronary artery gave off a large branch that crossed the right ventricular outflow tract, joined the left anterior descending artery, and thus circuitously communicated with the fistula.

While virtually all coronary artery-cardiac cham-

Figure 4. Schematic and radiographic depiction of fistula in case 9. See text and Table 1 for details.

Figure 5. Schematic depiction of varieties of fistulae entering right atrium. Type 1 illustrated by Figure A. Type 2 by figures B, C. Type 3 illustrated by Figure C. See text for details.

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umber fistulae appear to be of congenital origin, Searcy\textsuperscript{470} has recently proposed that the small fistulae found in some adults with arteriosclerotic coronary disease might be a response to altered hemodynamics and therefore be acquired, rather than congenital, in origin. Normally, the dilated arterial segment involved in a fistula is not significantly arteriosclerotic.

Hemodynamically, fistulae terminating in either atrium behave differently from those terminating in other cardiac chambers or associated structures. First, the atrial chamber, because of its size and large inflow and outflow channels, can easily accommodate large shunts. The reserve volume expansibility of the ventricles is less. The flow in the coronary sinus is limited by the size of the ostium into the right atrium, which causes significant retrograde filling of the coronary venous system.\textsuperscript{470} Second, the fistula usually enters the atrium by a large ostium. Since this fistula is contained within a thin atrial wall, there is minimal change in the ostial size during the cardiac cycle and thus minimal change in the degree of shunting during systolic and diastolic phases. In contrast, the fistula with a ventricular termination must course through a thick muscular wall that often significantly narrows or completely closes the ostium during systole. Thus, shunt flow is usually diastolic in ventricular fistulae. In fistulae to the pulmonary artery, the single ostium is usually small or there may be multiple small ostia, with a small shunt-flow.\textsuperscript{469}

In contrast to ventricular fistulae, only 28 of 93 patients with atrial fistulae were asymptomatic. Fifteen of 65 had significant congestive failure, and 26 had mild congestive failure. Only two cases of subacute bacterial endocarditis were reported, a much lower incidence than in fistulae to the coronary sinus (this is probably directly related to the "stagnation" of flow in fistulae to the coronary sinus,\textsuperscript{470} whereas there is a rapid "turnover" of the shunt flow in the fistulae to the atrium).

Electrocardiographic changes appeared to be more common in atrial termination than in other chamber fistulae. Usually a conduction defect or arrhythmia was present. The cause of these changes was probably directly related to the usual source of blood to the sinoatrial (SA) and atrioventricular (AV) nodes being partially diverted through the main fistula shunt. Hudspeth\textsuperscript{468} did flow studies during surgery that showed flow in the proximal coronary artery of 785 ml/min, with a fistula flow of 735 ml/min, leaving an effective myocardial flow of 50 ml/min. It is significant that the majority of these fistulae to the atria involve the sinus node branch, the major source of blood supply to the SA node.

Accurate diagnosis of fistulae to either atrium is possible only with contrast studies, either aortic root or selective coronary injections. However, selective coronary catheterization in children probably should be approached carefully, as this can lead to cardiac arrest when the normal side is occluded by the catheter.\textsuperscript{470}

Corrective surgery was undertaken in 56 cases (both right and left atrial involvement). In 41 cases the involved artery was ligated at or near the site of the atrial communication. In eight patients the fistula was closed from within the atrium. In four cases the right coronary artery was ligated at both its aortic origin as well as the fistula (no electrocardiographic changes were noted after operation). Four

\textsuperscript{469} Hudspeth, H.D.: Personal communication.

patients died following surgery, all with evidence of significant arrhythmias or infarction after operation.

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REFERENCES*

469 Ogden JA: Congenital variations of the coronary arteries. Thesis, Yale University School of Medicine, 1968

*This article does not contain references 1-488. These references are available on request to author.