Diagnosis of Coronary Artery Fistula by Two-Dimensional Echocardiography, Pulsed Doppler Ultrasound and Color Flow Imaging

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Ten consecutive patients with a coronary artery fistula, aged 1 day to 4 years, were studied by two-dimensional echocardiography, pulsed Doppler ultrasound and color flow imaging. All patients underwent cardiac catheterization, and seven patients had surgical closure of the fistula. The origin, course and site of drainage of the coronary artery fistula were correctly identified prospectively by echocardiographic examination in all patients. Color flow imaging was particularly helpful in visualizing the site of drainage of the fistula.

Diameters of the right and left coronary arteries at their origin and of the aortic root were measured from two-dimensional echocardiographic frames and compared with measurements obtained in normal children. The ratio of coronary artery diameter to aortic root diameter in normal children was 0.14 ± 0.03 (mean ± SD) for the right coronary artery and 0.17 ± 0.03 for the left coronary artery. These normal ratios were greatly exceeded for coronary arteries feeding the fistula, and ranged from 0.68 to 0.84 for the right coronary artery and from 0.34 to 0.52 for the left coronary artery.

All anatomic information needed for surgical treatment of coronary artery fistula was consistently obtained by echocardiography with color flow imaging. The fistula was closed from within the heart in five patients and by ligation from the epicardial surface in two patients. In these latter patients, intraoperative color flow imaging at the time of ligation proved to be extremely valuable in achieving complete closure.

The actual fistula comprises the short, usually narrow connection or connections between the feeding coronary artery and the chamber or vessel of drainage. However, the term "coronary artery fistula" has commonly been used (1) and will be used in this sense to describe both the dilated feeding coronary artery and the actual fistulous connection.

The diagnosis of coronary artery fistula has been made by cardiac catheterization and angiography with injection of contrast material either into the aortic root or selectively into the coronary arteries. More recently, diagnostic information has also been obtained by two-dimensional echocardiography complemented by pulsed Doppler ultrasound (8–10), contrast echocardiography (11,12), contrast-enhanced cine computed tomography (13) and nuclear magnetic resonance imaging (14). The anatomic information needed for adequate diagnosis and selection of the optimal surgical approach includes identification of the origin, course and site of drainage of the coronary artery fistula (6,7). Although two-dimensional echocardiography and pulsed Doppler ultrasound may yield this information (15,16), in the past this has not consistently been possible (10,17).
Color flow imaging may facilitate echocardiographic evaluation of a coronary artery fistula by displaying the direction and character of blood flow on two-dimensional images (18). We report our experience with echocardiography, including color flow imaging, in 10 consecutive patients who presented with coronary artery fistula, and describe the value of color flow imaging performed intraoperatively in assessing the completeness of surgical closure of the fistula.

**Methods**

**Study patients.** In 1987 and 1988, 10 patients, aged 1 day to 4 years, were referred to the University of California–San Francisco Medical Center for evaluation and treatment of suspected coronary artery fistula. All patients underwent echocardiographic examination and cardiac catheterization. Seven patients had surgical closure of the fistula.

**Echocardiography.** The echocardiographic examination included two-dimensional and pulsed Doppler studies using an Ultramark 8 sector scanner (Advanced Technology Laboratories) with 5 and 7.5 MHz mechanical transducers and 3 and 5 MHz annular array transducers. Color flow imaging was performed with a Hewlett Packard 77020A ultrasound system with 5 MHz short and medium focused transducers. In two patients, color flow imaging was also performed intraoperatively.

A variety of planes were used to image proximal and distal parts of the coronary arteries (19). The proximal right coronary artery, the left main coronary artery and the proximal portions of the left anterior descending and left circumflex arteries were visualized from parasternal short-axis, high parasternal sagittal and subcostal coronal views. The distal right coronary artery was imaged at the acute margin of the heart from the subcostal coronal view and in the posterior atrioventricular (AV) groove from the apical four chamber view with posterior angulation of the transducer. The posterior descending coronary artery was visualized from parasternal short-axis, subcostal coronal and apical four chamber views. The left circumflex coronary artery was imaged in parasternal short- and long-axis and subcostal sagittal views. The distal left anterior descending coronary artery was evaluated from parasternal long- and short-axis and subcostal coronal views. All studies were recorded on 0.5 in. (1.27 cm) videotape for measurements and evaluation of the specific contributions of two-dimensional echocardiography, pulsed Doppler ultrasound and color flow imaging to define the origin, course and site of drainage of the coronary artery fistula.

**Diameter measurements of the aortic root and the proximal coronary arteries** were made with use of a Microsonics 886 video analysis system. The diameter of the ascending aorta at the level of the aortic valve anulus and the diameters of the right and left main coronary arteries at the site of origin from the aortic root were measured from systolic two-dimensional images in parasternal long- and short-axis planes, respectively (Fig. 1). The ratio of coronary artery diameter to aortic root diameter was calculated and compared with the ratio obtained from measurements in 10 normal children and teenagers, aged 0.1 to 19 years.

**Cardiac catheterization.** Cardiac catheterization, including an aortic root or left ventricular angiogram, was performed in all 10 patients. The diameters of the aortic root at the level of the aortic valve annulus and the diameters of the right and left coronary arteries at the site of origin from the aortic root were measured during systole from aortic root or left ventricular angiograms. The ratio of either the right or left main coronary artery diameter to aortic root diameter was calculated and compared with the ratio obtained from echocardiographic measurements.

**Inter- and intraobserver variability.** To assess interobserver and intraobserver variability, all echocardiographic and angiographic measurements were performed independently by two observers. In five patients, the measurements were repeated by the same observer, who was unaware of the results of the previous measurements. Variability was calculated from the difference between two measurements and expressed as a percent of the mean of these measurements.

**Results**

**Clinical data (Table 1).** Seven of the 10 patients were asymptomatic and presented with a continuous cardiac murmur. Two neonates were symptomatic; one (Patient 7) was born with severe hydrops fetalis, presumably caused by intrauterine supraventricular tachycardia, and the other (Patient 3) presented shortly after birth with congestive heart failure from coarctation of the aorta and shunts at ductal, ventricular and atrial levels. A third symptomatic patient (Patient 10) was 3 months old and in mild congestive heart failure. Moderate cardiomegaly was present on chest X-ray study in all asymptomatic patients, and mild cardiomegaly was present in two asymptomatic patients. Abnormalities on the electrocardiogram (ECG) were seen in four patients, three with minor right ventricular conduction delay and one with left ventricular hypertrophy. In one patient (Patient 7), there was septal ischemia as demonstrated by ECG and thallium perfusion scan.

**Two-dimensional echocardiography (Table 2).** The proximal dilation of the coronary artery feeding the fistula was demonstrated in all 10 patients. The entire course of the coronary artery fistula, including the site of drainage, was visualized in all five cases in which the left circumflex coronary artery was the feeding vessel and the fistula drained into the right atrium (Fig. 2), the mouth of the coronary sinus (Fig. 3) or the right ventricle. In the three cases in which the right coronary artery was the feeding vessel, the course of the coronary artery fistula was imaged...
because the dilated right coronary artery could be seen in the anterior AV groove and at the acute margin of the heart. However, two-dimensional echocardiography did not demonstrate whether the coronary artery fistula drained from the posterior AV groove into the right atrium or the right ventricle. In both cases in which the left anterior descending coronary artery was the feeding vessel, neither the course beyond the proximal 2 cm nor the site of drainage of the coronary artery fistula was demonstrated by two-dimensional echocardiography.

Pulsed Doppler ultrasound (Table 2). Pulsed Doppler ultrasound demonstrated disturbed flow in dilated coronary arteries feeding the fistula in eight patients. This flow occurred primarily in late systole and early diastole. Disturbed flow in the chamber into which the fistula drained was detected in nine patients; however, in two patients, concomitant blood flow disturbances due to an atrial or ventricular septal defect were present. The pulsed Doppler characteristics of the flow disturbance caused by the coronary artery fistula were dependent on the exact sampling site within the chamber of drainage. At sites relatively remote from the site of drainage, flow was disturbed and of low velocity, whereas at sites very close to the site of drainage, flow was disturbed and occurred mainly in late systole and early diastole and at velocities that were >3 m/s in several patients.

Color flow imaging (Table 2). Color flow imaging readily demonstrated the site of drainage in all 10 patients and disturbed flow anywhere along the course of the coronary artery fistula in 9 patients (Fig. 4 to 6). In the two patients with additional anomalies (Patients 2 and 3), it clearly differentiated flow disturbances caused by an atrial or ventricular septal defect (Fig. 7) from the disturbed flow at the site of drainage of the coronary artery fistula.

Coronary artery measurements (Table 2). The diameter of the proximal coronary arteries feeding the fistula greatly exceeded the diameter of the nonfeeding coronary arteries in all cases. The ratio of the proximal right or left coronary artery diameter to the aortic root diameter is reported (20,21) to be a measure of coronary artery size that is independent of age and body size, allowing the comparison of coronary artery size in children of different ages. In normal children, we found this ratio to be 0.14 ± 0.03 (mean ± SD) for the right and 0.17 ± 0.03 for the left coronary artery. In our 10 patients, this ratio was 1.5 to 4 times greater than normal for proximal coronary arteries feeding the fistula and ranged from 0.68 to 0.84 for the right and from 0.34 to 0.52 for the left coronary artery. Figure 8 demonstrates the distinct separation between ratios found in normal coronary arteries and those found in coronary arteries feeding the fistula. The ratios observed in the nonfeeding coronary arteries of patients with a coronary artery fistula were within normal limits in all but two patients. In both of these patients, the ratios were just above upper limits of normal, but ventricular hypertrophy of the ventricle supplied by the nonfeeding coronary artery was present. Echocardiographic measurements correlated well with angiographic measurements (y = 0.002 + 0.99x; SE = 0.019, r = 0.99). Interobserver variability for both angiographic and echocardiographic measurements and intraobserver variability for echocardiographic measurements were <2%.

Cardiac catheterization (Table 1). Seven patients had a small left to right shunt with a pulmonary to systemic (Qp:Qs) flow ratio between 1.1:1 and 1.8:1, one patient had a moderately large shunt, one patient had no shunt measured by oximetry and in one patient the total shunt could not be calculated because pulmonary artery oxygen saturation was not measured. The origin, course and site of drainage of the coronary artery fistula were seen on aortic root or left ventricular angiograms and the findings were in agreement with the echocardiographic diagnosis in all 10 patients.

Surgery. To date, seven patients have undergone surgical closure of the coronary artery fistula; the three remaining patients are awaiting surgery. In the five patients whose
Table 1. Clinical, Roentgenologic, Electrocardiographic and Catheterization Data in 10 Patients With Coronary Artery Fistula

<table>
<thead>
<tr>
<th>Patient</th>
<th>Age symptoms noted</th>
<th>Clinical presentation</th>
<th>Chest X-ray study</th>
<th>Electrocardiogram</th>
<th>Cardiac catheterization</th>
<th>Fistula course</th>
<th>Additional anomalies</th>
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<tbody>
<tr>
<td></td>
<td>48 mo</td>
<td>Murmur</td>
<td>Cardiomegaly</td>
<td>RVCD, LVDH</td>
<td>LVEDP (mm Hg) 6 8</td>
<td>LCAx-&gt;RA</td>
<td>ASD</td>
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<tr>
<td></td>
<td>1 mo</td>
<td>Murmur</td>
<td>+</td>
<td></td>
<td>RVEDP (mm Hg) 2 7</td>
<td>LAD-&gt;RV</td>
<td>VSD, ASD</td>
</tr>
<tr>
<td></td>
<td>1 day</td>
<td>CHF</td>
<td>-</td>
<td></td>
<td>PAP (mm Hg) 20/10</td>
<td>RCA-&gt;RA</td>
<td>PDA, A0</td>
</tr>
<tr>
<td></td>
<td>6 mo</td>
<td>Murmur</td>
<td>+</td>
<td></td>
<td>Qp/Qs 1.0/1.1</td>
<td>RCA-&gt;CS</td>
<td>LVH</td>
</tr>
<tr>
<td></td>
<td>48 mo</td>
<td>Murmur</td>
<td>+</td>
<td></td>
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<td>LAD-&gt;RV</td>
<td></td>
</tr>
<tr>
<td></td>
<td>36 mo</td>
<td>Murmur</td>
<td>-</td>
<td></td>
<td>RVEDP (mm Hg) 5/7</td>
<td>LCx-&gt;RA</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Birth</td>
<td>+</td>
<td>-</td>
<td></td>
<td>PAP (mm Hg) 20/10</td>
<td>LCx-&gt;RA</td>
<td></td>
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<tr>
<td></td>
<td>5 mo</td>
<td>CHF</td>
<td>+</td>
<td></td>
<td>Qp/Qs 1.0/1.1</td>
<td>LCx-&gt;CS</td>
<td></td>
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<tr>
<td></td>
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<td>LVEDP (mm Hg) 10/14</td>
<td>LAD-&gt;RV</td>
<td></td>
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<tr>
<td></td>
<td>3 mo</td>
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<td>+</td>
<td></td>
<td>RVEDP (mm Hg) 5/7</td>
<td>LCx-&gt;RA</td>
<td></td>
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ASD = atrial septal defect; CHF = congestive heart failure; CoArc = coarctation of the aorta; CS = coronary sinus; LAD = left anterior descending coronary artery; LCx = left circumflex coronary artery; LVEDP = left ventricular end-diastolic pressure; LVH = left ventricular hypertrophy; NE = not entered; PAP = pulmonary artery pressure; PDA = patent ductus arteriosus; Qp/Qs = ratio of pulmonary to systemic blood flow; RA = right atrium; RCA = right coronary artery; RV = right ventricle; RVCD = right ventricular conduction delay; RVEDP = right ventricular end-diastolic pressure; RVH = right ventricular hypertrophy; SVT = supraventricular tachycardia; VSD = ventricular septal defect; - = absent; + = present.

Table 2. Echocardiographic Findings in 10 Patients With Coronary Artery Fistula

<table>
<thead>
<tr>
<th>Patient</th>
<th>Two-dimensional echocardiography</th>
<th>Pulsed Doppler ultrasound</th>
<th>Measurements by echocardiography</th>
<th>Measurements by angiography</th>
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<td></td>
<td>Dilated proximal LMCA</td>
<td>Difficulty in imaging</td>
<td>Proximal RCA (cm) 0.30 0.24 0.71</td>
<td>RCA/Ao ratio 0.14 0.17 0.84</td>
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<tr>
<td></td>
<td>Dilated proximal RCA</td>
<td>Difficulty in imaging</td>
<td>Proximal LMCA (cm) 0.91 0.60 0.20</td>
<td>LMCA/Ao ratio 0.45 0.44 0.24</td>
</tr>
<tr>
<td></td>
<td>Course visualized</td>
<td>Difficulty in imaging</td>
<td>RCA/Ao ratio 0.14 0.15 0.80</td>
<td>LMCA/Ao ratio 0.45 0.44 0.24</td>
</tr>
<tr>
<td></td>
<td>Site of drainage visualized</td>
<td>Difficulty in imaging</td>
<td>LMCA/Ao ratio 0.45 0.44 0.24</td>
<td>Color flow imaging</td>
</tr>
<tr>
<td></td>
<td>+(RA)</td>
<td>Difficulty in imaging</td>
<td>LMCA/Ao ratio 0.45 0.44 0.24</td>
<td>Course visualized +</td>
</tr>
<tr>
<td></td>
<td>+(RA)</td>
<td>Difficulty in imaging</td>
<td>LMCA/Ao ratio 0.45 0.44 0.24</td>
<td>Site of drainage visualized +</td>
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<td></td>
<td>+(RA)</td>
<td>Difficulty in imaging</td>
<td>LMCA/Ao ratio 0.45 0.44 0.24</td>
<td>+(RA)</td>
</tr>
<tr>
<td></td>
<td>+(RA)</td>
<td>Difficulty in imaging</td>
<td>LMCA/Ao ratio 0.45 0.44 0.24</td>
<td>+(RA)</td>
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<td></td>
<td>+(RA)</td>
<td>Difficulty in imaging</td>
<td>LMCA/Ao ratio 0.45 0.44 0.24</td>
<td>+(RA)</td>
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<td></td>
<td>+(RA)</td>
<td>Difficulty in imaging</td>
<td>LMCA/Ao ratio 0.45 0.44 0.24</td>
<td>+(RA)</td>
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<td></td>
<td>+(RA)</td>
<td>Difficulty in imaging</td>
<td>LMCA/Ao ratio 0.45 0.44 0.24</td>
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<td></td>
<td>+(RA)</td>
<td>Difficulty in imaging</td>
<td>LMCA/Ao ratio 0.45 0.44 0.24</td>
<td>+(RA)</td>
</tr>
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*Separate origin of normal-sized left anterior descending and left circumflex coronary arteries. CA = coronary artery; LMCA = left main coronary artery; LMCA/Ao = ratio of left main coronary artery diameter to aortic root diameter; RCA/Ao = ratio of right coronary artery diameter to aortic root diameter; other abbreviations as in Table 1.
coronary artery fistula drained into the right atrium or the mouth of the coronary sinus, the fistula was closed from within the heart on cardiopulmonary bypass with use of the mattress suture technique and Teflon felt patches to ensure closure against a pressure gradient. In two patients, the feeding coronary artery was ligated from the epicardial surface; in one of them (Patient 8), the fistula originated from the distal left anterior descending coronary artery and drained into the right ventricle near the apex of the heart. Color flow imaging performed intraoperatively demonstrated complete disappearance of the shunt after ligation (Fig. 9). In the other patient (Patient 10), the fistula originated from the right coronary artery in the posterior AV groove and drained in a fenestrated fashion into the right ventricle. In this patient, the epicardial approach was selected because the site of drainage in the right ventricle behind the posterior leaflet of the tricuspid valve would have made intracardiac closure difficult. After the base of the fistula was closed with pledgeted horizontal mattress sutures, intraoperative color flow imaging showed a residual shunt. Thus, the dilated right coronary artery was ligated just proximal and distal to the fistula between the acute marginal and posterior descending coronary arteries, with complete disappearance of the shunt as demonstrated by color flow imaging. The postoperative course was complicated by global ischemia and left ventricular dysfunction, which completely resolved after 36 h. A small area of myocardial infarction in the posterior right ventricular wall was demonstrated by ECG and radiolabeled phosphate scan.

Discussion

Echocardiography. The noninvasive diagnosis of the origin, course and site of drainage of the coronary artery fistula was consistently possible with combined two-dimensional echocardiography, color flow imaging and pulsed Doppler ultrasound. Two-dimensional echocardiography allowed excellent qualitative and quantitative evaluation of the proximal coronary arteries. In our experience, the ratio of coronary artery diameter to aortic root diameter provided a reliable index to define coronary artery dilation and substantiated the subjective impression of dilation. The complete course of the coronary artery fistula was visualized by two-dimensional echocardiography when either the left cir-
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Figure 3. Patient 7. Coronary artery fistula (CAF) with the left circumflex coronary artery as the feeding vessel and drainage into the mouth of the coronary sinus. **Top**, Parasternal short-axis view (P S Ax) showing the separate origin of the normal-sized left anterior descending coronary artery (LAD) (closed arrow) and the dilated left circumflex coronary artery (open arrow). **Middle**, Subcostal sagittal view (S C Sag) showing the coronary artery fistula (CAF) in a posterior course typical for the normal course of the left circumflex coronary artery. **Bottom**, Subcostal coronal view (S C Cor) with posterior angulation of the transducer shows the coronary artery fistula (CAF) in the left posterior atrioventricular groove. The double contour in the mouth of the coronary sinus is the fistulous connection. Abbreviations as in Figure 1.

cinated in the posterior AV groove or near the apex of the right ventricle.

**Pulsed Doppler ultrasound** was capable of detecting disturbed flow at the site of drainage in nine patients, but in two of the nine, pulsed Doppler ultrasound findings may have resulted from additional anomalies that were present in close spatial relation to the site of drainage of the fistula. It has also been reported that flow disturbance caused by a coronary artery fistula is difficult to detect by pulsed Doppler ultrasound when it is small or very localized (10,22).

These difficulties were readily overcome with color flow imaging, which proved to be an important addition to the conventional echocardiographic examination because it precisely located the site of drainage of the coronary artery fistula, facilitated the delineation of the course of the dilated coronary artery feeding the fistula and provided unequivocal differentiation of the fistula from other anomalies. Furthermore, our intraoperative experience with color flow imaging confirmed the ease with which even small shunts can be detected. This is an extremely important characteristic of color flow imaging performed during surgical ligation because often there are multiple fistulous connections between the feeding coronary artery and the chamber of drainage. The value of color flow imaging in the demonstration of the site of drainage of a coronary artery fistula, especially in fistulas with small shunts, has also been described in two recent case reports (22,23) on three patients.

**Diagnostic and surgical implications.** The importance of imaging the origin and the entire course of the dilated feeding coronary artery as well as the site of drainage is twofold. First, it enables differentiation of coronary artery dilation due to coronary artery fistula from congenital or acquired forms of coronary artery dilation such as that seen in the right coronary artery when pulmonary origin of the left coronary artery is present (24) or in Kawasaki disease. Second, it provides important information for determining the surgical approach to closure of the coronary artery fistula. This approach is mainly determined by the extent of myocardial blood flow supplied by the feeding coronary artery beyond the origin of the fistulous connection and by the accessibility of the site of drainage from inside the heart. If the fistula originates from a distal portion of the feeding coronary artery, that artery may be most safely approached from the epicardial surface without significantly jeopardizing myocardial blood flow. A more proximal origin of the fistula will usually require closure from inside the heart or rarely, in the case of a very dilated coronary artery, from inside the coronary artery (7). The surgical approach may be modified when access to the site of drainage appears difficult from inside the heart.

Three patients had a fistula that originated from a branch of the left coronary artery and drained at the junction of the right atrium and the superior vena cava. The course of this fistula appeared similar to and required differentiation from a
Figure 4. Patient 4. Color flow imaging of coronary artery fistula (CAF) with the right coronary artery as the feeding vessel and drainage into the right ventricle (RV). Top, An apical view with anterior and sagittal angulation of the transducer shows the dilated right coronary artery and the normal-sized left coronary artery (not labeled) arising from the aorta (Ao). Flow toward the transducer (red) in the proximal right coronary artery and flow away from the transducer (blue) in the coronary artery fistula (CAF) running in the right anterior atrioventricular groove are demonstrated. Middle, Posterior angulation of the transducer shows disturbed flow in the coronary artery fistula (CAF) at the acute margin of the heart. Bottom, More posterior angulation demonstrates disturbed flow in the coronary artery fistula (CAF) in the right posterior atrioventricular groove and through the fistulous connection (FC) into the right ventricle (RV). Abbreviations as in Figure 1.

Figure 5. Patient 7. Color flow imaging of coronary artery fistula (CAF) with the left circumflex coronary artery as the feeding vessel and drainage into the mouth of the coronary sinus (CS). From both parasternal short-axis (top) and apical four chamber (bottom) views, disturbed flow is seen in the coronary artery fistula in the left posterior atrioventricular groove with drainage into the coronary sinus (CS). The bottom frame should be compared with the bottom frame in Figure 3. LVOT = left ventricular outflow tract; RA = right atrium; RVOT = right ventricular outflow tract; other abbreviations as in Figure 1.

condition referred to as congenital aortico-right atrial communication (25). The diagnosis of coronary artery fistula in these patients was made based on the identification of normal-sized coronary artery branches arising from the dilated structure. The course of the feeding coronary artery...
Figure 6. Upper left panel. Patient 5. Color flow imaging (subcostal coronal view) of coronary artery fistula (CAF) with a branch of the left circumflex coronary artery as the feeding vessel and drainage into the right atrium (RA) at the junction with the superior vena cava. Flow is seen in the feeding coronary artery and the aneurysmal dilation (*). Flow is disturbed at the site of the fistulous connection (arrow) with the right atrium. This color flow image frame should be compared with C in Figure 2. Other abbreviations as in Figure 1.

Figure 8. Lower left panel. Illustration of the ratio of coronary artery diameter to aortic root diameter (CA/Ao ratio) obtained from 17 normal right coronary arteries (RCA) (open squares), 3 right coronary arteries feeding a coronary artery fistula (closed squares), 13 normal left coronary arteries (LCA) (open circles) and 7 left coronary arteries feeding a coronary artery fistula (open circles). A distinct separation between ratios for normal coronary arteries and coronary arteries feeding coronary artery fistulas is demonstrated.

Figure 7. Upper right panels. Patient 2. Apical four chamber view. Color flow imaging at different intervals in the cardiac cycle demonstrates the difference in direction of disturbed blood flow created by the coronary artery fistula (left panel taken in diastole) (arrow) near the apex of the right ventricle (RV) and by a midmuscular ventricular septal defect (VSD) (right panel taken in systole). Abbreviations as in Figure 1.

Figure 9. Lower right panels. Patient 8. Intraoperative color flow imaging showing a coronary artery fistula with the left anterior descending coronary artery as the feeding vessel and drainage near the apex of the right ventricle (RV). In the left panel, color flow imaging from an apical four chamber view shows the flow from an apical fistula before ligation. Right panel. After ligation from the epicardial surface, there is complete disappearance of the shunt. Abbreviations as in Figure 1.
in these cases may suggest that the sinus node branch, which originates from the proximal left circumflex coronary artery in 41% of normal subjects (26), was involved in the fistula. In one other instance, we visualized the separate origin of a normal-sized left anterior descending coronary artery and a dilated left circumflex coronary artery (Fig. 3). In this patient, the absence of a normal-sized left circumflex coronary artery favored the diagnosis of a coronary artery fistula over an aortico-right atrial communication.

Conclusions. Our study demonstrates that all anatomic information regarding the origin, course and site of drainage of coronary artery fistula that is required for adequate diagnosis and planning of surgical treatment can be obtained from a comprehensive echocardiographic examination that includes color flow imaging. Color flow imaging performed intraoperatively may aid in assessing the completeness of surgical closure of the fistula. Further experience will determine whether echocardiography can replace cardiac catheterization and angiography as the preferred diagnostic modality for the evaluation of coronary artery fistula.

References