Is Routine Preoperative Cardiac Catheterization Necessary Before Repair of Secundum and Sinus Venosus Atrial Septal Defects?

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Between January 1976 and July 1983, 217 patients with atrial septal defect underwent surgical repair at Children's Hospital. Thirty with a primum atrial septal defect and 26 who underwent cardiac catheterization elsewhere before being seen were excluded from analysis. Of the 161 remaining patients, 52 (31%) underwent preoperative cardiac catheterization, 38 because the physical examination was considered atypical for a secundum atrial septal defect and 14 because of a preexisting routine indication. One hundred nine (69%) underwent surgery without catheterization, with the attending cardiologist relying on clinical examination alone in 5, additional technetium radionuclide angiocardiography in 5, M-mode echocardiography in 13 and two-dimensional echocardiography in 43; both M-mode echocardiography and radionuclide angiography were performed in 24 and two-dimensional echocardiography and radionuclide angiography in 19. Since 1976, there has been a trend toward a reduction in the use of catheterization and use of one rather than two noninvasive or semi-invasive techniques for the detection of atrial defects.

Of the 52 patients who underwent catheterization, the correct anatomic diagnosis was made before catheterization in 47 (90%). Two patients with a sinus venosus defect and one each with a sinus venosus defect plus partial anomalous pulmonary venous connection, partial anomalous pulmonary venous connection without an atrial septal defect and a sinus septal defect were missed. Of 109 patients without catheterization, a correct morphologic diagnosis was made before surgery in 92 (84%). Nine patients with a sinus venosus defect, three with sinus venosus defect and partial anomalous pulmonary venous connection, four with partial anomalous pulmonary venous return without an atrial septal defect and one with a secundum defect were incorrectly diagnosed.

In each case where the diagnosis was missed, the surgeon was able to repair the anomaly found without additional morbidity. In children with typical findings for atrial septal defect, routine preoperative catheterization is unnecessary.

Although cardiac catheterization has a well deserved reputation as the reference standard in the evaluation of cardiovascular physiology and anatomy, recent advances in the noninvasive evaluation of congenital heart disease have provided information previously unavailable except by invasive techniques. Specifically, radionuclide angiography allows a semi-invasive method for quantitating left to right shunts (1) and M-mode echocardiography, introduced clinically in the early 1970s, provides information on right ventricular size and septal motion that has been shown to correlate with atrial level shunting (2). With two-dimensional echocardiography, defects in the atrial septum and entrance of the pulmonary veins can often be visualized especially in the infant or young child (3,4), differentiating atrial defects from total anomalous pulmonary venous connection.

As noninvasive techniques have improved, one must question whether cardiac catheterization remains a necessary prelude to all cardiac surgery. Over the past 7 years, we have increasingly relied on our clinical ability and noninvasive or semi-invasive tests and have started to recommend surgery in selected children with secundum and sinus venosus atrial septal defects without prior catheterization. In this report, we review our recent experience.

Methods

Patients. The surgical records and charts of all 217 patients with an atrial septal defect operated on at Children's Hospital between January 1976 and July 1983 were re-
viewed. Thirty of these had repair of an atrial septal defect of the primum variety and were excluded from the analysis. Also excluded were 26 children who had had cardiac catheterization before being seen at Children’s Hospital. This left a total of 161 patients who were considered clinically to have an atrial septal defect and had an inferior QR5 axis on the electrocardiogram. They ranged in age from 4 months to 33 years with a median and a mode of 5 years. The decision whether to perform cardiac catheterization at Children’s Hospital was made by 1 of 13 staff pediatric cardiologists.

Preoperative cardiac catheterization. Of the 161 patients, 52 (31%) underwent preoperative cardiac catheterization. In 38 of these 52, the attending cardiologist thought the presentation was atypical for a simple atrial septal defect. In 13 patients, there was concern that the child might have significant additional pulmonary valve stenosis, usually because of an excessive degree of right ventricular hypertrophy on the electrocardiogram or a thrill at the left upper sternal border or suprasternal notch on physical examination. In 11 patients, the physical examination, X-ray film or echocardiogram was thought to be suggestive of additional lesions, usually a ventricular septal defect, aortic stenosis or mitral regurgitation. In four patients, the murmur, X-ray film and electrocardiogram were thought to be consistent with an atrial defect, but the splitting of the aortic and pulmonary components of the second heart sound varied with respiration. On cardiac catheterization, a typical atrial septal defect was found in each. Three patients had a very loud pulmonary component of the second heart sound and underwent catheterization to rule out pulmonary hypertension. In two patients, both younger children, congestive heart failure was present which was thought to be so atypical for an atrial defect that catheterization was deemed necessary. In five patients, cardiac catheterization was performed because the diagnosis remained unclear after clinical examination, electrocardiography and X-ray examination. The remaining 14 patients underwent routine catheterization. These studies were performed earlier in the experience when we felt less comfortable about sending children to the operating room without prior invasive study.

Operation without catheterization. One hundred nine children (69%) were taken to the operating room without prior invasive study. In 5 patients, the cardiologist relied exclusively on clinical examination, electrocardiography and chest X-ray study. In five patients, technetium radionuclide angiography was added to document the presence of a significant left to right shunt. In 13 patients, the clinical examination was supplemented by an M-mode echocardiogram and in 43 patients, by a two-dimensional echocardiogram. In 24 children, both an M-mode study and radionuclide angiography were used, while in the remaining 19 patients, a two-dimensional echocardiogram and radionuclide angiography were used.

There has been a temporal relation between the use of cardiac catheterization and noninvasive tests (Fig. 1). Between 1976 and 1979, approximately 50% of the children underwent cardiac catheterization. An additional 25 to 33% had both a radionuclide angiogram and an echocardiogram. Only 20% were sent to the operating room with only one confirmatory noninvasive test. During 1980 and 1981, there was a decreasing reliance on cardiac catheterization and an increasing use of both radionuclide angiography and echocardiography for confirmation. In the most recent time period, 1982 and 1983, cardiac catheterization has been used less frequently and there has been an increasing reliance on only one noninvasive test, usually two-dimensional echocardiography.

All patients were operated on using standard techniques of cardiopulmonary bypass by one of the two cardiothoracic surgeons (W.I.N. or A.R.C.). The follow-up period ranged from 3 months to 7 years (median 2 years).

Results

Diagnostic accuracy with catheterization (Table 1). Of the 52 patients who underwent cardiac catheterization, 50 were thought to have a secundum type atrial septal defect and 2 a sinus venosus defect with a partial anomalous pulmonary venous connection. At surgery, the diagnosis of secundum atrial septal defect was confirmed in 46. Two patients thought to have a secundum defect had, in fact, a sinus venosus defect, and one had a sinus venous defect with partial anomalous pulmonary venous connection of the
Table 1. Pre- and Postoperative Diagnosis With Catheterization

<table>
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<th>Operative Diagnosis</th>
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<td>Sinus septal defect</td>
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<td>Totals</td>
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<td>2</td>
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ASD = atrial septal defect; PAPVC = partial anomalous pulmonary venous connection; SV = sinus venosus atrial septal defect.

right upper lobe pulmonary vein into the right atrium-superior vena cava junction. One patient thought to have a secundum defect had instead a coronary sinus septal defect without a defect in the atrial septum itself. This was recognized at surgery by an intact atrial septum, normal pulmonary venous return and a dilated left superior vena cava draining into the coronary sinus. The orifice of the left superior vena cava was probed and an opening found between the left vena cava and the left atrium. This was repaired by using a Goretex patch to roof the coronary sinus diverting the left caval blood to the right atrium. Of the two patients thought to have a sinus venosus defect with anomalous pulmonary venous connection, one had this lesion while the other had partial anomalous pulmonary venous connection of the right pulmonary veins without an atrial septal defect. In 47 (90%) of the 52 children, the diagnosis made at cardiac catheterization was confirmed at surgery.

Diagnostic accuracy without catheterization (Table 2). For patients in whom localization of the defect was not attempted, that is, those who were sent to the operating room on the basis of clinical examination, M-mode echocardiography or technetium radionuclide angiocardiography, we have assumed a preoperative diagnosis of secundum defect. The diagnosis of secundum atrial defect, suspected in 98 patients, was confirmed in 87 of them at surgery. An additional nine had a sinus venosus defect and two had partial anomalous pulmonary venous connection without an atrial septal defect. In 5 of 10 patients suspected of having a sinus venosus defect, the diagnosis was confirmed at surgery, while in 3 there were additional unrecognized anomalously connecting pulmonary veins and 2 patients had partial anomalous pulmonary venous connection without an atrial septal defect. The two-dimensional echocardiogram of one patient was thought to show a primum type atrial septal defect, but at surgery it proved to be a secundum defect. In retrospect, a dilated left superior vena cava draining into the coronary sinus was incorrectly thought to be a defect in the inferior portion of the atrial septum.

The diagnostic accuracy in the group without cardiac catheterization was 84% (92 of 109). All patients clinically believed to have an atrial septal defect, did, indeed, have a large left to right shunt at the atrial level that could be identified and corrected at surgery. In no patient did the surgeon think that the diagnostic error caused any intraoperative problems.

Clinical course and complications. The group of children who did not undergo cardiac catheterization was discharged from 3 to 8 days after surgery (median 5) compared with 4 to 9 days after surgery (median 6) in the group who had undergone previous cardiac catheterization. Six of the 161 patients who had surgery were hospitalized more than 7 days afterward; 4 of the 6 had had a preoperative cardiac catheterization.

There was no mortality in either group. Early postoperative complications were not significantly different in the two groups. In the group of 52 patients who had cardiac catheterization, a pericardial effusion was recognized in 2 patients and 1 patient developed atrial flutter requiring cardioversion. Of the 109 patients who did not undergo cardiac catheterization, 2 developed a pericardial effusion, 1 had recurrent atelectasis and 1 required reoperation for bleeding on the night of surgery. The only late postoperative complication was a recurrence of the atrial septal defect, requiring reoperation in one of the children who had cardiac catheterization.

Table 2. Pre- and Postoperative Diagnosis Without Catheterization

<table>
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<th>Postoperative Diagnosis</th>
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<td>Secundum</td>
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<td>Primum</td>
<td>Total</td>
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<td>Primum: ASD</td>
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<td>Totals</td>
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</tbody>
</table>

Abbreviations as in Figure 1.

Discussion

Preoperative evaluation of patients suspected of having atrial septal defect. Since the introduction of clinical cardiac catheterization almost 40 years ago, enormous strides have been made in the evaluation of cardiovascular anatomy and physiology that have allowed for, and paralleled, the development of surgical techniques to deal with the most complex types of congenital heart disease. With the increasing utility of noninvasive and semi-invasive assessments of cardiac anatomy and physiology, we are convinced that it will be possible to rely on such methods for the diagnosis of the simpler and possibly more complex forms of congenital heart disease. In this study, we were unable
to demonstrate any adverse effects from relying on such methods for more than two-thirds of the children with typical findings for an atrial septal defect.

In addition, a considerable financial savings has been realized. If one assumes that the 1983 prices including professional fees for cardiac catheterization were: hospital cost $1,875, professional fee $700, 2 days' hospitalization $720, M-mode echocardiography $180, two-dimensional echocardiography $255 and technetium radionuclide angiocardiography $384, the cost to the 109 patients without catheterization was $42,710 rather than $359,155, which was the cost of the hospitalization and catheterization without a noninvasive assessment. This represents a savings of more than 88%.

Recently Shub et al. (7) reviewed the Mayo Clinic experience with an older group of patients with atrial septal defect repaired between 1978 to 1982. Of 166 patients, 39 (23%) underwent surgical repair without prior catheterization. No complications were found, and investigators concluded that "in selected patients with the typical findings of uncomplicated atrial septal defect whose diagnosis is confirmed by two-dimensional echocardiogram and, when indicated, other noninvasive tests, routine preoperative catheterization may be unnecessary." In the younger patients in whom the atrial septum is more easily visualized by two-dimensional echocardiogram, this may be even more likely.

Differential diagnosis. The preoperative evaluation of patients suspected of having an atrial septal defect must provide information that an atrial defect or partial anomalous pulmonary venous connection is present, that the degree of left to right shunt is significant and that no other significant intracardiac anomalies are present.

The clinical diagnosis of atrial septal defect has always been relatively straightforward. Although the typical clinical picture does not localize the atrial defect, patients with a primum defect, often associated with anomalies of the atrioventricular valves, have a characteristic superior counterclockwise loop on the frontal plane electrocardiogram (5). The differentiation of secundum atrial defect from sinus venous defect, with or without partial anomalous pulmonary venous connection, is less important since this area is easily visualized in the operating room and adds little if any additional risk to the operation. In addition, anomalies of pulmonary venous connection are uncommon, occurring in 9% of 664 cases reviewed by Gotsman et al. (8) and in 6% of our cases. When partial anomalous pulmonary venous connection is present, it almost invariably involves the right veins draining into the superior vena cava, right atrium or inferior vena cava. The left veins may drain anomalously, but this is a very unusual occurrence and can be suspected by a widened superior mediastinum on chest X-ray examination and repaired by connecting the anomalous veins into the left atrial appendage.

The magnitude of the left to right shunt is almost invariably quite large if the clinical examination, electrocardiogram and X-ray examination suggest shunting at the atrial level. In questionable cases, the finding of a dilated right ventricle on the echocardiogram is very suggestive of a significant atrial septal defect and the technetium radionuclide angiocardiogram can often quantitatively determine the pulmonary to systemic flow ratio.

Implications. There will always be some children whose history, physical examination, electrocardiogram, chest X-ray film, radionuclide angiocardiogram or echocardiogram are atypical or confusing. For these patients, cardiac catheterization and angiography may continue to be necessary, but from our recent experience, we expect that this will be less than 20% of the time. In the majority of patients, however, with the typical clinical features of an atrial septal defect and echocardiographic findings that are confirmatory, cardiac surgery can be performed without catheterization with little fear that diagnostic error will cause any intra- or postoperative problems.

References