The Origin of an Immediate Diastolic Murmur in Atrioventricular Defects

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The presence of an immediate diastolic murmur following the second heart sound in patients with atrial septal defect, has usually been attributed to pulmonary regurgitation. Associated complicating lesions, such as persistence of the ductus arteriosus, aortic regurgitation, and cor triatriatum may also give rise to an immediate diastolic murmur. In this study, the source of immediate diastolic murmurs in patients with the atrioventricular type of atrial septal defect has been investigated by intracardiac phonocardiography, and an alternative explanation found.

**Material and Method**

Twenty-two patients aged 3 to 54 years with atrioventricular defects have been investigated. The presence of an audible immediate diastolic murmur at the left sternal edge was noted and when possible recorded on a Cambridge external phonocardiogram (fig. 1, left).

Routine cardiac catheterization was performed in all patients and particular note was taken of the pressure in the left and right atria and the presence or absence of an interatrial pressure gradient. The Allard-Laurens micromanometer catheter was then introduced through the same vein, and pressure and sound recordings were made in the left ventricle, left atrium, pulmonary artery, right ventricle, and right atrium. Numerous recordings were taken in each patient across the atrial septum. Reference tracings, which were taken simultaneously, included an external phonocardiogram from the pulmonary area to determine the position of aortic and pulmonary valve closure (A2 and P2), lead II of the electrocardiogram, the respiratory cycle and, in some patients, the carotid pulse. All records were taken photographically at a paper speed of 80 mm. per second. Sinus rhythm was present in 20 patients; one had nodal bradycardia and one was in complete heart block at the time of the investigation. The effect of 0.25 mg. of phenylephrine given

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**Figure 1**

External phonocardiogram from a patient with ostium primum defect and mitral regurgitation complicated by complete heart block, recorded from the left sternal edge at high and medium frequency. Left. Preoperative recording shows intense pansystolic murmur and an immediate diastolic murmur following closure of the aortic valve (A2). Right. Postoperatively the immediate diastolic murmur is no longer recorded although a soft pansystolic murmur remains.
intravenously on the murmur was noted in four patients. The intracardiac phonocardiogram recorded in each site was examined for the presence of an immediate diastolic murmur in patients with and without an audible immediate diastolic murmur at the left sternal edge.

The diagnosis of atrioventricular defect was proved at open-heart surgery in 10 patients. All patients had an ostium primum defect with cleft anterior cusp of the mitral valve except two, in whom a complete common atrioventricular canal was present. Additional pulmonary valve stenosis was present in two patients.

Results

In 10 patients, an immediate diastolic murmur was audible at the bedside and was recorded externally (fig. 1). In five of these patients the immediate diastolic murmur was soft, evanescent, and difficult to record on the external phonocardiogram as is often the case with this type of murmur. The murmur was loudest in patients with complete heart block and nodal bradycardia and increased in intensity in those patients who received phenylephrine intravenously. Intracardiac phonocardiograms showed an immediate diastolic murmur which, despite careful exploration of all the heart chambers by the micromanometer catheter, was only recorded at the site of the atrial defect (fig. 2) where it often appeared to be part of a continuous murmur. The intensity of the murmur was greatest internally in the patients with nodal bradycardia and complete heart block (fig. 3). The murmur was not recorded beneath the pulmonary valve in any patient nor in any other part of the heart. It was repeatedly shown that the murmur was a separate phenomenon from the delayed diastolic murmur heard at the left sternal edge and apex and recorded in the region of the tricuspid or mitral valve (fig. 4). There was no evidence of aortic regurgitation in any of the patients submitted to cardiopulmonary bypass and no additional fistulous communications, such as persistence of the ductus arteriosus or other anomalies that might give rise to an immediate diastolic murmur, were found. In the 10 patients with an audible immediate diastolic murmur, mitral regurgitation was moderate or severe and the left atrial v wave was higher than the right atrial v wave. However, the left and right atrial pressures were equal in

![Figure 2](image-url)

Intracardiac phonocardiogram recorded in the left atrium and right atrium from a patient with an ostium primum defect and mitral regurgitation. Lead II of the electrocardiogram is recorded above. Beneath is shown the pressure pulse and sound recorded by the micromanometer catheter. On the lowest channel an external phonocardiogram is recorded to fix the timing of aortic and pulmonary valve closure—A₂ and P₂. In the left atrium a pansystolic murmur of mitral regurgitation has been recorded. In the region of the atrial septal defect an immediate diastolic murmur is shown. The v wave in the left atrial pressure pulse is higher than in the right atrial.
the other 10 patients in whom no immediate diastolic murmur was audible or recorded internally. Two of these patients with no immediate diastolic murmur had severe mitral regurgitation but in both the atrial septal defect was unusually large and did not permit the formation of an interatrial pressure gradient.

**Discussion**

Immediate (or early) diastolic murmurs have often been noted in patients with atrial septal defect. Barber, Magidson, and Wood (1950) found an early diastolic murmur in 36 of 62 patients and presumed that the murmur was due to pulmonary regurgitation although it was not confined to patients with
extreme cardiomegaly or pulmonary artery dilatation. In a series of 122 atrioventricular defects an immediate diastolic murmur has been heard in 16 per cent. Although pulmonary regurgitation unquestionably occurs in some patients with atrial septal defect, it was not demonstrated in any of the present series of patients investigated by intracardiac phonocardiography. The intracardiac phonocardiogram recorded beneath the pulmonary valve has been found by us to be a sensitive indicator of pulmonary regurgitation, which may even be produced by the catheter when it is absent under normal circumstances. As none of the patients with an audible immediate diastolic murmur showed an immediate diastolic murmur in the right ventricular outflow tract, it was considered that pulmonary regurgitation was not the cause of the murmur. Other lesions that may give rise to an immediate diastolic murmur were excluded by angiocardiography and open-heart surgery, so that some other explanation of this phenomenon was needed. Although Soulíé and his colleagues, using the intracardiac phonocardiogram, concluded that murmurs in patients with atrial septal defect did not arise at the site of the defect, an immediate diastolic murmur has been clearly demonstrated to originate at the site of the atrial septal defect in the 10 patients of the present series in whom the murmur was clinically audible. This murmur was often most intense on the left atrial side of the defect but was constantly demonstrated to be a separate entity from the delayed diastolic murmur originating from the mitral valve. In the 10 patients mitral regurgitation complicated the defect and in all of these the left atrial v wave was higher than the right atrial v wave. It is likely that flow continues across the atrial septal defect during the early phase of diastole and gives rise to the immediate diastolic murmur which may be clinically audible. This phenomenon appears to depend on the combination of important mitral regurgitation and an atrial septal defect of certain size, for in the two patients with severe mitral regurgitation and no immediate diastolic murmur the atrial septal defect was unusually large and pressures were identical in the two atria. The intensity of the immediate diastolic murmur was noted to be variable in the same patient with different physiologic states and was often absent after rest in bed and well heard after effort, excitement, or phenylephrine. It is considered that this results from alteration of the severity of mitral regurgitation, which in these patients increases after effort and phenylephrine and as a result may cause an increase in the interatrial pressure gradient in early diastole. As has already been noted, the immediate diastolic murmur was loudest internally and externally in the patients with nodal bradydardia and complete heart block, which like phenylephrine were associated with prolonged diastolic filling time and probable increase in mitral regurgitation. In other patients, this murmur was sometimes recorded by the intracardiac phonocardiogram within the heart and was not audible clinically until phenylephrine was given. A number of the patients with neither v wave gradient nor an immediate diastolic murmur showed an interatrial gradient on the a wave. In these patients an atrial systolic murmur was frequently recorded on the left atrial side of the defect, which presumably results in the same way and may occasionally be audible clinically. The combination of mitral regurgitation with a defect in the atrial septum is far more often found in atrioventricular defects than other forms of atrial septal defect. It is presumed that this murmur may occur in patients with secundum defects and mitral regurgitation but we have not been able to investigate such patients.

The immediate diastolic murmur always disappeared after closure of the defect, even when mitral regurgitation persisted (fig. 1, right). It is considered that this further supports the concept that this murmur arises at the site of the defect rather than at the atrioventricular or semilunar valves.

Summary

The origin of an audible immediate diastolic murmur in 10 of 22 patients with
atrioventricular defects was investigated by intracardiac phonocardiography. It was shown to arise at the site of the atrial septal defect, and all other possible causes of such a murmur were excluded.

The production of the murmur depended on the combination of mitral regurgitation and an atrial septal defect of such a size as to permit an interatrial pressure gradient in early diastole.

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References

Automation and Happiness
Meanwhile machines deprive us of two things which certainly are important ingredients of human happiness, namely, spontaneity and variety. Machines have their own pace, and their own insistent demands: a man who has an expensive plant must keep it working. The great trouble with the machine, from the point of view of the emotions, is its regularity. And, of course, conversely, the great objection to the emotions, from the point of view of the machine, is their irregularity.—BERTRAND RUSSELL, Sceptical Essays (1928).
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