

## Fetal Atrial Septal Aneurysm: A Cause of Fetal Atrial Arrhythmias

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Atrial arrhythmias are commonly found during fetal echocardiography performed during pregnancy to evaluate fetal arrhythmias. An association between atrial arrhythmias and an atrial septal aneurysm has been noted in children and adults. In this study, 105 fetuses were evaluated by fetal echocardiography, 39 (37%) referred to evaluate fetal arrhythmia and 66 (63%) to rule out congenital heart disease. An atrial septal aneurysm was found in 42 (40%) of

the fetuses and an atrial arrhythmia in 37 (35%). An atrial septal aneurysm was found in 25 (64%) of the 39 fetuses referred to evaluate a fetal arrhythmia compared with only 17 (26%) of the 66 fetuses referred to rule out congenital heart disease. In this study, the association of an atrial septal aneurysm with an atrial arrhythmia was highly significant ( $p < 0.001$ ).

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An aneurysm of the atrial septum was first described in 1966 by Thompson et al. (1). Before the use of two-dimensional echocardiography, an atrial septal aneurysm was considered in the differential diagnosis of a right atrial filling defect by angiography (1,2) or was described at autopsy (3). Aneurysm of the atrial septum was first diagnosed by two-dimensional echocardiography in children with hypoplasia of the right heart chambers (4,5) and later in patients with other congenital or acquired heart defects (6-17) as well as in patients without other abnormalities (1,14,15,18-22). In patients with heart disease, an atrial septal aneurysm could be caused by abnormal atrial pressures, a weakened atrial septum, abnormal flow patterns or a combination of these factors. However, in several cases atrial septal aneurysm has been found with normal atrial pressure (3,8,18,20). There is speculation that atrial septal aneurysm is caused by premature closure of the foramen ovale and that the aneurysm may contribute to spontaneous closure of an atrial septal defect (12,14,22). Atrial septal aneurysm has been associated with a systolic click (18,15,23), atrial septal defect (3,6,8,11,15,16,22), mitral and tricuspid valve prolapse (9,11,12,15), thromboembolism (1,2,15), atrioventricular valve obstruction (24) and pulmonary venous obstruction (7).

Several recent publications (3,9,15,16,23-25) have noted an increased incidence of atrial arrhythmias in patients with

atrial septal aneurysm. In children and most adults there appear to be no other cardiac abnormalities that would predispose them to atrial arrhythmias (15,16,23-25). In two children with an atrial arrhythmia, the atrial septal aneurysm resolved when the arrhythmia was controlled (16). In two patients with a right atrial aneurysm, resection of the aneurysm led to abolition of preoperative atrial arrhythmias (26,27). Therefore, the association between atrial septal aneurysm and atrial arrhythmias is firmly established. Whether this finding is present in the fetus is uncertain. The purpose of this study was to look at the incidence of atrial septal aneurysm in a group of fetuses referred for evaluation to our echocardiographic laboratory.

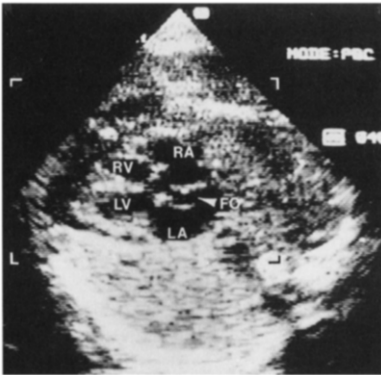
### Methods

**Study patients.** The fetal echocardiograms and their reports of 132 fetuses were retrospectively reviewed for the presence of an atrial septal aneurysm or atrial arrhythmia. In 16 fetuses the atrial septum was not visualized well enough to determine whether there was an atrial septal aneurysm. Eleven fetuses had congenital heart disease and were eliminated from the main study group although their echocardiographic studies were evaluated for the presence of an atrial septal aneurysm or atrial arrhythmia. Therefore, 105 fetuses with a gestational age of 18 to 41 weeks were included in our study group, which comprised two sets of fetuses: 1) those referred for a fetal echocardiogram to evaluate a fetal arrhythmia ( $n = 39$ ) and 2) those referred to rule out congenital heart disease ( $n = 66$ ). This study also looked at the reason for referral and correlated it with the presence or absence of an atrial septal aneurysm or atrial arrhythmia.

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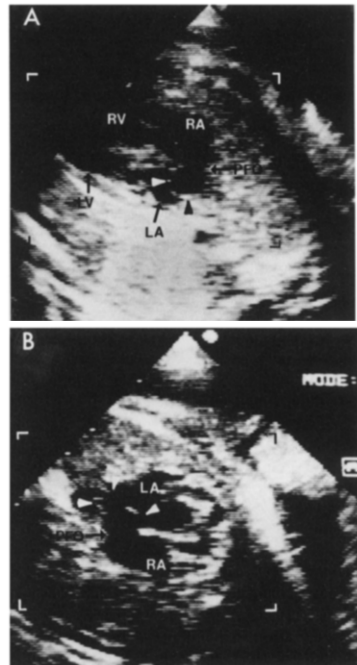


**Figure 1.** Two-dimensional fetal echocardiogram showing the foramen ovale (FO) with normal flap created by the septum primum. LA = left atrium; LV = left ventricle; RA = right atrium; RV = right atricle.

**Echocardiographic review.** Many fetuses have a recognizable flap, created by the septum primum, that projects into the left atrium and is of limited extension and mobility (Fig. 1). This structure closes the foramen ovale postnatally. The differentiation between this normal flap and mobile, redundant atrial septal tissue, i.e., an atrial septal aneurysm, was not difficult. When an atrial septal aneurysm was seen, it was a consistent and persistent structure. We diagnosed an atrial septal aneurysm only when the septum primum extended at least halfway across the left atrium (Fig. 2A) or consisted of redundant atrial septal tissue (Fig. 2B), or both. In addition, the atrial septal aneurysm was a very mobile structure varying in its extent during the cardiac cycle whereas the flap showed little movement throughout the cardiac cycle. This mobility can only be appreciated with real-time echocardiography. The atrial septal aneurysm was often seen to strike the left atrial free wall or mitral valve annulus.

*Atrial arrhythmias were usually documented with Doppler echocardiography, but in a few cases the arrhythmia was infrequent and only seen during the two-dimensional echocardiographic study. The echocardiographic study lasted for an average of 45 min (range 30 to 90) and an atrial arrhythmia was considered present if any atrial ectopic activity was detected during the examination. The frequency of atrial ectopic activity, excluding the four cases of supra-ventricular tachycardia, ranged from atrial bigeminy to two ectopic beats during the entire study.*

*Three reviewers independently reviewed the echocardiograms. In 96 of the 105 studies there was no disagreement as to the presence or absence of an atrial septal aneurysm; in the remaining 9 studies, the presence or absence of an*



**Figure 2.** Two-dimensional fetal echocardiogram of atrial septal aneurysm. A. Aneurysm (arrowheads) extending into the left atrium (LA) almost to the posterior wall. B. Redundant aneurysm tissue (arrowheads) striking the left atrial wall. Abbreviations as in Figure 1.

aneurysm was agreed on by two of the three reviewers. There was no disagreement as to the presence or absence of an atrial arrhythmia.

**Equipment.** The Hewlett-Packard 77020A two-dimensional phased array sector scanner with 2.25 and 3.5 MHz transducers was used for the echocardiographic studies. The echocardiograms were recorded on videotape and the videotapes were reviewed for this study.

**Statistical analysis.** The statistical correlation between the presence of an atrial septal aneurysm and an atrial arrhythmia was analyzed by the chi-square method and for small numbers, by Fisher's exact test.

## Results

**Prevalence of atrial arrhythmias (Table 1).** Of the 105 fetuses that had an adequately visualized atrial septum and

**Table 1. Correlation of Atrial Septal Aneurysm and Atrial Arrhythmia in 105 Fetuses**

A. Fetuses With Supraventricular Tachycardia or Premature Atrial Contractions			
Presence of atrial septal aneurysm	Presence of Atrial Arrhythmia		
	+	-	
+	28 (26.5%)	14 (13.5%)	42 (40%)
-	9 (8.5%)	54 (51.5%)	63 (60%)
	37 (35%)      68 (65%)		
	(p < 0.001)		

B. Fetuses With Premature Atrial Contractions Only			
Presence of atrial septal aneurysm	Presence of Atrial Arrhythmia		
	+	-	
+	24 (24%)	14 (14%)	38 (38%)
-	9 (9%)	54 (53%)	63 (62%)
	33 (33%)      68 (67%)		
	(p < 0.001)		

no congenital heart disease, 42 (40%) had an atrial septal aneurysm; of these 42 fetuses, 28 (67%) had an atrial arrhythmia and 14 (33%) did not. In 2 cases the atrial arrhythmia was sustained supraventricular tachycardia (Fig. 3A), in 2 it was single premature atrial contractions and short runs (6 to 15 beats) of supraventricular tachycardia (Fig. 3B) and in 24 there were single conducted and nonconducted premature atrial contractions (Fig. 3C). Of the 63 fetuses (60%) that did not have an atrial septal aneurysm, 9 (14%) had an atrial arrhythmia and 54 (86%) did not. All nine atrial arrhythmias were single premature atrial contractions. The association of an atrial septal aneurysm with an atrial arrhythmia was highly significant ( $p < 0.001$ ) (Table 1A). After exclusion of the four fetuses with supraventricular tachycardia, the association of an atrial septal aneurysm with an atrial arrhythmia was still highly significant ( $p < 0.001$ ) (Table 1B).

**Prevalence of arrhythmia in fetuses referred to rule out congenital heart disease (Table 2).** Of the 105 fetuses, 39 were referred for fetal echocardiography to evaluate a fetal arrhythmia and 66 were referred to rule out congenital heart disease. In 28 (72%) of the 39 fetuses referred to evaluate an atrial arrhythmia, an atrial arrhythmia was detected during the echocardiographic study. Of the 66 fetuses referred to rule out congenital heart disease, only 8 (12%) had an atrial arrhythmia detected. An atrial septal aneurysm was found in 25 (64%) of the 39 fetuses referred for evaluation of fetal arrhythmia compared with only 17 (26%) of 66 referred to rule out congenital heart disease. Both an atrial septal

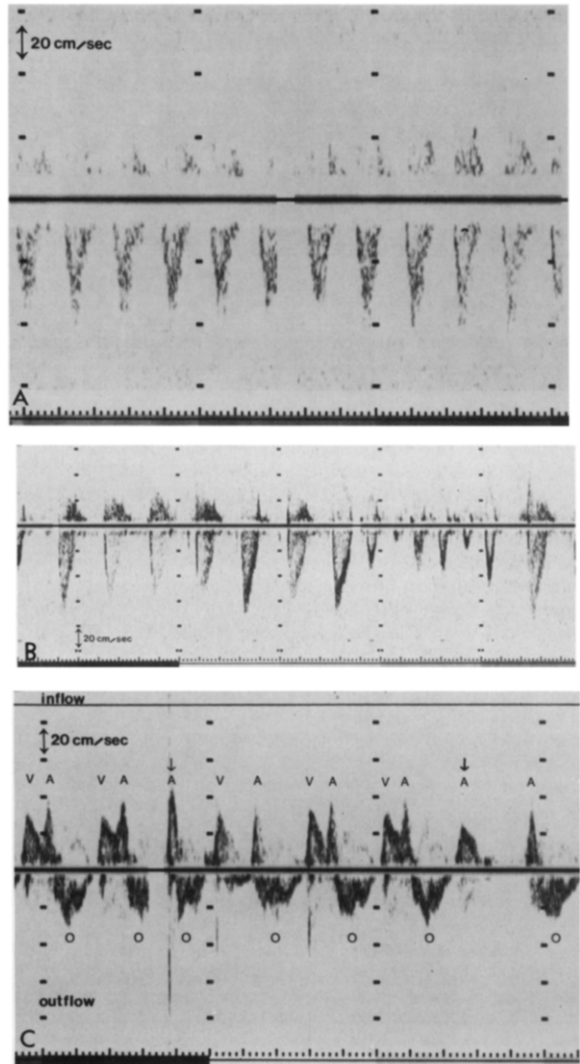
aneurysm and an atrial arrhythmia were found in 22 (56%) of 39 fetuses referred to evaluate fetal arrhythmia compared with only 6 (9%) of 66 referred to rule out congenital heart disease. Either an atrial septal aneurysm or an atrial arrhythmia was found in 31 (79%) of 39 fetuses referred to evaluate fetal arrhythmia compared with only 20 (30%) of 66 referred to rule out congenital heart disease. In the 39 fetuses referred to evaluate fetal arrhythmia, 11 had no arrhythmia detected during the echocardiographic examination; 3 of these had an atrial septal aneurysm and 8 did not.

**Atrial arrhythmia in fetuses with congenital heart disease.** Though the 11 fetuses with congenital heart disease were excluded from our study group, their echocardiographic studies were reviewed. Only one fetus had an atrial arrhythmia and this fetus did not have an atrial septal aneurysm; this fetus had been referred to evaluate a fetal arrhythmia. Three fetuses had an atrial septal aneurysm and none of them had an atrial arrhythmia. No fetus with congenital heart disease had both an atrial septal aneurysm and an atrial arrhythmia.

## Discussion

The association of an atrial septal aneurysm with atrial arrhythmias has been noted in children and adults (3,9,15,16,23-25). Casta et al., (28) identified four fetuses with supraventricular tachycardia, all with an atrial septal aneurysm. In our study we had two fetuses that had sustained supraventricular tachycardia (Fig. 3A) and two that had short runs of supraventricular tachycardia (Fig. 3B), all with an atrial septal aneurysm. In addition, we found a high correlation of an atrial septal aneurysm in fetuses in which only premature atrial contractions were detected (Table 1B).

**Role of atrial septal aneurysm in fetal atrial arrhythmias.** The redundant atrial tissue seen in an atrial septal aneurysm is often seen striking the left atrial free wall or the mitral valve annulus and occasionally prolapsing into the mitral valve. It is therefore not difficult to imagine this tissue causing atrial arrhythmia. In fetuses with a significant atrial arrhythmia such as supraventricular tachycardia, it is possible that abnormal flow patterns could create an atrial septal aneurysm. However, it is more difficult to imagine this happening with only single premature atrial contractions, which were all that were detected in the majority of our fetuses. In addition, among the fetuses with congenital heart disease and abnormal flow patterns, only 3 (27%) of 11 had an atrial septal aneurysm. In this study, an atrial septal aneurysm was a common finding (40%) in the fetus, an incidence much higher than that seen in children and adults (15). This high frequency suggests the possibility that an atrial septal aneurysm may be a variant of normal, whereas postnatally it appears to be associated with other cardiac abnormalities, especially atrial septal defect (3,6-9,11,12, 15,16,22,24). Atrial arrhythmias were also a common finding (35%) in our study. Although the association between



**Figure 3.** Fetal arrhythmias demonstrated by Doppler echocardiography. A, Doppler flow study in aorta showing supraventricular tachycardia at a rate of 230 beats/min. B, Doppler flow study in aorta showing a short run (six beats) of supraventricular tachycardia. C, Doppler flow study of mitral inflow and aortic outflow showing a conducted premature atrial contraction (thin arrow) followed by ventricular outflow (O) and a nonconducted premature atrial contraction (thick arrow) followed by no ventricular outflow. A = A wave of ventricular inflow; V = V wave of ventricular inflow.

these two findings was highly significant, the etiologic relation between an atrial septal aneurysm and an atrial arrhythmia remains speculative. Clearly, more information is needed to resolve this question.

**Atrial aneurysm and arrhythmia in congenital heart disease.** Though the 11 fetuses with congenital heart disease are a small group, they did have a higher incidence (27%) of atrial septal aneurysm unassociated with an atrial arrhythmia

**Table 2. Prevalence of Atrial Septal Aneurysm and Atrial Arrhythmia in 105 Fetuses**

Findings	Reason for Referral	
	Arrhythmia (n = 39)	Other (n = 66)
1. Atrial arrhythmia	28 (72%)	8 (12%)
2. Atrial septal aneurysm	25 (64%)	17 (26%)
3. 1 and 2	22 (56%)	6 (9%)
4. 1 and/or 2	31 (79%)	20 (30%)

compared with the study group (13.5%). Only 1 (2.1%) of the 46 fetuses with an atrial arrhythmia had congenital heart disease. Though the incidence of congenital heart disease in fetuses with atrial arrhythmias is higher than that in the general population (0.8%), the association of congenital heart disease and an atrial arrhythmia was of borderline statistical significance ( $p = 0.05$ ) because of the small number of cases in this study.

**Limitations.** There are two significant limitations of our study. The first is the lack of a true control population. In our echocardiography laboratory, referral for fetal echocardiography is for fetal arrhythmia or to rule out congenital heart disease. In the studies to rule out congenital heart disease, there was either a suspicion of congenital heart disease on fetal ultrasound or an increased risk of congenital heart disease, i.e. positive family history, teratogenic exposure, chromosomal abnormality. Except for some of the fetuses with abnormal fetal ultrasound findings, the pregnancies were otherwise unremarkable. Fetuses were placed in this group whether or not they had had a fetal arrhythmia detected. In addition, all fetuses with congenital heart disease were eliminated from the main study group. Therefore, the group of fetuses referred to rule out congenital heart disease can be considered a limited control group. Finally, the main conclusion of our study is that there is a high correlation between atrial septal aneurysm and atrial arrhythmia in the fetus but the true incidence of either is uncertain.

The second limitation of our study is the lack of neonatal follow-up as to the frequency of either atrial septal aneurysm or atrial arrhythmia postnatally. We are currently attempting to systematically evaluate these infants for these findings, although this evaluation is more difficult because most of the infants were delivered at other hospitals throughout the state. Whether or not these findings persist in the newborn does not lessen the importance of this significant correlation in the fetus.

**Conclusions.** We found a highly significant association between the presence of an atrial septal aneurysm and an atrial arrhythmia in the fetus. With newer diagnostic techniques, atrial arrhythmias in the fetus have been increasingly recognized. This study demonstrates not only that atrial

septal aneurysm is fairly common in the fetus, but also that it is highly associated with fetal atrial arrhythmia. The etiologic relation between these two findings and the post-natal natural history remains to be determined.

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