

# Predictors of Heart Failure in Nigerian Children with Ostium Secundum Atrial Septal Defects and Associated Structural Defects

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## Authors' contributions

This work was carried out in collaboration between both authors. Author CD designed the study and wrote the first draft of the manuscript. Author JC managed the statistical analyses of the study and literature searches. Both authors read and approved the final manuscript.

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## ABSTRACT

**Background:** Atrial septal defects are common congenital heart defects which could be discovered incidentally during cardiac screening of a child in heart failure. The aim of this study was to determine the predictors of heart failure in children with ostium secundum Atrial Septal Defects (os-sec ASD) and other associated structural lesions.

**Methods:** Seventy-five children with os-sec ASD seen in two tertiary centres in Southern Nigeria were recruited prospectively. Details of age, gender, anthropometric parameters and echocardiographic findings were entered into a proforma. The sizes of the ASDs were categorized into 3 groups; small size= $\leq 5$  mm, moderate size=5-9mm and large size= $\geq 10$  mm. The modified Ross Classification was used to determine the presence of heart failure. Data were analyzed using SPSS v 25.0 software.

**Results:** The ages of the children ranged from 0.25 months to 242 months with a mean age of  $3.2 \pm 1.7$  months and a male: female ratio of 1.5:1. Forty (53.3%) children had isolated os-sec ASD

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while 35 (46.7%) children had os-sec ASD with other structural defects. Thirty-eight (50.7%) of the children had features of heart failure at presentation out of which 50% were infants and 88.0% were mildly wasted. There was no significant association between the presence of heart failure in the study subjects and age, gender or nutritional status ( $p > 0.05$ ). There was however a significant association between the presence of heart failure and other structural defects co-existing with ASD ( $p = 0.038$ ) and Large sized os-sec ASD of greater than 10mm ( $p = 0.0001$ ) in those with isolated os-sec ASD.

**Conclusion:** Children with ostium secundum Atrial septal defects could present with heart failure, which is more likely if the defect is  $>10$ mm or associated with other structural heart lesions.

*Keywords: Heart failure; prevalence; predictors; atrial septal defects; children.*

## 1. INTRODUCTION

Ostium secundum atrial septal defects (os-sec ASD) are defects located in the area of the fossa ovalis of the atrial septum [1,2]. They are commonly caused by the failure of the septum secundum to close during the process of cardiogenesis in the fetus [1,2]. They are common congenital heart defects and could be detected at any age but usually occur as incidental findings in children [1,3]. Atrial septal defects allow communication between the systemic and the pulmonary circulations. The magnitude and direction of blood flow depends on both the size of the defect and the relative compliances of the ventricles [2-5]. Longstanding and significant interatrial shunting will lead to right ventricular volume overload and pulmonary over circulation especially with large defects greater than 10 mm [5,6]. This would subsequently result in the development of symptoms such as effort intolerance, palpitations, fatigue and signs of heart failure which ultimately lead to increased morbidity and mortality in adulthood [7].

Isolated atrial defects account for 3% of children presenting with congenital heart disease and about 1% of those with moderate to large isolated ASDs will present in heart failure [3,8]. In addition, children with isolated os-sec ASD usually have no overt symptoms except for subtle features of failure to thrive [9,10]. Reports of heart failure in children with os-sec ASD has been reported to be low unlike in adults with long standing uncorrected ASD where it has been attributed to be due to the concomitant tricuspid regurgitation, tricuspid annular dilatation and development of pulmonary arterial hypertension that occurs over time [1,11]. The presence of heart failure as a complication has been shown to increase morbidity and mortality in children with uncorrected structural heart defects [8]. Though there are studies on the prevalence and

pattern of Atrial septal defects in our locale, its association with heart failure in children with os-sec ASD has not been documented [12,13] This study is therefore aimed at determining the prevalence and predictors of heart failure in children with os-sec ASD associated cardiac defects seen in two tertiary hospitals in Southern Nigeria.

## 2. METHODS

### 2.1 Study Area

This was a prospective study of cases of ostium secundum Atrial Septal Defects seen over a 7-year period (1st April 2013 to 31st March 2020) at the Paediatric Cardiology Units of two tertiary hospitals; - the Niger Delta University Teaching Hospital (NDUTH) Okolobiri, Bayelsa State and University of Nigeria Teaching Hospital (UNTH) Enugu, Enugu State both in Southern Nigeria. Both are referral hospitals for the care of Paediatric Cardiology cases from peripheral hospitals in Southern Nigeria.

### 2.2 Study Design

This was a descriptive study where children with an echocardiographic diagnosis of os-sec ASD with or without an associated structural defect were consecutively recruited into the study by convenient sampling. Children aged 0-18 years whose parents gave consent were recruited. Assent was also obtained from those who were 7 years and older. Children with any other type of ASD (primum ASD, coronary sinus ASD or sinus venosus ASD) were excluded.

### 2.3 Data Collection

A total of 75 cases of os-sec ASD were seen over the study period. A proforma was opened for each patient and information such as age, sex, socioeconomic status of parents, presenting

complaints, echocardiographic diagnosis including other associated structural defects and the presence or absence of heart failure on admission was noted. Weights were measured using a standard weighing scale and an electronic baby scale to the nearest 0.5 kg. Heights or recumbent length (for children <2 years of age) were measured to within 0.25 cm using a portable stadiometer and infantometer respectively. A transthoracic echocardiogram was performed on each child using a portable My Lab Gamma Esaote® cardiac ultrasound machine at NDUTH and an E2 Sonoscape cardiac ultrasound machine at UNTH by the two authors who are experienced paediatric cardiologists in the respective institutions. Each machine was fitted with appropriate frequency probes depending on the age of the child and image quality. Structural defects were identified and noted and those with os-sec ASD with or without other structural lesions were recruited for the study. A diagnosis of heart failure was determined using the modified Ross classification of heart failure for each child [14] Z scores were ascertained using Anthrop WHO to assess nutritional status of the children [15].

### 2.4 Data Analysis

Descriptive analysis (mean, frequency and percentage) was carried out on the variables as appropriate. The chi-square test was used to determine the association of selected variables with the occurrence of heart failure among the subjects. All analysis was done with the SPSS v25 software (IBM, USA) at a 95% confidence interval and a p-value less than 0.05 was considered significant.

## 3. RESULTS

### 3.1 Socio Demographics and Anthropometry

A total of 75 children were seen over the study period. The ages of the children ranged from 0.25 months to 242 months with a mean age of 3.2±1.7 months. As shown in Table 1, nearly half of the children were less than 12 months old and there was a male: female ratio of 1.5. Using the Z scores to calculate their weight for age, Table 1 also shows that the vast majority; 66 (88.0%) were mildly wasted while only 4 (5.3%) were of normal weight.

**Table 1. Sociodemographic data of the study participants**

	Frequency (n=75)	Percent (%)
<b>Age-groups (years)</b>		
< 1 year	37	49.3
1- 5	21	28.0
6 – 10	7	9.3
>10	10	13.3
<b>Gender</b>		
Male	45	60.0
Female	30	40.0
<b>Weight for age</b>		
Mild wasting	66	88.0
Normal weight	4	5.3
Overweight	2	2.7
Obese	3	4.0

### 3.2 Characteristics of Ostium Secundum Atrial Septal Defects and Associated Defects

In 40 (53.3%) of the study participants, the ASD was solitary while in 35 (46.7%) it was associated with other structural defects, the commonest being ventricular septal defects and patent ductus arteriosus as shown in Table 2. The sizes of the ASD were divided into 3 categories; small size=<5mm, moderate size=5-9mm and large size=≥10mm. Their distribution is depicted in Fig. 1.

**Table 2. Distribution of ostium secundum ASD and other structural heart defects seen among the 75 subjects**

Structural heart defects	Total (n=75,%)
Isolated os-sec ASD	40 (53.3)
Os- sec ASD + VSD	10 (13.3)
Os- sec ASD + PDA	9 (12.0)
Os- sec ASD + Cor triatriatum dextrum	4 (5.3)
Os- sec ASD + PS	3 (4.0)
Os- sec ASD + others*	9 (12.0)

*Others include: Atrioventricular septal defect, Tetralogy of Fallot, Cor triatriatum dextrum, Partial anomalous pulmonary venous drainage, dextro-Transposition of the Great arteries, Bicuspid aortic valve, Dextrocardia, Mitral valve regurgitation*

### 3.3 Heart Failure and Relationship with Age, Gender and Nutritional Status

Of the 75 children with ASD, 38 (50.7%) had features of heart failure. Of these; 19 (50.0%) were infants and most were male (55.3%) (Table 3). There was no significant difference between those who had heart failure and those who did not in terms of age ( $\chi^2 = 2.18, p=0.535$ ) and gender ( $\chi^2 = 0.72, p = 0.396$ ). The distribution of subjects with heart failure according to nutritional status showed that the majority 86.8% of them were mildly wasted. However, there was no significant association between nutritional status and heart failure among the study subjects ( $\chi^2 = 3.32, p = 0.345$ ) (Table 3).

■ Small ASD ■ Medium ASD ■ Large ASD

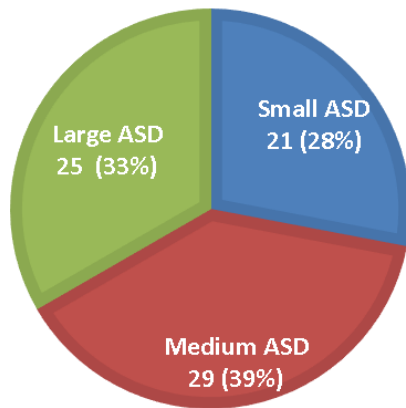


Fig. 1. Distribution of size of ASD in the 75 study subjects

### 3.4 Relationship between the Presence of Heart Failure and the Size of Atrial Septal Defects and Presence of Associated Structural Defects

Most of the subjects with heart failure had a Large sized os-sec ASD; 21 (55.3%), followed by moderate os-sec ASD and small os-sec ASD in 12 (31.6%) and 5 (13.2%) subjects respectively. There was a significant association of the size of os-sec ASD with the occurrence of heart failure in the study subjects ( $p = 0.0001$ ) Majority of the study subjects with heart failure; 25(65.7) had os-sec ASD associated with other structural heart defects. The presence of heart failure was significantly more common in the children with associated lesions than those

with isolated os ASD ( $\chi^2 = 24.67, p = 0.038$ ) (Table 4).

### 3.5 Relationship between the Presence of Heart Failure and Age, Sex, Weight for Age and Size of Atrial Septal Defects in 40 Subjects with Isolated Ostium Secundum Atrial Septal Defects

Of the 40 children with Isolated os sec ASD, 13 (32.5%) had features of heart failure out of which a third (30.7%) were above 10 years old. There was a slight male preponderance of cases with heart failure (M: F ratio: 1.2:1). Most of the subjects with heart failure; 10 (76.9%) were mildly wasted. There was no significant association of heart failure with the age distribution ( $p=0.118$ ), gender ( $p=0.304$ ) and weight for age ( $p=0.347$ ) in the subjects with Isolated os-sec ASD (Table 5). The distribution of the size of ASD by occurrence of heart failure in the subjects showed that majority of the subjects with heart failure; 9 (69.2%) had large ASD and this was statistically significant ( $p = 0.0001$ ). Hence, ASD size is shown to have a significant association with the occurrence of heart failure in subjects with isolated os sec ASD (Table 5).

### 3.6 Relationship between the Presence of Heart Failure and Age, Sex, Weight for Age and Size of Atrial Septal Defects in 35 Subjects with Ostium Secundum ASD Associated with Other Structural Heart Defects

Of the 35 children with os-sec ASD and other structural heart defects, 25 (71.4%) had features of heart failure out of which majority; 16 (64.0%) were infants and 3 (12.0%) were more than 10 years old. Most of the subjects with heart failure were male ( $n = 14, 56%$ ) and majority of the subjects were mildly wasted (23; 92.0%). There was however no significant association between heart failure and the age distribution ( $p=0.274$ ), gender ( $p=0.748$ ) or weight for age ( $p=0.347$ ) in the subjects with os-sec ASD and associated structural defects (Table 6). The distribution of the size of ASD and occurrence of heart failure in the subjects showed that most of the subjects had large sized ASD (12; 48.0%) but this was not statistically significant. Hence, ASD size had no significant association with the occurrence of heart failure in subjects with associated structural defects.

**Table 3. Relationship between the presence of heart failure and age, gender and nutritional status in the study participants**

Variables	Presence of heart failure		Chi-square $\chi^2$ (p-value)
	Yes (n=38, %)	No (n=37, %)	
<b>Age-groups (years)</b>			
< 1	19 (50.0)	18 (48.6)	2.18 (0.535)
1- 5	9 (23.7)	12 (32.4)	
6 – 10	3 (7.9)	4 (10.8)	
>10	7 (18.4)	3 (8.1)	
<b>Gender</b>			
Male	21 (55.3)	24 (64.9)	0.72 (0.396)
Female	17 (44.7)	13 (35.1)	
<b>Nutritional status</b> Mild			
wasting	33 (86.8)	33 (89.2)	3.32 (0.345)
Normal	1 (2.6)	3 (8.1)	
Overweight	2 (5.3)	0 (0.0)	
Obese	2 (5.3)	1 (2.7)	

**Table 4. Relationship between presence of heart failure and the size of Atrial Septal Defect and presence of associated structural heart defects**

Size of ASD	Presence of heart failure		Chi-square (p-value)
	Yes (n=38, %)	No (n=37, %)	
Small	5 (13.2)	16 (43.2)	18.17 (0.0001)*
Moderate	12 (31.6)	17 (46.0)	
Large	21 (55.3)	4 (10.8)	
<b>Type of CHD</b>			
Isolated os-sec ASD	13 (34.2)	27 (73.0)	24.67 (0.038) *
Os-sec ASD + other structural defects#	25(65.7)	10 (27.0)	

\*Statistically significant ( $p < 0.05$ ); Note: os-sec ASD-Ostium Secundum atrial septal defects.

#associated structural defects: Ventricular septal defect, Pulmonary stenosis, Tetralogy of Fallot, Partial anomalous pulmonary venous drainage, Mitral valve regurgitation, dextro-Transposition of the Great arteries, Patent ductus arteriosus, Atrioventricular septal defect, Bicuspid aortic valve, Cor triatum dextum

**Table 5. Relationship between presence of heart failure and age, gender, weight for age and size of atrial septal defect in children with isolated atrial Septal defects**

Variables	Presence of heart failure		Chi-square (p-value)
	Yes (n=13, %)	No (n=27, %)	
<b>Age-groups (years)</b>			
< 1	3 (23.1)	14 (51.9)	5.87 (0.118)
1- 5	3 (23.1)	8 (29.6)	
6 – 10	3 (23.1)	3 (11.1)	
>10	4 (30.7)	2 (7.4)	
<b>Gender</b>			
Male	7 (53.8)	19 (70.4)	1.05 (0.304)
Female	6 (46.2)	8 (29.6)	
<b>Weight for age</b>			
Mild wasting	10(76.9)	24(88.9)	3.30(0.347)
Normal weight	1(7.7)	2(7.4)	
Overweight	1(7.7)	0(0.0)	
Obese	1(7.7)	1(3.7)	
<b>Size of os-sec ASD</b>			
Small	2(15.4)	12(44.4)	24.14(0.0001)*
Moderate	2(15.4)	15(55.6)	
Large	9(69.2)	0(0.0)	

\*Statistically significant ( $p < 0.05$ ); Os-sec ASD-Ostium Secundum atrial Septal defects

**Table 6. Relationship between presence of heart failure and age, gender, weight for age and size of Atrial Septal Defects of 35 children with ostium secundum Atrial Septal Defects and other structural heart defects**

Variables	Presence of heart failure		Chi-square (p-value)
	Yes (n=25, %)	No (n=10, %)	
<b>Age-groups (years)</b>			
< 1	16 (64.0)	4 (40.0)	3.88 (0.2742)
1- 5	6 (24.0)	4 (40.0)	
6 - 10	0 (0.0)	1 (10.0)	
>10	3 (12.0)	1 (10.0)	
<b>Gender</b>			
Male	14 (56.0)	5 (50.0)	0.12 (0.7475)
Female	11 (44.0)	5 (50.0)	
<b>Weight for age</b>			
Mild wasting	23(92.0)	9(90.0)	3.30 (0.347)
Normal	0 (0.0)	1(10.0)	
Overweight	1 (4.0)	0 (0.0)	
Obese	1 (4.0)	0(0.0)	
<b>Size of ASD</b>			
Small	3(12.0)	4(40.0)	3.733(0.1546)
Moderate	10(40.0)	2(20.0)	
Large	12 (48.0)	4(40.0)	

Note: ASD- atrial septal defect

#### 4. DISCUSSION

Atrial septal defects are relatively common congenital heart defects in children and are usually incidental findings. Most of the children in our study were infants which is not unexpected since congenital heart defects are usually first detected in children under the age of 5 years [2]. Atrial septal defects however are most often asymptomatic except where associated with other structural defects which was also the case in this study. The male preponderance of cases of ASD noted in our study is at variance with other reports which have described ASD to be more common in females. [2,11] The fact that we studied os- sec ASD alone rather than all types of atrial septal defects might have accounted for this gender difference. Though ASDs have been known to be sporadic in nature, various reports have described regional and geographic differences to account for the variations of pattern of CHD in different climes [12].

Heart failure was observed in 34.2% of the children with isolated os- ASD in our study. Ejim and his colleagues [13] in Enugu reported the presence of heart failure in 21% of cases of os-sec ASD seen but their study population comprised of adults alone. Our figure was much higher than the 3.1% noted in children with isolated ASD described by Behjati-Ardakani [12] et al. in Iran. In their study none of the infants

with ASD had features of heart failure unlike the present study where heart failure was seen in 50% of the infants. In our study, most of those with heart failure had large sized lesions unlike in the Iran study where majority of the infants had small ASDs which were therefore of low haemodynamic significance. Being a hospital based study could also have accounted for this increased detection of heart failure among our study participants due to screening of symptomatic patients.

There was a significant association between heart failure and the size of isolated ASDs with heart failure being more prevalent in those with larger defects. Other authors have similarly reported that large ASDs of greater than 10 mm are associated with the development of complications such as heart failure, pulmonary arterial hypertension and Eisenmenger's syndrome [4-6,9,16]. The smaller the defect, the more likely is early spontaneous closure to occur resulting in less haemodynamic effect on the heart [1,17]. Since the magnitude and direction of flow through an ASD depends on the size of the defect and relative diastolic compliance of the ventricles, larger defects would be associated with increased pulmonary blood flow thus leading to heart failure [2-5]. This study showed that ASD size had no significant association with the occurrence of heart failure in subjects with associated structural defects. The most prevalent

associated structural defect noted were Ventricular septal defects (VSD) and Patent ductus arteriosus (PDA) which are also both left to right shunt lesions. When os-sec ASD occurs in association with other heart defects such as VSD, or a large PDA, heart failure is usually results from the additional left to right shunting of blood and pulmonary over-circulation posed by these post tricuspid structural defects irrespective of ASD size [12]. In fact, the shunt at the inter atrial level is often minimal in such situations [12].

In our study, the cases of heart failure in those with isolated os-sec ASD were mostly noted in the adolescent age group. Children and adolescents with large isolated ASD have been noted to remain asymptomatic till adulthood and are rarely reported to manifest with symptoms [3]. Even adult patients become symptomatic from the 3<sup>rd</sup> and 4<sup>th</sup> decade of life when pulmonary hypertension sets in especially in those with large defects [7].

Despite the fact that most of the children were mildly wasted, there was no relationship between the occurrence of heart failure and nutritional status. Malnutrition is a known complication of congenital heart diseases and has often been attributed to the presence of heart failure [18-20]. Okoromah [18] et al. who studied 76 children in Lagos with CHD reported a high prevalence of wasting in those with acyanotic CHD which was postulated to be due to associated congestive cardiac failure and poor nutritional intake in them. Children with ASD, even when asymptomatic, have been described to have subtle forms of growth failure which has been attributed to delayed pulmonary hypertension from possible relative or functional pulmonary stenosis [19-21].

This study is not without its limitations. Atrial septal defects are generally known to be asymptomatic and are often detected during routine screening. The relatively high prevalence of heart failure in the patients with os-sec ASD in our study could be due to the fact that this was a hospital based study and thus the lesions were discovered during investigation for underlying causes of heart failure.

## 5. CONCLUSION

Children with ostium secundum Atrial septal defects could present with heart failure which is more likely if the defect is >10 mm or associated with other structural heart lesions.

## CONSENT

As per international standard, parental written consent has been collected and preserved by the author(s).

## ETHICAL APPROVAL

This was part of a larger study on congenital heart diseases and ethical approval was obtained from the Research and Ethics Committee of the Niger Delta University Teaching Hospital Okolobiri Bayelsa State and the University of Nigeria Teaching Hospital, Ituku-Ozalla, Enugu State.

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## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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