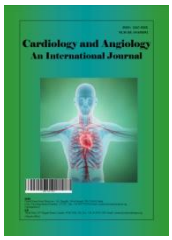

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Clinical Profile and Effects of Ductal Size on Anthropometry of Children with Patent Ductus Arteriosus (PDA)

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Authors' contributions

This work was carried out in collaboration among all authors. JMC was involved in the conception and design of the article. BFC was involved in the analysis and interpretation of the data. JMC was involved in the drafting of the paper, while COD, ATC and ACA were involved in critical revision of the article for intellectual content; and the final approval of the version to be published. *All authors read and approved the final manuscript.*

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ABSTRACT

Background
It is not known at which size a congenital Patent ductus arteriosus (PDA) in children becomes associated with a resultant severe malnutrition in children. Furthermore, the effect of ductal size on anthropometry of children with PDA is yet to be determined.
Objectives
This study was aimed to asses if the ductal size had any effect on anthropometry of children with PDA and at which size evidence of severe malnutrition ensues
Methods
This was a five-year observational cross-sectional study of children who presented at three tertiary institutions with PDA.

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Results
There was a negative non-significant correlation between the size of PDA and the weight of patients, (Pearson correlation coefficient = -0.1, p = 0.7). There was also a negative non-significant correlation between the size of PDA and patient's height/length, (correlation coefficient = -0.1, p = 0.5).
The association between the size of PDA and the severity of malnutrition revealed greater proportion of 35.3% (6/17) for wasting and stunting in patients who had large PDA sizes of >7mm, when compared with fewer proportions in those with PDA sizes of 3- 6mm (26.1% (6/23) and those with tiny PDA of <3mm (33.3% (10/30); ($\chi 2$ = 10.21, p = 0.8).
There was a positive correlation between ductal size and nutritional status of patients, and severe malnutrition ensued from ductal size of 3.2mm; with ETA square of 0.072.
The majority of children with PDA presented with severe forms of malnutrition (wasting and stunting).
Conclusion: Severe malnutrition ensues when ductal size is 3.2mm. The size of PDA has no effect on weight and height of children with PDA.

Keywords: Children; PDA; ductal size; anthropometry.

KEY MESSAGES

1. Majority of children with PDA present with severe forms of malnutrition.
2. Symptoms of severe malnutrition ensues when the ductal size is 3.2mm.
3. There is no gender difference in the severity of malnutrition among children with PDA.

1. INTRODUCTION

Patent ductus arteriosus (PDA), occurs when there is a persistent communication between the descending aorta and the left pulmonary artery [1]. This is usually due to the failure of the closure of the ductus arteriosus [1].

PDA could also coexist with other congenital heart anomalies or could even occur as a ductal dependent lesion as in Transposition of the great arteries (TGA) with an intact septum and critical pulmonary stenosis [2,3].

The reported prevalence of PDA in term neonates is 1 in 2,000 births, accounting for 5%–10% of all congenital heart disease [4]. These prevalence rates are higher in preterm neonates with values ranging from 20%–60% [5]. The increased prevalence in the preterm infant is probably due to the lack of normal closure mechanisms from immaturity [5].

Previous documentation revealed malnutrition as a very common issue in congenital heart disease and even worse in PDA [6-9]. No known study in this locality has considered any link between anthropometry and the size of PDA among children. Studies abound on the nutritional status of children with congenital heart disease, but very few focused on assessing the effects of anthropometry on the size of PDA. This study is therefore aimed to determine if the size of PDA has any effect on anthropometry (weight, height, z scores). It also determines at which size of PDA does severity of malnutrition begins to ensue.

2. METHODS

2.1 Study Design

This study was an observational cross-sectional study conducted in three institutions from the year 2016 to 2020. During the study period, echocardiography was done on children with various forms of cardiac disease.

2.2 Study Location

This study was done at the University of Nigeria Teaching Hospital Ituku Ozalla Enugu and Niger Delta University Teaching Hospital, Okolobiri over a 5-year-period.

2.3 Study Population

Children aged 1 day to 18 years with congenital heart defects who fulfilled the diagnostic criteria for patent ductus arteriosus from 2016 to 2020 at the University of Nigeria Teaching Hospital were recruited in the study. We defined patent ductus

arteriosus (PDA) as a defect seen between the descending aorta and the left pulmonary artery and with a left to right shunt. Relevant clinical features were also elicited by a thorough history taking and socio-demographic variables were also enumerated.

Anthropometric measurements included height in centimetre for age more than 2 years and supine length in centimetre for age below two. Weight was measured by standardized methods and recorded in kilograms. *Z* scores for weight for age (WAZ), weight for height (WHZ), and height for age (HAZ) were also calculated using the WHO Anthro software. The clinical features were also elicited.

2.4 Echocardiographic Measurement of Patent Ductus Ateriousus

Though PDA can be seen from many windows, left-sided parasternal otherwise called the ductal view is the best option used in this study to obtain a clear image. The ductal size was ascertained and measured at the narrowest diameter, which is at the pulmonary end [10].

2.6 Assessment of size of Patent Ductus Arteriosus

Size of patent ductus arteriosus of 1-3mm was taken as a small size PDA in this study. Moderate size PDA were those PDAs with a diameter of 4-6mm while the ductal diameter of equal to and more than 7mm is classified as large PDA.

3. DATA ANALYSIS

The data were analysed with the IBM SPSS statistics for windows, version 20 (IBM Corp, Chicago). Differences in proportions were compared using the chi-square test. The weight and height z-scores were calculated using WHO Anthro and Anthro Plus software. The nutritional status was based on the WHO classification of weight for age (WAZ), weight for height (WHZ), and height for age (HAZ). P-value < 0.05 was regarded as significant.

4. RESULTS

There was a total of 758 children with heart anomalies examined within the study period, of which 70 children had confirmed diagnosis of PDA. The patients with PDA were made up of 45.7% males and 54.3% females. The age distribution of the patients is as in Table 1, with a predominance of infants. Their mean age was 30.0±39.2 months.

The patients' mean weight and height were 11.8±10.5kg and 84 .6± 29.2cm respectively. The mean weight for males, 11.3±8.3kg was comparable to that for females, 12.2±12.5kg ($t = -0.29$, $p = 0.8$). Also, the mean height/length for males, 84.7±27.3cm was comparable to that for females, 81.1±35.2cm ($t = 0.41$, $p = 0.7$). Out of 48 children assessed for nutritional status, 29.2 % were well-nourished, 45.8% (22/48) were both wasted and stunted, 14.6% wasted, 8.3% stunted while 2.1% were obese.

There was no significant difference in the nutritional status between the males and females as illustrated in Table 2.

Although there was a positive correlation between ductal size and nutritional status of patients, severe malnutrition ensues when ductal size is 3.2mm; Fig. 1, with ETA square of 0.072.

The frequency of some clinical features varied among these patients with PDA as illustrated in Table 3. The commonest feature was fast breathing, observed in 68.9% of the patients assessed for the clinical feature, followed by pulmonary hypertension in 51.4%.

Table I. Age distribution of the patients

Age group	Frequency	%
Infants	35	50.0
preschool	24	34.3
school age	7	10.0
adolescents	4	5.7
Total	70	100.0

infants; 1-12 months, preschool; > 12 months to 5 years, school age; > 5 years to 10 years, adolescents; >10 to 18 years

Table 2. Nutritional status among the males and females

		Nutritional status					Total
		Normal (%)	Wasted (%)	Stunted (%)	Wasted and stunted (%)	Obese (%)	
Sex	male	5 (20.8)	2 (8.3)	3 (12.5)	13 (54.2)	1 (4.2)	24
	female	9 (37.5)	5 (20.8)	1 (4.2)	9 (37.5)	0 (0)	24
Total		14 (29.2)	7 (14.6)	4 (8.3)	22 (45.8)	1 (2.1)	48

Chi-square = 5.2, p = 0.3. Wasted = Z-score weight-for-age or weight-for-height <2SD, stunted = height/length-for-age <2SD, obese = BMI for age ≥2SD. The calculation was made using WHO "anthro" and "anthroPlus" software.

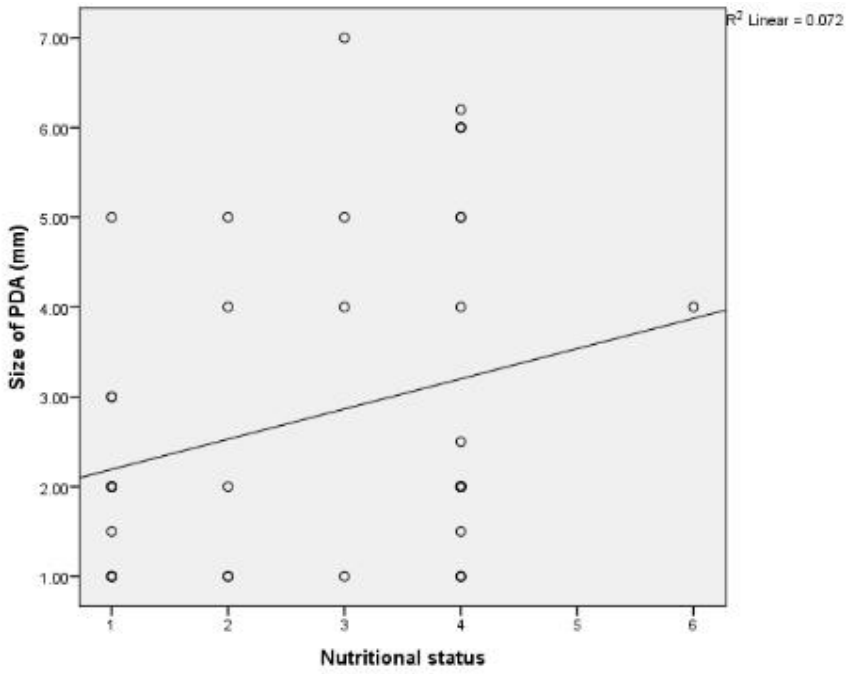

Fig. 1. Graph of PDA size and nutritional status

1, well nourished; 2, wasted; 3, stunted; 4, wasted and stunted; 5, overweight; 6, obese
The graph shows that severe malnutrition ensues when ductal size is 3.2mm.

Table 3. Frequency of different clinical features among patients with PDA

Clinical feature	Frequency (n/N)	% (n/N) X 100
Cough	0/39	0.0
Fast breathing	40/58	68.9
Failure to gain weight	22/46	47.8
Easy fatigability	30/67	44.8
Pulmonary hypertension	36/70	51.4

N = number of patients with complete data for the assessed feature, n = actual number of patients with the symptoms.

The majority of the patients (42.9%) had small PDA while 32.8% and 24.3% had moderate and large PDA respectively. Analysis of the size of PDA with nutritional status indicates that 35.3% (6/17) of patients with large PDA are wasted and stunted compared with 26.1 (6/23) and 33.3% (10/30) of those with small and tiny PDA respectively ($\chi 2 = 10.21$, $p = 0.8$).

Although there was a negative correlation between weight and the size of PDA, the correlation was not significant (Pearson

correlation coefficient = -0.1, p = 0.7). There was a negative correlation between the height/length and size of PDA, but the correlation was still not significant (correlation coefficient = -0.1, p = 0.5).

5. DISCUSSION

This study was aimed to determine if size of PDA had any effect on anthropometry. The study showed no effect of size of PDA on weight and height of the children with PDA. We noted that severe malnutrition begins in children whose PDA size is 3.2mm and above. Increased metabolic stress from cardiac failure, high fat-free mass to fat mass ratio, prolonged hypoxia, metabolic acidosis, and worsening sympathetic system activity could explain this finding [11-17]. Another reason for children with large size PDA presenting with wasting and stunting could be due to elevated pulmonary artery pressure in children with large PDA. The pulmonary pressure is caused by pulmonary over-circulation and pulmonary vascular disease, either in combination or alone could create a nidus for chest infections [15]. This could further worsen malnutrition. Accentuated pulmonary hypertension, poor intake due to anorexia, easy fatigability, uncoordinated breast sucking, neurological dysfunction, easy satiety, and fast breathing all get accentuated in children with large size PDA [16].

The commonest symptom seen in this study were fast breathing and this was seen mostly in children with large PDA. This could be caused by pulmonary hypertension which is seen in over 50% of the children. Some studies have also documented PDA-associated symptoms as been triggered by mesenteric, cerebral hypo-perfusion, renal, and pulmonary oedema secondary to pulmonary hypertension seen in over 50% of those with persistent PDA [18-21]. Abhijeet et al [22] also noted breathlessness and history of recurrent respiratory tract infections as the commonest symptoms in their series and noted that these symptoms are seen in majority of children who had large PDA.

The prevalence of severe malnutrition in children with Patent Ductus Arteriosus noted in this study is high, this is seen mostly among the under-fives. This prevalence is higher compared with prevalence values seen in children without any congenital heart disease. Chinawa [23] et al. have documented that children with congenital heart disease who are less than five years old are prone to malnutrition when compared to those who had no congenital heart disease. This could be explained by increase metabolic demands seen at this age, late surgical intervention, progressive hypoxemia and progressive pulmonary hypertension which is usually seen in children less than five years old who had congenital heart disease and who had no intervention [24-29].

Other forms of malnutrition seen in this study included stunting, wasting, or both. Mechanisms for malnutrition are multifaceted. These include associated chromosomal anomalies or genetic syndromes, feeding difficulties, poor absorption from congestive cardiac failure (CCF). Besides, increased caloric demand, altered respiratory and neuro-humoral dysfunction, chronic hypoxia with impaired cellular metabolism have all been implicated in malnutrition in children with PDA [30]. Malnutrition in children with PDA is a known cause of frequent hospitalization, pulmonary hypertension, and death [31,32].

6. LIMITATIONS

It is known that the echocardiography has many limitations in the measurement of the size of the duct. In older children and young adults, the lung limits the visualization of the duct and hence difficulty in measuring the size.

7. CONCLUSION

The majority of children with PDA present with severe forms of malnutrition (wasting and stunting). Severe malnutrition ensues when ductal size is 3.2mm. The size of PDA has no effect on weight and height of children with PDA.

DISCLAIMER

The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

ETHICS APPROVAL AND CONSENT

Ethical approval was obtained from the Ethics and Research committee of the University of Nigeria Teaching hospital, Enugu.

AVAILABILITY OF DATA AND MATERIALS

Data supporting the findings of this study are available from the corresponding author (JMC) on request.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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