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Correlation of Patent Ductus Arteriosus (PDA) Size and Morphology with Left Ventricular Size and Function: An Echocardiographic Study in Tertiary Care Hospital

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Abstract

Background: One of the most common heart defects that babies are born with is Patent Ductus Arteriosus (PDA). It causes blood to flow from the left side of the heart to the right side, which makes the left ventricle too full. Echocardiography is the best way to look at the shape of a PDA and how it affects the size and function of the left ventricle. **Objectives:** To determine the relationship between PDA size and morphology and left ventricular size and function through echocardiography in patients admitted to a tertiary care hospital. **Material and Methods:** This cross-sectional study took place at a tertiary care hospital. There were 91 patients in total who were diagnosed with Patent Ductus Arteriosus. All patients underwent echocardiographic evaluation. We wrote down the size, shape (using the Krichenko classification), direction, severity, and flow pattern of the PDA. We measured the left ventricle's LV End-Diastolic Diameter (LVEDd) and Ejection Fraction (EF). We used IBM

SPSS version 26 to look at the data.. We used the Spearman correlation, the Kruskal-Wallis test, and the Chi-Square test. A P value of less than 0.05 was deemed significant. **Results:** There were 91 patients, 40 of whom were men (44%) and 51 of whom were women (56%). The average age was 2.02 ± 3.44 years. The average diameter of the PDA was 2.98 ± 1.23 mm, and the average LVEDd was 30.78 ± 9.39 mm. Type A (Conical) was the most common shape for PDAs (45.1%). The most common size of PDA was moderate (2–4 mm), which was 42.9% of the time. The Spearman correlation demonstrated a robust positive correlation between PDA diameter and LVEDd ($r=0.651$, $p<0.001$). PDA size, and shunt severity all had a big impact on LV size ($p<0.001$). The majority of patients (87.9%) exhibited a normal ejection fraction. The direction of the shunt had a big effect on LV function ($p=0.012$). Chi-Square analysis indicated a significant correlation between PDA size and EF category ($p=0.025$). **Conclusion:** There is a strong link between the size and shape of the PDA and the size of the left ventricle. A bigger PDA is linked to a bigger LV dilatation. LV systolic function is mostly still intact, but it gets worse as the PDA size gets bigger.

Keywords: Patent Ductus Arteriosus, Echocardiography, Left Ventricular Size, Ejection Fraction, Krichenko Classification.

Introduction

Patent ductus arteriosus (PDA) is a common congenital heart defect resulting from the failure of the fetal ductus arteriosus to close after birth. Under normal physiological conditions, functional closure occurs within the first few days of life due to increased arterial oxygen tension and decreased circulating prostaglandin levels. Persistence of the ductus arteriosus establishes a left-to-right shunt between the aorta and pulmonary artery, leading to increased pulmonary blood flow and chronic volume overload of the left ventricle (LV). If left untreated, a hemodynamically significant PDA may result in left ventricular dilation, pulmonary hypertension, ventricular dysfunction, and ultimately heart failure (Schneider & Moore, 2006; Brida et al., 2018).

The clinical consequences of PDA largely depend on its size and anatomical morphology. Small PDAs are often asymptomatic with minimal hemodynamic effects, whereas moderate and large PDAs produce significant shunting, resulting in progressive enlargement of the left-sided cardiac chambers and altered ventricular geometry.

Chronic volume overload increases left ventricular preload and myocardial workload, eventually impairing systolic performance if intervention is delayed (Mitchell et al., 2018; El Hajjar et al., 2005).

PDA morphology is commonly classified using the Krichenko angiographic classification, which categorizes the duct into Types A–E based on its anatomical configuration. These morphological variations influence the degree of shunting, feasibility of transcatheter closure, and the extent of ventricular remodeling. Tubular and window-type PDAs are generally associated with larger shunt volumes and greater hemodynamic burden than elongated or conical ducts (Krichenko et al., 1989).

Echocardiography remains the cornerstone for diagnosing PDA and assessing its hemodynamic significance. In addition to confirming ductal patency, echocardiography provides comprehensive evaluation of ductal size, morphology, shunt direction, pulmonary artery pressure, and left ventricular dimensions and systolic function. Parameters such as left ventricular end-diastolic diameter (LVEDD), left ventricular end-systolic diameter (LVESD), ejection fraction (EF), and fractional shortening (FS) are widely used to quantify ventricular remodeling and functional impairment associated with PDA (Mertens et al., 2011; Lopez et al., 2010).

Previous studies have demonstrated that larger PDAs are associated with greater LV enlargement and transient deterioration in systolic function following ductal closure due to sudden changes in ventricular loading conditions. Furthermore, successful closure is often followed by reverse remodeling and gradual recovery of ventricular function, emphasizing the importance of timely diagnosis and intervention (Kim et al., 2008; El Hajjar et al., 2005). However, limited data are available regarding the combined influence of PDA size and morphological subtype on left ventricular structure and function, particularly among pediatric patients in tertiary care settings.

Therefore, the present study aims to evaluate the correlation between PDA size and morphology with left ventricular size and systolic function using echocardiography. Understanding these relationships may improve risk stratification, optimize treatment planning, and facilitate better clinical outcomes for children with PDA.

Materials and Methods

This retrospective cross-sectional study was conducted at the Department of Cardiology, Lady Reading Hospital, Peshawar, using echocardiographic records of pediatric patients diagnosed with patent ductus arteriosus (PDA). The study was completed over a period of four months. A total sample of **91 patients** was calculated using the correlation coefficient formula described by Hulley et al., assuming an expected correlation coefficient of 0.3, 95% confidence level, and 80% study power. Non-probability convenience sampling was used to include all eligible patients.

Children from birth to 5 years of age with echocardiographically confirmed PDA and complete records of PDA morphology and left ventricular (LV) measurements were included. Patients with incomplete echocardiographic data or a history of cardiac surgery affecting LV function before echocardiography were excluded.

Data were collected retrospectively from hospital records using a structured data collection form, including demographic characteristics, PDA size and morphology, and echocardiographic parameters of LV size and function. Statistical analysis was performed using **SPSS version 26.0**. Continuous variables were expressed as mean ± standard deviation, while categorical variables were presented as frequencies and percentages. The association between PDA size, morphology, and LV size and function was assessed using **Spearman's correlation coefficient**, with a **p-value < 0.05** considered statistically significant.

RESULTS

This study was conducted on 91 patients diagnosed with Patent Ductus Arteriosus. Data was collected through echocardiographic assessment and analyzed using IBM SPSS Statistics. The following results were obtained regarding PDA size, morphology and their correlation with left ventricular size and function.

Table 1 shows the descriptive statistics of continuous variables. The mean age of patients was 2.02 ± 3.44 years with a range of 0.01 to 15 years. The mean PDA diameter was 2.98 ± 1.23 mm ranging from 1.00 to 5.10 mm. The mean LV End-Systolic Diameter was 30.78 ± 9.39 mm with a range of 16 to 50 mm.

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Table 1: *Descriptive Statistics of Age, PDA Diameter and LVESd*

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std. Deviation
Age of patient in years	91	.01	15.00	2.0245	3.43397
PDA Diameter in mm	91	1.00	5.10	2.9824	1.22525
LV End-Systolic Diameter (mm)	91	16	50	30.78	9.396
Valid N (listwise)	91				

Table 2 shows that out of 91 patients, 51 (56%) were female and 40 (44%) were male indicating slight female predominance in the study population.

Table 2: *Frequency Distribution of Gender*

Gender of Patient					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Male	40	44.0	44.0	44.0
	Female	51	56.0	56.0	100.0
	Total	91	100.0	100.0	

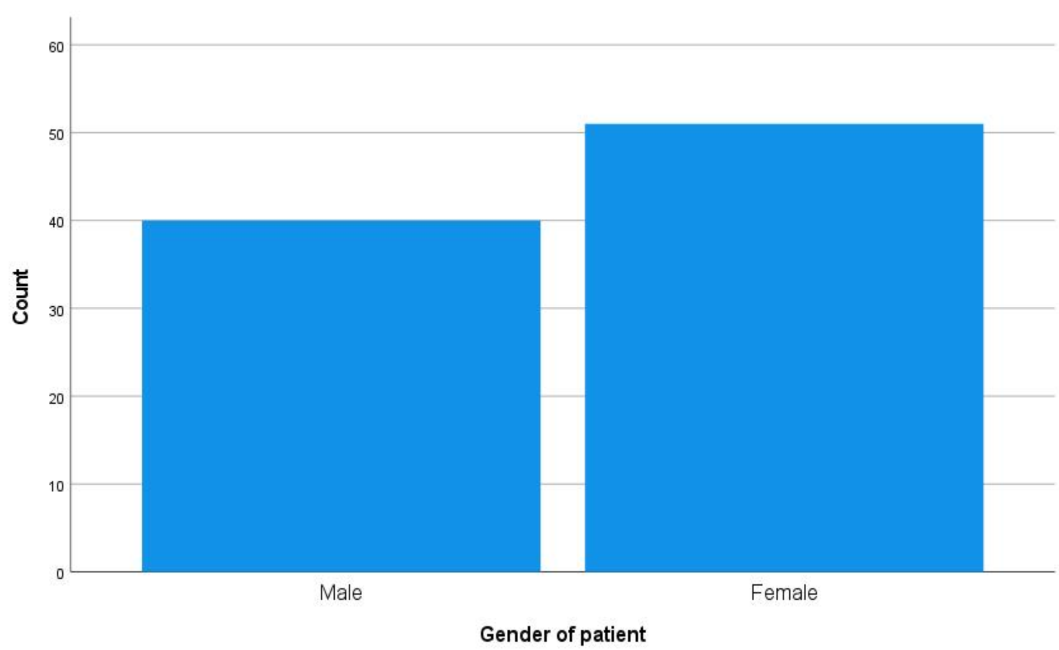

Figure1: Bar Chart showing Gender Distribution of Patients

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Figure 1 shows the gender distribution of the study population. Out of 91 patients, 40 (44%) were male and 51(56%) were female.

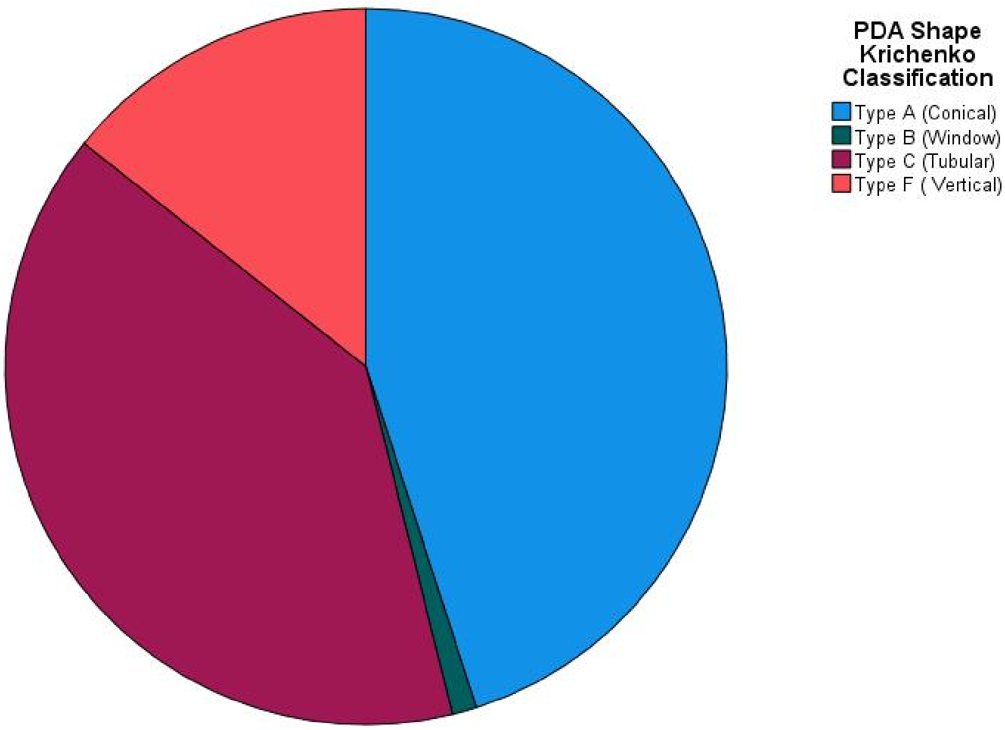

Figure 2: Pie Chart showing PDA Shape Krichenko Classification Distribution

Figure 2 shows the distribution of PDA morphology according to Krichenko Classification. Type A Conical was the most common type.

Table 3: *Frequency Distribution of PDA Shape Krichenko Classification*

PDA Shape Krichenko Classification					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Type A (Conical)	41	45.1	45.1	45.1
	Type B (Window)	1	1.1	1.1	46.2
	Type C (Tubular)	36	39.6	39.6	85.7
	Type F (Vertical)	13	14.3	14.3	100.0

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Table 3 shows that Type A Conical was most common (45.1%), followed by Type C Tubular (39.6%), Type F Vertical (14.3%) and Type B Window (1.1%).

Table 3 shows the frequency distribution of PDA morphology according to Krichenko classification among the study participants. Type A (Conical) was the most common PDA morphology, observed in 41 patients (45.1%), followed by Type C (Tubular) in 36 patients (39.6%). Type F (Vertical) was seen in 13 patients (14.3%), while Type B (Window) was the least common, observed in only 1 patient (1.1%).

Table 4: *Spearman Correlation between PDA Diameter, LVEDd and EF Category*

Correlations

			PDA Diameter in mm	**LV End-Systolic Diameter (mm)**	**Ejection Fraction Category**
Spearman's rho	PDA Diameter in mm	Correlation Coefficient	1.000	.651**	.386**
		Sig. (2-tailed)	.	.000	.000
	LV End-Diastolic Diameter (mm)	Correlation Coefficient	91	91	91
		Sig. (2-tailed)	.651**	1.000	.454**
		N	.000	.	.000
	Ejection Fraction Category	Correlation Coefficient	91	91	91
		Sig. (2-tailed)	.386**	.454**	1.000
		N	.000	.000	.
			91	91	91

**. Correlation is significant at the 0.01 level (2-tailed).

Table 4 presents the Spearman correlation analysis between PDA diameter, left ventricular end-diastolic diameter (LVEDd), and ejection fraction (EF) category. A strong positive and statistically significant correlation was observed between PDA diameter and LVEDd (r = 0.651, p < 0.001), indicating that larger PDA diameter was associated with greater left ventricular dilatation. A moderate positive correlation was also found between PDA diameter and EF category (r = 0.386, p < 0.001). Furthermore, LVEDd showed a significant positive correlation with EF category (r = 0.454, p < 0.001). These findings suggest that increasing PDA diameter is associated with structural and functional changes in the left ventricle.

Table 5: *Kruskal-Wallis Test showing LVEDd across PDA Shape Groups*

Ranks

	PDA Shape Krichenko Classification	N	Mean Rank
LV End-Diastolic Diameter (mm)	Type A (Conical)	41	28.90
	Type B (Window)	1	39.00
	Type C (Tubular)	36	61.85
	Type F (Vertical)	13	56.58
	Total	91	

Table 5 shows significant difference in LVEDd across PDA shape groups (H=32.404, p<0.001)

PDA size Category * Ejection Fraction Category Crosstabulation

			Ejection Fraction Category		Total
			Normal (55%)	Midly Impaired (45-54%)	
PDA size Category	Small (<2mm)	Count	31	0	31
		% within PDA size Category	100.0%	0.0%	100.0%
	Moderate (2-4mm)	Count	33	6	39
		% within PDA size Category	84.6%	15.4%	100.0%
	Large(>4mm)	Count	16	5	21
		% within PDA	76.2%	23.8%	100.0%

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		size Category			
Total		Count	80	11	91
		% within PDA size Category	87.9%	12.1%	100.0%

Table 6: *Chi-Square Test — PDA Size Category vs EF Category*

PDA size Category * Ejection Fraction Category Crosstabulation

			Ejection Fraction Category		Total
			Normal (55%)	Midly Impaired (45-54%)	
PDA size Category	Small (<2mm)	Count	31	0	31
		% within PDA size Category	100.0%	0.0%	100.0%
	Moderate (2-4mm)	Count	33	6	39
		% within PDA size Category	84.6%	15.4%	100.0%
	Large(>4mm)	Count	16	5	21
		% within PDA size Category	76.2%	23.8%	100.0%
Total		Count	80	11	91
		% within PDA size Category	87.9%	12.1%	100.0%

Table 6 shows significant association between PDA size category and Ejection Fraction category (χ^2=7.377, p=0.025). Small PDA had 0% EF impairment while Large PDA showed 23.8% EF impairment.

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Table 7: *Distribution of Ejection Fraction Category According to PDA Morphology (Krichenko Classification)*

PDA Shape Krichenko Classification * Ejection Fraction Category Crosstabulation

Count

		Ejection Fraction Category		
		Normal (55%)	Midly Impaired (45-54%)	Total
PDA Shape Krichenko Classification	Type A (Conical)	40	1	41
	Type B (Window)	1	0	1
	Type C (Tubular)	29	7	36
	Type F (Vertical)	10	3	13
Total		80	11	91

Table 7 presents the distribution of ejection fraction categories according to PDA morphology. Type A (Conical) PDA was the most common morphology, accounting for 41 patients, of whom 40 (97.6%) had normal ejection fraction and 1 (2.4%) had mildly impaired ejection fraction. Among patients with Type C (Tubular) PDA, 29 (80.6%) had normal ejection fraction while 7 (19.4%) had mildly impaired ejection fraction. In the Type F (Vertical) group, 10 (76.9%) patients had normal ejection fraction and 3 (23.1%) had mildly impaired ejection fraction. The only patient with Type B (Window) PDA had normal ejection fraction. Overall, normal ejection fraction was observed in 80 (87.9%) patients, while mildly impaired ejection fraction was observed in 11 (12.1%) patients.

Table 8: *Chi-Square Analysis Showing Association Between PDA Morphology and Ejection Fraction Category*

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	7.040[a]	3	.071
Likelihood Ratio	8.183	3	.042
Linear-by-Linear Association	5.417	1	.020
N of Valid Cases	91		

Table 8 shows the association between PDA morphology and ejection fraction category using the Chi-Square test. Pearson Chi-Square analysis revealed no statistically significant association between PDA morphology and ejection fraction category (χ^2 = 7.040, df = 3, p = 0.071). Therefore, PDA morphology was not significantly associated with left ventricular systolic function among the study participants.

DISCUSSION

The present study evaluated the relationship between PDA size, morphology, and left ventricular size and function in pediatric patients using echocardiography. A strong positive and statistically significant correlation was observed between PDA diameter and left ventricular end-diastolic diameter (LVEDd) ($r = 0.651$, $p < 0.001$). This finding indicates that larger PDA diameters are associated with greater left ventricular dilatation due to increased left-to-right shunting and volume overload. Similar findings have been reported in previous studies, which demonstrated that increasing PDA size results in progressive enlargement of left-sided cardiac chambers and increased hemodynamic burden.

Most patients in the present study (87.9%) had normal ejection fraction, indicating that left ventricular systolic function remained preserved in the majority of cases despite left ventricular enlargement. This observation is consistent with previous literature suggesting that children with PDA often maintain normal systolic function through compensatory mechanisms for a prolonged period before ventricular dysfunction develops.

A statistically significant association was observed between PDA size category and ejection fraction category ($p = 0.025$). Larger PDA sizes were associated with greater impairment of left ventricular function. This finding supports the concept that increasing shunt volume may eventually affect myocardial performance and contribute to systolic dysfunction if left untreated.

The study also demonstrated that shunt direction significantly influenced left ventricular function ($p = 0.012$). Patients with bidirectional shunting showed relatively poorer ventricular function compared with those having left-to-right shunts. This finding highlights the importance of hemodynamic burden in determining cardiac remodeling and ventricular performance.

In contrast, PDA morphology according to the Krichenko classification did not show a statistically significant association with left ventricular function ($p > 0.05$). Although different PDA morphologies may alter blood flow patterns, the findings suggest that PDA size and shunt severity may have a greater influence on ventricular function than anatomical shape alone. The absence of a significant association may also be related to the unequal distribution of PDA morphology types, particularly the very small number of patients in some subgroups.

The mean age of the study population was 2.02 ± 3.44 years, reflecting the common presentation of PDA during infancy and early childhood. A slight female predominance was observed (56% females and 44% males), which is consistent with previous studies reporting a higher frequency of PDA among females.

Overall, the findings of the present study emphasize the importance of echocardiographic assessment of PDA size and left ventricular parameters. Early identification of ventricular enlargement and functional impairment may help guide timely intervention and prevent long-term cardiac complications.

CONCLUSION

This echocardiographic study of 91 patients demonstrated a strong and statistically significant positive correlation between PDA diameter and left ventricular end-diastolic diameter ($r = 0.651$, $p < 0.001$), indicating that larger PDA is associated with greater left ventricular dilatation. Most patients (87.9%) had preserved left ventricular systolic function with normal ejection fraction. A significant association was observed between PDA size and ejection fraction category, suggesting that larger PDA may be associated with reduced ventricular function. The study population was predominantly pediatric, reflecting the common presentation of PDA in early childhood. These findings highlight

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the importance of echocardiographic assessment of PDA size and cardiac changes for early diagnosis and timely management to prevent progressive left ventricular enlargement.

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