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Clinical Spectrum of Ventricular Septal Defects in Children at Regional Institute of Medical Sciences Imphal, Manipur

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ABSTRACT

Introduction: Ventricular septal defect (VSD) is the most common congenital heart disease in children and represents a significant proportion of pediatric cardiac anomalies. The clinical presentation varies widely depending on the size and location of the defect, ranging from asymptomatic cases to severe complications such as congestive cardiac failure and pulmonary hypertension. Early identification and evaluation are essential for appropriate management and prevention of complications.

Objectives: The objectives of the present study were to evaluate the clinical profile of pediatric patients diagnosed with ventricular septal defect (VSD) attending the tertiary care hospital at RIMS, Imphal, with particular emphasis on determining the size and anatomical type of the defect. In addition, the study aimed to assess the association between various demographic and clinical variables and the characteristics of VSD, as well as to identify the relationship between the size of the defect and the occurrence of related complications.

Materials and Methods: A cross-sectional study was conducted in the Department of Paediatrics, Regional Institute of Medical Sciences (RIMS), Imphal, from May 2023 to April 2025. A total of 47 children aged 0–12 years with clinically suspected VSD were included. Diagnosis was confirmed by echocardiography. Demographic data, clinical features, type and size of VSD, complications, and spontaneous closure were recorded and analyzed using appropriate statistical methods.

Results: Most children presented between 1 month and 1 year of age (55.3%), and 65.9% developed their first symptoms during infancy. A slight male predominance was observed (53.2%). Perimembranous VSD was the most common type (76.6%). The most frequent clinical features were cough (65.9%), fever (63.8%), tachypnea (61.7%), and tachycardia (61.7%), while pansystolic murmur was present in all cases. Larger VSDs were significantly associated with complications such as congestive cardiac failure, pulmonary hypertension, and malnutrition ($p < 0.05$). Spontaneous closure occurred predominantly in small VSDs (77.3%).

Conclusion: VSD commonly presents during infancy, with perimembranous defects being the most prevalent type. Larger defects are associated with increased complications, while smaller defects show a higher rate of spontaneous closure. Early diagnosis and timely management are essential for improving clinical outcomes.

Keywords: *Ventricular septal defect, congenital heart disease, pediatric cardiology, echocardiography, spontaneous closure, pulmonary hypertension.*

INTRODUCTION

Ventricular septal defect (VSD) is the most common congenital heart defect diagnosed in children and accounts for a substantial proportion of congenital cardiac anomalies worldwide. It is defined as an abnormal opening in the interventricular septum that permits communication between the right and left ventricles, resulting in abnormal blood flow between these chambers. Because the pressure in the left ventricle is higher than that in the right ventricle, blood typically flows from left to right across the defect, producing a left-to-right shunt and increased pulmonary blood flow [1]. VSDs may occur as isolated cardiac defects or may be associated with other congenital heart diseases such as tetralogy of Fallot, transposition of the great arteries, atrioventricular septal defects, or patent ductus arteriosus [2]. The clinical significance of a VSD depends largely on the size of the defect, the resistance in the pulmonary vasculature, and the presence of associated cardiac abnormalities.

Congenital heart disease occurs in approximately 8–10 per 1000 live births globally, and ventricular septal defects constitute nearly 20–30% of these cases, making them the most frequently encountered congenital cardiac malformation in infancy and childhood [3,4]. With the increasing availability of echocardiography and improved neonatal screening, the detection rate of VSDs has increased significantly in recent decades. Many small defects may remain asymptomatic and are detected incidentally during routine clinical examination or cardiac evaluation. However, larger defects can cause significant hemodynamic disturbances leading to symptoms in early infancy [5].

Embryologically, the ventricular septum develops from multiple components, including the muscular septum, endocardial cushions, and the conotruncal septum. Failure of proper formation or fusion of these structures during fetal development results in the formation of a ventricular septal defect [6]. Based on anatomical location, VSDs are commonly classified into perimembranous, muscular, inlet, and outlet (supracristal or subarterial) types. Among these, the perimembranous type is the most common and accounts for nearly 70–80% of all ventricular septal defects diagnosed in clinical practice [7]. The anatomical location and size of the defect play a crucial role in determining the hemodynamic impact and clinical presentation.

The pathophysiological effects of VSD depend primarily on the size of the defect and the magnitude of the shunt. In small defects, the resistance across the defect remains high, resulting in minimal shunting and often no symptoms. Such defects are frequently referred to as restrictive VSDs and are often detected due to the presence of a characteristic loud pansystolic murmur on auscultation [8]. In contrast, large defects allow significant left-to-right shunting, leading to increased pulmonary blood flow, left atrial and ventricular volume overload, and eventually pulmonary hypertension if left untreated. Persistent large shunts may also result in congestive heart failure during infancy and early childhood [9].

The clinical spectrum of ventricular septal defects in children varies widely. Some children remain completely asymptomatic, while others may present with symptoms such as tachypnea, feeding difficulties, failure to thrive, recurrent respiratory tract infections, and excessive sweating during feeding. Physical examination typically reveals a harsh pansystolic murmur best heard at the lower left sternal border, often accompanied by a palpable thrill [10]. In severe cases, signs of congestive heart failure including hepatomegaly, tachycardia, and respiratory distress may be present.

The natural history of VSD also varies considerably depending on the size and location of the defect. Small muscular VSDs frequently close spontaneously during early childhood due to the growth of surrounding myocardial tissue or fibrous tissue formation around the margins of the defect. Studies have reported spontaneous closure rates ranging from 40% to 70% during the first few years of life [4]. However, larger defects rarely close spontaneously and may require medical management or surgical closure to prevent complications such as pulmonary hypertension, Eisenmenger syndrome, aortic valve prolapse, or infective endocarditis [3].

With advances in diagnostic imaging, particularly two-dimensional echocardiography and Doppler studies, early diagnosis and accurate assessment of ventricular septal defects have become possible. Early identification of clinically significant defects allows timely intervention and improved long-term outcomes. Understanding the varied clinical manifestations and complications associated with VSD is essential for appropriate management and follow-up of affected children. Therefore, studying the clinical spectrum of ventricular septal defects in children remains important for early diagnosis, optimal treatment planning, and prevention of long-term morbidity.

This study aims to evaluate the clinical profile of pediatric patients with ventricular septal defect (VSD) attending the tertiary care hospital at RIMS, Imphal. It also aims to assess the size and type of VSD and determine the association between relevant demographic and clinical variables with the characteristics of the defect.

MATERIALS AND METHODS

- **Study Design:** Cross-sectional study.

- **Study Setting:** Department of Paediatrics, Regional Institute of Medical Sciences (RIMS), Imphal, Manipur.
- **Study Duration:** The study was conducted for a period of 2 years, from May 2023 to April 2025.
- **Study Population:** All children aged 0–12 years attending the Paediatric outpatient department (OPD) or inpatient department (IPD) with a clinical diagnosis of ventricular septal defect (VSD), including both newly diagnosed and previously known cases, were included in the study. All suspected cases underwent echocardiographic evaluation to confirm the diagnosis of ventricular septal defect.

Inclusion Criteria:

1. Children aged 0–12 years attending the Paediatric OPD or IPD.
2. Patients diagnosed with isolated ventricular septal defect confirmed by echocardiography.

Exclusion Criteria:

1. Very sick neonates with cardiorespiratory compromise who could not undergo echocardiography.
2. Neonates whose parents or legal guardians did not give consent for participation in the study.
3. Patients with VSD associated with other congenital heart diseases.

Sample Size: The study was 47 subjects

Statistical Analysis: Data were entered into Microsoft Excel and analyzed using SPSS software version 27.0 (SPSS Inc., Chicago, IL, USA) and GraphPad Prism version 5. Continuous variables were expressed as mean ± standard deviation, while categorical variables were presented as frequencies and percentages. The unpaired t-test was used to compare continuous variables between independent groups, and the paired t-test was applied for within-group comparisons. Categorical variables were analyzed using the Chi-square test or Fisher's exact test as appropriate. A p-value of <0.05 was considered statistically significant.

RESULT

Table 1: Demographic and Baseline Characteristics of Study Population (n = 47)

Variable	Category	Frequency (n)	Percentage (%)	p-value
Age at Presentation	1 month–1 year	26	55.3	**0.003**
	1–5 years	14	29.7	
	>5 years	7	15	
Age at First Symptom	1 month–1 year	31	65.9	**<0.001**
	1–5 years	9	19.1	
	>5 years	7	15	
Gender	Male	25	53.2	**0.66**
	Female	22	46.8	
Religion	Hindu	20	42.5	**0.08**
	Christian	18	38.3	
	Muslim	4	8.5	
	Others	5	10.7	
Socioeconomic Status	Upper	5	10.7	**0.04**
	Upper middle	5	10.7	
	Lower middle	9	19.1	
	Upper lower	13	27.6	
	Lower	15	31.9	
Consanguineous Marriage	Yes	19	40.4	**0.18**
	No	28	59.6	
Maternal Age at Pregnancy	<20 years	12	25.5	**0.02**
	21–34 years	11	23.4	
	>35 years	24	51.1	

Table 2: Distribution of Clinical Features in Study Population (n = 47)

Clinical Feature	Present n (%)	Absent n (%)	p-value
Cough	31 (65.9)	16 (34.1)	0.02
Fever	30 (63.8)	17 (36.2)	0.04
Breathlessness	25 (53.2)	22 (46.8)	0.64
Failure to thrive	22 (46.8)	25 (53.2)	0.64

Fatigue	19 (40.4)	28 (59.6)	0.19
Tachypnea	29 (61.7)	18 (38.3)	0.06
Tachycardia	29 (61.7)	18 (38.3)	0.06
Crepitation	26 (55.3)	21 (44.7)	0.47
Hepatomegaly	16 (34.0)	31 (66.0)	0.02
Asymptomatic	7 (14.9)	40 (85.1)	<0.001
Pan systolic murmur	47 (100)	0	<0.001

Table 3: Association Between Size of VSD and Complications (n = 47)

Complication	Small VSD (n=22)	Medium VSD (n=14)	Large VSD (n=11)	Total	p-value
Pneumonia	13 (59%)	8 (57%)	6 (54.5%)	27	0.96
CCF	2 (9%)	6 (42.8%)	8 (72.7%)	16	0.002
Pulmonary Hypertension	0	3 (21.4%)	5 (45.4%)	8	0.004
Malnutrition	5 (22.2%)	8 (57.1%)	10 (90.9%)	23	<0.001

Table 4: Association Between Size of VSD and Spontaneous Closure

VSD Size	Total Cases	Spontaneous Closure	Percentage	p-value
Small	22	17	77.30%	<0.0001
Medium	14	6	42.90%	
Large	11	3	27.30%	

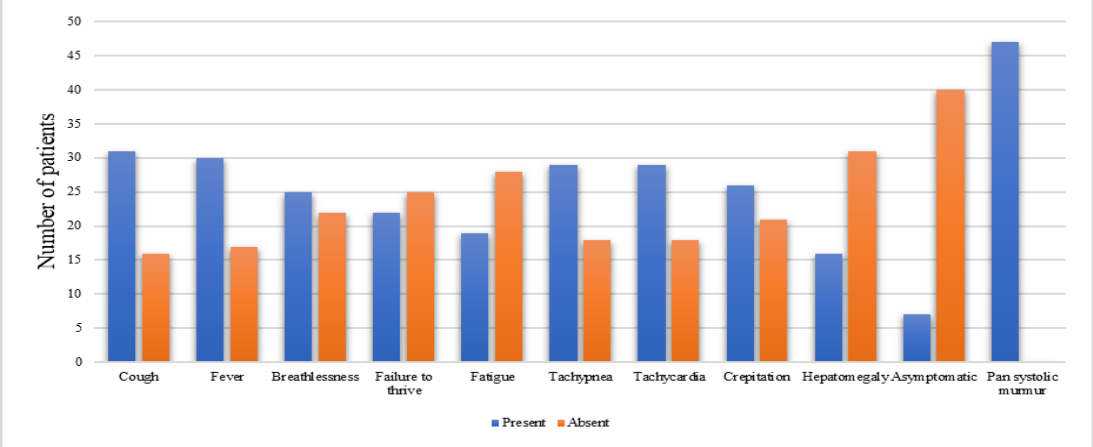

Figure: 1. Distribution of Clinical Features in Study Population

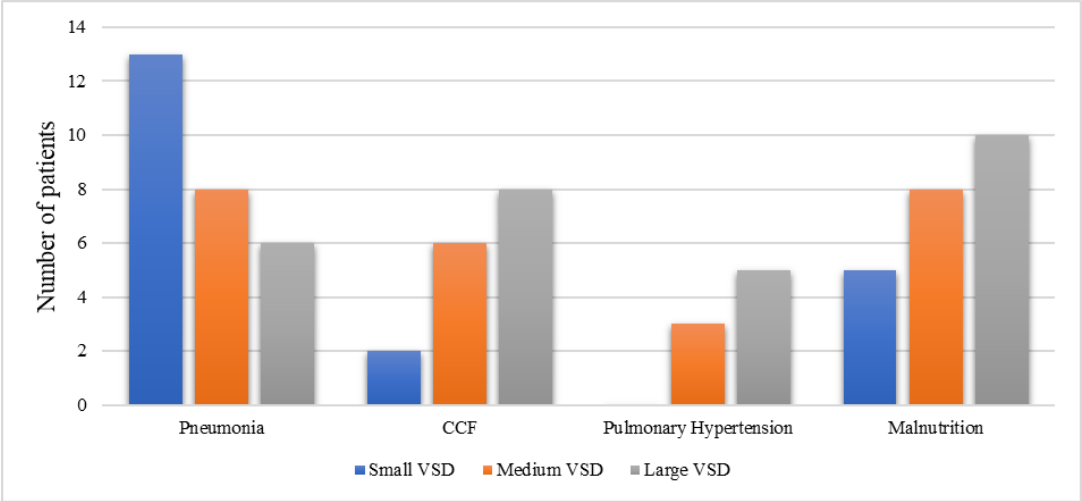

Figure: 2. Association Between Size of VSD and Complications

Table 1: Demographic and Baseline Characteristics of Study Population (n = 47)

Table 1 shows the demographic and baseline characteristics of the study population. The majority of children presented between 1 month and 1 year of age (55.3%, 26/47), followed by 1–5 years (29.7%, 14/47) and >5 years (15%, 7/47), which was statistically significant ($p = 0.003$). Similarly, most children developed their first symptoms during infancy (65.9%, 31/47), while 19.1% (9/47) developed symptoms between 1–5 years and 15% (7/47) after 5 years, showing a highly significant distribution ($p < 0.001$). Regarding gender distribution, males constituted 53.2% (25/47) and females 46.8% (22/47), indicating a slight male predominance, though this difference was not statistically significant ($p = 0.66$). In terms of religion, Hindu children accounted for 42.5% (20/47), followed by Christians 38.3% (18/47), Muslims 8.5% (4/47), and others 10.7% (5/47), which was not statistically significant ($p = 0.08$). Socioeconomic status revealed that the largest proportion belonged to the lower class (31.9%, 15/47) and upper lower class (27.6%, 13/47), followed by lower middle class (19.1%, 9/47), upper middle class (10.7%, 5/47), and upper class (10.7%, 5/47), showing a significant distribution ($p = 0.04$). Consanguineous marriage was present in 40.4% (19/47) of cases, while 59.6% (28/47) were from non-consanguineous marriages, which was not statistically significant ($p = 0.18$). Regarding maternal age at pregnancy, the majority of mothers were aged >35 years (51.1%, 24/47), followed by <20 years (25.5%, 12/47) and 21–34 years (23.4%, 11/47), which showed a significant association ($p = 0.02$).

Table 2: Distribution of Clinical Features in Study Population (n = 47)

Table 2 presents the distribution of clinical features among the study population. The most common symptom was cough observed in 65.9% (31/47) of children, which was statistically significant ($p = 0.02$). Fever was reported in 63.8% (30/47) of cases ($p = 0.04$). Breathlessness was present in 53.2% (25/47) of patients and failure to thrive in 46.8% (22/47), though these findings were not statistically significant ($p = 0.64$). Fatigue was observed in 40.4% (19/47) of cases ($p = 0.19$). Clinical signs such as tachypnea and tachycardia were present in 61.7% (29/47) of children each, but these findings were not statistically significant ($p = 0.06$). Crepitations were noted in 55.3% (26/47) of patients ($p = 0.47$). Hepatomegaly was detected in 34.0% (16/47) of children and showed statistical significance ($p = 0.02$). Asymptomatic cases accounted for 14.9% (7/47) and showed a highly significant distribution ($p < 0.001$). Notably, pansystolic murmur was present in all patients (100%, 47/47) and was highly significant ($p < 0.001$), representing the most consistent clinical finding in the study population.

Table 3: Association Between Size of VSD and Complications (n = 47)

Table 3 illustrates the relationship between the size of ventricular septal defect (VSD) and associated complications. Pneumonia was the most common complication, occurring in 59% (13/22) of patients with small VSD, 57% (8/14) with medium VSD, and 54.5% (6/11) with large VSD, accounting for 57.4% (27/47) of the total study population. However, the association between pneumonia and VSD size was not statistically significant ($p = 0.96$). Congestive cardiac failure (CCF) showed a clear increase with larger defects, occurring in 9% (2/22) of small VSD, 42.8% (6/14) of medium VSD, and 72.7% (8/11) of large VSD cases, which was statistically significant ($p = 0.002$). Pulmonary hypertension (PHTN) was absent in small VSDs but occurred in 21.4% (3/14) of medium VSD and 45.4% (5/11) of large VSD cases, showing a significant association ($p = 0.004$). Malnutrition was present in 22.2% (5/22) of children with small VSD, 57.1% (8/14) with medium VSD, and 90.9% (10/11) with large VSD, affecting 48.9% (23/47) of the total population, and this association was highly significant ($p < 0.001$). These findings indicate that larger VSDs are associated with increased risk of complications, particularly CCF, pulmonary hypertension, and malnutrition.

Table 4: Association Between Size of VSD and Spontaneous Closure

Table 4 demonstrates the association between VSD size and spontaneous closure. Among 22 cases of small VSD, 17 cases (77.3%) showed spontaneous closure. In comparison, 6 out of 14 cases (42.9%) of medium VSD underwent spontaneous closure, while only 3 out of 11 cases (27.3%) of large VSD closed spontaneously. This trend indicates that smaller defects have a much higher likelihood of spontaneous closure compared to medium and large defects, and this association was highly statistically significant ($p < 0.0001$). These findings support the established clinical understanding that small ventricular septal defects often close spontaneously during childhood, whereas larger defects are less likely to resolve without medical or surgical intervention.

DISCUSSION

In the present study, the majority of children with ventricular septal defect (VSD) presented during infancy, with 55.3% presenting between 1 month and 1 year of age, and 65.9% developing their first symptoms within the same age group. This finding indicates that VSD commonly manifests early in life due to hemodynamic changes that occur after birth as pulmonary vascular resistance decreases. Similar observations were reported by Penny and Vick, who noted that most clinically significant VSDs are detected within the first year of life because symptoms such as respiratory distress, poor feeding, and failure to thrive become apparent during infancy [11]. A study conducted by Hoffman and Kaplan also reported that congenital heart diseases, particularly VSD, are most frequently diagnosed in the first year of life due to early manifestation of symptoms related to increased pulmonary blood flow [12]. Likewise, Baro et al. observed that the majority of children with VSD presented before one year of age, emphasizing the importance of early clinical evaluation and

echocardiographic screening in infants with cardiac murmurs or respiratory symptoms [13]. These findings are consistent with the current study, reinforcing that infancy remains the most common period for clinical detection of VSD.

Regarding gender distribution, the present study showed a slight male predominance (53.2% males vs 46.8% females), although the difference was not statistically significant. Similar gender patterns have been described in several epidemiological studies. Mitchell et al. reported a marginal male predominance in congenital heart disease, including ventricular septal defects, although the gender difference was minimal and not consistently significant across studies [14]. Similarly, Van der Linde et al. found that the prevalence of VSD did not show a strong gender bias, with nearly equal distribution between males and females [15]. These findings align with the current study, suggesting that while slight male predominance may be observed, VSD generally affects both sexes almost equally.

The present study also demonstrated that a large proportion of the study population belonged to lower socioeconomic groups, with 31.9% from the lower class and 27.6% from the upper lower class, indicating that nearly 60% of patients were from economically disadvantaged backgrounds. This finding is comparable to the observations by Saxena et al., who reported that congenital heart disease in developing countries is often more frequently detected in children from lower socioeconomic groups due to factors such as limited access to antenatal care, poor maternal nutrition, and increased exposure to environmental risk factors [16]. Similarly, Kumar et al. observed that children from lower socioeconomic backgrounds had a higher prevalence of congenital heart disease, possibly due to delayed diagnosis and inadequate healthcare access [17]. These findings highlight the influence of socioeconomic factors on the detection and management of congenital heart diseases.

In the current study, maternal age greater than 35 years accounted for the largest proportion (51.1%) of cases. Advanced maternal age has been recognized as a potential risk factor for congenital anomalies, including congenital heart defects. Friedman et al. reported that increasing maternal age is associated with a higher risk of congenital anomalies due to genetic and chromosomal abnormalities during pregnancy [18]. Similarly, Jenkins et al. identified maternal age as an important risk factor contributing to the development of congenital heart defects, particularly when combined with other maternal risk factors such as diabetes or infections during pregnancy [19]. The findings of the present study therefore support the existing evidence that advanced maternal age may contribute to an increased occurrence of congenital cardiac anomalies.
The clinical profile of children in the present study revealed that respiratory symptoms were the most common presenting features, with cough (65.9%), fever (63.8%), and breathlessness (53.2%) being frequently reported. Clinical signs such as tachypnea and tachycardia were also observed in 61.7% of cases, while failure to thrive was present in 46.8% of children. These findings are consistent with the pathophysiology of VSD, where increased pulmonary blood flow leads to recurrent respiratory infections and growth failure. Similar results were reported by Park, who noted that infants with moderate or large VSD commonly present with respiratory distress, recurrent chest infections, and poor weight gain due to increased pulmonary circulation and cardiac workload [11]. Likewise, Kliegman et al. reported that tachypnea, tachycardia, and feeding difficulties are typical manifestations of significant left-to-right shunts in infants with VSD [20]. In addition, the present study observed that pansystolic murmur was present in 100% of cases, making it the most consistent clinical finding. This observation aligns with the classical description of VSD in pediatric cardiology literature, where a harsh pansystolic murmur at the lower left sternal border is considered the hallmark clinical sign.

The distribution of VSD types in the present study showed that perimembranous VSD was the most common type (76.6%), followed by muscular VSD (19.2%), while inlet and infundibular VSDs were rare (2.1% each). These findings are consistent with previous studies. Anderson et al. reported that perimembranous VSD accounts for nearly 70–80% of all ventricular septal defects, making it the most frequently encountered anatomical subtype [13]. Similarly, Penny and Vick also observed that perimembranous VSD is the predominant form in most clinical series, while muscular and other types occur less frequently [11]. The predominance of perimembranous defects observed in the present study therefore aligns with global epidemiological patterns of VSD.

The relationship between VSD size and complications was another important finding in this study. Larger VSDs were associated with significantly higher rates of congestive cardiac failure, pulmonary hypertension, and malnutrition. For instance, 72.7% of children with large VSD developed congestive cardiac failure, and 45.4% developed pulmonary hypertension, compared with much lower rates in small VSDs. These findings are supported by previous research. Hoffman and Kaplan reported that large ventricular septal defects produce substantial left-to-right shunts, leading to increased pulmonary blood flow, volume overload of the heart, and the development of congestive heart failure and pulmonary hypertension if untreated [12]. Similarly, Mitchell et al. observed that complications such as malnutrition and heart failure are more common in children with large defects due to increased metabolic demands and poor feeding associated with cardiac dysfunction [14]. The results of the present study therefore confirm the strong association between the size of the defect and the severity of clinical complications.

Finally, the present study demonstrated that spontaneous closure occurred most frequently in small VSDs (77.3%), compared to 42.9% in medium VSD and only 27.3% in large VSD, with a highly significant association. This observation is consistent with the natural history of VSD described in previous studies. Mehta and Chidambaram reported that small muscular VSDs often close spontaneously during early childhood due to progressive growth of the interventricular septum and formation of fibrous tissue around the defect margins [15]. Similarly, Rao et al. noted that spontaneous closure rates are significantly higher in small defects, whereas large defects usually persist and require medical or surgical intervention [16]. These findings correspond closely with the present study, confirming that defect size plays a crucial role in determining the likelihood of spontaneous closure.

CONCLUSION

The present study highlights the clinical spectrum of ventricular septal defects (VSD) among pediatric patients attending a tertiary care hospital. The majority of cases presented during infancy, emphasizing the importance of early detection and evaluation in young children with cardiac symptoms. Perimembranous VSD was identified as the most common anatomical type, consistent with previous literature. Respiratory symptoms such as cough, fever, breathlessness, and clinical signs like tachypnea and pansystolic murmur were frequently observed. The study also demonstrated a clear association between the size of the defect and the occurrence of complications. Larger VSDs were significantly associated with increased rates of congestive cardiac failure, pulmonary hypertension, and malnutrition, whereas smaller defects had a higher likelihood of spontaneous closure. These findings underline the importance of early diagnosis through clinical examination and echocardiography to guide appropriate management. Timely monitoring and intervention can help prevent complications and improve long-term outcomes in children with ventricular septal defects.

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