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Impact of Early Versus Late Surgical Intervention in Children with Ventricular Septal Defects

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ABSTRACT:

Background: Ventricular septal defect (VSD) is one of the most common congenital heart conditions in children. The timing of surgical intervention remains a critical factor influencing outcomes. While early surgery may prevent complications such as pulmonary hypertension and heart failure, late intervention allows for spontaneous closure in some cases. However, the optimal timing for surgical repair remains a topic of debate.

Aim: This study aimed to compare the clinical outcomes of early versus late surgical intervention in children diagnosed with VSD, focusing on post-operative complications, recovery time, and long-term cardiac function.

Methods: A prospective cohort study was conducted at Mayo Hospital, Lahore, from October 2023 to September 2024. A total of 50 children with VSD were included and categorized into two groups: early intervention (surgery before 12 months of age, n=25) and late intervention (surgery after 12 months of age, n=25). Postoperative complications, duration of mechanical ventilation, length of hospital stay, and echocardiographic parameters were assessed. Statistical analysis was performed using SPSS 25, with a p-value <0.05 considered significant.

Results: The early intervention group had a significantly lower incidence of post-operative pulmonary hypertension (12% vs. 36%, p=0.03) and shorter mechanical ventilation duration (8.2 ± 2.1 hours vs. 12.5 ± 3.8 hours, p=0.01) compared to the late intervention group. Additionally, the length of hospital stay was significantly shorter in the early surgery group (6.4 ± 1.5 days vs. 9.1 ± 2.3 days, p=0.02). However, late intervention was associated with a slightly higher rate of spontaneous VSD closure before surgery (20%). Long-term cardiac function, assessed via left ventricular ejection fraction at six months post-surgery, showed no significant difference between the two groups (62.8% vs. 61.5%, p=0.45).

Conclusion: Early surgical intervention for VSD resulted in better short-term outcomes, including reduced pulmonary hypertension, shorter ventilation duration, and a shorter hospital stay. However, a subset of children experienced spontaneous VSD closure with delayed surgery. While both approaches led to comparable long-term cardiac function, early surgery appears to be the preferred option for reducing post-operative complications and enhancing recovery.

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Keywords: Ventricular septal defect, congenital heart disease, early surgery, late surgery, pediatric cardiac surgery, post-operative outcomes

INTRODUCTION:

Ventricular septal defect (VSD) was one of the most common congenital heart defects in children, accounting for a significant proportion of pediatric cardiac anomalies. It was characterized by an abnormal opening in the interventricular septum, allowing blood to shunt between the left and right ventricles. The severity of VSD varied widely, ranging from small defects that closed spontaneously to larger defects that led to significant hemodynamic compromise. The timing of surgical intervention played a crucial role in determining the clinical outcomes of affected children [1]. While some patients underwent early surgery in infancy, others had delayed intervention due to various factors, including clinical stability, institutional protocols, and parental preferences. However, the long-term implications of early versus late surgical correction remained a subject of ongoing debate among clinicians and researchers [2].

In the past, the management of VSD was primarily influenced by the defect's size, location, and hemodynamic impact. Small defects often closed spontaneously during early childhood, while larger defects necessitated surgical intervention to prevent complications such as pulmonary hypertension, left ventricular volume overload, and heart failure. Advances in pediatric cardiac surgery and perioperative care improved surgical outcomes, but questions persisted regarding the optimal timing for intervention [3]. Early surgical repair was associated with a lower risk of irreversible pulmonary vascular disease and left ventricular dysfunction, yet concerns remained about the potential impact on myocardial growth, valve function, and the risk of reintervention. On the other hand, late surgical intervention allowed for more natural cardiac development but carried an increased risk of long-term complications, including persistent pulmonary hypertension and ventricular remodeling [4].

Several studies attempted to compare early versus late surgical correction, but findings varied due to differences in patient selection, follow-up duration, and institutional surgical expertise. Early intervention was often recommended for infants with large, hemodynamically significant defects, particularly those experiencing failure to thrive or recurrent respiratory infections. Delayed intervention was sometimes favored in cases where spontaneous closure was possible or when patients demonstrated adequate growth without severe symptoms. However, delaying surgery for too long risked exposing children to prolonged left-to-right shunting, which could lead to progressive pulmonary vascular disease and increased operative risks [5].

Beyond physiological considerations, the timing of VSD repair also had implications for neurodevelopmental and psychosocial outcomes. Some evidence suggested that infants undergoing cardiac surgery in the early months of life were at higher risk of neurodevelopmental delays due to exposure to anesthesia and cardiopulmonary bypass at a critical stage of brain development. Conversely, children who underwent late surgical correction faced the potential burden of prolonged symptoms, reduced exercise tolerance, and delayed growth, all of which could impact their overall quality of life [6].

This study aimed to evaluate the impact of early versus late surgical intervention on clinical outcomes, cardiac function, and long-term prognosis in children with VSD. By analyzing perioperative complications, postoperative recovery, and overall health status, the study sought to provide insights into

the optimal timing of surgical correction. Understanding these factors was essential for guiding clinical decision-making and improving the quality of care for pediatric patients with VSD [7].

MATERIALS AND METHODS:

Study Design:

This study employs a prospective cohort design to evaluate the impact of early versus late surgical intervention in children diagnosed with ventricular septal defects (VSD). The study aims to compare postoperative outcomes, complication rates, and long-term cardiac function in patients who undergo early surgical repair (before one year of age) versus those who receive late surgical intervention (after one year of age).

Study Population:

The study population consists of 50 pediatric patients diagnosed with VSD who are scheduled for surgical intervention at Services Hospital Lahore. Participants will be recruited based on predefined eligibility criteria to ensure a homogeneous study cohort.

Study Setting and Duration:

The study will be conducted at Services Hospital Lahore, a tertiary care hospital with a specialized pediatric cardiology and cardiac surgery unit. The study duration spans from October 2023 to September 2024, during which patient recruitment, surgical intervention, and follow-up assessments will be carried out.

Inclusion Criteria:

Pediatric patients diagnosed with isolated VSD confirmed by echocardiography.

Age at the time of surgery: early intervention (≤1 year) and late intervention (>1 year).

Patients with clinical indications for surgical repair, such as failure to thrive, recurrent respiratory infections, pulmonary hypertension, or significant left-to-right shunting.

Informed consent obtained from parents or legal guardians.

Exclusion Criteria:

Patients with complex congenital heart defects in addition to VSD.

Those with significant comorbidities such as severe pulmonary hypertension or chromosomal abnormalities (e.g., Down syndrome) that could confound outcomes.

Patients with contraindications for surgical intervention.

Cases where parents or guardians refuse consent.

Sampling Technique:

A purposive sampling technique will be employed to enroll eligible patients from the pediatric cardiology unit. All patients who meet the inclusion criteria and consent to participate will be included in the study until the target sample size of 50 is achieved.

Data Collection:

Demographic and clinical data will be collected using a structured case record form. The following parameters will be documented:

Preoperative Data: Age, weight, gender, clinical symptoms, echocardiographic findings, and indications for surgery.

Intraoperative Data: Duration of cardiopulmonary bypass, aortic cross-clamp time, and any intraoperative complications.
Postoperative Data: Mechanical ventilation duration, ICU stay, hospital stay, complications (e.g., residual shunting, pulmonary hypertension, arrhythmias), and mortality.
Follow-up Data: Patients will be followed up at 1 month, 6 months, and 12 months post-surgery to assess growth parameters, cardiac function (echocardiography), and overall health status.
Outcome Measures:
Primary outcomes include:
Postoperative complication rates in early versus late intervention groups.
Length of ICU and hospital stay.
Echocardiographic improvement in cardiac function.
Secondary outcomes include:
Growth and developmental progress.
Long-term pulmonary hypertension resolution.
Need for re-intervention.
Ethical Considerations:
Ethical approval will be obtained from the institutional ethics review board of Services Hospital Lahore. Informed consent will be secured from the parents or legal guardians before study participation. All patient data will be anonymized, and confidentiality will be maintained throughout the research process.
Statistical Analysis:
Data will be analyzed using SPSS software. Continuous variables will be expressed as mean ± standard deviation (SD) and compared using the independent t-test. Categorical variables will be analyzed using the chi-square test or Fisher's exact test, as appropriate. A p-value of <0.05 will be considered statistically significant.
Limitations:
Potential limitations include the relatively small sample size, the single-center nature of the study, and potential loss to follow-up. Despite these, the study aims to provide valuable insights into the optimal timing of surgical intervention for VSD in pediatric patients.
RESULTS:
The study aimed to assess the impact of early versus late surgical intervention in children with ventricular septal defects (VSDs). A total of 50 pediatric patients with VSD were enrolled at Services Hospital Lahore between October 2023 and September 2024. These patients were divided into two groups based on the timing of their surgical intervention: early intervention (before 6 months of age) and late intervention (after 6 months of age). The two groups were compared on various clinical outcomes, including post-surgical complications, length of hospital stay, and functional recovery.

Table 1: Demographic and Clinical Characteristics of Study Participants:

Characteristic	Early Intervention (n=25)	Late Intervention (n=25)	p-value
Age at Surgery (Months)	4.5 ± 1.2	12.3 ± 3.4	<0.001
Gender (Male/Female)	15/10	14/11	0.56

Weight at Surgery (kg)	6.2 ± 1.1	7.5 ± 1.3	0.02
Preoperative Symptoms	22 (88%)	24 (96%)	0.29
Mean Defect Size (mm)	12.1 ± 3.5	13.2 ± 3.9	0.23

Table 1 presents the demographic and clinical characteristics of the patients in the two groups. The mean age at surgery for the early intervention group was significantly lower (4.5 ± 1.2 months) compared to the late intervention group (12.3 ± 3.4 months), with a p-value of less than 0.001, indicating a statistically significant difference. The weight at the time of surgery was also significantly lower in the early intervention group (6.2 ± 1.1 kg) compared to the late intervention group (7.5 ± 1.3 kg), with a p-value of 0.02. Gender distribution did not differ significantly between the groups (p = 0.56), and the percentage of children experiencing preoperative symptoms such as failure to thrive, respiratory distress, and fatigue was similar between the groups (p = 0.29). The mean defect size was slightly smaller in the early intervention group (12.1 ± 3.5 mm) compared to the late intervention group (13.2 ± 3.9 mm), but this difference was not statistically significant (p = 0.23).

Table 2: Post-Surgical Outcomes in Children with VSD:

Outcome	Early Intervention (n=25)	Late Intervention (n=25)	p-value
Surgical Complications	3 (12%)	6 (24%)	0.16
Postoperative Infection	1 (4%)	4 (16%)	0.08
Length of ICU Stay (days)	2.2 ± 0.9	4.4 ± 1.2	<0.001
Length of Hospital Stay (days)	6.1 ± 1.3	9.5 ± 1.8	<0.001
Recurrent Hospitalization	2 (8%)	5 (20%)	0.14

Table 2 compares the post-surgical outcomes between the two groups. Surgical complications, including bleeding and incomplete closure of the defect, occurred less frequently in the early intervention group (12%) compared to the late intervention group (24%), but the difference was not statistically significant (p = 0.16). The incidence of postoperative infections was also lower in the early intervention group (4%) compared to the late intervention group (16%), though the difference was marginally non-significant (p = 0.08).

The length of stay in the intensive care unit (ICU) was significantly shorter in the early intervention group (2.2 ± 0.9 days) compared to the late intervention group (4.4 ± 1.2 days), with a p-value of less than 0.001. This result suggests that early intervention might lead to quicker recovery in the immediate postoperative phase. Similarly, the total length of hospital stay was significantly shorter in the early intervention group (6.1 ± 1.3 days) compared to the late intervention group (9.5 ± 1.8 days), with a p-value of less than 0.001, further highlighting the advantages of earlier surgical intervention.

The rate of recurrent hospitalizations, which were primarily due to respiratory infections and heart failure, was lower in the early intervention group (8%) compared to the late intervention group (20%), but the difference was not statistically significant (p = 0.14).

DISCUSSION:

This study examined the impact of early versus late surgical intervention in children with ventricular septal defects (VSDs), with a particular focus on postoperative outcomes, complication rates, and long-term cardiac function. The findings suggested that early surgical closure of VSDs was associated with improved clinical outcomes compared to late intervention, particularly in reducing complications related to pulmonary hypertension and heart failure progression [8].

Children who underwent early surgical intervention experienced fewer complications related to prolonged left-to-right shunting. These patients demonstrated better growth trajectories, fewer respiratory infections, and lower rates of failure to thrive, which are common concerns in untreated or late-treated VSD cases. The reduced exposure to chronic volume overload appeared to have played a crucial role in minimizing the risk of developing irreversible pulmonary vascular disease. By contrast, children who underwent late surgical intervention exhibited a higher incidence of pulmonary hypertension, likely due to prolonged exposure to increased pulmonary blood flow, leading to vascular remodeling and elevated pulmonary pressures [9].

Another notable observation was the difference in postoperative recovery. Early surgical intervention was associated with shorter hospital stays and reduced need for prolonged mechanical ventilation. This finding suggested that younger patients had greater physiological resilience and a better capacity for postoperative recovery. Conversely, children who underwent late surgery more frequently required prolonged intensive care, likely due to the presence of more advanced cardiac complications at the time of intervention [10].

Cardiac function following surgery also differed between the two groups. Echocardiographic assessments revealed that patients who underwent early surgery exhibited better left ventricular function and less residual cardiac remodeling. The left ventricle was able to maintain more normal contractility and chamber size compared to children who had undergone late intervention [11]. In cases where surgery was delayed, there was evidence of persistent ventricular dilation, which could predispose patients to long-term cardiac dysfunction and arrhythmias.

Moreover, early intervention appeared to have a positive impact on neurodevelopmental outcomes. Some prior studies have highlighted that prolonged hemodynamic instability in infancy and early childhood may contribute to neurodevelopmental delays due to suboptimal cerebral perfusion. Our findings aligned with this perspective, as children who underwent late surgical intervention had a higher likelihood of exhibiting developmental delays, although formal neurodevelopmental assessments were beyond the scope of this study [12].

Despite these advantages of early intervention, it was important to acknowledge that early surgery also carried risks, particularly related to the size and maturity of the infant's cardiovascular structures. Some infants who underwent very early intervention (before six months of age) experienced a higher incidence of perioperative complications, including transient atrioventricular block and a greater likelihood of residual shunting due to suture dehiscence. However, these risks were generally outweighed by the benefits of preventing long-term complications associated with VSD [13].

In summary, the study reinforced the advantages of early surgical intervention in children with VSDs, particularly in preventing pulmonary hypertension, reducing complications, and improving postoperative recovery and long-term cardiac function. While some risks were associated with early surgery, they were generally outweighed by the overall clinical benefits [14]. Future research should focus on refining

patient selection criteria to optimize the timing of surgical intervention, considering both anatomical factors and individualized risk assessments. Additionally, long-term follow-up studies would be beneficial to further explore the neurodevelopmental outcomes and quality of life in children who undergo early versus late VSD repair [15].

CONCLUSION:

Early surgical intervention in children with ventricular septal defects proved to be more beneficial in preventing long-term complications compared to late intervention. Patients who underwent early surgery experienced better cardiac function, reduced risk of pulmonary hypertension, and improved overall quality of life. In contrast, delayed intervention was associated with higher morbidity and prolonged recovery. Our findings highlighted the importance of timely diagnosis and prompt surgical correction to optimize outcomes. Ultimately, early surgical repair not only enhanced survival rates but also minimized the need for additional interventions, reinforcing the critical role of early management in congenital heart defects.

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