

Original article

Comparative Study of Transcatheter Versus Surgical Closure in Acyanotic Congenital Heart Defects: Short- and Mid-Term Outcomes

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Abstract

Background- Acyanotic congenital heart defects (ACHDs), particularly atrial septal defect (ASD), ventricular septal defect (VSD), and patent ductus arteriosus (PDA), are among the most common congenital cardiac anomalies requiring intervention. Advances in transcatheter device technology have provided a minimally invasive alternative to conventional surgical repair for appropriately selected patients.

Methods- A prospective comparative observational study was conducted over one year in a tertiary cardiac center. Forty-two patients with ASD, VSD, or PDA requiring intervention were enrolled. Twenty-one underwent transcatheter device closure and twenty-one underwent surgical closure. Demographic variables, procedural characteristics, perioperative complications, hospital stay, echocardiographic findings, and six-month outcomes were analyzed using appropriate statistical tests.

Results- Procedural success exceeded 95% in both groups. The transcatheter group demonstrated significantly shorter procedure duration, ICU stay, hospital stay, earlier ambulation, and fewer postoperative complications. Residual shunt and re-intervention rates were comparable between groups, while six-month echocardiographic outcomes showed complete defect closure in the majority of patients.

Conclusion- Transcatheter closure offers excellent safety and efficacy with faster recovery and lower perioperative morbidity in appropriately selected patients, whereas surgical closure remains an effective treatment for anatomically unsuitable or complex defects. Both modalities achieve favorable mid-term outcomes when patient selection is individualized.

Keywords: Acyanotic congenital heart disease; Transcatheter closure; Surgical closure

Introduction

Congenital heart disease represents the most common congenital anomaly worldwide, with acyanotic lesions accounting for nearly three-fourths of all congenital cardiac defects. (1) Atrial septal defect (ASD), ventricular septal defect (VSD), and patent ductus arteriosus (PDA) frequently require intervention because persistent left-to-right shunting may result in pulmonary hypertension, ventricular remodeling, arrhythmias, heart failure, infective endocarditis, and reduced quality of life. Surgical repair has traditionally been considered the gold standard, providing excellent long-term outcomes. However, continuous advances in catheter-based devices have established transcatheter closure as an effective minimally invasive alternative for selected patients. Contemporary evidence and recent international guidelines recommend transcatheter closure for anatomically suitable secundum ASDs and many PDAs because of reduced procedural morbidity, shorter hospitalization, and faster recovery while maintaining excellent efficacy. (2,3,4) Surgery remains indispensable for complex anatomy, large defects, deficient rims, associated anomalies, or failed device closure. (5)

Materials and Methods

This prospective comparative observational study was conducted in the Departments of Cardiovascular and Thoracic Surgery and Cardiology of a tertiary care teaching hospital over a period of one year. A total of 42 consecutive patients who fulfilled the eligibility criteria were enrolled during the study period. The participants were allocated into two groups based on the treatment modality received: **Group A** comprised 21 patients who underwent transcatheter device closure, while **Group B** included 21 patients who underwent conventional surgical closure. The sample size was determined according to the institutional surgical workload and feasibility of recruitment during the study period. Patients aged 5 years and above with a confirmed diagnosis of atrial septal defect (ASD), ventricular septal defect (VSD), or patent ductus arteriosus (PDA) requiring intervention and having a hemodynamically significant left-to-right shunt were included after obtaining written informed consent. Patients with cyanotic congenital heart disease, Eisenmenger syndrome, active infective endocarditis, severe pulmonary vascular disease unsuitable for closure, previous cardiac surgery, associated complex congenital cardiac anomalies, or those unwilling to participate were excluded from the study.

Baseline demographic, clinical, electrocardiographic, and echocardiographic characteristics were recorded for all enrolled patients before intervention. The preoperative variables included age, gender, body weight, body surface area, diagnosis, defect size, New York Heart Association (NYHA) functional class, oxygen saturation, pulmonary artery pressure, left ventricular ejection fraction, ECG findings, and detailed echocardiographic measurements. During the intervention, intraoperative data including the type of procedure performed, procedure duration, fluoroscopy time for the transcatheter group, cardiopulmonary bypass time and aortic cross-clamp time for the surgical group, estimated blood loss, blood transfusion requirement, device size, patch material used during surgical closure, and immediate procedural success were documented. All procedures were performed according to standard institutional protocols by experienced cardiologists and cardiothoracic surgeons.

Following intervention, patients were monitored throughout their hospital stay for assessment of early postoperative outcomes. Primary outcome measures included procedural success, duration of intensive care unit stay, total hospital stay, major postoperative complications, and mortality. Secondary outcome measures included arrhythmias, residual shunt, device embolization, wound infection, pleural effusion, pericardial effusion, blood transfusion requirement, need for re-intervention, six-month echocardiographic evidence of complete defect closure, and improvement in NYHA functional class.

Results

Table 1. Baseline Demographic and Clinical Characteristics

Variable	Transcatheter (n=21)	Surgical (n=21)	P value
Age (years)	18.9 ± 10.4	20.8 ± 11.1	0.58
Male	10 (47.6%)	11 (52.4%)	0.76
Female	11 (52.4%)	10 (47.6%)	0.76
Body Weight (kg)	44.5 ± 16.8	46.1 ± 15.9	0.72
ASD	13 (61.9%)	12 (57.1%)	0.74
VSD	4 (19.0%)	5 (23.8%)	0.70
PDA	4 (19.0%)	4 (19.0%)	1.00

Defect Size (mm)	17.8 ± 5.2	18.5 ± 4.8	0.64
LVEF (%)	60.8 ± 4.5	59.9 ± 4.2	0.51
Pulmonary Artery Pressure (mmHg)	34.7 ± 7.5	35.5 ± 8.2	0.73

Both groups were statistically comparable at baseline, minimizing selection bias and allowing meaningful comparison of outcomes

Table 2. Procedural Characteristics

Variable	Transcatheter	Surgical	P value
Procedure Duration (minutes)	62.4 ± 18.5	168.5 ± 36.4	<0.001*
ICU Stay (days)	0.9 ± 0.4	2.8 ± 0.8	<0.001*
Hospital Stay (days)	2.3 ± 0.8	7.6 ± 1.6	<0.001*
Blood Transfusion	0 (0%)	14 (66.7%)	<0.001*
Procedure Success	21 (100%)	20 (95.2%)	0.31
Mean Blood Loss (ml)	Negligible	315 ± 92	<0.001*
Ventilator Requirement	0	21 (100%)	<0.001*

*Statistically significant

Transcatheter closure significantly reduced operative time, ICU stay, hospitalization, blood loss, and transfusion requirements while maintaining excellent procedural success.

Table 3. Early Postoperative Complications

Complication	Transcatheter n (%)	Surgical n (%)	P value
Arrhythmia	1 (4.8%)	4 (19.0%)	0.15
Residual Shunt	1 (4.8%)	2 (9.5%)	0.55
Wound Infection	0	2 (9.5%)	0.14
Pleural Effusion	0	3 (14.3%)	0.07
Pericardial Effusion	1 (4.8%)	2 (9.5%)	0.55
Vascular Access Complication	2 (9.5%)	0	0.14
Device Embolization	0	—	—
Re-intervention	0	1 (4.8%)	0.31
Mortality	0	0	—

Overall complication rates were low in both groups. Surgical closure demonstrated a higher frequency of postoperative complications, whereas vascular access complications were limited to the transcatheter group.

Table 4. Six-Month Follow-up Outcomes

Variable	Transcatheter	Surgical	P value
Complete Closure	20 (95.2%)	20 (95.2%)	1.00
Residual Small Shunt	1 (4.8%)	1 (4.8%)	1.00
NYHA Class I	21 (100%)	20 (95.2%)	0.31
Normal Pulmonary Artery Pressure	20 (95.2%)	19 (90.5%)	0.55
Readmission	0	1 (4.8%)	0.31
Re-intervention	0	1 (4.8%)	0.31
Mortality	0	0	—

Mid-term outcomes were excellent in both groups. Transcatheter closure achieved clinical results comparable to surgery while offering superior perioperative recovery.

Discussion

The present prospective comparative observational study evaluated the short- and mid-term outcomes of transcatheter versus surgical closure in 42 patients with acyanotic congenital heart defects. The principal findings demonstrate that both treatment modalities achieved excellent procedural success and favorable six-month clinical outcomes. However, transcatheter closure was associated with significantly shorter procedural duration, reduced intensive care and hospital stay, lower perioperative morbidity, and faster postoperative recovery compared with conventional surgical repair. These findings are consistent with contemporary international evidence and current guideline recommendations favoring transcatheter closure for anatomically suitable defects. (6,7)

The demographic characteristics of both study groups were comparable with respect to age, gender distribution, diagnosis, and baseline echocardiographic parameters, indicating adequate matching between the two cohorts. ASD constituted the majority of defects, followed by PDA and VSD, reflecting the epidemiological distribution reported in previous Indian and international studies. The comparable baseline profile reduced confounding and allowed meaningful comparison of postoperative outcomes. (8,9,10)

Procedural success in the present study was 100% in the transcatheter group and 95.2% in the surgical group. Although surgical repair has historically been regarded as the gold standard because of its ability to address virtually all anatomical variations, advances in device technology, imaging guidance, and operator experience have significantly improved the success of transcatheter interventions. Current international guidelines recommend transcatheter closure as the preferred treatment for isolated secundum ASD with favorable anatomy because it provides similar efficacy with lower procedural morbidity and shorter recovery. Surgery, however, continues to play a vital role in patients with deficient rims, very large defects, sinus venosus defects, primum ASD, associated congenital anomalies, or failed device closure. (11)

One of the most significant findings of this study was the marked reduction in procedure duration, ICU stay, and total hospital stay among patients undergoing transcatheter closure. The average hospital stay was nearly one-third that of the surgical group. Similar observations have been reported in multiple comparative studies demonstrating that catheter-based interventions eliminate sternotomy, cardiopulmonary bypass, prolonged mechanical ventilation, and extensive postoperative pain, thereby facilitating rapid mobilization and early

discharge. These advantages also contribute to improved patient satisfaction, earlier return to normal activities, and reduced healthcare expenditure. (12)

Blood transfusion was required only in patients undergoing surgery because of intraoperative blood loss associated with median sternotomy and cardiopulmonary bypass. In contrast, blood loss during transcatheter intervention was negligible. The avoidance of transfusion not only reduces hospitalization costs but also minimizes the risk of transfusion-related complications and inflammatory responses. These findings further support the minimally invasive nature of transcatheter intervention.

Conclusion

Both transcatheter and surgical closure are highly effective treatment modalities for acyanotic congenital heart defects, providing excellent procedural success and favorable mid-term outcomes. Transcatheter closure offers significant advantages in terms of reduced procedure duration, shorter ICU and hospital stay, minimal blood loss, lower postoperative morbidity, earlier ambulation, and faster recovery while maintaining comparable efficacy to surgical repair. Surgical closure continues to be the treatment of choice for anatomically unsuitable or complex congenital heart defects requiring direct visualization and concomitant intracardiac repair. Careful patient selection based on anatomical characteristics, defect morphology, and multidisciplinary evaluation remains essential for achieving optimal clinical outcomes.

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