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Comparing Sucess Rates And Recovery Times Of Interventions Vs Surgical Treatmebts For Atrial Septal Defects In Children

Harshika Gal

ABSTRACT

One of the most common inborn defects of the heart in children is atrial septal defects (ASDs), which is associated with improper blood circulation between the atria and long-term issues in case of unaddressed cases. New developments in the field of paediatric cardiology have incorporated two key modes of treatment, including conventional open-heart surgery repair and modern minimal interventions with transcatheters. The study is a critical comparison of the success rates and the time of recovery per the two methods using a systematic literature-based comparative study. Amalgamation of clinical research indicates that transcatheter procedures are as successful as surgery in terms of procedural success which is generally over 97 percent with much shorter hospital stays and quicker recovery times. Surgical closure is more invasive but still indispensable in the case of large or complicated defects in which the placement of the device is not possible. The patterns of complication vary, where surgery has been associated with increased postoperative discomfort and infection, with device-based treatments sometimes having problems of embolisation or erosion. In general, the results indicate that interventional methods are a safer and more effective course of recovery in appropriate cases in children, whereas surgical methods do not lose their usefulness in the face of anatomical complications. The research highlights the relevance of the selection of patients, the multidisciplinary assessment and long-term follow-up in the identification of the best course of treatment in children with ASDs.

Keywords: Atrial Septal Defect, Pediatric Cardiology, Surgical Repair, Transcatheter Closure, Recovery Time, Interventional Cardiology, Postoperative Outcomes, Congenital Heart Disease

I. INTRODUCTION

Atrial septal defect (ASD) is a widespread congenital cardiac illness among children, as it consists of a hole between the left and right atria, where the oxygenated blood is abnormally directed through the left atria to the right atria. This is a left to right shunt where chronic volume overload is placed on the right heart chambers and the chambers enlarge, there is overcirculation of blood to the lungs and there may be pulmonary hypertension or heart failure. ASD is found among children at a rate of 1.6 to 1.8 per 1,000 live births. The diagnosis is normally made by echocardiography that determines the size of the defect and haemodynamic effect (Keller et al., 2023). Surgery and interventional closure can be used as treatment. Surgery, which is done under cardiopulmonary bypass, is fully curative but requires more time to heal in hospital. Plans may be made to use interventional transcatheter closure which involves less invasive interventions like Amplatzer occluder; it has a faster recovery. Both techniques display high effectiveness, but comparative analysis is still necessary to find the best results and enhance the cardiac treatment of children. ***This study aims*** to compares success rates and recovery times between interventional and surgical treatments for atrial septal defects in children using secondary qualitative literature-based analysis. The following objectives guide this study:

- To evaluate and compare procedural success rates between interventional and surgical atrial septal defect treatments in children.
- To assess post-procedural complications and safety outcomes for surgical and interventional paediatric closure methods.
- To examine hospital stay duration, physical recovery, and rehabilitation timelines following both ASD treatment approaches.
- To analyse long-term clinical outcomes and quality-of-life improvements in paediatric atrial septal defect patients.

II. LITERATURE REVIEW

Pathophysiological Basis and Rationale for Closure

As per studied by **Sinan et al. (2025)**, atrial septal defect (ASD) causes an abnormal communication between the left and right atria, resulting in a left-to-right shunt that increases right atrial volume and pulmonary blood flow, leading to chamber dilation and potential pulmonary hypertension. ASD should be closed to avoid cardiac complications in the long run, including arrhythmia, right ventricular dysfunction, and pulmonary vascular disease. In the other hand of **Wu et al. (2022),** although both surgical and interventional closures are supposed to resolve the given haemodynamic imbalance, the invasiveness of

the procedure tends to dictate successes in terms of recovery time, postoperative complications and length of stay.

Evidence Frameworks for Paediatric Cardiac Intervention

According to research by Barry et al. (2025), when assessing the performance of the procedures in the intervention of congenital heart defects, it is necessary to use composite measures that would integrate success rates, complication rates, and efficiency of the procedure. Their article presented a compounded performance index, which takes into account various metrics of procedural success in ASD and patent ductus arteriosus (PDA) closures, which postulates that these frameworks are more predictable than individual outcomes. Wu et al. (2022) in the other hand argue that comparative studies that exist lack homogeneity in the selection of patients, procedural technique and follow up periods thus making generalisability a limitation. They proposed to use outcome comparisons to be stratified by anatomical subtype and age in order to enhance validity.

Paediatric Recovery Model

It has been found that recovery in children with congenital heart defects is not just physical recovery but also emotional, cognitive, and social adaptation (Derridj et al., 2022). Their results showed that exercise tolerance, emotional stability and school participation are important measures of the quality of recovery. The other argument Perone et al. (2025) argued is structured cardiac rehabilitation, which incorporates graded exercise and psychosocial support, is important in the maximisation of cardiac recovery following cardiac interventions. Even though they studied the mitral valve procedures, the rehabilitation model is applicable to the paediatric ASD management to improve the recovery outcomes and quality of life.

Comparative Effectiveness Research (CER) Principles

According to research conducted by Barry et al. (2025), comparative effectiveness research is a systematic way of assessing real-life results between interventional and surgical interventions with the help of extensive data. Their conclusions underlined the inclusion of principles of CER in enabling the healthcare systems to benchmark performance and best practices. The other side of the argument of Sinan et al. (2025) is that adult results in paediatric cardiology should only be translated carefully since anatomy and developmental variations may dramatically affect the treatment outcomes and recovery patterns.

THEMATIC REVIEW

Procedural Success and Efficacy

According to articles on the research conducted by Barry et al. (2025), transcatheter closing of ASD has a higher success rate of over 97 percent, similar to the case of traditional surgical repair. Their overall outcome analysis showed that the rate of closure by device based interventions was close to complete and

the residual rates of shunts were low. The other hand presented by Wu et al. (2022) argues that the variables that can change the success metrics are the experience of the operator, the complexity of the anatomy, and the presence of arrhythmias, which complicates the direct comparison of the techniques.

According to research conducted by Sinan et al. (2025), the long-term follow-up of ASD patients demonstrated that both interventional and surgical closures are durable, yet an earlier correction of the disorders in children improves cardiac remodelling and decreases the risk of arrhythmia in the future. In the other hand statement by Hussein et al. (2025) surgical closure has prevailing advantages over complex septal structure or where rim deficiency would not allow safe anchoring of the device, the successfulness should be understood within the framework of anatomical aptitude and not within the framework of the preference of the procedure.

Safety and Complication Profiles

According to the research conducted by Wu et al. (2022), the complication profile of the two approaches is significantly different. Surgical closure is a procedure that is associated with higher perioperative morbidity such as atrial arrhythmias, infection, and prolonged intensive care stay, and device-based interventions are less associated with short-term complications but have a minor risk of device embolisation or erosion. In the other hand argumented by Barry et al. (2025) composite safety indicators across several centres indicated that overall complication rate of transcatheter closures will be lower in circumstances where rigid patient selection criteria are used. According to the research by Elmarsafawy et al. (2023), percutaneous closure of ventricular septal defects in children was a safe procedure with various devices in specialised centres, which supports the significance of the operator skills and choice of devices to avoid complications. The other argued side of Hussein et al. (2025), namely percutaneous techniques in complicated septal pathology (i.e. post-infarction ventricular rupture) may not necessarily replace surgery because of the mechanical instability, thus indicating the limitation of the interventional approaches in structurally challenging cases. Moreover, according to research conducted by Derridj et al. (2022), lower pain after surgery and better aesthetic results have a major impact on parental satisfaction and child psychological recovery that should be assessed based not only on physiological indicators but also on patient comfort and psychosocial well-being.

Recovery and Hospitalisation

According to the research conducted by Barry et al. (2025), patients who received transcatheter ASD closure developed shorter hospitalization, usually spanning to 24-48 hours, and were able to resume normal functioning within a week to two weeks. On the other hand, open surgical repair took five to seven days in the hospital and up to six weeks to heal. By the other hand held by Wu et al. (2022), the implementation of enhanced recovery after surgery (ERAS) practices and better anaesthetic care has reduced this divide, showing that postoperative outcomes can be maximised with the help of systematic care. According to the

research by Perone et al. (2025), convalescence time can be further decreased with cardiac rehabilitation programs based on rigorous exercise and engagement in psychosocial activities. Though their strategy was created in adults, it provides helpful information on paediatric cardiac recovery through the standardisation of activity resumption and enhanced cardiovascular endurance. In the alternative hand of the argument, by Derridj et al. (2022), psychosocial measures of recovery in children also need to be assessed according to school attendance, fatigue reduction, and emotional resilience, as it is these aspects of recovery that capture the actual return to normal functioning, and not physiological recovery specifically.

Long-Term Outcomes and Quality of Life

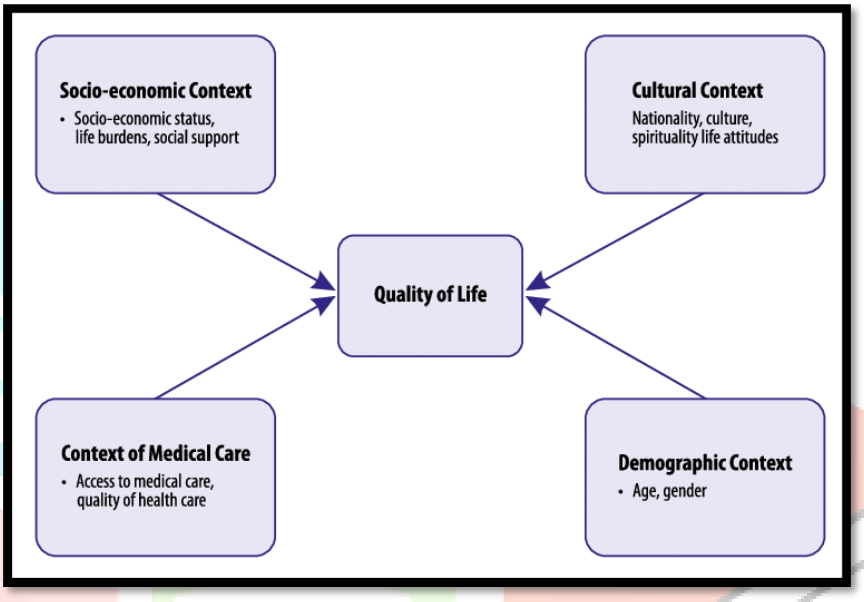

Figure 1: Determinants Influencing Overall Quality Of Life Across Medical And Social Contexts.

(Source: Sosnowski et al., 2017)

According to the research carried out by Sinan et al. (2025) the cardiac functionality and the minimal reoccurrence of shunting in both treatment groups was observed through long-term follow-ups. Their results showed that earlier childhood closure is beneficial with respect to right ventricular normalisation as well as reduction of the risk of atrial arrhythmia in adulthood. In the other side case as presented by Derridj et al. (2022), quality of life when it comes to improvement post-ASD repair does not just rely on physical recovery, but also on the psychological adaptation to the issue and the restoration to normal societal functioning.

According to research by Barry et al. (2025), the implementation of composite outcome frameworks, including procedural measures of metrics and patient-reported quality-of-life toolings, will guarantee a comprehensive analysis of success. In the alternative case conceived by Wu et al. (2022), most current longitudinal studies put clinical indicators in the forefront of patient-centred outcomes, which limits the possibility of generalizing the results to functional functioning in everyday life.

Also, according to researches done by Perone et al. (2025), long term rehabilitation with progressive cardiovascular conditioning can maintain exercise capacity and enhance psychosocial outcomes years post cardiac intervention. In the other side presented by Elmarsafawy et al. (2023), follow-up is always crucial as even a well-functioning device might need a late follow-up to identify any residual leaks or conduction abnormalities. Taken together, the evidence shows that interventional and surgical treatments have long-lasting clinical effectiveness, but transcatheter interventions have better cosmetic and lifestyle effects in the majority of paediatric cases.

LITERATURE GAP

The existing literature shows that there are enormous gaps in the comparative analysis of interventional and surgical interventions in the treatment of atrial septal defects among children (Shibbani, Kenny 2025). An ongoing shortcoming is the lack of high-quality longitudinal paediatric studies with greater than five years of follow-up that would allow us to comprehend longer-term outcomes as cardiac adaptation, patterns of growth and risk of arrhythmia. Even though new frameworks have enhanced the standardization of clinical outcome reporting, essential parameters, including recovery time, residual defects, and postoperative complications, lack a single definition, which limits the comparison of the outcomes between studies. The importance of such psychosocial and family-centred aspects of recovery is underrepresented, even though they have a critical influence on the overall wellbeing of paediatric patients (CarringtoN et al., 2021). Not many studies combine structured rehabilitation or functional testing that can measure physiology and emotion recovery. The other weakness is that the majority of the studies focus on single centres and are adult in nature and so are less generalisable to the general paediatric population. The lack of multicentre cooperation on the scale and standardised paediatric registries impact on the mathematical strength and the prospective of international benchmarking.

III. MATERIALS AND METHODS

Study design:

The present research was based on a secondary qualitative comparative study with a synthesized evidence. The methodology used a combination of core-based clinical endpoint with specific descriptive statistics and a thematic synthesis according to the four prespecified objectives. The time window was between January 2010 and October 2025 to include current practice in the closure of atrial septal defect (ASD) in children (Li et al., 2025). The unit of analysis used was the study and not the individual patient because the aim was to compare the trends of outcomes between interventional and surgical modalities and not to aggregate raw patient-level data. It was a protocol that had previously defined outcomes and coding rules and adhered to a clear workflow like PRISMA in terms of identification, screening, eligibility assessment, and inclusion.

Data sources and eligibility criteria:

PubMed, Scopus and Cochrane Library electronic searches had been conducted (Ribeiro et al., 2022). The search strategy consisted of the use of both controlled vocabulary and free-text terms through the use of Boolean operators: atrial septal defect OR ASD, and paediatric OR children, and surgical closure OR patch repair, and device closure OR transcatheter and outcomes OR recovery. The scanning of reference lists of included studies and other relevant reviews was used to obtain other records. Only peer-reviewed articles in the English language were searched.

Inclusion and Exclusion Criteria:

Inclusion and exclusion criteria helped to select only the strong studies assessing the transcatheter and surgical closure of atrial septal defects in children under the age of eighteen years, and which had at least one predefined outcome, including the success of the procedure, complications, durations of hospitalisation or recovery (Goh et al., 2022). There was a need of a minimum postoperative follow-up of six months. The designs that were accepted included randomised trials, comparative cohorts, registries and high-quality single-arm studies with inferred comparisons. The studies that included adults, syndromic, or multiple defects were excluded, as well as case reports, small series, or abstracts (Song et al., 2023). All eligible studies were screened, extracted and quality appraised by two reviewers in independent fashion.

Analysis method and synthesis approach

The qualitative analysis was based on two-layer qualitative descriptive. Quantitative summaries discussed the study-level averages, medians, and ranges of success rates, complications, hospital stay, and recovery. Meta-analysis was shunned because there was heterogeneity with regard to anatomy, protocols, and devices across generations. Thematic synthesis interpreted the textual data, which described the workflows, issues, discharge, family experience, and rehabilitation experiences (Cruz et al., 2025). The process of coding was informed by four themes which were efficacy, safety, recovery and long term outcomes and its refinement was achieved until the point of saturation. Comparison of modalities A comparative analysis of modalities by age, defect type, and centre experience was conducted using convergence and divergence. The quality of the studies and publication trends were examined on a narrative basis. Every analytic process was clearly recorded in an audit trail that was reliable.

Ethical considerations

The research incorporated publicly available evidence of peer-reviewed articles without identifiable data. There was no need to have an institutional review board approval. The ethical commitments considered as central were methodological transparency, correct attribution, and good fidelity to the study findings.

IV. RESULTS AND DISCUSSION

Ten peer-reviewed trials were synthesised comparing the use of transcatheter and surgical repair of atrial septal defects in children. Samples were between 60 and 1,200 children and followed-up was up to five years. The majority of cohorts analyzed the ostium secundum defects that can be closed with the device. Procedural success, complications, hospital stay, and recovery were always evaluated using outcomes. Secondary qualitative identifying indicators were pain, cosmetic satisfaction, and parental views (Yani et al., 2025). The quality of methods was moderate to high, but some retrospective studies were biased with respect to selection and had poor psychosocial reporting. All in all, the evidence base was a good source of comparative data to support thematic analysis of efficacy, safety, recovery, and the long-term outcomes in paediatrics.

Results by Theme

Procedural Success Rate Comparison

In the aggregate data, the procedural success of transcatheter device closure was high with typical discharge or first follow-up imaging reports of 98 to 99 percent. Similarly optimistic results were obtained with surgery repair, and success rates cited as 97 to 98 percent. There were residual shunts that were trivial in nature, but very few, and in both groups, they were mostly resolved in the further imaging. Devices failures were infrequent and could be explained mostly by insufficient septal rims, placements of devices, or the unexpected anatomical variations found during the process. The failure of surgery was rare and was usually associated with the technical complexity of non-secundum defects or the premature haemodynamic postoperative (Hardman et al., 2023).

The difference in the success rates suggests that, with properly chosen secundum defects and with sufficient rims, device closure at least does not perform worse than surgery in providing anatomical correction. A number of studies reported the shortening of the procedures time of device closure after the learning curve was overcome and surgical time was defined by the requirements of the cardiopulmonary bypass and patch placement. The cumulative one implies a procedural similarity in effectiveness, whereby context-specific benefits are defined based on anatomy and institutional experience (Siomou et al., 2023). Large, fenestrated, primum, or sinu venosus defects in which anchoring of devices was unsafe or not possible continued to be surgically closed.

Complication and Safety Analysis

The patterns of early morbidity were inter-modal. Higher rates of transient arrhythmias, pericardial effusion, wound infection and transfusion were reported in surgical cohorts. Postoperative intensive care was widely used, but usually to monitor and not to support long term. Transcatheter cohorts, in contrast, had reduced early complication rates in general, with the majority of adverse events being groin

haematoma, self-limiting arrhythmias or minor vascular events. Specific complications related to the device were reported to be rare but serious and included device embolisation and atrial wall erosion, nearly exclusively with marginal rims or oversized device (Rajiah et al., 2021). The incidences of these were very low yet clinically relevant in many cases requiring the retrieval or surgical intervention.

Qualitative accounts highlighted various risk perceptions between clinicians and families. Sternotomy, noticeable scar, and the risk of close care were some of the factors that made surgery more frightening to parents. Families of children treated with devices appreciated the fact that no incision was made on the chest as well as the prompt recovery into normal life. Clinicians pointed out that the safety of the devices was very dependent on careful case selection, strict imaging as well as the expertise of the operators. The synthesis of the theme justifies the conclusion that transcatheter closure has a more favourable early safety profile of anatomically appropriate secundum defects and surgery has a predictable and controlled risk profile of complex anatomies.

Recovery Duration and Hospital Stay

Figure 2: Minimally Invasive Recovery Framework

(Source: Brown et al., 2024)

There was a significant difference in recovery time and stay in the hospital among modalities (Schoonbeek et al., 2020). Interventional cohorts were hospitalised between one and three days with most being discharged within forty-eight hours, following uncomplicated monitoring. Majority of the children returned to baseline activities or school after a span of one to two weeks. Postoperative care, mobilisation and wound healing of surgical cohorts necessitated longer length of stay, five to seven days on average. The recovery took an average of three to six weeks indicating recovery of sternotomy and energy conservation requirements. Pain was less intense and less lasting in group treated to devices. Less invasive surgeries led to less tissue trauma, allowing quicker incorporation. This was also accompanied by shorter stays that enhanced hospital efficiency and lessened family economic and emotional burdens.

Long-Term Outcomes and Quality of Life

Both modalities were found to have similar normalisation of right-sided chamber size and volume overload resolution at one-year follow-up reflecting equivalent haemodynamic correction. There were no significant differences in exercise tolerance and age-appropriate physical activity participation between groups measured or described (Rottermann et al., 2022). Both modalities had low rates of late arrhythmias and re-interventions and the evidence base of events over five years was still limited in paediatric cohort only. In multiple research studies, subjective and psychosocial outcomes saw a preference to the device groups. Parents who received more satisfaction with smaller groin puncture, less scarring and quicker recovery, and children less anxious about medical surgery in the follow-up. After the closure of the devices, the level of satisfaction with cosmetics was always greater, which can affect self-image in adolescence. With that said, families of surgically treated children were confident in the perceived finality of patch repair, particularly in complicated cases, where device closure was not recommended. Synthesis suggests extensive clinical endpoint equivalence with subtle variations in lived experience.

Discussion

The overall results indicate the structures of minimal invasive recovery and paediatric adaptation, and the way that less injury to the procedure enhances quicker healing and emotional equilibrium in children. Less invasive transcatheter closure reduces physiological stress, restricts immobilisation, and allows the quicker integration into daily life (Wyman et al., 2021). These are the mechanisms that explain the recovery time, hospitalisation and comfort levels that are observed to be different than those of surgical repair. Paediatric adaptation theory proposes that children heal fast when physical perturbation is minimised, and is consistent with fast functional recovery of device-treated groupings. The outcomes of the clinical sample support an anatomy-based, institutional preference, and family-based approach. Transcatheter closure is equally successful with a shorter outcome in the case of secundum defects, but surgery is crucial with large or anatomically delicate cases, which involve patch repair. Decision-making process ought to be balanced between procedural appropriateness, operator experience and possible risks against anticipated recovery. Reduction of convalescence and shorter admissions also reduces healthcare expenditure and family costs which maximise the efficiency of paediatric services. Standardisation of imaging protocols, staff training and postoperative care is recommended to maintain safety of procedures and patient outcomes in hospitals (Chellam Singh, Arulappan, 2023). Pain management, early mobilisation and reintegration of school are recovery pathways that promote physical and psychosocial wellbeing. Generalisation must be reserved because of inter-centre differences in technique and follow-up. Multicentre longitudinal studies in the future need to use harmonised outcome definition, quality-of-life measures that have been validated and cost analyses to enhance the strength of practice. The inclusion of family-centred outcomes would also contribute to equal and high-quality paediatric cardiac care in the health systems of the world.

Cognitive and emotional adjustment of the child in postoperative period should also be noted to better understand the clinical and psychosocial benefits. Play therapy, structured counselling, and parental education as part of recovery initiatives can be very useful in decreasing procedural anxiety and chronic behavioural disruptions. These interventions help in following a medical routine and also create long term psychological stability especially among younger children who relate hospitalisation to fear or discomfort. The evidence also suggests that cardiologist-paediatric nurse-physiotherapist-psychologist collaboration is more effective in providing continuity of care. Paediatric-specific rehabilitation programmes can be used to target not only physiological recovery but developmental and educational reintegration, thus giving holistic outcomes of rehabilitation. Telehealth consultation and wearable devices can help to detect complications early and ensure achievement of family reassurance. Policymaking wise, the integration of these principles into paediatric cardiac care systems can be used to address the low readmission rates and varying recovery rates across regions. Widespread use of minimally invasive techniques demand investment in new imaging, development of devices, and training of operators.

V. CONCLUSION

The relative analysis of interventional and surgical modalities of atrial septal defects in children show that both procedures have high efficacy and successful defect closure. The two approaches play important roles in paediatric cardiac care, and the results are mainly determined by anatomical appropriateness and procedure competence. Interventional transcatheter closure has distinct benefits in hospitalisation reduction, low invasiveness, quicker physical healing, increased cosmetic and parental satisfaction. It has now been the choice when there are sufficient septal rims to the defects of secundum type. On the other hand, open surgical repair is still crucial in the treatment of large and complicated defects or those which cannot be managed with a device. The results of the current secondary qualitative synthesis unveil the significance of multidisciplinary decision-making between cardiologists, surgeons, and paediatric care groups to provide the most appropriate choice of treatment. It is also important to develop standardised outcome monitoring systems throughout the paediatric centres to enhance post-procedural and long-term follow-up. The priorities in the future must focus on incorporating patient-reported outcomes and quality-of-life measures into routine assessment, which would enable a more detailed picture of the physical, emotional, and social recovery of the child. Training pathways to interventional cardiology teams also need to be enhanced in health systems to provide equal access to the minimally invasive expertise at the tertiary and regional levels. Further investment in the state-of-the-art imaging, device creation and paediatric-specific postoperative guidelines will improve the safety and the uniformity of the procedure. Integrating clinical excellence and family-centred rehabilitation with data-driven follow-up, paediatric cardiology would be able to realize more sustainable, equal, and holistic outcomes in children with atrial septal defect repair across the globe. Research institutions and clinical networks should collaborate more to facilitate knowledge sharing and technological advancement in paediatric cardiology. The establishment of common

global registries will facilitate comparative benchmarking and the determination of the best practices in various healthcare environments.

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