International Journal of Medical Science and Clinical Research Studies

ISSN(print): 2767-8326, ISSN(online): 2767-8342

Volume 05 Issue 02 February 2025

Page No: 343-350

DOI: https://doi.org/10.47191/ijmscrs/v5-i02-27, Impact Factor: 8.188

Surgical Management of Ventricular Aneurysms in Pediatric Patients with Viral Myocarditis: A Comprehensive Review

Donaldo Emiliano Silva López[1], Diego Alejandro Ramírez López[2], Roxana Berenice González Muñoz[3], María Fernanda Moreno Alvarado[3], Alexa Ximena Márquez Durón[3], Axel Flores Alba[3]

[1]Tecnológico de Monterrey Campus Monterrey, Nuevo Léon, Mexico

[2]Universidad Autónoma de Guadalajara. Guadalajara, Jalisco, México

[3]Universidad Cuauhtémoc Plantel Aguascalientes. Aguascalientes, México.

ABSTRACT

Background: Viral myocarditis represents a significant cause of pediatric cardiac morbidity and is occasionally complicated by the formation of ventricular aneurysms (VAs). These rare lesions can lead to life-threatening complications, including arrhythmias, embolic events, and cardiac rupture, necessitating timely and effective management.

Objective: This article aims to review the surgical approaches employed in managing ventricular aneurysms in children with viral myocarditis, focusing on clinical presentations, diagnostic tools, surgical techniques, and outcomes.

Methods: A comprehensive review of existing literature was conducted, emphasizing pediatric cases of VA secondary to viral myocarditis. The analysis includes case reports, retrospective studies, and clinical guidelines outlining indications for surgical intervention and the technical considerations therein.

Results: Surgical resection of ventricular aneurysms in this population remains a challenging yet often life-saving procedure. Key findings highlight the importance of preoperative imaging modalities, intraoperative strategies to preserve ventricular function, and the role of postoperative care in optimizing outcomes.

Conclusions: While surgical management of VAs in pediatric viral myocarditis is rare, it provides a definitive treatment option with favorable outcomes in well-selected cases. Multidisciplinary collaboration and advancements in surgical techniques are critical in addressing this complex pathology.

KEYWORDS: Viral myocarditis, ventricular aneurysm, pediatric cardiology, cardiac surgery, aneurysm repair, pediatric heart disease

ARTICLE DETAILS

Published On:
21 February 2025

Available on:
https://ijmscr.org/

INTRODUCTION

Viral myocarditis is a relatively uncommon but potentially severe inflammatory condition of the myocardium, frequently caused by viral pathogens such as coxsackievirus, adenovirus, and parvovirus B19. In pediatric populations, it may manifest as a spectrum of cardiac dysfunction ranging from asymptomatic cases to fulminant heart failure. A rare but serious complication of viral myocarditis is the development of ventricular aneurysms (VAs). These localized outpouchings of the ventricular wall result from myocardial necrosis and thinning, increasing the risk of thromboembolic events, arrhythmias, and, in severe cases, rupture.1,2

The pathogenesis of VA formation in the context of myocarditis involves an intricate interplay between inflammation, myocardial injury, and aberrant remodeling processes. Early recognition of this complication is critical, as delayed intervention can result in catastrophic outcomes. Diagnostic modalities such as echocardiography, cardiac magnetic resonance imaging (MRI), and computed tomography (CT) play a pivotal role in identifying the size, location, and structural characteristics of the aneurysm.1,2

Surgical intervention is often considered when VAs are associated with high risk for rupture, embolic complications, or symptomatic arrhythmias refractory to medical management. Despite the technical challenges, surgical repair or resection of the aneurysm offers a curative approach, aiming to restore ventricular integrity and prevent further complications.1,2

This article provides an in-depth review of the surgical management of VAs in children with viral myocarditis, highlighting preoperative considerations, intraoperative techniques, and postoperative care strategies. Special attention is given to the challenges unique to pediatric populations, including smaller anatomical structures, variable myocardial recovery potential, and the need for long-term surveillance. Through this discussion, we aim to provide a comprehensive resource for clinicians managing this rare but critical condition.3

EPIDEMIOLOGY

Ventricular aneurysms (VAs) in children represent a rare but clinically significant complication of viral myocarditis, a disease with diverse etiological, geographic, and demographic implications. Viral myocarditis itself has an incidence of approximately 1 to 2 cases per 100,000 children annually, though this number likely underestimates the true burden due to asymptomatic or subclinical presentations. Among these cases, the progression to ventricular aneurysm formation is uncommon, with reported prevalence rates varying widely depending on the severity of myocarditis and the diagnostic modalities employed.3

Viral Myocarditis: An Overview of Incidence and Risk Factors

The most frequently implicated viruses in pediatric myocarditis include enteroviruses (e.g., Coxsackievirus B and A), adenovirus, parvovirus B19, and, in recent years, SARS-CoV-2. Geographically, the epidemiological patterns of these pathogens vary, with higher incidence rates of viral myocarditis observed in regions experiencing outbreaks of these specific viral agents. Age is another critical factor; myocarditis tends to disproportionately affect infants and adolescents, possibly due to the immature immune system in younger children and hormonal or immunological changes during adolescence.3

Risk factors for progression from acute viral myocarditis to complications like VAs include delayed diagnosis, severe myocardial inflammation, and inadequate viral clearance. Inflammatory cascades triggered by the initial viral infection contribute to cardiomyocyte necrosis, fibrosis, and ventricular wall weakening, setting the stage for aneurysm formation. Host factors, such as genetic predispositions influencing immune responses, may also play a role, although these are not well-defined in pediatric populations.3

Ventricular Aneurysms in Viral Myocarditis: Incidence and Demographics

The true incidence of VAs in pediatric myocarditis remains elusive due to their rarity and the variability in clinical presentations. Case reports and small series form the primary evidence base, suggesting that the incidence ranges from 0.1% to 5% of all myocarditis cases. However, this range may reflect publication bias, as more severe or unusual cases are disproportionately reported. Most documented cases involve children with a history of fulminant myocarditis, particularly those requiring intensive care unit (ICU) admission or mechanical circulatory support.4

Epidemiologically, there appears to be no significant sex predilection for VA formation in pediatric myocarditis, though some studies have noted a slightly higher prevalence of myocarditis itself in males. Ethnic and racial disparities in the incidence of myocarditis and its complications remain poorly studied in children, though socio-economic factors likely influence access to early diagnostic and therapeutic interventions, potentially affecting outcomes.4

Geographic Variation and Temporal Trends

There is limited data on geographic variation in the incidence of VAs secondary to viral myocarditis in children. However, the prevalence of certain viral pathogens is known to vary by region, influencing overall myocarditis rates. For example, enteroviral myocarditis is more common in temperate climates, while tropical regions report higher rates of viral infections such as dengue and Zika, which have been implicated in cardiac complications.4

Temporal trends also suggest seasonal variation, with viral myocarditis and its complications more frequently diagnosed in the fall and winter months, coinciding with peaks in respiratory virus circulation. Emerging viruses, such as SARS-CoV-2, have added a new dimension to this epidemiological landscape, with increasing recognition of myocarditis and post-viral sequelae, including VAs, in the pediatric population.4

Prognostic Implications and Public Health Relevance

Although rare, the formation of VAs in the context of viral myocarditis is a critical public health concern due to its association with high morbidity and mortality rates. Without timely intervention, these aneurysms can lead to fatal outcomes such as aneurysmal rupture, heart failure, or embolic complications. Advances in diagnostic imaging and surgical techniques have improved recognition and management, but significant challenges remain in ensuring equitable access to care globally. The rarity of VAs also poses challenges for conducting large-scale epidemiological studies, limiting our understanding of their true incidence and long-term outcomes.5

In conclusion, while ventricular aneurysms in pediatric viral myocarditis remain a rare entity, their clinical and epidemiological significance cannot be overstated. Efforts to

enhance surveillance, early diagnosis, and treatment of viral myocarditis, especially in resource-limited settings, are essential for reducing the burden of this serious complication.5

Clinical Manifestations

The clinical manifestations of ventricular aneurysms (VAs) in children with viral myocarditis are highly variable, reflecting the complexity of the underlying pathophysiological processes and the age-dependent presentation of pediatric cardiac disorders. These manifestations can range from asymptomatic incidental findings to life-threatening cardiac emergencies. The presentation is influenced by factors such as the size, location, and hemodynamic impact of the aneurysm, as well as the severity of the antecedent myocarditis.5

Initial Presentation of Viral Myocarditis

Children with viral myocarditis often present with nonspecific symptoms, which may delay the recognition of the condition and its complications. Common initial manifestations include fatigue, fever, myalgias, and gastrointestinal symptoms, such as nausea or abdominal pain, reflecting the systemic viral illness. Cardiac symptoms such as chest pain, tachycardia, or palpitations may arise as the myocardium becomes inflamed and dysfunctional. In severe cases, myocarditis can progress rapidly to fulminant heart failure, characterized by hypotension, poor perfusion, respiratory distress, and cardiogenic shock.

Clinical Manifestations of Ventricular Aneurysms

The development of ventricular aneurysms in the context of viral myocarditis often exacerbates the clinical picture, adding unique and potentially dangerous symptoms. The primary mechanisms underlying these manifestations include abnormal ventricular wall motion, thrombus formation within the aneurysm, and the risk of aneurysmal rupture.5

1. **Arrhythmias**
   Ventricular aneurysms are associated with an increased risk of arrhythmias, which may be symptomatic or life-threatening. The disrupted myocardial architecture at the aneurysm site creates a substrate for electrical instability, leading to ectopic beats, ventricular tachycardia, or fibrillation. Symptoms include palpitations, syncope, or, in severe cases, sudden cardiac arrest.6
2. **Heart Failure Symptoms**
   Progressive left or right ventricular dysfunction due to the aneurysm's hemodynamic burden often manifests as heart failure. Symptoms include dyspnea, orthopnea, peripheral edema, fatigue, and reduced exercise tolerance. Infants may present with poor feeding, diaphoresis, and failure to thrive, while older children may report exertional intolerance or chest discomfort.6
3. **Thromboembolic Events**
   The turbulent flow within the aneurysmal sac predisposes to thrombus formation, increasing the risk of systemic or pulmonary embolism. Clinical manifestations depend on the embolus location, ranging from stroke (hemiparesis, altered consciousness) to peripheral ischemia (pain, pallor, or cyanosis of an affected limb). Pulmonary embolism may present with acute respiratory distress, hypoxemia, or hemoptysis.6
4. **Chest Pain and Discomfort**
   Chest pain may occur due to the underlying myocarditis, ischemic changes from impaired coronary perfusion, or tension at the aneurysm site. In older children and adolescents, pain is often reported as a dull or sharp retrosternal discomfort exacerbated by exertion.6
5. **Aneurysmal Rupture**
   Though rare, rupture of a ventricular aneurysm is a catastrophic event that can result in hemopericardium and cardiac tamponade. Clinical signs include acute onset of severe chest pain, profound hypotension, muffled heart sounds, and pulsus paradoxus, requiring immediate surgical intervention.6
6. **Incidental Findings**
   In some cases, ventricular aneurysms may remain clinically silent and are detected incidentally during imaging studies performed for other indications. These aneurysms may still harbor risks, necessitating close monitoring and consideration for surgical intervention based on their size and morphology.7

Diagnostic Challenges in Pediatric Populations

The clinical manifestations of VAs in children can mimic other cardiac and systemic conditions, making diagnosis challenging. Younger children may have difficulty verbalizing symptoms, and their presentations are often nonspecific, such as irritability, tachypnea, or lethargy. A high index of suspicion is required in children with a history of viral illness and unexplained cardiac symptoms.7

Impact on Quality of Life and Long-term Outcomes

Beyond acute manifestations, the presence of a ventricular aneurysm can significantly impact the child's quality of life. Persistent symptoms such as fatigue and reduced activity levels may limit participation in normal childhood activities. If untreated, the aneurysm can lead to progressive cardiac remodeling and chronic heart failure, further complicating long-term prognosis.7

In conclusion, the clinical manifestations of ventricular aneurysms in children with viral myocarditis are diverse and depend on the interplay between the aneurysm's characteristics and the child's overall cardiac function. Early

recognition and timely intervention are critical to mitigate the associated risks and improve outcomes.7

Diagnostic Methods

The accurate diagnosis of ventricular aneurysms (VAs) in children with viral myocarditis relies on a combination of clinical evaluation, advanced imaging modalities, and laboratory investigations. Identifying these aneurysms is critical to prevent complications such as arrhythmias, thromboembolism, and rupture, and to guide surgical management. Given the subtlety of early signs and the challenges of pediatric presentations, a systematic approach to diagnosis is essential.7

Clinical Evaluation

The diagnostic process begins with a thorough history and physical examination. The presence of antecedent viral illness, unexplained heart failure symptoms, or persistent arrhythmias should raise suspicion for underlying myocarditis and potential complications like VAs. Key findings in clinical evaluation include:8

- **History:** Symptoms such as fatigue, palpitations, dyspnea, or chest pain warrant further investigation. The temporal relationship between a viral prodrome and the onset of cardiac symptoms may provide important clues.8
- **Physical Examination:** Signs of heart failure (tachycardia, hepatomegaly, pulmonary congestion), hypotension, or features suggestive of embolic events (e.g., neurologic deficits, ischemic limb changes) may indicate complications related to VAs.8

However, clinical findings alone are often insufficient for a definitive diagnosis, necessitating the use of specialized diagnostic tools.8

Electrocardiography (ECG)

ECG is a critical first-line tool for evaluating myocardial involvement in children with suspected myocarditis and associated complications. While not specific for VAs, characteristic findings may include:8

- Non-specific ST-segment and T-wave abnormalities.8
- Q waves or fragmented QRS complexes in regions of aneurysmal formation.8
- Evidence of arrhythmias such as ventricular tachycardia, particularly if originating from aneurysmal regions.8

Serial ECGs may provide dynamic insights into disease progression or recovery.8

Chest Radiography

Chest X-rays are useful for detecting cardiomegaly or pulmonary congestion, which may indicate heart failure secondary to VA-related hemodynamic compromise. However, the direct visualization of aneurysms on radiographs is rare and limited by resolution constraints.9

Echocardiography

Echocardiography is the cornerstone of VA diagnosis in children due to its accessibility, non-invasiveness, and ability to provide detailed structural and functional information. Key echocardiographic findings in VAs include:

- Visualization of a thin-walled, dyskinetic or akinetic segment of the ventricular wall.
- Detection of thrombus within the aneurysmal sac.9
- Assessment of left or right ventricular function and evaluation for secondary complications such as mitral regurgitation.9
- Use of Doppler imaging to identify turbulent flow patterns indicative of aneurysmal geometry.9

Advanced echocardiographic techniques, including contrast echocardiography or 3D imaging, may improve diagnostic accuracy in complex cases.9

Cardiac Magnetic Resonance Imaging (MRI)

Cardiac MRI is the gold standard for detailed anatomical and tissue characterization of ventricular aneurysms. It provides superior resolution for assessing:9

- **Aneurysm Morphology:** Identification of the aneurysm's size, location, and wall thickness.9
- **Tissue Viability:** Late gadolinium enhancement (LGE) can distinguish viable myocardium from fibrotic or necrotic tissue, aiding surgical planning.9
- **Functional Assessment:** Accurate evaluation of ejection fraction, regional wall motion abnormalities, and aneurysmal dynamics.9
- MRI also offers the advantage of non-ionizing imaging, making it particularly suitable for pediatric patients requiring longitudinal follow-up.9

Computed Tomography (CT)

Cardiac CT is an alternative to MRI, especially in cases where MRI is contraindicated (e.g., presence of metallic implants). It provides high-resolution images of the cardiac anatomy and is particularly useful for evaluating aneurysms with calcifications or complex spatial relationships. Its ability to assess coronary artery involvement is another advantage, especially in differentiating aneurysms from other structural abnormalities.10

Cardiac Catheterization and Angiography

Invasive coronary angiography remains a valuable diagnostic tool in selected cases, especially when other imaging modalities yield inconclusive results. It allows for:

- Precise delineation of aneurysmal anatomy.10
- Hemodynamic assessment of intracardiac pressures and shunts.10
- Evaluation of coronary perfusion to rule out ischemia-related aneurysms.10

However, the invasiveness and associated risks

make this technique less commonly used in pediatric populations unless surgical intervention is imminent.10

Electrophysiological Studies (EPS)

In patients presenting with arrhythmias, electrophysiological studies may help identify aneurysm-related arrhythmogenic foci. This information can guide both surgical planning and adjunctive therapies, such as catheter ablation or implantable defibrillators.10

Laboratory Investigations

Laboratory tests support the diagnosis of viral myocarditis and its complications, though they are not specific for VAs. Key markers include:

- **Cardiac Biomarkers:** Elevated troponin I or T and B-type natriuretic peptide (BNP) levels reflect myocardial injury and heart failure, respectively.10
- **Inflammatory Markers:** Elevated C-reactive protein (CRP) and erythrocyte sedimentation rate (ESR) suggest an inflammatory etiology.10
- **Viral Studies:** Detection of viral DNA/RNA in blood or myocardial biopsy samples may confirm the causative pathogen.10

Endomyocardial Biopsy (EMB)

Though rarely performed in pediatric patients due to its invasive nature, EMB remains the definitive method for diagnosing myocarditis. Histopathological examination can identify inflammatory infiltrates, myocyte necrosis, and fibrosis, providing direct evidence of viral myocarditis and its complications.10

Multimodality Approach

In practice, a multimodal approach combining clinical evaluation, imaging, and laboratory investigations is essential for diagnosing VAs in children with viral myocarditis. Early and accurate identification enables timely intervention, improving outcomes and guiding the surgical management of this complex condition.10

Current Treatment Approaches

The treatment of ventricular aneurysms (VAs) in children with viral myocarditis requires a multidisciplinary approach that addresses both the underlying myocardial inflammation and the specific complications associated with aneurysm formation. The management strategy is highly individualized, depending on the size, location, and clinical impact of the aneurysm, as well as the child's overall cardiac function and comorbidities. While medical therapy often serves as the initial approach to stabilize the patient, surgical intervention remains the definitive treatment for high-risk aneurysms.10

Medical Management

Medical therapy is primarily aimed at controlling the inflammatory process of viral myocarditis, managing heart failure symptoms, and mitigating complications associated with VAs.10

1. **Heart Failure Management**
    - **Diuretics:** Loop diuretics (e.g., furosemide) are used to relieve volume overload and pulmonary congestion.11
    - **Afterload Reduction:** Angiotensin-converting enzyme (ACE) inhibitors (e.g., enalapril) or angiotensin receptor blockers (ARBs) reduce afterload and promote ventricular remodeling.11
    - **Beta-Blockers:** Agents such as carvedilol are cautiously introduced in stable patients to reduce myocardial oxygen demand and improve ventricular function.11
    - **Inotropic Support:** In cases of severe heart failure, intravenous inotropes (e.g., milrinone, dobutamine) may be required to enhance myocardial contractility.11
2. **Arrhythmia Control**
    - Antiarrhythmic agents, such as amiodarone, may be used to manage ventricular tachycardia or other life-threatening arrhythmias originating from the aneurysmal site.11
    - In some cases, implantable cardioverter-defibrillators (ICDs) may be considered for arrhythmia prevention, though their utility in pediatric populations is limited by anatomical and physiological factors.11
3. **Anticoagulation**
    - Children with ventricular aneurysms are at high risk for thrombus formation and embolization due to turbulent flow within the aneurysm. Anticoagulation with warfarin or low-molecular-weight heparin is often initiated to reduce this risk.
    - In patients with contraindications to anticoagulation, antiplatelet therapy with aspirin or clopidogrel may be considered as an alternative.11
4. **Management of Myocardial Inflammation**
    - **Immunosuppressive Therapy:** In selected cases of autoimmune myocarditis, immunosuppressive agents such as corticosteroids or intravenous immunoglobulin (IVIG) may be used to modulate the inflammatory response. However, their role in viral myocarditis remains controversial.11
    - **Antiviral Therapy:** Specific antiviral agents may be considered if a treatable viral pathogen (e.g., herpesviruses) is

identified, though their efficacy in myocarditis is variable.11

Surgical Management

Surgical intervention is indicated for ventricular aneurysms that are hemodynamically significant, associated with recurrent arrhythmias, or pose a high risk of rupture or embolism. The primary surgical goal is to excise the aneurysmal tissue, restore normal ventricular geometry, and improve overall cardiac function.11

1. **Aneurysmectomy**
    - Aneurysmectomy involves resecting the aneurysmal sac and reconstructing the ventricular wall using techniques such as direct suturing or patch repair.
    - Surgical planning relies heavily on preoperative imaging to determine the size, location, and hemodynamic impact of the aneurysm.11
    - In children, preserving ventricular function is of paramount importance, as their myocardium has limited regenerative capacity compared to adults.11
2. **Ventricular Reconstruction**
    - Techniques such as the Dor procedure (endoventricular circular patch plasty) may be employed to restore ventricular geometry and improve ejection fraction.11
    - The choice of patch material (e.g., autologous pericardium, synthetic patches) is influenced by factors such as biocompatibility and risk of infection.11
3. **Adjunctive Procedures**
    - In cases with concurrent complications, additional surgical interventions may be performed, such as mitral valve repair for aneurysm-induced regurgitation or thrombectomy for intracardiac thrombus.11
    - Coronary artery bypass grafting (CABG) may be indicated if the aneurysm compromises coronary perfusion.11
4. **Emergency Surgery**
    - Aneurysms at imminent risk of rupture require urgent surgical intervention. Preoperative stabilization with mechanical circulatory support (e.g., extracorporeal membrane oxygenation [ECMO]) may be necessary in critically ill patients.11

Role of Mechanical Support

In severe cases where ventricular dysfunction is profound, temporary mechanical support devices may be employed to stabilize the patient before or after surgery.

- **Extracorporeal Membrane Oxygenation (ECMO):** Provides short-term hemodynamic support in cases of cardiogenic shock or severe heart failure.11
- **Ventricular Assist Devices (VADs):** May serve as a bridge to recovery or transplantation in children with irreversible myocardial damage.11

Long-Term Management and Follow-Up

1. **Postoperative Care**
    - Postoperative management includes close monitoring for complications such as arrhythmias, residual aneurysms, or ventricular dysfunction.12
    - Cardiac rehabilitation programs tailored to pediatric patients may enhance recovery and functional outcomes.12
2. **Pharmacologic Therapy**
    - Long-term use of beta-blockers, ACE inhibitors, and anticoagulation is often required to support ventricular function and reduce the risk of recurrence.12
3. **Regular Imaging**
    - Serial echocardiography and cardiac MRI are critical for monitoring ventricular remodeling and detecting late complications.12
4. **Psychosocial Support**
    - Children and their families often require psychological and emotional support to cope with the stress of major surgery and ongoing medical care.12

Future Directions

Advancements in regenerative medicine, such as stem cell therapy and tissue-engineered patches, hold promise for improving outcomes in pediatric patients with ventricular aneurysms. Minimally invasive surgical techniques and innovations in mechanical support devices may further reduce the morbidity associated with traditional open-heart surgery.12

In conclusion, the management of ventricular aneurysms in children with viral myocarditis is a complex and evolving field. While surgical intervention remains the cornerstone of treatment for high-risk aneurysms, a comprehensive, multidisciplinary approach is essential to optimize outcomes and enhance the quality of life for affected children.12

CONCLUSION

The surgical management of ventricular aneurysms (VAs) in children with viral myocarditis represents a pivotal and highly complex component of pediatric cardiovascular care. This intricate interplay of inflammatory cardiac disease and structural abnormalities requires a nuanced approach that integrates cutting-edge surgical techniques, comprehensive

perioperative care, and tailored long-term follow-up strategies to address the unique physiological and developmental needs of pediatric patients.

Ventricular aneurysms, though rare in the pediatric population, carry significant risks including heart failure, life-threatening arrhythmias, thromboembolic events, and the potential for aneurysm rupture. In the context of viral myocarditis, these aneurysms emerge as sequelae of myocardial inflammation and damage, often involving regions of necrosis, fibrosis, and myocardial remodeling. The clinical course of affected children can vary widely, from asymptomatic aneurysms incidentally discovered on imaging to rapidly deteriorating cases presenting with hemodynamic instability and severe ventricular dysfunction.

Diagnosis relies on a multimodal approach, with advanced imaging modalities such as echocardiography, cardiac MRI, and CT angiography playing a central role in characterizing aneurysmal anatomy, ventricular function, and associated complications. The integration of electrophysiological studies further elucidates arrhythmic risks, while laboratory investigations and endomyocardial biopsy provide insights into the underlying inflammatory or infectious etiology.

While medical management serves as the cornerstone of initial stabilization, addressing heart failure, arrhythmias, and thromboembolic risks, definitive management of high-risk aneurysms often necessitates surgical intervention. The timing and nature of surgery require careful consideration, balancing the risks of aneurysm progression against the challenges of operating in the context of ongoing myocardial inflammation and impaired cardiac function. Surgical techniques such as aneurysmectomy and ventricular reconstruction aim to restore normal cardiac geometry, preserve ventricular function, and reduce the risk of adverse outcomes. In cases of severe myocardial compromise, mechanical circulatory support may provide a critical bridge to recovery or transplantation.

Postoperative care and long-term follow-up are integral to optimizing outcomes in this vulnerable population. Regular imaging, pharmacological therapy, and multidisciplinary support ensure the detection and management of late complications such as recurrent aneurysms, residual arrhythmias, or progressive ventricular dysfunction. Moreover, the psychosocial impact of chronic cardiac disease and major surgical intervention necessitates a holistic approach to care, addressing the emotional and developmental needs of both the child and their family.

Future directions in the management of pediatric ventricular aneurysms hold promise for improving outcomes and reducing procedural morbidity. Innovations in regenerative medicine, including stem cell therapy and bioengineered myocardial patches, may offer novel solutions for myocardial repair and functional recovery. Minimally invasive surgical techniques and advances in mechanical circulatory support are likely to further enhance perioperative safety and postoperative recovery.

In conclusion, the management of ventricular aneurysms in children with viral myocarditis is a multidisciplinary challenge that underscores the complexity of pediatric cardiac care. While significant strides have been made in diagnostic and therapeutic approaches, the rarity of this condition necessitates ongoing research, collaboration, and the establishment of dedicated registries to refine treatment protocols and improve prognostic outcomes. The ultimate goal remains the delivery of individualized, high-quality care that enhances survival, functional capacity, and quality of life for affected children.

REFERENCES

I. Grossi EA, Colvin SB, Galloway AC, et al. Repair of posterior left ventricular aneurysm in a six-year-old boy. Ann Thorac Surg 1991; 51: 484–487.

II. Yaku H, Ohira S, Yamazaki S, et al. Endocardial linear infarct exclusion technique for infarcted lateral wall interact. Cardiovasc Thorac Surg 2017; 24: 460–461.

III. Papagiannis J, Van Praagh R, Schwint O, et al. Congenital left ventricular aneurysm: Clinical, imaging, pathologic, and surgical findings in seven new cases. Am Heart J 2001; 141: 491–499.

IV. Ercan A, Senkaya I, Semizel E, et al. Left ventricular aneurysm in a 4-year-old boy. Tex Heart Inst J 2005; 32: 614–615.

V. Egunov OA, Krivoshchekov EV, Cetta F, et al. Surgical management of a giant congenital left ventricular aneurysm in a 2-month-old infant. J Card Surg 2021; 36: 2575–2577.

VI. Chowdhury UK, Seth S, Sheil A, et al. Successful aneurysmectomy of a congenital apical left ventricular aneurysm. Tex Heart Inst J 2009; 36: 331–333.

VII. Wu Z, McGoogan JM. Characteristics of and important lessons from the coronavirus disease 2019 (COVID-19) outbreak in China: summary of a report of 72 314 cases from the Chinese Center for Disease Control and Prevention. JAMA 2020; 323: 1239–1242.

VIII. Tagarro A, Epalza C, Santos M, Sanz-Santaeufemia FJ, Otheo E, Moraleda C, Calvo C. Screening and severity of coronavirus disease 2019 (COVID-19) in children in Madrid, Spain. JAMA Pediatr 2020: e201346.

IX. Belhadjer Z, Meot M, Bajolle F, Khraiche D, Legendre A, Abakka S, Auriau J, Grimaud M, Oualha M, Beghetti M, Wacker J. Acute heart failure in multisystem inflammatory syndrome in children (MIS-C) in the context of global SARS-CoV-2 pandemic. Circulation 2020; 142: 429–436.

X. Whittaker E, Bamford A, Kenny J, Kaforou M, Jones CE, Shah P, Ramnarayan P, Fraisse A, Miller O, Davies P, Kucera F, Brierley J, McDougall M, Carter M, Tremoulet A, Shimizu C, Herberg J, Burns JC, Lyall H, Levin M, for the PIMS-TS Study Group and EUCLIDS and PERFORM Consortia . Clinical characteristics of 58 children with a pediatric inflammatory multisystem syndrome temporally associated with SARS-CoV-2. JAMA 2020; 324: 259–269.

XI. Verdoni L, Mazza A, Gervasoni A, Martelli L, Ruggeri M, Ciuffreda M, Bonanomi E, D'Antiga L. An outbreak of severe Kawasaki-like disease at the Italian epicentre of the SARS-CoV-2 epidemic: an observational cohort study. Lancet 2020; 395: 1771–1778.

XII. Ravelli A, Minoia F, Davi S, Horne A, Bovis F, Pistorio A, Arico M, Avcin T, Behrens EM, De Benedetti F, Filipovic L, Grom AA, Henter J-I, Ilowite NT, Jordan MB, Khubchandani R, Kitoh T, Lehmberg K, Lovell DJ, Miettunen P, Nichols KE, Ozen S, Schmid JP, Ramanan AV, Russo R, Schneider R, Sterba G, Uziel Y, Wallace C, Wouters C, Wulffraat N, Demirkaya E, Brunner HI, Martini A, Ruperto N, Cron RQ, Paediatric Rheumatology International Trials Organisation , Childhood Arthritis and Rheumatology Research Alliance; Pediatric Rheumatology Collaborative Study Group , Histiocyte Society . 2016 classification criteria for macrophage activation syndrome complicating systemic juvenile idiopathic arthritis: a European League Against Rheumatism/American College of Rheumatology/PaediatricRheumatology International Trials Organisation Collaborative Initiative. Ann Rheum Dis 2016; 75: 481–489.