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## **Catheter ablation in pediatric Wolff–Parkinson–White syndrome – A Narrative Review**

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**ABSTRACT**

**Background.** Wolff–Parkinson–White (WPW) syndrome is a frequent cause of supraventricular tachycardia in children and results from an accessory atrioventricular pathway causing ventricular pre-excitation. Although often asymptomatic, it carries a risk of serious arrhythmias and may impair cardiac function due to ventricular dyssynchrony. Catheter

ablation is the main treatment for symptomatic patients and is increasingly considered in selected asymptomatic cases.

**Aim.** This narrative review aims to summarize current evidence regarding the efficacy, safety, and functional outcomes of catheter ablation in pediatric patients with WPW syndrome.

**Methods.** This narrative review analyzed selected clinical and observational studies involving pediatric patients with Wolff–Parkinson–White syndrome. Studies evaluating electrophysiological characteristics, ablation results, and functional effects were included and synthesized thematically, focusing on efficacy, safety, recurrence, and cardiac and exercise outcomes.

**Results.** Available data suggest that catheter ablation achieves high acute success rates exceeding 85–90%, with overall long-term success approaching 99% after repeat procedures. Recurrence occurs in approximately 5–12% of cases but is usually effectively managed with re-ablation. The procedure demonstrates a favorable safety profile, especially when performed in specialized centers. Importantly, elimination of accessory pathway conduction may improve left ventricular function and reverse pre-excitation–related dyssynchrony. Preliminary evidence also suggests improvements in exercise capacity following successful ablation.

**Conclusions.** Catheter ablation is an effective and safe treatment for pediatric WPW syndrome, offering not only arrhythmia control but also potential benefits in cardiac function and physical performance. Further prospective studies are needed to better define long-term functional outcomes and optimize management strategies in asymptomatic patients.

**Keywords:** Wolff–Parkinson–White syndrome, pediatric, arrhythmia, catheter ablation, accessory pathway, radiofrequency ablation, supraventricular arrhythmias, pre-excitation, physical performance, exercise capacity

## **Introduction**

Wolff–Parkinson–White (WPW) syndrome is one of the most common causes of supraventricular tachycardia in the pediatric population and is caused by an additional electrical connection between atria and ventricles that circumvents the physiological conduction route. This abnormal conduction enables premature activation of the ventricles, a phenomenon known as ventricular pre-excitation, and predisposes patients to tachyarrhythmias. WPW may present with symptomatic arrhythmias such as atrioventricular re-entrant tachycardia, but it can also remain asymptomatic and be detected incidentally on electrocardiography. Reports from

clinical studies suggest that ventricular pre-excitation affects between 1 and 3 per 1000 individuals across various populations. [1], [2]

Although many pediatric patients remain asymptomatic, WPW syndrome carries a risk of potentially serious arrhythmic events. If atrial fibrillation develops, the accessory connection may permit unfiltered impulse transmission to the ventricles, potentially resulting in hemodynamic compromise or, exceptionally fatal ventricular arrhythmias. Consequently, appropriate risk stratification and management of children with WPW syndrome remain important clinical challenges. Over recent decades, advances in electrophysiological diagnostics have improved the identification of accessory pathways and enabled more accurate assessment of arrhythmia risk in pediatric patients. [3], [4]

Beyond arrhythmia-related complications, ventricular pre-excitation may also affect cardiac function. When an accessory connection conducts antegrade, the resulting non-physiological depolarization sequence may produce inter- and intraventricular asynchrony, an effect that appears most pronounced for connections situated along the septum or the free wall of the right ventricle. This dyssynchrony may impair left ventricular function and, in some cases, contribute to the development of pre-excitation-induced cardiomyopathy. Importantly, published data suggest that once the anomalous connection is ruptured, indices of myocardial performance tend to recover toward reference values. [1]

Catheter ablation of the accessory connection is now regarded as the standard curative approach for patients presenting with arrhythmias and is increasingly considered in selected asymptomatic patients with high-risk electrophysiological characteristics. The procedure aims to eliminate accessory pathway conduction using radiofrequency or cryothermal energy during an electrophysiological study. Technological advances in mapping systems and catheter techniques have significantly improved the safety and efficacy of ablation procedures in children, leading to high success rates and relatively low complication rates. [2], [5]

In addition to preventing arrhythmia recurrence, successful ablation may provide important functional benefits. Ventricular dyssynchrony associated with pre-excitation can impair exercise capacity, and restoration of normal ventricular activation following accessory pathway elimination may improve cardiovascular efficiency during exertion. However, evidence in this area remains limited and is primarily derived from small observational studies. [1], [6]

Therefore, the purpose of this narrative review is to summarize current evidence regarding catheter ablation in pediatric patients with Wolff–Parkinson–White syndrome. Specifically, this review aims to discuss the pathophysiological consequences of ventricular pre-excitation, evaluate the efficacy and safety of catheter ablation procedures in children, and highlight the

potential benefits of treatment with particular attention to physical performance and functional outcomes after accessory pathway elimination.

## **Methods**

This narrative review was conducted to synthesize and contextualize current evidence regarding catheter ablation in pediatric patients with Wolff–Parkinson–White (WPW) syndrome, with particular attention to procedural efficacy, safety, long-term outcomes, and the impact of treatment on cardiac function and physical performance. The methodological approach followed the principles of narrative synthesis, enabling integration of findings from heterogeneous clinical studies and facilitating interpretation of electrophysiological, clinical, and functional outcomes reported in pediatric populations.

The literature considered in this review was limited to the scientific sources provided within this project. These sources included clinical studies, observational analyses, pilot investigations, and original research evaluating electrophysiological characteristics, catheter ablation techniques, procedural outcomes, recurrence rates, and functional consequences of treatment in children with WPW syndrome.

No restrictions were applied to study design due to the integrative nature of narrative synthesis. The included publications comprised retrospective cohort studies, multicenter registry analyses, pilot studies, and clinical observational investigations involving pediatric patients undergoing electrophysiological study and catheter ablation for accessory pathway elimination.

Studies were considered relevant if they met the following criteria:

1. involved pediatric patients diagnosed with Wolff–Parkinson–White syndrome or ventricular pre-excitation,
2. evaluated electrophysiological characteristics, catheter ablation procedures, or procedural outcomes, and
3. reported clinical or functional consequences of treatment, including recurrence rates, ventricular function, or exercise performance following ablation.

The available evidence was analyzed thematically, with findings organized into key clinical domains, including procedural efficacy and safety of catheter ablation, recurrence and long-term outcomes, and physiological effects of accessory pathway elimination on cardiac function and physical performance. This thematic synthesis allowed integration of results across studies with different methodologies and outcome measures.

Because the aim of this review was to provide an integrative overview of current knowledge rather than a quantitative synthesis, no formal meta-analysis or structured risk-of-bias assessment was performed. Instead, emphasis was placed on interpreting the available findings within their clinical and physiological context.

## **Results**

### **1. Effectiveness of catheter ablation in pediatric WPW syndrome**

Evidence from clinical studies consistently indicates that catheter ablation is an effective treatment for Wolff–Parkinson–White (WPW) syndrome in children. Across analyzed studies, ablation procedures achieved high acute success rates and favorable long-term outcomes. In contemporary pediatric cohorts, acute procedural success generally exceeds 85–90%. When initial and subsequent interventions are considered together, near-complete pathway eradication has been documented in up to 99% of treated children, indicating that a single procedural failure rarely precludes ultimate cure. [5], [7], [8]

Accessory pathways in pediatric patients may occur in various anatomical locations, with septal pathways representing approximately one third of them all. Ablation of septal pathways may pose a greater technical difficulty because of the target tissue lying in close anatomical relation to the compact node and bundle of His. In studies focusing on septal accessory pathways, acute success rates of approximately 89–90% have been reported. Modern ablation techniques allow effective treatment with both radiofrequency energy and cryoablation. In the analyzed septal-pathway cohort, cryothermal energy was the predominant modality, yet comparable procedural outcomes were reported regardless of the energy source employed ( $p = 0.617$ ). [5]

### **2. Recurrence and long-term procedural outcomes**

Although catheter ablation is highly effective, recurrence of accessory pathway conduction remains a recognized clinical phenomenon. Long-term follow-up studies show that recurrence figures vary from 5% to 12% of patients after the initial procedure [9], with a disproportionate share attributable to connections in posteroseptal right-sided positions. [10] Importantly, repeat procedures are generally successful in eliminating recurrent conduction, resulting in very high long-term success rates. [5], [8], [11]

Advances in electrophysiological mapping and catheter technology have also improved procedural precision. Integration of volumetric electroanatomical navigation into the procedural workflow has refined lesion placement and contributed to lower fluoroscopy exposure, both of which are associated with improved long-term pathway elimination and fewer

adverse events. These technological developments have contributed to improved long-term outcomes and reduced recurrence rates in contemporary pediatric electrophysiology practice. [2], [5]

### **3. Safety of catheter ablation in pediatric patients**

The safety profile of catheter ablation in children with WPW syndrome is generally favorable. Studies evaluating large pediatric cohorts report low rates of serious complications when procedures are performed in specialized centers. In long-term observational studies of septal accessory pathway ablation, long-term surveillance did not reveal clinically significant procedural sequelae. [5], [7], [12]

The choice of ablation technique may also influence procedural safety. The growing adoption of cryothermal technology in younger patients reflects its capacity to produce test lesions that can be reversed if conduction through the physiological conduction system is compromised, thereby offering an additional safety margin when the target site abuts the compact node. At the same time, radiofrequency ablation remains widely used and demonstrates high efficacy, particularly when pathways are located farther from the conduction system. [5]

### **4. Cardiac function and structural changes before and after ablation**

Beyond arrhythmia control, several studies have demonstrated that ventricular pre-excitation may affect myocardial function in children with WPW syndrome. Abnormal ventricular activation caused by accessory pathway conduction can lead to mechanical dyssynchrony and impaired left ventricular function. Echocardiographic studies in selected pediatric cohorts have shown a spectrum of subclinical abnormalities, including chamber dilatation, a reduction in shortening and longitudinal deformation indices and heterogeneous wall-motion patterns. [13] Following successful radiofrequency ablation, significant improvements in cardiac function have been observed. Post-procedural reassessment demonstrated recovery of both conventional and deformation-based echocardiographic measures, with most values reaching age-appropriate reference ranges within the first months after the intervention. These findings suggest that ablation may reverse pre-excitation-related myocardial dysfunction and restore more physiological ventricular activation patterns. [1,13]

## **5. Exercise capacity and physical performance before and after ablation**

Functional benefits of catheter ablation have also been demonstrated in studies evaluating exercise performance in children with pre-excitation syndrome. Based on available data, cardiopulmonary exercise testing performed before and after ablation revealed improvements in several exercise parameters following successful elimination of the accessory pathway. In particular, post-ablation testing revealed a statistically significant rise in absolute aerobic capacity, per-beat oxygen delivery and peak mechanical output, although the magnitude of change varied among individuals. [6]

These findings suggest that restoration of normal ventricular activation improves cardiovascular efficiency during physical exertion. Improved exercise performance may reflect enhanced stroke volume, improved ventricular synchrony, and more effective hemodynamic responses during exercise. [6] Consequently, successful ablation may allow pediatric patients to safely participate in physical activity with improved functional capacity. [2]

However, improvements in exercise capacity are not consistently observed across all parameters, and evidence remains limited. Therefore, conclusions regarding the effect of ablation on physical performance should be interpreted with caution.

## **6. Clinical implications of ablation in pediatric WPW syndrome**

Taken together, the available evidence indicates that catheter ablation provides not only effective arrhythmia control but also may offer additional physiological and functional benefits in children with WPW syndrome. Elimination of accessory pathway conduction potentially improves ventricular synchrony, may reverse pre-excitation-related myocardial dysfunction and enhance exercise performance. These results support the role of catheter ablation as a key therapeutic strategy in the management of pediatric WPW syndrome, offering both arrhythmia prevention and improvement in overall cardiovascular function.

## **Discussion**

The available evidence indicates that catheter ablation is an effective and safe therapeutic option for pediatric WPW syndrome. Advances in electrophysiological mapping techniques and energy delivery systems have significantly improved procedural outcomes and reduced complication rates. Success rates in contemporary studies typically exceed 90%, although variability exists depending on accessory pathway location and patient characteristics.

Despite high efficacy, recurrence of accessory pathway conduction remains an important consideration. Because pathway re-conduction is not always accompanied by symptoms,

periodic electrocardiographic surveillance after the index procedure remains advisable, particularly during the first year when the majority of recurrences are detected. Routine electrocardiographic monitoring and clinical evaluation are therefore recommended after the procedure.

An important aspect of WPW management in children concerns physical activity. A practical consequence of persistent pre-excitation is the cautious approach many practitioners adopt toward competitive athletics. Once the accessory connection has been definitively abolished, these activity restrictions can generally be lifted, which has considerable relevance for the child's psychosocial development and overall well-being. Improvements observed in cardiopulmonary exercise parameters after ablation further support the positive impact of treatment on functional capacity and quality of life.

Additionally, ablation may reverse ventricular dysfunction associated with pre-excitation-induced dyssynchrony. Eliminating the accessory pathway can restore normal ventricular activation and may potentially lead to recovery of myocardial function in affected patients.

However, several limitations should be acknowledged. The included studies are heterogeneous in terms of design, patient populations, and outcome measures. In particular, data regarding functional outcomes and exercise performance are derived from relatively small cohorts, limiting generalizability. Furthermore, the narrative nature of this review and the lack of formal risk-of-bias assessment may influence interpretation of the findings.

## **Conclusions**

Catheter ablation represents an effective and safe therapeutic strategy in pediatric patients with Wolff–Parkinson–White syndrome. Contemporary data confirm that both immediate pathway elimination and durable freedom from recurrence can be achieved in the vast majority of children, with adverse-event rates that remain acceptably low in experienced facilities. Although recurrence of accessory pathway conduction may occur, particularly in anatomically complex locations, repeat procedures are typically successful, resulting in excellent overall outcomes. Beyond arrhythmia control, ventricular pre-excitation may adversely affect myocardial function through electrical dyssynchrony, and available evidence suggests that successful elimination of the accessory pathway can lead to improvement or normalization of left ventricular function. Furthermore, preliminary data indicate that ablation may enhance selected cardiopulmonary exercise parameters, suggesting potential benefits in physical performance and functional capacity. Taken together, these findings support the role of catheter ablation not only as a curative treatment for arrhythmias but also as an intervention with broader

physiological benefits. However, further prospective studies in larger pediatric populations are needed to better define long-term functional outcomes and optimize risk stratification in asymptomatic patients.

**Disclosure:**

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During the preparation of this work, the author used generative AI to assist with grammar and stylistic editing to ensure appropriate academic language and for translation into English. After using this tool, the author reviewed and edited the content as needed and takes full responsibility for the final content of the manuscript.

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