Cardiac Resynchronization Therapy: From Coronary Sinus to Conduction System Pacing: An Overview

La resynchronisation cardiaque : du sinus coronaire à la stimulation du système de conduction. : Une Mise au pointchez un jeune hommeà propos d'un cas

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Summary

Cardiac resynchronization therapy stands as a cornerstone in the management of heart failure patients afflicted with ventricular dyssynchrony, offering a therapeutic avenue to enhance cardiac function and alleviate debilitating symptoms; however, the field is in constant evolution, driven by the need to overcome limitations associated with conventional coronary sinus pacing and to address the unique challenges presented by diverse patient anatomies and underlying pathologies. This overview delves into the progression of cardiac resynchronization therapy, contrasting conventional coronary sinus pacing with innovative conduction system pacing techniques, particularly in the context of complex congenital heart diseases like congenitally corrected transposition of the great arteries where traditional approaches may be limited by anatomical variations.

Keywords

Cardiac Resynchronization Therapy, Conduction System Pacing, Coronary Sinus, Heart Failure

Résumé

La resynchronisation cardiaque constitue une pierre angulaire dans la prise en charge des patients insuffisants cardiaques présentant un asynchronisme ventriculaire, en offrant une approche thérapeutique visant à améliorer la fonction cardiaque et à soulager des symptômes invalidants. Toutefois, ce domaine est en constante évolution, motivé par la nécessité de surmonter les limites associées à la stimulation conventionnelle par le sinus coronaire et de répondre aux défis spécifiques posés par la diversité des anatomies et des pathologies sous-jacentes des patients.

Cette synthèse explore l'évolution de la thérapie de resynchronisation cardiaque, en allant de la stimulation conventionnelle via le sinus coronaire aux techniques innovantes de stimulation du système de conduction, en particulier dans le contexte de cardiopathies congénitales complexes telles que la transposition des gros vaisseaux corrigée, où les approches traditionnelles peuvent être limitées par des variations anatomiques.

Mots-clés

Resynchronisation cardiaque, Stimulation du système de conduction, Sinus coronaire,

Insuffisance cardiaque.

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INTRODUCTION

Cardiac resynchronization therapy has emerged as a pivotal treatment modality for patients grappling with symptomatic heart failure and left ventricular systolic dysfunction, revolutionizing the management of this complex condition [1]. Its primary aim is to restore synchronized ventricular contraction, thereby improving cardiac output and alleviating the debilitating symptoms associated with heart failure [2]. The evolution of cardiac resynchronization therapy has seen significant advancements, initially focusing on pacing via the coronary sinus to more recently exploring conduction system pacing techniques, offering new hope for patients with heart failure [2]. Patients who survive sudden cardiac death are at very high risk and qualify for an implantable cardioverter-defibrillator, while identifying patients for primary prevention of sudden cardiac death remains a complex challenge [3]. In patients with symptomatic heart failure despite optimal medical therapy and reduced left ventricular ejection fraction, cardiac resynchronization therapy has been shown to improve clinical outcomes, including reduction in mortality, improvement in functional capacity, and reverse remodeling of the left ventricle. Despite these benefits, a significant proportion of patients do not respond to conventional cardiac resynchronization therapy, highlighting the need for alternative pacing strategies and patient selection criteria

Evolution of Cardiac Resynchronization Therapy Techniques

Coronary Sinus Pacing

Coronary sinus pacing initially represented the standard approach for delivering cardiac resynchronization therapy, involving the placement of a left ventricular lead in a branch of the coronary sinus to stimulate the left ventricle [2]. This technique aimed to overcome the limitations of traditional right ventricular pacing, which can exacerbate ventricular dyssynchrony and worsen heart failure symptoms. By directly stimulating the left ventricle, coronary sinus pacing sought to restore coordinated contraction, leading to improved hemodynamic function. However, coronary sinus pacing is not without its limitations, as anatomical variations in the coronary venous system, such as the presence of small or tortuous veins, can hinder lead placement and limit the achievable pacing location. Furthermore, coronary sinus pacing may not always correct the underlying conduction abnormalities responsible for ventricular dyssynchrony, particularly in patients with conduction system disease.

Conduction System Pacing

Conduction system pacing represents a more physiological approach to cardiac resynchronization therapy, directly engaging the heart's intrinsic conduction system to achieve ventricular synchrony. His-bundle pacing involves the placement of a pacing lead near the His bundle, allowing for direct activation of the normal conduction pathway and resulting in more coordinated ventricular contraction [2]. Alternatively, left bundle branch pacing aims to stimulate the left bundle branch directly, bypassing conduction delays and achieving more synchronous activation of the left ventricle. Compared to coronary sinus pacing, conduction system pacing offers the potential for more precise and physiological ventricular activation, leading to improved hemodynamic outcomes and a greater likelihood of response to cardiac resynchronization therapy. The location of the His bundle in patients with congenitally corrected transposition of the great arteries is different from individuals with normal cardiac anatomy, which may favor consistent long-term pacing [4]. In some cases where conventional cardiac resynchronization therapy is not feasible due to coronary sinus abnormalities, conduction system pacing may be considered [4].

Alternative Methods of Cardiac Resynchronization Therapy Delivery

In certain cases where transvenous approaches are not feasible, alternative methods such as left ventricular septal pacing via a transvenous approach through the interventricular septum have been explored [5]. Endocardial pacing, where the left ventricle is stimulated from inside the left ventricular cavity, is another novel method to improve the response to cardiac resynchronization therapy [6]. Epicardial pacing, involving surgical placement of pacing leads on the surface of the heart, may be necessary in patients with failed transvenous lead placement or anatomical constraints. In Mustard/Senning patients, understanding the anatomy of the intra-atrial baffles and ruling out venous or baffle stenosis is crucial [2].

His-bundle pacing and left bundle branch pacing represent advancements in cardiac resynchronization therapy, directly engaging the heart's intrinsic conduction system to achieve ventricular synchrony [7]. Further research is warranted to determine the optimal pacing strategy for different patient subgroups and to refine patient selection criteria for cardiac resynchronization An injectable hydrogel electrode may allow for simultaneous pacing from multiple sites to stimulate wide areas of ventricular tissue that would have otherwise been subject to delayed activation .therapy.[8]

Efficacy of Cardiac Resynchronization Therapy Techniques

Studies have demonstrated the efficacy of cardiac resynchronization therapy in improving outcomes for patients with heart failure and ventricular dyssynchrony. Compared to coronary sinus pacing, conduction system pacing offers the potential for more physiological ventricular activation, which translates into improved hemodynamic function and a greater likelihood of response to cardiac resynchronization therapy [4].

Despite these advances, challenges remain in optimizing cardiac resynchronization therapy for all patients.

The lack of concordance between the optimal sites of left ventricular pacing, as determined by invasive hemodynamic recordings, and the sites of latest left ventricular mechanical activation, as determined by tissue Doppler imaging, highlights the need for improved methods of patient selection and lead placement [9].The long term data of arrhythmia and defibrillator therapies in patients undergoing cardiac resynchronization therapy with defibrillator are lacking [10].

Safety Considerations

When considering implantable cardiac electronic devices in patients with a systemic right ventricle, specific technical challenges must be addressed, such as the anatomical feasibility of pacemaker lead insertion through the superior venous baffle in patients with transposition of the great arteries after an atrial switch repair, or the coronary sinus anatomy for transvenous insertion of the epicardial right ventricular lead in patients with congenitally corrected transposition of the great arteries [2]. Furthermore, device programming requires special attention in this population [2]. Careful consideration of the risks and benefits of each pacing modality is essential to ensure patient safety and maximize the effectiveness of cardiac resynchronization therapy.

CONCLUSION

Cardiac resynchronization therapy has emerged as a valuable treatment option for patients with heart failure and ventricular dyssynchrony.

Conduction system pacing, including His-bundle pacing and left bundle branch pacing, offers a more physiological approach to cardiac resynchronization therapy compared to traditional coronary sinus pacing [4]. Future research should focus on refining patient selection criteria, optimizing lead placement techniques, and developing novel pacing strategies to further improve outcomes for patients undergoing cardiac resynchronization therapy.

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