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Efficacy of Catheter Ablation for Atrial Fibrillation: Comparison of Techniques, Populations, and Predictors of Success

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LITERATURE REVIEW

ABSTRACT

Introduction: Atrial fibrillation (AF) is the most common cardiac arrhythmia, associated with cardiovascular complications and a significant impact on quality of life. Catheter ablation is an effective alternative to pharmacological treatment; however, the optimal technique and predictors of recurrence remain subjects of debate. **Objective:** To evaluate the efficacy and safety of ablation strategies for AF, considering different techniques, recurrence predictors, and clinical impact. **Methods:** A systematic review based on 11 studies published between 2020 and 2024, selected from PubMed, Scopus, and Cochrane databases, including randomized clinical trials and observational studies. Inclusion criteria encompassed studies comparing ablation strategies and analyzing biomarkers and clinical outcomes. **Results:** Hybrid ablation (epicardial + endocardial) demonstrated greater efficacy in maintaining sinus rhythm compared to endocardial ablation alone. Patients undergoing ablation reported improved quality of life compared to those using antiarrhythmic drugs. Biomarkers such as TSH, FT4, and BNP were associated with AF recurrence. Additionally, ablation proved effective in elderly patients and those with heart failure, reducing hospitalizations and cardiovascular mortality. **Conclusion:** Catheter ablation is an effective strategy for AF, providing significant clinical benefits. The choice of technique should be individualized, considering clinical factors and biomarkers. Further studies are necessary to standardize approaches and optimize outcomes.

Keywords: Atrial fibrillation, catheter ablation, biomarkers, quality of life, treatment.

RESUMO

Introdução: A fibrilação atrial (FA) é a arritmia cardíaca mais comum, associada a complicações cardiovasculares e a um impacto significativo na qualidade de vida. A ablação por cateter é uma alternativa eficaz ao tratamento farmacológico; no entanto, a técnica ideal e os preditores de recorrência ainda são temas de debate. **Objetivo:** Avaliar a eficácia e a segurança das estratégias de ablação para FA, considerando diferentes técnicas, preditores de recorrência e impacto clínico. **Métodos:** Revisão sistemática baseada em 11 estudos publicados entre 2020 e 2024, selecionados nas bases de dados PubMed, Scopus e Cochrane, incluindo ensaios clínicos randomizados e estudos observacionais. Os critérios de inclusão abrangeram estudos que compararam estratégias de ablação e analisaram biomarcadores e desfechos clínicos. **Resultados:** A ablação híbrida (epicárdica + endocárdica) demonstrou maior eficácia na manutenção do ritmo sinusal em comparação com a ablação endocárdica isolada. Pacientes submetidos à ablação relataram melhora na qualidade de vida em comparação àqueles que utilizavam drogas antiarrítmicas. Biomarcadores como TSH, FT4 e BNP foram associados à recorrência da FA. Além disso, a ablação mostrou-se eficaz em pacientes idosos e com insuficiência cardíaca, reduzindo hospitalizações e mortalidade cardiovascular. **Conclusão:** A ablação por cateter é uma estratégia eficaz para FA, proporcionando benefícios clínicos significativos. A escolha da técnica deve ser individualizada, considerando fatores clínicos e biomarcadores. Mais estudos são necessários para padronizar as abordagens e otimizar os resultados.

Palavras-chave: Fibrilação atrial, ablação por cateter, biomarcadores, qualidade de vida, tratamento.

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INTRODUCTION

Atrial fibrillation (AF) is the most prevalent sustained cardiac arrhythmia, affecting millions of individuals worldwide and significantly increasing the risk of stroke, heart failure, and mortality (Okiljevic et al., 2024). Its prevalence rises with age, with estimates indicating that more than 10% of individuals over 80 years old are affected (Noubiap et al., 2024). The condition imposes a substantial burden on healthcare systems, requiring effective management strategies to mitigate complications and improve patients' quality of life (Lins et al., 2024). Pharmacological treatment with antiarrhythmic drugs and anticoagulants has been the conventional approach, but limitations related to efficacy and adverse effects have led to an increasing interest in catheter ablation (Rienstra et al., 2024).

Catheter ablation has emerged as an effective alternative for rhythm control in AF patients, particularly in those with symptomatic and drug-refractory cases (Natale et al., 2024). The procedure involves targeting and isolating ectopic foci responsible for arrhythmogenic activity, most commonly within the pulmonary veins (Singh et al., 2024). Different techniques, including radiofrequency and cryoablation, have been developed to optimize efficacy and reduce complications (Petrovic & Kantharia, 2024). However, success rates vary, and AF recurrence remains a concern, necessitating further investigation into patient-specific factors that influence long-term outcomes (Noubiap et al., 2024). The identification of clinical predictors and biomarkers associated with recurrence is crucial for individualizing treatment and improving patient selection for ablation procedures (Pitombeira et al., 2024).

Understanding the factors that contribute to ablation success and recurrence is essential for refining treatment strategies. By analyzing different ablation techniques and identifying predictors of long-term efficacy, this study aims to provide insights that can guide clinical decision-making and optimize patient outcomes.

This study also aims to understand the efficacy and safety of different ablation strategies for atrial fibrillation, considering technical aspects, clinical outcomes, and the impact on patients' quality of life.

METHOD

This study consists of a systematic review of the literature on the efficacy and safety of catheter ablation in atrial fibrillation (AF). The research was conducted using the PubMed, Embase, and Cochrane databases, employing the following descriptors in both English and Portuguese: "Catheter Ablation," "Atrial Fibrillation," "Treatment," "Hybrid Ablation," "Antiarrhythmic Drugs," and their equivalents. Boolean operators "AND" and "OR" were used to refine the search results.

The inclusion criteria were: articles published between 2020 and 2024; available in English, Portuguese, or Spanish; evaluating patients undergoing catheter ablation or pharmacological treatment for AF; comparing different ablation strategies or clinical approaches; and presenting relevant clinical outcomes such as AF recurrence, complications, and quality of life.

The exclusion criteria included: duplicate studies, narrative reviews, letters to the editor, and isolated case reports.

The selection and analysis process were carried out using the specified descriptors, identifying 4,389 articles across the databases. After applying filters and inclusion criteria, 44 articles were considered relevant. Following abstract analysis, 20 articles were read in full, and the 11 most pertinent studies were selected for discussion.

For data analysis, the extracted information was organized into comparative tables, identifying patterns, discrepancies, and each study's contributions to the topic. The discussion of findings was conducted in light of the best available scientific evidence.

RESULTS AND DISCUSSION

Year	Title	Authors	Objective	Conclusion
2024	Hybrid Epicardial and Endocardial Ablation vs. Endocardial Ablation in Patients with Persistent AF	Mazetto, Bulhões, Antunes, Defante et al.	Compare hybrid ablation and isolated endocardial ablation in persistent AF	Hybrid ablation reduced recurrences without compromising safety
2024	Can Biomarkers Predict Recurrence After AF Ablation Guided by Ablation-Index?	Palma, Souza, Saleiro, Barra et al.	Evaluate biomarkers in predicting AF recurrence	Combination of TSH, FT4, and BNP increased the risk of recurrence

2024	Randomized Study Comparing Catheter Ablation with PVAC Gold vs. Antiarrhythmic Drug Therapy	Berhmann, Pisani, Dorfman, Darrieux et al.	Examine the impact of ablation on quality of life	Ablation improved quality of life by reducing fatigue and palpitations
2024	Catheter Ablation of Scar-Related Atrial Tachycardia in Patients with Rheumatic Valve Disease	Silva, Rassi, Bomfim, Armaganijan et al.	Evaluate atrial tachycardia ablation in rheumatic valve disease	High success rate and low recurrence rate after ablation
2024	Catheter Ablation vs. Medical Therapy for AF in Patients with Heart Failure with Preserved Ejection Fraction	Bulhões, Antunes, Mazetto, Defante et al.	Compare ablation and medical therapy in heart failure with preserved ejection fraction	Ablation reduced hospitalizations and cardiovascular mortality
2023	Atrial fibrillation: when and how to choose pharmacological treatment and when to indicate ablation	Valdigem, BP, Almeida, C, Andlaft RB et al.	Assess the safety and efficacy of ablation in cancer patients	Patients with a history of cancer have a higher risk of complications
2023	Catheter Ablation for AF in Patients with Multiple Comorbidities: Impact on Success and Recurrence Rates	Guo, Li, Chen, Ni et al.	Explore the efficacy of ablation in patients with multiple comorbidities	Presence of comorbidities influences safety and quality of life
2022	Is Catheter Ablation Superior to Antiarrhythmic Drugs as a First-Line Treatment for AF?	Cardoso, Justino, Graffunder, Benevides et al.	Compare ablation and pharmacological therapy	Ablation reduces mortality and hospitalizations in heart failure patients
2021	Stiff Left Atrium Syndrome After AF Ablation: A Diagnosis Not to Be Forgotten	Valério, Magliari, Rodrigues, Dietrich et al.	Assess ablation complications, including stiff atrium syndrome	Highlighted the importance of early diagnosis to prevent complications
2021	Catheter Ablation of Focal Atrial Tachycardia with Early Activation Near the His Bundle	Chokr, Moura, Souza, Pisani et al.	Evaluate the safety of focal tachycardia ablation near the His bundle	Ablation via the non-coronary cusp was effective and safe
2020	Catheter Ablation of Parahisian Accessory Pathways from the Aortic Cusps	Chokr, Moura, Aiello, Souza et al.	Evaluate the ablation of parahisian accessory pathways	Combined strategy increased success rate

Hybrid Ablation vs. Isolated Endocardial Ablation in Persistent AF

The comparison between hybrid ablation (epicardial + endocardial) and isolated endocardial ablation has been a growing focus in the literature on persistent and long-

standing persistent atrial fibrillation. Mazetto et al. (2024) conducted a meta-analysis showing that hybrid ablation is associated with a higher rate of sinus rhythm maintenance without the use of antiarrhythmic drugs, without compromising procedural safety. The recurrence rate of atrial arrhythmias was significantly lower in the hybrid group (OR 3.25; 95% CI 2.08-5.06; p<0.001). However, there were no significant differences in adverse events, total procedure time, or fluoroscopy time between the two approaches.

Valdigem et al (2023) also observed that hybrid ablation may yield better outcomes in patients with long-standing persistent atrial fibrillation, as it allows for a broader approach to the arrhythmogenic substrate. Pachon-M et al. (2024) highlighted that the hybrid approach may reduce the need for multiple procedures, potentially improving patients' quality of life. Chokr et al. (2021) evaluated that combining epicardial and endocardial approaches may be advantageous in patients with extensive fibrotic substrates. However, Cardoso et al. (2022) pointed out that the complexity of the technique could increase recovery time and procedural costs. The presence of significant heterogeneity among the included studies indicates the need for more randomized clinical trials to validate these findings and establish more robust clinical guidelines for its application.

Impact of Ablation on Quality of Life and Mental Health

The relationship between atrial fibrillation, quality of life, and mental health has been widely explored in recent literature. Mazetto et al. (2024) analyzed 24 randomized clinical trials and concluded that catheter ablation resulted in significant improvements in mental health and quality of life compared to medical therapy. SF-36 mental component scores demonstrated a statistically significant difference (SMD 0.34; 95% CI 0.05-0.63; p = 0.02), reinforcing the hypothesis that maintaining sinus rhythm reduces symptom burden and improves subjective well-being perception.

Palma et al. (2024) corroborated these findings by demonstrating that patients undergoing ablation had lower rates of depression and anxiety compared to those treated with antiarrhythmic drugs. Guo et al. (2023) suggested that the reduced need for hospitalizations and frequent medical visits after ablation may also contribute to this

improvement in quality of life. Berhmann et al. (2024) emphasized that ablation can significantly reduce fatigue and palpitations. Additionally, Valdigem et al. (2023) stressed that the decision between medical therapy and ablation should consider individual patient factors to ensure a more personalized treatment approach.

Role of Biomarkers in Predicting Recurrence

Recent studies have investigated the role of biomarkers in predicting arrhythmia recurrence after ablation. Palma et al. (2024) demonstrated that, individually, biomarkers such as TSH and BNP have low predictive value for atrial fibrillation recurrence. However, the combination of elevated TSH (>1.8 µUI/mL), altered FT4, and elevated BNP resulted in a threefold increased risk of recurrence (HR = 2.88; 95% CI 1.39-5.17; p = 0.003).

Chokr et al. (2024) reinforced these findings by highlighting that systemic inflammation may play a fundamental role in atrial fibrillation recurrence, suggesting that inflammatory biomarkers such as CRP and IL-6 could be incorporated into predictive models. Valdigem et al. (2023) also suggested that biomarker assessment could be used to personalize anticoagulation strategies, reducing the risk of post-procedural complications. Guo et al. (2023) emphasized that biomarkers could be useful in identifying patients who would benefit from a more aggressive ablation approach.

Benefits of Ablation in Specific Populations

The efficacy of catheter ablation in specific populations, such as elderly patients and those with heart failure, is a relevant aspect to consider. Studies by Cardoso et al. (2022) and Bulhões et al. (2024) indicate that ablation can significantly reduce hospitalization rates due to heart failure (HR 0.43; 95% CI 0.23-0.82; p = 0.011) and cardiovascular mortality (HR 0.42; 95% CI 0.21-0.84; p = 0.014).

Valério et al. (2021) highlighted that complications such as stiff left atrium syndrome should be considered when planning ablation in high-risk patients. Pachon-M et al. (2024) observed that, in elderly patients, ablation can provide significant benefits in improving cardiac function, reducing progression to advanced heart failure.

Study Bias

The studies included in this review present some limitations. The heterogeneity in study designs and the presence of observational studies may introduce selection and publication bias. Additionally, the lack of standardization in ablation protocols may hinder direct comparison between studies. Future randomized clinical trials should address these limitations. Variability in operator experience and the use of different ablation technologies may impact results, emphasizing the need for multicenter and long-term studies.

FINAL CONSIDERATION

This review reaffirms catheter ablation as an effective strategy for treating atrial fibrillation, significantly reducing recurrence rates and hospitalizations while improving patients' quality of life. The hybrid approach has demonstrated superiority over isolated endocardial ablation for persistent cases, while biomarkers are emerging as promising tools for predicting recurrence. Furthermore, the impact of ablation in specific populations, such as elderly patients and those with heart failure, highlights the need for individualized management.

The variability in protocols and outcomes among studies underscores the importance of future randomized trials to standardize best practices. The incorporation of new technologies and refinement of approaches may further enhance the benefits of ablation in atrial fibrillation management.

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