

Medical Policy



Title: Catheter Ablation as Treatment for Atrial Fibrillation

Professional	Institutional
Original Effective Date: December 12, 2006	Original Effective Date: March 30, 2007
Revision Date(s): March 30, 2007; May 2, 2007; January 26, 2010; October 8, 2010; March 28, 2011; June 6, 2011; August 24, 2012; January 15, 2013; June 14, 2013; July 10, 2015; October 27, 2015; October 1, 2015; June 22, 2016; July 1, 2017; June 22, 2018; August 28, 2019; October 1, 2019; March 23, 2021; July 2, 2021; January 03, 2022; July 1, 2022	Revision Date(s): May 2, 2007; January 26, 2010; November 8, 2010; March 28, 2011; June 6, 2011; August 24, 2012; January 15, 2013; June 14, 2013; July 10, 2015; October 27, 2015; October 1, 2015; June 22, 2016; July 1, 2017; June 22, 2018; August 28, 2019; October 1, 2019; March 23, 2021; July 2, 2021; January 03, 2022; July 1, 2022
Current Effective Date: August 28, 2019	Current Effective Date: August 28, 2019

State and Federal mandates and health plan member contract language, including specific provisions/exclusions, take precedence over Medical Policy and must be considered first in determining eligibility for coverage. To verify a member's benefits, contact Blue Cross and Blue Shield of Kansas Customer Service.

The BCBSKS Medical Policies contained herein are for informational purposes and apply only to members who have health insurance through BCBSKS or who are covered by a self-insured group plan administered by BCBSKS. Medical Policy for FEP members is subject to FEP medical policy which may differ from BCBSKS Medical Policy.

The medical policies do not constitute medical advice or medical care. Treating health care providers are independent contractors and are neither employees nor agents of Blue Cross and Blue Shield of Kansas and are solely responsible for diagnosis, treatment and medical advice.

If your patient is covered under a different Blue Cross and Blue Shield plan, please refer to the Medical Policies of that plan.

Populations	Interventions	Comparators	Outcomes
Individuals: • With symptomatic paroxysmal or persistent atrial fibrillation who	Interventions of interest are: • Radiofrequency ablation or cryoablation	Comparators of interest are: • Medication management	Relevant outcomes include: • Overall survival • Symptoms • Morbid events

Populations	Interventions	Comparators	Outcomes
have failed antiarrhythmic drugs			• Quality of life
Individuals: • With symptomatic atrial fibrillation and congestive heart failure who have failed rate control and antiarrhythmic drugs	Interventions of interest are: • Radiofrequency ablation or cryoablation	Comparators of interest are: • Atrioventricular nodal ablation and pacemaker insertion	Relevant outcomes include: • Overall survival • Symptoms • Morbid events • Quality of life
Individuals: • With recurrent symptomatic paroxysmal atrial fibrillation	Interventions of interest are: • Radiofrequency or cryoablation as an initial rhythm-control strategy	Comparators of interest are: • Medication management	Relevant outcomes include: • Overall survival • Symptoms • Morbid events • Quality of life

DESCRIPTION

Atrial fibrillation (AF) frequently arises from an abnormal focus at or near the junction of the pulmonary veins and the left atrium, thus leading to the feasibility of more focused ablation techniques directed at these structures. Catheter-based ablation, using radiofrequency ablation (RFA) or cryoablation, is being studied as a treatment option for various types of AF.

OBJECTIVE

The objective of this evidence review is to evaluate whether the use of transcatheter ablation improves the net health outcomes in patients with paroxysmal or persistent atrial fibrillation.

BACKGROUND

Atrial Fibrillation

Atrial fibrillation (AF) is the most common cardiac arrhythmia, with an estimated prevalence of 0.4% of the population, increasing with age. The underlying mechanism of AF involves the interplay between electrical triggering events and the myocardial substrate that permits propagation and maintenance of the aberrant electrical circuit. The most common focal trigger of AF appears to be located within the cardiac muscle that extends into the pulmonary veins.

Atrial fibrillation can be subdivided into 3 types: paroxysmal, persistent, and permanent. Atrial fibrillation accounts for approximately one-third of hospitalizations for cardiac rhythm disturbances. Symptoms of AF (e.g., palpitations, decreased exercise tolerance, dyspnea) are primarily related to poorly controlled or irregular heart rate. The loss of atrioventricular synchrony results in a decreased cardiac output, which can be significant in patients with compromised cardiac function. Also, patients with AF are at higher risk for stroke, with anticoagulation typically recommended. Atrial fibrillation is also associated with other cardiac conditions, such as valvular heart disease, heart failure, hypertension, and diabetes. Although episodes of AF can be converted to normal sinus rhythm using pharmacologic or electroshock

conversion, the natural history of AF is that of recurrence, thought to be related to fibrillation-induced anatomic and electrical remodeling of the atria.

Treatment strategies can be broadly subdivided into rate control, in which only the ventricular rate is controlled and the atria are allowed to fibrillate, or rhythm control, in which there is an attempt to re-establish and maintain normal sinus rhythm. Rhythm control has long been considered an important treatment goal for the management of AF, although its primacy has recently been challenged by the results of several randomized trials reporting that pharmacologically maintained rhythm control offered no improvement in mortality or cardiovascular morbidity compared with rate control.

However, rhythm control is not curative. A variety of ablative procedures have been investigated as potentially curative approaches, or as modifiers of the arrhythmia so that drug therapy becomes more effective. Ablative approaches focus on the interruption of the electrical pathways that contribute to AF through modifying the arrhythmia triggers and/or the myocardial substrate that maintains the aberrant rhythm. The maze procedure, an open surgical procedure often combined with other cardiac surgeries (e.g., valve repair), is an ablative treatment that involves sequential atriotomy incisions designed to create electrical barriers that prevent the maintenance of AF. Because of the highly invasive nature of this procedure, it is currently, mainly reserved for patients undergoing open-heart surgery for other reasons (e.g., valve repair, coronary artery bypass grafting).

Catheter Ablation for Atrial Fibrillation

Radiofrequency ablation (RFA) using a percutaneous catheter-based approach is widely used to treat a variety of supraventricular arrhythmias, in which intracardiac mapping identifies a discrete arrhythmogenic focus that is the target of ablation. The situation is more complex for AF because there may be no single arrhythmogenic focus. Atrial fibrillation most frequently arises from an abnormal focus at or near the junction of the pulmonary veins and the left atrium, thus leading to the feasibility of more focused, percutaneous ablation techniques. Strategies that have emerged for focal ablation within the pulmonary veins originally involved segmental ostial ablation guided by pulmonary vein potential (electrical approach) but currently more typically involve circumferential pulmonary vein ablation (anatomic approach). Circumferential pulmonary vein ablation using radiofrequency energy is the most common approach at present.

Research into specific ablation and pulmonary vein isolation techniques is ongoing.

The use of current radiofrequency catheters for AF has a steep learning curve because they require extensive guiding to multiple ablation points. The procedure can also be done using cryoablation technology. One of the potential advantages of cryoablation is that cryoablation catheters have a circular or shaped endpoint, permitting a "one-shot" ablation.

Repeat Procedures

Repeat procedures following initial RFA are commonly performed if AF recurs or if atrial flutter develops post-procedure. The need for repeat procedures may, in part, depend on the clinical characteristics of the patient (e.g., age, persistent vs paroxysmal AF, atrial dilatation), and the type of ablation initially performed. Repeat procedures are generally more limited in scope than

the initial procedure. Additional clinical factors associated with the need for a second procedure include the length of AF, permanent AF, left atrial size, and left ventricular ejection fraction.

REGULATORY STATUS

In February 2009, the NaviStar® ThermoCool® Irrigated Deflectable Diagnostic/Ablation Catheter and EZ Steer ThermoCool NAV Catheter (Biosense Webster) received expanded approval by the U.S. Food and Drug Administration (FDA) through the premarket approval process for RFA to treat drug-refractory recurrent symptomatic paroxysmal AF. FDA product code: OAD.

Devices using laser or cryoablation techniques for substrate ablation have been approved by the FDA through the premarket approval process for AF (FDA product code: OAE). They include:

- Arctic Front™ Cardiac CryoAblation Catheter and CryoConsole (Medtronic) in 2010.
- TactiCath™ Quartz Catheter and TactiSysQuartz® Equipment (St. Jude Medical) in 2014.
- HeartLight® Endoscopic Ablation System (Cardiofocus) in 2016.
- The Freezor™ Xtra Catheter (Medtronic) in 2016.

Also, numerous catheter ablation systems have been approved by the FDA for other ablation therapy for arrhythmias such as supraventricular tachycardia, atrial flutter, and ventricular tachycardia. FDA product code: LPB.

POLICY

- A. Transcatheter radiofrequency ablation or cryoablation to treat atrial fibrillation may be considered **medically necessary** as a treatment for either of the following indications which have failed to respond to adequate trials of antiarrhythmic medications (or has intolerance of or a contraindication to appropriate antiarrhythmic medications):
1. Symptomatic paroxysmal or symptomatic persistent atrial fibrillation; **OR**
 2. As an alternative to atrioventricular nodal ablation and pacemaker insertion in individuals with class II or III congestive heart failure and symptomatic atrial fibrillation.
- B. Transcatheter radiofrequency ablation or cryoablation to treat atrial fibrillation may be considered **medically necessary** as an initial treatment for individuals with recurrent symptomatic paroxysmal atrial fibrillation in whom a rhythm-control strategy is desired.
- C. Repeat radiofrequency ablation or cryoablation may be considered **medically necessary** in individuals with recurrence of atrial fibrillation and/or development of atrial flutter following the initial procedure (see Policy Guidelines).
- D. Transcatheter radiofrequency ablation or cryoablation to treat atrial fibrillation is considered **experimental / investigational** as a treatment for cases of atrial fibrillation that do not meet the criteria outlined above.

POLICY GUIDELINES

- A. Transcatheter treatment of atrial fibrillation may include pulmonary vein isolation and/or focal ablation.
- B. There is no single procedure for catheter ablation. Electrical isolation of the pulmonary vein musculature (pulmonary vein isolation) is the cornerstone of most AF ablation procedures, but additional ablation sites may be included during the initial ablation. Potential additional ablation procedures include: creation of linear lesions within the left atrium; ablation of focal triggers outside the pulmonary veins; ablation of areas with complex fractionated atrial electrograms; and ablation of left atrial ganglionated plexi. The specific ablation sites may be determined by electroanatomic mapping to identify additional sites of excitation. As a result, sites may vary from patient to patient, even if they are treated by the same physician. Individuals with long-standing persistent AF may need more extensive ablation. Similarly, repeat ablation procedures for recurrent AF generally involve more extensive ablation than do initial procedures.
- C. As many as 30% of individuals will require a follow-up (repeat) procedure due to recurrence of atrial fibrillation or to development of atrial flutter. In most published studies, success rates may have been based on having as many as 3 separate procedures, although these repeat procedures may be more limited in scope than the initial procedure.

Please refer to the member's contract benefits in effect at the time of service to determine coverage or non-coverage of these services as it applies to an individual member.

RATIONALE

This evidence review has been updated regularly with searches of the PubMed database. The most recent literature update was performed through March 16, 2022.

Evidence reviews assess the clinical evidence to determine whether the use of a technology improves the net health outcome. Broadly defined, health outcomes are the length of life, quality of life, and ability to function—including benefits and harms. Every clinical condition has specific outcomes that are important to patients and managing the course of that condition. Validated outcome measures are necessary to ascertain whether a condition improves or worsens; and whether the magnitude of that change is clinically significant. The net health outcome is a balance of benefits and harms.

To assess whether the evidence is sufficient to draw conclusions about the net health outcome of technology, 2 domains are examined: the relevance, and quality and credibility. To be relevant, studies must represent one or more intended clinical use of the technology in the intended population and compare an effective and appropriate alternative at a comparable intensity. For some conditions, the alternative will be supportive care or surveillance. The quality and credibility of the evidence depend on study design and conduct, minimizing bias and confounding that can generate incorrect findings. The randomized controlled trial (RCT) is preferred to assess efficacy; however, in some circumstances, nonrandomized studies may be adequate. RCTs are rarely large enough or long enough to capture less common adverse events and long-term effects. Other types of studies can be used for these purposes and to assess generalizability to broader clinical populations and settings of clinical practice.

In patients with paroxysmal or persistent atrial fibrillation (AF), catheter ablation may be considered an alternative to drug therapy.¹ In patients with permanent AF, catheter ablation may be considered an alternative to drug therapy or atrioventricular (AV) nodal ablation and pacing.² For all types of AF, it is possible that catheter ablation may not be curative as a sole treatment but might alter the underlying myocardial triggers or substrate in such a way that subsequent pharmacologic therapy may become more effective.

There is an ongoing controversy about the relative benefits of rhythm versus rate control in AF, which underlies the evaluation of evidence on catheter ablation. Randomized trials of pharmacologic therapies have not demonstrated the superiority of rhythm control versus rate control.^{3,4,5} However, the apparent equivalency of these 2 strategies with pharmacologic therapy cannot be extrapolated to the rhythm control achieved with ablation. Antiarrhythmic medications used for rhythm control are only partially effective and have serious complications, including proarrhythmic properties, which can be lethal. Therefore, nonpharmacologic strategies for rhythm control have the potential to achieve outcomes superior to those seen with pharmacologic strategies.

Evidence on ablation procedures for AF was reviewed, with a focus on RCTs reporting on the AF-related outcomes of interest (see below). Also, nonrandomized studies and noncomparative studies reporting on longer-term outcomes were included to evaluate for durability.

CATHETER ABLATION FOR SYMPTOMATIC PAROXYSMAL OR PERSISTENT ATRIAL FIBRILLATION WHO HAVE FAILED MEDICAL MANAGEMENT

Clinical Context and Therapy Purpose

The purpose of catheter ablation using radiofrequency ablation (RFA) or cryoablation is to provide a treatment option that is an alternative to or an improvement on existing therapies in patients with symptomatic paroxysmal or persistent AF who have failed medical management.

The question addressed in this evidence review is: Does the use of catheter ablation using RFA or cryoablation improve the net health outcome in patients with paroxysmal or persistent AF who have failed medical management?

The following PICO was used to select literature to inform this review.

Populations

The relevant population of interest is individuals with symptomatic paroxysmal or persistent AF who have failed medical management. Paroxysmal AF episodes last <7 days and are self-terminating. Persistent AF episodes last for >7 days and can be terminated pharmacologically or by electrical cardioversion.

Interventions

The therapy being considered is RFA or cryoablation. In RFA, an electrical current produced by a radio wave is used to destroy an arrhythmogenic focus. Cryoablation uses an extreme cold thermoconductive technique to destroy tissue.

Comparators

Comparators of interest include medication management. Medication management can include heart rate or rhythm control medications. Rate control medication therapy includes calcium channel blockers, beta-blockers, and digoxin. Rhythm control medications include dronedarone and amiodarone.

Currently, the main indications for a rhythm-control strategy are for patients with paroxysmal or persistent AF who have hemodynamic compromise associated with episodes of AF or who have bothersome symptoms, despite adequate rate control. A rhythm-control strategy involves initial pharmacologic or electronic cardioversion, followed by pharmacologic treatment to maintain normal sinus rhythm. However, antiarrhythmic medications are often not effective in maintaining sinus rhythm. As a result, episodes of recurrent AF are typical, and patients with persistent AF may require multiple episodes of cardioversion. Implantable atrial defibrillators, which are designed to detect and terminate an episode of AF, are an alternative in patients otherwise requiring serial cardioversions.

Outcomes

The general outcomes of interest are overall survival (OS), symptoms, morbid events, and quality of life. Individual clinical trials and case series have reported relatively low rates of complications but may be limited in their ability to detect uncommon outcomes due to small sample sizes. Gupta et al (2013) conducted a systematic review evaluating periprocedural complications following catheter ablation for AF.⁶ Reviewers selected 192 studies that included

at least 100 participants undergoing catheter ablation for symptomatic AF and that reported complications. The total sample size was 83,236 patients. The overall acute complication rate was 2.9% (95% confidence interval [CI], 2.6% to 3.2%), with significant heterogeneity across studies. The most common complications were vascular complications (1.4%), cardiac tamponade (1.0%), pericardial effusion (0.7%), stroke/transient ischemic attack (TIA) (0.6%), and pulmonary vein stenosis (0.5%).

Various outcomes for the treatment of AF may be considered.⁷ The mortality and morbidity related to AF (e.g., cardiovascular mortality, stroke, heart failure) are the most important clinical outcomes. However, they are uncommon events, and currently available trials have not been powered to detect differences in these outcomes. Quality of life is also an important outcome because quality of life measures reflect important manifestations of AF, such as symptoms and reduced exercise tolerance. Atrial fibrillation has been shown to be associated with lower quality of life scores, and maintenance of sinus rhythm has been associated with higher quality of life scores for patients with paroxysmal AF.

Recurrence of AF is a more problematic outcome measure because the intermittent and often transient nature of recurrences makes accurate measurement difficult.⁷ This outcome measure has been reported in different ways. For example, the proportion of patients in sinus rhythm at the end of the study, the time to the first recurrence, and the number of recurrences within a period have been reported. Shemin et al (2007) highlighted the difficulties in measuring AF recurrence and recommended a measure of AF "burden," defined as the percentage of time an individual is in AF, as the optimal measure of treatment efficacy.⁷ However, this parameter requires continuous monitoring over a relatively long period, which is inconvenient for patients, resource-intensive, and usually not pragmatic in patients who do not already have an implanted pacemaker.

Recommendations for outcome assessment in trials of AF treatment were included in the American College of Cardiology, American Heart Association, and European Society of Cardiology (2006) practice guidelines for the treatment of AF.⁸ These guidelines pointed out that the appropriate endpoints for evaluation of treatment efficacy in patients with paroxysmal or persistent AF have little in common. For example, in studies of persistent AF, the proportion of patients in sinus rhythm at the end of follow-up is a useful endpoint, but this endpoint is less useful in studies of paroxysmal AF. Given all these variables, ideally, controlled clinical trials would report a range of outcomes (including quality of life) and complications in the homogeneous patient groups and compare them with the most relevant treatment alternatives (e.g., pharmacologic therapy, defibrillator therapy, AV nodal ablation), depending on the classification of AF (paroxysmal, persistent, permanent).

Study Selection Criteria

Methodologically credible studies were selected using the following principles:

- To assess efficacy outcomes, comparative controlled prospective trials were sought, with a preference for RCTs;
- In the absence of such trials, comparative observational studies were sought, with a preference for prospective studies.
- To assess long-term outcomes and adverse events, single-arm studies that capture longer periods of follow-up and/or larger populations were sought.

- Studies with duplicative or overlapping populations were excluded.

REVIEW OF EVIDENCE

RADIOFREQUENCY ABLATION

Systematic Reviews

The literature review for this evidence review was informed by a TEC Assessment (2008).⁹ Six RCTs met the Assessment inclusion criteria.^{10,11,12,13,14,15} The trials differed in patient populations, specific catheter ablation techniques used, and comparisons made. The trials addressed 3 distinct indications for catheter ablation: (1) patients with paroxysmal AF, as a first-line treatment option (1 trial¹⁵); (2) patients with symptomatic paroxysmal or persistent AF who had failed treatment with antiarrhythmic drugs (4 trials^{10,12,13,14}); and (3) patients with symptomatic AF and heart failure who had failed treatment with standard medications for rate control and who would otherwise be considered for AV nodal ablation and pacemaker insertion (1 trial¹¹).

All 6 trials reported that maintenance of sinus rhythm was improved for the catheter ablation group. Recurrence rates of AF at 1 year ranged from 11% to 44% for the catheter ablation groups compared with 63% to 96% for the medication groups. Four of the 6 trials reported on quality of life outcomes. One of these only reported within-group comparisons, as opposed to between-group comparisons.¹² The other 3 trials reported improvements in quality of life associated with catheter ablation.^{10,11,15} None of the available trials reported meaningful data on cardiovascular morbidity and mortality associated with AF. The Assessment concluded that catheter RFA is more effective than medications in maintaining sinus rhythm across a wide spectrum of patients with AF and different variations of catheter ablation. The evidence on quality of life is suggestive, but not definitive, of a benefit for patients undergoing catheter ablation. For other outcomes, the evidence did not permit conclusions. Based on these findings, TEC criteria were met for 2 indications: patients with symptomatic paroxysmal or persistent AF who have failed treatment with antiarrhythmic drugs and patients with symptomatic AF and heart failure who have failed treatment with standard medications for rate control and who would otherwise be considered for AV nodal ablation and pacemaker insertion. For the first indication, the conclusion followed from the premise that reducing episodes of recurrent AF for this population will reduce or eliminate the symptoms associated with episodes of AF. For the other indication, the single multicenter RCT available was judged sufficient to conclude that catheter ablation improved outcomes compared with the alternative, AV nodal ablation, and pacemaker insertion. While this trial was relatively small, it was judged to be otherwise of high quality and reported improvements of a relatively large magnitude across a range of clinically important outcome measures including quality of life, exercise tolerance, left ventricular ejection fraction (LVEF), and maintenance of sinus rhythm.

Since the publication of the TEC Assessment, additional systematic reviews and meta-analyses of catheter ablation for AF have been reported.

Asad et al (2019) reported on the results of a meta-analysis of all-cause mortality using data from 18 RCTs that compared catheter ablation (n=2286) to medical therapy (n=2178) in all types of patients with AF.¹⁶ Although the meta-analysis encompassed a broad range of patient

populations, it also reported results of a subgroup analysis based on the presence of heart failure with reduced ejection fraction. Review authors reported that overall, compared to medical therapy, catheter ablation resulted in a significant reduction in all-cause mortality (relative risk [RR], 0.69; 95% CI, 0.54 to 0.88). However, they noted that this finding was largely driven by results from the Catheter Ablation for Atrial Fibrillation With Heart Failure (CASTLE-AF) RCT described below by Marrouche et al (2018),¹⁷ which is comprised of patients with AF and heart failure with reduced ejection fraction.

Nyong et al (2016) reported on a Cochrane review of ablation for individuals with nonparoxysmal AF, which included RCTs comparing radiofrequency catheter or surgical ablation with antiarrhythmic drugs for persistent or long-standing persistent AF.¹⁸ Reviewers selected 3 RCTs (N=261 ; Forleo et al [2009],¹⁹ Stabile et al [2006],¹⁴ and Mont et al [2014];²⁰ not discussed in detail herein), all comparing catheter RFA (n=159) to antiarrhythmic drugs (n=102) at 12 months. The trials were assessed to have a low or unclear risk of bias. Reviewers' primary outcomes are summarized in Table 1.

Table 1. Efficacy of Catheter Ablation for Nonparoxysmal Atrial Fibrillation

Outcome (Catheter vs Drug Therapy)	No. of Participants (Studies)	Evidence Quality ^a	RR	95% CI
Freedom from atrial arrhythmias or recurrence of any atrial arrhythmias	261 (3 studies)	Low	1.84	1.17 to 2.88
Need for cardioversion	261 (3 studies)	Moderate	0.62	0.47 to 0.82
Cardiac hospitalization	216 (2 studies)	Low	0.28	0.1 to 0.72

Adapted from Nyong et al (2016).¹⁸

CI: confidence interval; RR: relative risk.

^a Assessed using the GRADE assessment tool.

Overall, reviewers concluded that catheter RFA was superior to antiarrhythmic drugs for patients who had not responded to antiarrhythmic drug therapy but there was uncertainty related to their findings.¹⁸

Shi et al (2015) reported on the results of a meta-analysis of RCTs comparing catheter ablation with antiarrhythmic drug therapy for AF.²¹ The meta-analysis included 11 trials (N=1763), of which 4 included only patients with paroxysmal AF, 2 included only patients with persistent AF, and 5 included patients with paroxysmal or persistent AF. Eight RCTs included only patients who were drug-refractory or drug-intolerant and the remaining 3 RCTs included patients treated with catheter ablation as first-line therapy. Catheter ablation-treated patients had lower rates of AF recurrence than antiarrhythmic drug therapy-treated patients (RR, 0.47; 95% CI, 0.38 to 0.58; p<.001).

A Cochrane review by Chen et al (2012) evaluated catheter ablation for paroxysmal and persistent AF.²² It included 7 RCTs comparing catheter ablation with medical therapy. Reviewers' main conclusions were that catheter ablation was superior at reducing the recurrence of AF (RR, 0.27; 95% CI, 0.18 to 0.41), but that there were no differences in

mortality rates (RR, 0.50; 95% CI, 0.04 to 5.65), embolic complications (RR, 1.01; 95% CI, 0.18 to 5.68), or death from thromboembolism (RR, 3.04; 95% CI, 0.13 to 73.4).

Ganesan et al (2013) published results of a systematic review and meta-analysis of studies reporting long-term outcomes after percutaneous catheter ablation for paroxysmal and nonparoxysmal AF.²³ Reviewers included 19 studies (RCTs, case-control and cohort studies, case series) that reported catheter ablation outcomes at 3 years or more after the index ablation procedures. Sample sizes in these studies ranged from 39 to 1404 patients (N=6167). For a single procedure, the pooled overall success rate at 12 months post-procedure was 64.2% (95% CI, 57.5% to 70.3%). At late follow-up, the overall single-procedure success, defined as freedom from atrial arrhythmia at the latest follow-up, was 53.1% (95% CI, 46.2% to 60.0%). The pooled overall multiple-procedure long-term success rate was 79.8% (95% CI, 75.0% to 83.8%). The analysis did not identify any predictors of short- or long-term recurrence. Reporting of periprocedural complications was heterogeneous across studies but complication rates were generally low.

Other systematic reviews have assessed the effect of RFA on specific AF-related outcomes. Zhuang et al (2014) conducted a meta-analysis that evaluated the effect of RFA on left atrial volume and function in patients with AF.²⁴ In a summary of data from 26 studies enrolling 1821 patients, RFA was associated with improvements in left atrial volume measurements compared with pre-ablation (e.g., for left atrial diameter); the weighted mean difference (WMD) was -1.52 mm (95% CI, -2.57 to -0.47 mm). There were no significant improvements in left atrial function.

Randomized Controlled Trials

Since the TEC Assessment, additional RCTs comparing RFA with pharmacologic treatment have been identified. Wilber et al (2010) enrolled 167 patients who had failed at least 1 antiarrhythmic medication and had at least 3 AF episodes in the prior 6 months.²⁵ Patients were randomized to catheter ablation or continued drug therapy and followed for 9 months. At the end of follow-up, 66% of patients in the ablation group were free of recurrent AF compared with 16% of patients in the medication group. Adverse events related to treatment occurred in 4.9% (5/103) of patients treated with ablation and in 8.8% (5/57) of patients treated with medications.

Forleo et al (2009) randomized 70 patients with type 2 diabetes and paroxysmal or persistent AF to RFA or an antiarrhythmic medication.¹⁹ Follow-up was for 1 year, with the primary outcome of recurrence of AF. At the end of the trial, 42.9% (15/35) of patients in the medication group were free of AF compared with 80% (28/35) of patients in the ablation group. Quality of life also improved significantly for patients in the ablation group. Adverse events from medications occurred more frequently (17.2% [6/35]) than complications from ablation (2.9% [1/35]).

Mont et al (2014) conducted an RCT comparing catheter RFA with antiarrhythmic drug therapy among 146 patients with symptomatic persistent AF.²⁰ Patients were randomized in a 2:1 fashion to catheter RFA (n=98) or antiarrhythmic drug therapy (n=48). Although the trial was terminated before the planned sample size of 208 was enrolled (due to low enrollment), at 12 months of follow-up, the proportion of patients who were free of sustained AF episodes was

higher in the catheter ablation group (70.4%) than in the antiarrhythmic drug therapy group (43.7%; $p=.002$). Quality of life scores did not differ significantly between groups. Longer-term outcomes were not reported.

Marrouche et al (2018) conducted an RCT comparing catheter ablation with medical therapy in 363 patients with systematic paroxysmal or persistent AF who had no response to, were unwilling to take, or had unacceptable side effects to antiarrhythmic drugs.¹⁷ Patients were randomized to catheter ablation ($n=179$) or medical therapy ($n=184$), with a median follow-up of 38 months. For patients treated with catheter ablation, there was a significantly lower rate of death from cardiac causes (20 [11.2%] vs 41 [22.3%]; hazard ratio [HR], 0.49; 95% CI, 0.29 to 0.84; $p=.009$) or hospitalization for worsening heart failure (37 [20.7%] vs 66 [35.9%]; HR, 0.56; 95% CI, 0.37 to 0.83; $p=.004$) than found in patients treated with medical therapy alone.

Kuck et al (2021) conducted a multicenter RCT comparing RFA with medical therapy in patients with paroxysmal AF to evaluate which strategy is more effective in delaying the progression to persistent AF.²⁶ Patients were included if they had paroxysmal AF for at least 2 years and failed treatment with 1 to 2 antiarrhythmic drugs. The trial was terminated early due to slow enrollment after the inclusion of 255 patients (target enrollment was 322); 128 received RFA and 127 received medical therapy. The primary endpoint, rate of persistent AF or atrial tachycardia at 3 years, was significantly lower with RFA (2.4%; 95% CI, 0.6 to 9.4) than with medical therapy (17.5%; 95% CI, 10.7 to 27.9; one-sided $p=.0009$). However, only 36% and 41% of patients who received RFA and medical therapy, respectively, completed 3 years of follow-up. The incidence of recurrent AF was consistently lower with RFA than with medical therapy from 6 months through the 3-year follow-up period.

Wu et al (2021) published the results of a multi-center RCT comparing the effects of RFA and antiarrhythmic drug therapy in patients with persistent and long-standing AF.²⁷ A total of 648 participants were randomized to either the RFA group ($n=327$) or the antiarrhythmic drug therapy group ($n=321$). After a mean follow-up of 54 ± 10.6 months, fewer participants in the RFA versus antiarrhythmic drug therapy group experienced the primary composite outcome of stroke/transient ischemic attack (TIA), systemic embolism, major bleeding, and new-onset congestive heart failure (10.4% vs. 17.4%; HR, 0.59, 95% CI, 0.48 to 0.75). When considering the individual components of the primary outcome, only the difference in the incidence of stroke (both ischemic and hemorrhagic) and new-onset congestive heart failure reached statistical significance in favor of RFA over antiarrhythmic drug therapy.

Longer-Term Outcomes

The available RCTs have mainly reported on short-term outcomes (<1 year) and, therefore, do not provide data on the rate of recurrences after 3 years. Longer-term outcomes have been reported and have generally found rates of early recurrence in the range of 20% to 30%, requiring repeat ablations. Rates of longer-term recurrence are lower if early recurrence does not occur, in the range of 1% to 2% per year.

Hussein et al (2011) reported on 831 patients treated in 2005 (median follow-up, 55 months).²⁸ During the first year after ablation, 23.8% had a recurrence of AF. During the remaining follow-up, recurrences occurred in 8.9% of additional patients. The overall rate free

of arrhythmia and medications was 79.4% at 55 months. An additional 10.5% of patients were arrhythmia-free on medication, for a total clinical improvement rate of 89.9%. In a smaller study (N=509) with a follow-up to 5 years after initial ablation, Teunissen et al (2016) reported that, after a single procedure, 41.3% of patients had long-term maintenance of sinus rhythm.²⁹

Bunch et al (2013) reported on results from a prospective cohort study comparing the risk of stroke among patients with AF who had undergone catheter ablation, patients with AF who had not had ablation, and patients without a history of AF.³⁰ A total of 4212 patients with AF who had had catheter ablation were age- and sex-matched at a 1:4 ratio with 16,848 subjects in each of the other groups. Mean follow-up time was 3.9 years. At 1-year post-procedure, significantly more patients with AF who had not undergone ablation had a stroke (3.5%) than those with AF who had had ablation (1.4%) or had no history of AF (1.4%; $p < .001$ for trend). During the follow-up period, for all ages and CHADS₂ profiles, patients with AF who had ablation had a lower stroke risk than those with AF who had not.

Several smaller studies have also reported longer-term follow-up after catheter RFA. Weerasooriya et al (2011) reported on a 5-year follow-up in 100 patients treated with catheter ablation.³¹ Recurrences were most common within the first 6 months, with repeat procedures being common during that period. At 1, 2, and 5 years after ablation, arrhythmia-free survival rates were 87%, 81%, and 63%, respectively. Tzou et al (2010) reported on long-term follow-up for 123 patients who had a previous successful ablation, defined as free of AF at 1 year.³² At 3-year follow-up, 85% of patients were still free of AF and off all medications; at 5 years, 71% remained free of AF. The authors estimated a late recurrence rate of 7% per year for patients with an initially successful procedure. In a similar study, Bertaglia et al (2010) reported on outcomes after 6 years of follow-up for 229 patients who had had a single, successful ablation.³³ At 1-year follow-up, 77% (177/229) of patients were free of AF and off all medications. After a mean additional follow-up of 49.7 months for these 177 patients, 58% remained free of AF. Sawhney et al (2009) reported on 5-year success rates for 71 patients who underwent ablation in 2002 or 2003.³⁴ Freedom from symptomatic AF while off medications was achieved in 86% of patients at 1 year, in 79% at 2 years, and in 56% at 5 years. A substantial minority of patients (22.5%) had a recurrence at points more than 2 years after ablation. A study by Anselmino et al (2013) followed 196 patients who underwent catheter RFA for paroxysmal or persistent AF and had an LVEF of 50% or less for a mean of 46.2 months.³⁵ During follow-up, 29.6% of patients required repeat ablation procedures. At the end of follow-up, 37.8% had had at least 1 episode of AF, atrial flutter, or ectopic atrial tachycardia. Takigawa et al (2014) reported on long-term follow-up for 1220 patients who underwent RFA for symptomatic paroxysmal AF.³⁶ Atrial fibrillation recurrence-free survival probabilities at 5 years were 59.4% after the initial procedure and 81.1% after the final ablation procedure (average procedures per patient, 1.3).

Repeat Procedures

Repeated procedures for recurrent AF or atrial flutter were commonly performed in most clinical trials included in this evidence review. Of the 10 RCTs reviewed comparing RFA with medical management, only 2^{15,19} did not include repeated procedures. In the other 5 studies, 1 or more repeated procedures were allowed, and success rates reported generally incorporated the results of up to 3 procedures. In 4 studies reporting these data, repeated procedures were performed in 8.2%,²⁰ 9%,¹³ 20%,¹¹ and 32%¹² of patients randomized to ablation. In their

RCT of catheter ablation of AF in patients with heart failure, Hunter et al (2014) reported that repeat procedures were required in 65.4% of the catheter ablation group.³⁷ Stabile et al (2006) did not report specifics on how many patients actually underwent repeat procedures, but limited data in the publication suggested that up to 30% of treated patients were eligible for repeat procedures.¹⁴ In the Jais et al (2008) study, patients underwent a mean of 1.8 procedures per patient and a median of 2 procedures per patient, indicating that approximately 50% of patients in the ablation group underwent at least 1 repeated procedure.¹⁰

Because of this high rate of repeat procedures, the results reported in these studies do not reflect the single-procedure success rate. Rather, they more accurately estimate the success rate of an ablation strategy that includes repeat procedures for recurrences that occur within the first year of treatment. Nonrandomized evidence has suggested that early re-ablation increases the success of the procedure when defined as maintenance of sinus rhythm at 1 year.³⁸ There is variability in the protocol for when repeat procedures should be performed. There is also uncertainty concerning other details of repeat procedures, such as how soon after the initial procedure it should be done, the threshold for AF recurrence that should prompt a repeat, and whether medication regimens should be tried before a repeat procedure.³⁸

Pokushalov et al (2013) reported on the results of an RCT comparing repeat catheter ablation with antiarrhythmic drug therapy for patients with paroxysmal AF who had failed an initial pulmonary vein isolation procedure.³⁹ After an initial post-ablation blanking period, 154 patients with symptomatic AF recurrence were randomized to drug therapy (n=77) or repeat ablation (n=77). Patients were followed for 3 years with an implanted cardiac monitor. At the 3-year follow-up, 58% (45/77) of the repeat ablation group was free from AF or atrial tachycardia and antiarrhythmic drugs compared with 12% (9/77) of the antiarrhythmic therapy group (p<.01). In the antiarrhythmic drug group, 43 (56%) patients crossed over to receive repeat ablation; in the repeat ablation group, 21 (27%) patients required antiarrhythmic drug therapy. By intention-to-treat (ITT) analysis, 65% (50/77) of the repeat ablation group and 45% (35/77) of the drug therapy group were free from AF or atrial tachycardia (p=.02).

CRYOABLATION

Randomized Controlled Trials

Packer et al (2013) reported on the results of the Sustained Treatment of Paroxysmal Atrial Fibrillation trial, an RCT comparing cryoablation with antiarrhythmic medications.⁴⁰ This trial enrolled 245 patients with paroxysmal AF who had failed at least 1 (median, 1.2) membrane-active antiarrhythmic medication. Patients were randomized in a 2:1 fashion to cryoablation (n=163) or drug therapy (n=82). At 1-year follow-up, 69.9% of patients in the ablation group were free of AF versus 7.3% in the medication group. The single-procedure success rate was 57.7%. There was also a significantly greater reduction in symptoms for the ablation group. Seventy-nine percent of the drug treatment group crossed over to cryoablation during the 12-month follow-up because of recurrent, persistent AF. Cryoablation procedure-related adverse events occurred in 5 (3.1%) patients; major AF events occurred in 3.1% of the cryoablation group compared with 8.5% of the drug treatment group (p<.001 for noninferiority). Phrenic nerve injury occurred at a rate of 13.5%, of which 86% resolved at 12 months.

Nonrandomized Controlled Trials

Su et al (2018) performed a multicenter, retrospective study of patients with drug-refractory paroxysmal AF who underwent cryoballoon ablation.⁴¹ The patients (N=452) were successfully treated with pulmonary vein isolation (99%); with transient phrenic nerve injury found to be the most common complication (1.5%). After 12 months, 87% (n=393) of patients had freedom from atrial arrhythmia.

Longer-Term Follow-Up

Similar to RFA, the available RCTs for cryoablation have reported primarily on short-term outcomes. Examples of longer-term outcomes include Vogt et al (2013), who reported on 605 patients who underwent cryoablation for symptomatic, paroxysmal, or persistent AF.⁴² Follow-up data beyond 12 months were available for 451 patients (median follow-up, 30 months). Of those with follow-up available, 278 (61.6%) were free of AF recurrence with no need for repeat procedures after a 3-month blanking period. After 1, 2, and 3 repeat procedures, rates of freedom from AF were 74.9%, 76.2%, and 76.9%, respectively. Phrenic nerve palsy was the most common adverse event, occurring in 2% of patients, all of which resolved within 3 to 9 months. There were 2 periprocedural strokes (1 periprocedural pericardial tamponade, 1 pericardial effusion).

Smaller studies include Neumann et al (2013), who reported on 5-year outcomes after a single cryoablation procedure among 163 patients with symptomatic, drug-refractory paroxysmal AF.⁴³ Fifty-three percent of subjects were free from recurrent AF, atrial tachycardia, or atrial flutter at 5 years with no additional procedures (after a 3 month blanking period). Boho et al (2015) reported on the follow-up to a median of 3 years after cryoablation for 205 patients with symptomatic paroxysmal or early persistent AF treated at a single institution.⁴⁴ At the 6-, 12-, 24-, and 36-month follow-ups, 88%, 71%, 49%, and 31% had no documented recurrence of AF. Davies et al (2016) reported on AF recurrence rates (median follow-up, 56 months) for 200 patients with paroxysmal or persistent AF after cryoablation.⁴⁵ During follow-up, 46.7% and 35.6% of those with paroxysmal and persistent AF, respectively, had a recurrence of symptomatic AF after a single procedure.

Andrade et al (2014) published a follow-up analysis of the Sustained Treatment of Paroxysmal Atrial Fibrillation trial to evaluate the incidence and significance of early recurrence of AF after ablation.⁴⁶ Of the 163 subjects randomized to cryoablation, 84 (51.5%) patients experienced early recurrence of AF, defined as any recurrence of AF lasting more than 30 seconds between 3 and 12 months postablation. The presence of early AF recurrence was associated with late AF recurrence: late AF recurrence occurred in 41 (25.1%) patients and was more likely in those with early recurrence (55.6% in those with early recurrence vs 12.7% in those without early recurrence; $p < .001$).

Complications

Complications of catheter ablation were also reported by Dagues et al (2009) in a large cohort of 1000 patients undergoing ablation at a high-volume center in Europe.⁴⁷ No deaths were definitively attributed to the procedure, but there were 2 deaths of uncertain cause within the first 30 days following ablation. Overall, 3.9% of patients had a major complication resulting from the procedure. Tamponade was the most serious life-threatening complication (1.3%). Major vascular complications occurred in 1.1%. Thromboembolism, cerebrovascular accident or

TIA, atrioesophageal fistula, and endocarditis were all reported complications that occurred at a rate of less than 1%.

Cappato et al (2009) performed a multicenter, retrospective case series to estimate the overall mortality rate following ablation.⁴⁸ Data were collected on 32,569 patients from 162 clinical centers worldwide. Thirty-two deaths were reported, for a mortality rate of 0.98 per 1000 patients. The most common causes of death were tamponade (n=8), stroke (n=5), atrioesophageal fistula (n=5), and pneumonia (n=2).

One goal of the Mesh Ablator versus Cryoballoon Pulmonary Vein Ablation of Symptomatic Paroxysmal Atrial Fibrillation study was to identify adverse events, particularly cerebral thromboembolism, through the use of serial magnetic resonance imaging (MRI) and neuropsychologic testing. While there is some evidence that RFA for patients with AF reduces stroke risk, a clinically significant stroke or TIA attack occurs in 0.1% to 0.8% of patients undergoing catheter ablation, and several case series have demonstrated peridural brain lesions on diffusion-weighted MRI in up to 18% of patients undergoing catheter ablation of the left atrium. Thus, the Mesh Ablator versus Cryoballoon Pulmonary Vein Ablation of Symptomatic Paroxysmal Atrial Fibrillation investigators evaluated patients pre- and post-catheter ablation with brain MRI at 3 Tesla and neurologic and neuropsychological testing. Short-term outcomes from these evaluations were reported by Haeusler et al (2013) and demonstrated that new ischemic lesions occurred in 41% of all patients.⁴⁹ However, these brain lesions were not associated with cognitive dysfunction immediately post-procedure. Longer-term follow-up was reported by Herm et al (2013).⁵⁰ At follow-up MRI 6 months post-procedure, 31.3% of the acute brain lesions had formed a persistent glial scar. Similar to the short-term findings, there was no significant effect of either the ablation procedure or the presence of persistent brain lesions on attention or executive functions, short-term memory, or learning after 6 months

Waldo et al (2012) reported on the results of a U.S. Food and Drug Administration directed postmarketing safety study involving 1275 patients from 6 prospective, multicenter studies of RFA using an open-irrigated catheter.⁵¹ A total of 4.9% (63/1275) of patients experienced serious, acute complications within 7 days of the procedure. Vascular access complications were most common, ranging from 0.5% to 4.7% across the 6 studies. Exacerbations of heart failure occurred in 1.5% of patients, and 2 patients experienced cardiac tamponade. There were no strokes or TIAs reported after the procedure.

Shah et al (2012) used data from a California hospital database to evaluate complications in 4156 patients who underwent catheter ablation for AF.⁵² Major complications occurred in 5.1% (211/4156) patients, with approximately half (2.6% [110/4156]) consisting of hemorrhage or hematoma at the vascular entry site. The most common cardiac complication was cardiac perforation and/or tamponade, which occurred in 2.5% (104/4156) of patients. Less common rates of serious adverse events included death (0.02%), stroke/TIA (0.31%), and pneumothorax/hemothorax (0.1%). Factors predictive of complications were female sex, older age, prior hospitalizations for AF, and less hospital expertise with ablation.

In a study of Medicare beneficiaries, Ellis et al (2009) identified 6065 admissions from 168 hospitals in which RFA for AF was performed.⁵³ The total rate of in-hospital complications was 9.1%, with vascular complications accounting for over half the complications (5.7%). The

mortality rate was 0.4%, and 0.6% of patients suffered a stroke or TIA, respectively. Perforation or tamponade occurred in 3.1% of patients and pneumothorax in 0.4%. The presence of chronic obstructive pulmonary disease or unstable angina was associated with a higher risk of complications, while obesity and hyperlipidemia were associated with a lower risk. Age and hospital volume were not significant predictors of risk but low hospital RFA procedure volume was a significant predictor of in-hospital death.

Comparisons of Radiofrequency Ablation Techniques

Techniques for RFA for pulmonary vein isolation or substrate ablation have evolved. Specifying RFA techniques is not the focus of the present review but recent large studies are described briefly.

Reddy et al (2015) reported on the results of a noninferiority RCT comparing a contact force-sensing RFA catheter with a standard (noncontact force-sensing) catheter in 300 patients with treatment-refractory paroxysmal AF.⁵⁴ The trial's primary effectiveness endpoint was a composite of acute ablation success and long-term ablation success (freedom from symptomatic AF, atrial tachycardia, or atrial flutter at 12 months off antiarrhythmic drugs, after a 3-month blanking period). In the modified ITT population, patients in the contact force-sensing catheter group (n=149) were noninferior to the control catheter group (n=141; 67.8% vs 69.4%, respectively; absolute difference, -1.6%; lower limit of 1-sided 95% CI; -10.7; p=.007 for noninferiority).

A second, smaller RCT, published by Nakamura et al (2015), compared a contact force-sensing RFA catheter with a standard catheter (N=120) and reported lower rates of pulmonary vein reconnections in those treated with a contact force-sensing catheter.⁵⁵

Afzal et al (2015) performed a systematic review and meta-analysis, which included 9 studies (1 RCT [but not the Reddy RCT]), comparing RFA with contact force-sensing or noncontact force-sensing catheters.⁵⁶ At 12-month follow-up, contact force-sensing catheter-treated patients had lower AF recurrence compared with standard catheter-treated patients (RR, 0.63; 95% CI, 0.44 to 0.91; p=.01).

SECTION SUMMARY: INDIVIDUALS WITH SYMPTOMATIC PAROXYSMAL OR PERSISTENT ATRIAL FIBRILLATION WHO HAVE FAILED ANTIARRHYTHMIC DRUGS

Radiofrequency Ablation for Atrial Fibrillation

Numerous RCTs of RFA for isolation of the pulmonary veins versus medical management have reported that freedom from AF at 1 year is higher with RFA than with medical management. The trials mainly included patients who failed antiarrhythmic medications. These trials have reported that most patients undergoing RFA were free of AF at 1 year. Quality of life was also improved in these trials for patients undergoing catheter ablation. A smaller number of studies have evaluated outcomes longer than 1 year and reported that late recurrences occur up to 5 years but were uncommon after the first year. Complications from RFA were reported at low rates in the RCTs but the number of patients in these trials are too small to accurately estimate rates of uncommon events. Two RCTs have evaluated the use of catheter ablation as an initial strategy for paroxysmal AF; 1 RCT demonstrated reduced rates of AF recurrence, while the other reported reduced cumulative overall AF burden.

Cryoablation

Numerous RCTs and non-RCTs have reported the use of cryoablation in patients with symptomatic paroxysmal or persistent AF who have failed antiarrhythmic drugs. Longer-term follow-up in these patients has also been reported.

Complications and Adverse Events

Several large, database studies have estimated the adverse event rate from catheter ablation in the clinical care setting. The range of major adverse events in these studies is from 4% to 9%. Deaths have been reported and have occurred at rates less than 1%. Vascular complications at the groin site are the most common adverse events, occurring at rates of up to 5%. Serious cardiovascular adverse events such as tamponade and stroke occur uncommonly, at rates of approximately 1% or lower. There is some evidence that new ischemic lesions are commonly found using MRI after the procedure but the clinical significance of these defects is unclear.

INDIVIDUALS WITH SYMPTOMATIC ATRIAL FIBRILLATION AND CONGESTIVE HEART FAILURE WHO HAVE FAILED RATE CONTROL AND ANTIARRHYTHMIC DRUGS**Clinical Context and Therapy Purpose**

The purpose of RFA or cryoablation is to provide a treatment option that is an alternative to or an improvement on existing therapies in patients with symptomatic AF and congestive heart failure who have failed rate control and antiarrhythmic drugs.

The question addressed in this evidence review is: Does the use of transcatheter ablation improve the net health outcome in patients with symptomatic atrial fibrillation and congestive heart failure who have failed rate control and antiarrhythmic drugs?

The following PICO was used to select literature to inform this review.

Populations

The relevant population of interest is individuals with symptomatic AF and congestive heart failure who have failed rate control and antiarrhythmic drugs. Rate control medication therapy includes calcium channel blockers, beta-blockers, and digoxin. Rhythm control medications include dronedarone and amiodarone.

Interventions

The therapy being considered is RFA or cryoablation.

Comparators

Comparators of interest include AV nodal ablation and pacemaker insertion. Atrioventricular node ablation is a cardiac catheterization procedure applying energy to the pathway connecting the upper chambers and lower chamber of the heart through a catheter. Although AV nodal ablation produces symptomatic improvement, it entails lifelong anticoagulation (due to ongoing fibrillation of the atria), loss of AV synchrony, and lifelong pacemaker dependency. Implantable defibrillators are contraindicated in patients with permanent AF. It is an invasive procedure indicated when other rate and rhythm control interventions have failed.

Outcomes

The general outcomes of interest are OS, symptoms, morbid events, and quality of life.

Study Selection Criteria

Methodologically credible studies were selected using the following principles

- To assess efficacy outcomes, comparative controlled prospective trials were sought, with a preference for RCTs;
- In the absence of such trials, comparative observational studies were sought, with a preference for prospective studies.
- To assess long-term outcomes and adverse events, single-arm studies that capture longer periods of follow-up and/or larger populations were sought.
- Studies with duplicative or overlapping populations were excluded.

REVIEW OF EVIDENCE

RADIOFREQUENCY ABLATION

Systematic Reviews

Zhu et al (2016) reported on a systematic review and meta-analysis of RCTs comparing catheter ablation with medical rate control in patients who had persistent AF and heart failure.⁵⁷ Three trials (N=143 ; range, 41 to 52) met reviewers' inclusion criteria, all of which used blinded outcome assessment and were considered to have a low risk of bias. For the meta-analysis' primary endpoint, compared with medical rate control, catheter ablation was associated with larger improvements in left ventricular end-diastolic fraction (mean difference, 6.22%; 95% CI, 0.7% to 11.74%; $I^2=63%$). Measures of peak oxygen capacity, New York Heart Association functional class, and quality of life scores were also significantly improved in the catheter RFA-treated groups.

In that same year, Anselmino et al (2016) reported on a systematic review of available observational studies and RCTs evaluating catheter ablation for AF in patients with chronic heart failure or structural cardiomyopathies.⁵⁸ For the population of patients with chronic heart failure, reviewers identified 17 observational studies, 4 RCTs, and 4 meta-analyses. Among the 4 RCTs, 1 compared catheter ablation with AV node ablation plus biventricular pacemaker insertion, and the others compared catheter ablation with optimal medical therapy plus rate control. In the pooled analysis, the mean efficacy of catheter ablation in maintaining sinus rhythm was 59% after a single procedure, increasing to 77% after a repeat procedure.

Vaidya et al (2015) reported on the results of a systematic review and meta-analysis of RCTs comparing pulmonary vein isolation, pharmacologic rate control, and AV junction ablation plus pacemaker insertion for AF.⁵⁹ Subgroup analyses focused on patients with congestive heart failure. Reviewers identified 7 RCTs, 2 comparing AV junction ablation plus pacemaker insertion with pharmacologic rate control, 1 comparing AV junction ablation plus pacemaker insertion with pharmacologic rate control and pacemaker insertion, 1 comparing pulmonary vein isolation with AV junction ablation plus biventricular pacing, and 3 comparing pulmonary vein isolation with pharmacologic rate control. Sample sizes ranged from 36 to 99 patients, with 425 patients across the 7 studies. When pulmonary vein isolation was compared with pharmacologic rate

control, based on 3 RCTs, pulmonary vein isolation-treated patients had higher increases in LVEF (WMD= +6.5; 95% CI, 0.6 to 12.5; p=.03). When pulmonary vein isolation was compared with AV junction ablation plus pacemaker insertion, based on 1 RCT, pulmonary vein isolation-treated patients had higher increases in LVEF (WMD = +9.0; 95% CI, 6.3 to 11.7; p<.01). Patients treated with pulmonary vein isolation had greater reductions in heart failure symptoms, measured by the Minnesota Living with Heart Failure Questionnaire compared with pharmacologic rate control, in 3 RCTs that included only patients with congestive heart failure (WMD = -11.0; 95% CI, -19.4 to -2.6; p=.01). Minnesota Living with Heart Failure Questionnaire scores also improved when pulmonary vein isolation was compared with AV junction ablation plus pacemaker insertion.

Randomized Controlled Trials

Hunter et al (2014) conducted an RCT comparing catheter RFA with medical rate control for patients who had persistent AF and symptomatic heart failure, with adequate rate control at the time of enrollment.³⁷ There was no requirement for patients to have failed antiarrhythmic drug therapy. The trial's primary endpoint was the difference between groups in LVEF at 6 months post-procedure. Fifty patients were randomized, 26 to catheter ablation and 24 to medical management. At 6 months, 81% of the catheter ablation group was free from recurrent AF and antiarrhythmic drugs. The LVEF at 6 months post-procedure was 40% in the catheter ablation group compared with 31% (p=.015) in the medical management group. Catheter ablation was also associated with improvements in health-related quality of life.

Jones et al (2013) reported on results from an RCT comparing catheter ablation with medical rate control for patients who had symptomatic heart failure, an LVEF of 35% or less, and persistent AF.⁶⁰ Fifty-two patients were randomized, 26 each to catheter ablation or medical rate control. At 12 months post-procedure, sinus rhythm was maintained in 88% of the catheter ablation group, with a single-procedure success rate of 68%. For the trial's primary outcome (peak oxygen consumption at 12 months post-procedure), there was a significant increase in peak consumption in the catheter ablation group (2.13 mL/kg/min) compared with a decrease in the medical management group (-0.94 mL/kg/min; mean difference, +3.07 mL/kg/min; 95% CI, 0.56 to 5.59 mL/kg/min; p=.018).

Kuck et al (2019) reported on results from the Atrial Fibrillation Management in Congestive Heart Failure With Ablation (AMICA) RCT that compared catheter ablation in addition to optimal medical treatment with optimal medical treatment alone. The AMICA enrolled patients with a documented episode of symptomatic persistent or longstanding persistent AF and seriously advanced heart failure, defined as New York Heart Association class II or III heart failure, an LVEF of 35% or less, and an indication for an implantable cardioverter defibrillator or cardiac resynchronization therapy defibrillator (CRT-D) therapy.⁶¹ A total of 140 patients were randomized, 68 to the ablation group and 72 to the medication alone group. At 1 year, no benefits of the catheter ablation group were revealed and the RCT was terminated early for futility.

Packer et al (2021) reported results on the subgroup of patients with heart failure at baseline in the Catheter Ablation vs Antiarrhythmic Drug Therapy for Atrial Fibrillation (CABANA) trial, which evaluated whether catheter ablation is more effective than conventional medical therapy to prevent major cardiovascular events in AF (main trial results summarized below).⁶² Out of

the 2204 patients randomized in the main trial, 35% (n=778) had heart failure at baseline. The CABANA primary endpoint was a composite of death, disabling stroke, serious bleeding, and/or cardiac arrest. For the subgroup with heart failure, RFA resulted in a significant reduction in the primary endpoint (HR, 0.64; 95% CI, 0.41 to 0.99) and all-cause mortality (HR, 0.57; 95% CI, 0.33 to 0.96) compared to drug therapy alone over a median follow-up of 48.5 months.

Cryoablation

A search of the existing literature revealed no published evidence on the use of cryoablation to treat individuals with AF with heart failure.

Section Summary: Individuals with Symptomatic Atrial Fibrillation and Congestive Heart Failure Who Have Failed Rate Control and Antiarrhythmic Drugs

Evidence from systematic reviews, RCTs, and an observational study have suggested that catheter ablation improves heart failure outcomes for patients with heart failure and coexisting AF. No literature on cryoablation was identified.

INDIVIDUALS WITH RECURRENT SYMPTOMATIC PAROXYSMAL ATRIAL FIBRILLATION

Clinical Context and Therapy Purpose

The purpose of RFA or cryoablation as an initial rhythm-control strategy is to provide a treatment option that is an alternative to or an improvement on existing therapies in patients with recurrent symptomatic paroxysmal AF.

The question addressed in this evidence review is: Does the use of transcatheter ablation result in improved health outcomes in patients with recurrent symptomatic paroxysmal AF?

The following PICO was used to select literature to inform this review.

Populations

The relevant population of interest is individuals with recurrent symptomatic paroxysmal AF. Untreated paroxysmal AF recurs with a variable frequency which may be as high as 70% within 5 years. Recurrent paroxysmal AF is a risk factor for progression to persistent or permanent AF with attendant risks for heart failure and stroke.

Interventions

The therapy being considered is RFA or cryoablation as an initial rhythm-control strategy.

Comparators

Comparators of interest include medication management.

Outcomes

The general outcomes of interest are OS, symptoms, morbid events, and quality of life.

Study Selection Criteria

Methodologically credible studies were selected using the following principles:

- To assess efficacy outcomes, comparative controlled prospective trials were sought, with a preference for RCTs;
- In the absence of such trials, comparative observational studies were sought, with a preference for prospective studies.
- To assess long-term outcomes and adverse events, single-arm studies that capture longer periods of follow-up and/or larger populations were sought.
- Studies with duplicative or overlapping populations were excluded.

REVIEW OF EVIDENCE

Systematic Reviews (Multiple Modalities)

Turagam et al (2021) published a systematic review with a meta-analysis of 6 RCTs to assess the efficacy and safety of catheter ablation versus antiarrhythmic drug therapy as first-line treatment in patients with paroxysmal AF.⁶³ Five of the 6 RCTs included in the meta-analysis are summarized in greater detail in the sections below (Medical Antiarrhythmic Treatment or Radiofrequency Ablation in Paroxysmal Atrial Fibrillation: A Randomized Prospective Multicentre Study [MANTRA-PAF], First Line Radiofrequency Ablation Versus Antiarrhythmic Drugs for Persistent Atrial Fibrillation Treatment [RAAFT]-2, STOP-AF First: Cryoballoon Catheter Ablation in Antiarrhythmic Drug Naive Paroxysmal Atrial Fibrillation, Early Aggressive Invasive Intervention for Atrial Fibrillation [EARLY-AF], Cryo-FIRST). Ablation was performed using RFA catheters and cryoballoon catheters in 3 RCTs each. Results demonstrated that catheter ablation significantly reduced the risk of recurrence of any atrial arrhythmia (both symptomatic and asymptomatic) including AF, atrial flutter, or atrial tachycardia (RR, 0.62; 95% CI, 0.51 to 0.74). Furthermore, there was a significant reduction in the rate of hospitalizations with catheter ablation versus antiarrhythmic drug therapy (RR, 0.32; 95% CI, 0.19 to 0.53). The risk of adverse events was similar between treatment groups (RR, 1.52; 95% CI, 0.81 to 2.85).

Elsayed et al (2021) published a systematic review with a meta-analysis of the same 6 RCTs as Turagam et al (2021), but stratified results by the type of catheter ablation technology used.⁶⁴ When compared to antiarrhythmic drug therapy, the overall risk of recurrence of any atrial arrhythmia was significantly reduced with RFA (odds ratio [OR], 0.31; 95% credible interval [CrI], 0.10 to 0.71); the risk reduction with cryoablation was borderline statistically significant (OR, 0.39; 95% CrI, 0.16 to 1.00). Similarly, RFA significantly reduced the risk of hospitalizations compared to antiarrhythmic drug therapy (OR, 0.08; 95% CrI, 0.01 to 0.99), whereas cryoablation did not (OR, 0.77; 95% CrI, 0.44 to 1.39). Freedom from symptomatic AF recurrence was not significantly reduced with either cryoablation or RFA compared to antiarrhythmic drug therapy, but pooled analysis that included both technologies showed a reduced risk of arrhythmia recurrence in favor of catheter ablation (OR, 0.35; 95% CrI, 0.13 to 0.79). The risk of serious adverse events rates did not significantly differ between either ablation technology and antiarrhythmic drug therapy. Treatment ranking based on the surface under the cumulative ranking curve put RFA as most likely to be the best treatment for reducing the overall rates of AF recurrence, symptomatic recurrence, and hospitalizations, whereas cryoablation was most likely to reduce serious adverse events.

Randomized Controlled Trials (Multiple Modalities)

Packer et al (2019) published results from the Catheter Ablation vs Antiarrhythmic Drug Therapy for Atrial Fibrillation (CABANA) trial, an international multicenter RCT designed to

determine whether catheter ablation is more effective than conventional medical therapy to prevent major cardiovascular events in AF.⁶⁵ A total of 2204 patients were enrolled and randomized 1:1 from November 2009 to April 2016. Follow-up was conducted through December 2017. Catheter ablation devices used energy sources available at the clinical trial site and with which investigators had the requisite expertise. The primary endpoint (a composite of death, disabling stroke, serious bleeding, and/or cardiac arrest) occurred in 8.0% of patients in the catheter ablation group and in 9.2% of patients in the drug therapy group (HR, 0.86; 95% CI, 0.65 to 1.15; $p=.30$). There were 13 prespecified secondary outcomes; 3 of which were reported. All-cause mortality did not differ between groups. Death or cardiovascular hospitalization and AF recurrence were statistically significantly reduced in the catheter ablation group.

Mark et al (2019) published the results of 12-month quality of life outcomes (median follow-up of 48.5 months) for participants in the CABANA trial.⁶⁶ The Atrial Fibrillation Effect on Quality-of-Life (AFEQT) mean summary score in the catheter ablation group was 86.4 points versus 80.9 points in the drug therapy group (adjusted difference 5.3 points [95% CI, 3.7 to 6.9]; $p<.001$). The AFEQT scores range from 0 (complete AF-related disability) to 100 (no AF-related disability) and a change in score of ≥ 5 is considered a clinically meaningful difference (adjusted difference, -1.5 points; 95% CI, -2.0 to 1.1; $p<.001$). The trial used a modified Mayo AF-Specific Symptom Inventory (MAFSI) questionnaire combining frequency scores ranging from 0 to 4 (never to always) and severity scores ranging from 0 (no AF symptoms) to 40 (most severe AF symptoms). The investigators suggested a trial-specific clinically meaningful change of 1.6 points for the frequency score and 1.3 points for the severity score.

Blomstrom-Lundqvist et al (2019) published the results of the Catheter Ablation compared with Pharmacological Therapy for Atrial Fibrillation trial, an RCT designed to assess the quality of life after catheter ablation compared to medical therapy.⁶⁷ The primary outcome at 12 months was the difference in the General Health subscale score. The quality of life score increases in the catheter ablation group from 61.8 to 73.9 points versus 62.7 to 65.4 points in the medication group (95% CI, 3.1 to 14.7; $p=.003$).

RADIOFREQUENCY ABLATION

Systematic Reviews

Hakalathi et al (2015) reported on a systematic review and meta-analysis of RCTs comparing RFA with antiarrhythmic drug therapy as first-line therapy for symptomatic AF.⁶⁸ They selected 3 trials (N=491), including the RAAFT-2 (2014)⁶⁹ and MANTRA-PAF (2012)⁷⁰, trials (described below) and the earlier RAAFT-1 trial. The RAAFT-2 and MANTRA-PAF were considered to be at low risk of bias. RFA was associated with lower risk of recurrence of AF (RR, 0.63; 95% CI, 0.44 to 0.92; $p=.02$; $I^2=38\%$).

RANDOMIZED CONTROLLED TRIALS

First Line Radiofrequency Ablation Versus Antiarrhythmic Drugs for Persistent Atrial Fibrillation Treatment (RAAFT-2)

Morillo et al (2014) published results of the RAAFT-2 trial, an RCT comparing RFA with antiarrhythmic drug therapy as first-line therapy for paroxysmal AF.⁶⁹ Eligible patients had

symptomatic recurrent paroxysmal AF lasting more than 30 seconds, with 4 or fewer episodes in the prior 6 months and had had no previous antiarrhythmic drug treatment. The trial enrolled 127 patients at 16 centers; 66 were randomized to RFA and 61 to antiarrhythmic drug therapy, at the discretion of the treating physician. In the RFA group, 63 underwent ablation; during follow-up, 9 underwent re-ablation and 6 crossed over to receive antiarrhythmic drug therapy. In the drug therapy group, 26 crossed over to undergo ablation and 24 discontinued antiarrhythmic drug therapy but continued in the trial. Analysis was ITT. Patients were followed with biweekly scheduled trans-telephonic monitor recordings and symptomatic recordings through the 24-month follow-up period. The trial's primary outcome (recurrence of any atrial tachyarrhythmia lasting >30 seconds) occurred in 72.1% (n=44) in the antiarrhythmic drug group compared with 54.5% (n=36) in the ablation group (HR, 0.56; 95% CI, 0.35 to 0.90; p=.02). Fewer patients in the RFA group had recurrence of symptomatic AF, atrial flutter, or atrial tachycardia (47% vs 59%; HR, 0.56; 95% CI, 0.33 to 0.95; p=.03) or recurrence of symptomatic AF (41% vs 57%; HR, 0.52; 95% CI, 0.3 to 0.89; p=.02). Quality of life measures did not differ significantly between groups.

Medical Antiarrhythmic Treatment or Radiofrequency Ablation in Paroxysmal Atrial Fibrillation: A Randomized Prospective Multicentre Study (MANTRA-PAF)

An earlier RCT (MANTRA-PAF) that evaluated RFA as the initial therapy for paroxysmal AF was reported by Cosedis Nielsen et al (2012).⁷⁰ A total of 294 patients were randomized to initial treatment with catheter ablation or to pharmacologic therapy. Patients were followed for 24 months for the primary outcomes of the burden of AF (percentage of time in AF on a Holter monitor) at each time point and cumulative burden of AF over all time points. For individual time points, the burden of AF was lower in the catheter RFA group only at 24 months (9% vs 18%, p=.007). The 90th percentile cumulative burden did not differ significantly between groups (13% vs 19%; p=.10). The secondary outcome of a percentage of patients free from AF at 24 months was greater for the catheter ablation group (85% vs 71%, p=.004), as was the secondary outcome of freedom from symptomatic AF (93% vs 84%, p=.01). There was 1 death in the ablation group (due to a procedural-related stroke), and 3 patients in that group developed cardiac tamponade following the procedure.

Five-year follow-up from MANTRA-PAF was reported by Nielsen et al (2017).⁷¹ Follow-up was available for 245 (83%) of 294 patients, of whom 227 had Holter recordings. The randomized groups did not differ significantly in terms of their availability for follow-up. On ITT analysis, significantly more patients in the RFA group were free from any AF (126/146 [86%]) than those in the pharmacologic therapy group (105/148 [71%]; RR, 0.82; 95% CI, 0.73 to 0.93; p=.001). Symptomatic AF burden was also significantly lower in the RFA group, although quality of life scores did not differ between groups.

CRYOABLATION

Randomized Controlled Trials

Andrade et al (2021) evaluated the efficacy of first-line cryoablation in patients with symptomatic, paroxysmal, untreated AF as compared to antiarrhythmic drug therapy for initial rhythm control (EARLY-AF trial).⁷² The primary outcome was the first documented recurrence of any atrial tachycardia between 91 and 365 days after catheter ablation or the initiation of medication. A total of 303 patients were randomized to undergo cryoablation (n=154) or to

receive antiarrhythmic drug therapy (n=149) and followed for 12 months. At 12 months, recurrence of atrial tachyarrhythmia occurred in 42.9% of patients receiving cryoablation and 67.8% of patients receiving antiarrhythmic drugs (HR, 0.48; 95% CI, 0.35 to 0.66, $p < .001$). Symptomatic atrial tachyarrhythmia recurred in 11.0% assigned to cryoablation as compared to 26.2% assigned to receive antiarrhythmic drugs (HR, 0.39; 95% CI, 0.22 to 0.68).

Kuniss et al (2021) evaluated the efficacy of first-line cryoablation in patients with symptomatic, paroxysmal, untreated AF as compared to antiarrhythmic drug therapy for initial rhythm control (Cryo-FIRST trial).⁷³ The primary endpoint was ≥ 1 episode of recurrent atrial arrhythmia (AF, atrial flutter, or atrial tachycardia) > 30 seconds after a prespecified 90-day blanking period. A total of 218 patients were randomized to cryoablation or antiarrhythmic drug therapy. At month 12, freedom from atrial arrhythmia was achieved in 82.2% of participants in the cryoablation group and 67.6% of participants in the antiarrhythmic drug therapy group (HR, 0.48; $p = .01$). Pavlovic et al (2021) reported certain quality of life outcomes in the Cryo-FIRST trial that were likewise significantly improved. Symptomatic palpitations were significantly reduced with cryoablation versus antiarrhythmic drug therapy.⁷⁴ At 12 months, the mean adjusted difference in the AFEQT summary score was 9.9 points higher in the cryoablation group (95% CI, 5.5 to 14.2; $p < .001$). Conversely, while improvements in the 36-Item Short Form Survey (SF-36) summary score exceeded the clinically important difference (i.e., 2 points) in both groups, the between-group difference did not reach statistical significance. Palpitations were experienced by 28% of patients in the cryoablation group and 44.1% of patients in the antiarrhythmic drug therapy group ($p < .001$).

Wazni et al (2021) also evaluated the efficacy of first-line cryoablation in patients with symptomatic, paroxysmal, untreated AF as compared to antiarrhythmic drug therapy (STOP-AF trial).⁷⁵ The primary outcome was treatment success (freedom from initial failure of the procedure or atrial arrhythmia recurrence after a 90-day blanking period) at 1 year. A total of 203 patients were randomized to undergo cryoablation (104 patients) or to receive antiarrhythmic drug therapy (99 patients). In the cryoablation group, 97% achieved initial success with the procedure. At month 12, Kaplan-Meier estimates of the percentage of patients with treatment success were 74.6% (95% CI, 65.0 to 82.0) in the ablation group and 45.0% (95% CI, 34.6 to 54.7) in the drug-therapy group ($p < .001$). Wazni et al (2021) separately reported that cryoablation significantly improved quality of life outcomes in the STOP-AF trial.⁷⁶ A clinically meaningful improvement (i.e., > 5 points) in the AFEQT summary score from baseline to 12 months was observed in 96.0% of patients in the cryoablation group and 72.2% of patients in the antiarrhythmic drug therapy group ($p < .001$). However, there were no statistically significant between-group differences for the change in the European Quality of Life–5 Dimensions index or visual analog scale scores. After a 90-day blanking period, a higher proportion of patients in the cryoablation versus antiarrhythmic drug therapy group reported no AF-specific symptom recurrence (54.4% vs 29.7; $p = .0005$).

Section Summary: Individuals with Recurrent Symptomatic Paroxysmal Atrial Fibrillation

Numerous systematic reviews and RCTs, including those that evaluated long-term outcomes, have evaluated RFA and cryoablation in patients with recurrent symptomatic paroxysmal AF. The CABANA trial noted that the use of RFA did not show significant improvement over medications. However, 3 RCTs comparing cryoablation to antiarrhythmic drug therapy as first-

line therapy demonstrated improved outcomes for atrial arrhythmia recurrence up to 1 year. In a meta-analysis of 6 RCTs, catheter ablation as first-line therapy in patients with paroxysmal AF significantly reduced the risk of recurrence of atrial arrhythmia and the rate of hospitalizations when compared to antiarrhythmic drug therapy. In another meta-analysis of the same RCTs, treatment ranking based on surface under the cumulative ranking curve put RFA as most likely to be the best treatment for reducing the overall rates of AF recurrence, symptomatic recurrence, and hospitalizations, whereas cryoablation was most likely to reduce serious adverse events.

Summary of Evidence

For individuals who have symptomatic paroxysmal or persistent AF who have failed antiarrhythmic drugs who receive RFA or cryoablation, the evidence includes multiple RCTs and systematic reviews. Relevant outcomes are OS, symptoms, morbid events, and quality of life. The RCTs comparing RFA with antiarrhythmic medications have reported that freedom from AF is more likely after ablation than after medications. Results of long-term follow-up (5 to 6 years) after ablation have demonstrated that late recurrences continue in patients who are free of AF at 1 year. However, most patients who are AF-free at 1 year remain AF-free at 4 to 6 years. Radio frequency ablation and cryoablation differ in their adverse event profiles. For example, cryoablation is associated with higher rates of phrenic nerve paralysis but may permit a shorter procedure time. Given current data, it would be reasonable to consider both RFA and cryoablation effective for catheter ablation of AF foci or pulmonary vein isolation, provided there is a discussion about the risks and benefits of each. The evidence is sufficient to determine that the technology results in an improvement in the net health outcome.

For individuals who have symptomatic AF and congestive heart failure who have failed rate control and antiarrhythmic drugs who receive RFA or cryoablation, the evidence includes RCTs and systematic reviews. Relevant outcomes are OS, symptoms, morbid events, and quality of life. Findings from the RCTs have been supported by other comparative studies, which have reported improvements in AF. It is reasonable to consider both RFA and cryoablation effective for catheter ablation of AF foci or pulmonary vein isolation, provided that there is a discussion about the risks and benefits of each. The evidence is sufficient to determine that the technology results in an improvement in the net health outcome.

For individuals who have recurrent symptomatic paroxysmal AF who receive RFA or cryoablation as an initial rhythm-control strategy, the evidence includes RCTs, nonrandomized studies, and systematic reviews. Relevant outcomes are OS, symptoms, morbid events, and quality of life. One RCT with adequate follow-up compared pulmonary vein isolation by catheter ablation (using either cryoablation or RFA) to medical therapy. Catheter ablation was not superior to medical therapy for major cardiovascular outcomes, but secondary outcomes including AF recurrence favored catheter ablation. Quality of life measures reported in this RCT favored catheter ablation. Two other RCTs with low-risk of bias compared RFA for pulmonary vein isolation with antiarrhythmic medications. One RCT demonstrated reduced rates of AF recurrence, while the other reported reduced cumulative overall AF burden. Additionally, 3 RCTs comparing cryoablation to antiarrhythmic drug therapy as first-line therapy demonstrated improved outcomes for atrial arrhythmia recurrence up to 1 year. In a meta-analysis of 6 RCTs, catheter ablation as first-line therapy significantly reduced the risk of recurrence of atrial arrhythmia and the rate of hospitalizations compared to antiarrhythmic drug therapy. In another

meta-analysis of the same RCTs, treatment ranking based on the surface under the cumulative ranking curve put RFA as most likely to be the best treatment for reducing the overall rates of AF recurrence, symptomatic recurrence, and hospitalizations, whereas cryoablation was most likely to reduce serious adverse events. Together, these results suggest that, when a rhythm-control strategy is desired, catheter ablation using RFA or cryoablation is a reasonable alternative to antiarrhythmic drug therapy. The evidence is sufficient to determine that the technology results in an improvement in the net health outcome.

SUPPLEMENTAL INFORMATION

The purpose of the following information is to provide reference material. Inclusion does not imply endorsement or alignment with the evidence review conclusions.

Clinical Input From Physician Specialty Societies and Academic Medical Centers

While the various physician specialty societies and academic medical centers may collaborate with and make recommendations during this process, through the provision of appropriate reviewers, input received does not represent an endorsement or position statement by the physician specialty societies or academic medical centers, unless otherwise noted.

2015 Input

In response to requests, input was received from 3 physician specialty societies (6 reviewers) and 4 academic medical centers while this policy was under review in 2015. Input focused on the use of ablation as an initial procedure for symptomatic paroxysmal and persistent atrial fibrillation (AF) and the use of cryoablation for AF. There was consensus supporting the use of radiofrequency ablation (RFA) as an initial treatment for symptomatic paroxysmal AF, and the use of cryoablation as an alternative to RFA as a treatment for AF. For the use of RFA as initial treatment for symptomatic persistent AF, support from clinical input was more mixed.

2011 Input

In response to requests, input was received from 2 physician specialty societies (3 reviewers) and 2 academic medical centers while this policy was under review in 2011. While the input was mixed, there was general agreement with the policy statements. One reviewer commented that the use of cryoablation might have a specific role when ablation targets are close to the atrioventricular (AV)node.

Practice Guidelines and Position Statements

Guidelines or position statements will be considered for inclusion in 'Supplemental Information' if they were issued by, or jointly by, a US professional society, an international society with US representation, or National Institute for Health and Care Excellence (NICE). Priority will be given to guidelines that are informed by a systematic review, include strength of evidence ratings, and include a description of management of conflict of interest.

American Heart Association

In 2021, the American Heart Association published a scientific statement regarding the management of atrial fibrillation in patients with heart failure.⁷⁷ The statement included the following:

"In patients with AF and heart failure with reduced ejection fraction (HFrEF) who already have an indication for a cardiac resynchronization therapy defibrillator (CRT-D) device such as left bundle-branch block (LBBB) and in whom AF remains poorly controlled despite maximum efforts at restoration and maintenance of sinus rhythm or pharmacological rate control, atrioventricular node (AVN) ablation should be considered for rate control and promotion of adequate biventricular pacing

- In patients with AF and HFrEF who have a narrow QRS but in whom AF remains poorly controlled despite maximum efforts at restoration and maintenance of sinus rhythm or pharmacological rate control, a strategy of AV node ablation with cardiac resynchronization therapy (CRT) implantation is reasonable
- In patients with AF and HFrEF, surgical AF ablation is reasonable in those patients undergoing concomitant cardiac surgery"

Heart Rhythm Society et al

In 2012, an expert consensus document on catheter and surgical catheter ablation for AF was developed jointly by 7 cardiac specialty societies (Heart Rhythm Society, European Heart Rhythm Association, European Cardiac Arrhythmia Society, American College of Cardiology, American Heart Association, Asia Pacific Heart Rhythm Society, Society of Thoracic Surgeons).⁷⁸ A related group of cardiac specialty societies (Heart Rhythm Society, European Heart Rhythm Association, European Cardiac Arrhythmia Society, Asia Pacific Heart Rhythm Society, Latin American Society of Cardiac Stimulation and Electrophysiology) updated these guidelines in 2017,⁷⁹ suggesting the following recommendations for catheter ablation (see Table 2).

Table 2. Guidelines for Management of Catheter Ablation for Atrial Fibrillation

Recommendation	COR	LOE
Symptomatic AF refractory or intolerant to at least 1 class 1 or 3 antiarrhythmic medication		
Paroxysmal: Catheter ablation is recommended	I	A
Persistent: Catheter ablation is reasonable	IIa	B-NR
Long-standing persistent: Catheter ablation may be considered	IIb	C-LD
Symptomatic AF prior to initiation of antiarrhythmic drug therapy with a class 1 or 3 antiarrhythmic agent		
Paroxysmal: Catheter ablation is reasonable	IIa	B-R
Persistent: Catheter ablation may be considered	IIa	C-EO
Longstanding Persistent: Catheter ablation may be considered	IIb	C-EO

AF: atrial fibrillation; COR: class of recommendation; LOE: level of evidence.

American College of Cardiology et al

In 2014, the American College of Cardiology, American Heart Association, and Heart Rhythm Society (ACC/AHA/HRS) issued guidelines for the management of patients with AF.⁸⁰ In 2019, the ACC/AHA/HRS conducted a focused update of areas for which new evidence had emerged since the 2014 publication.⁸¹ Together, the guidelines included the following recommendations for rate control and rhythm control (see Table 3).

Table 3. Guidelines for Rate and Rhythm in Management of Atrial Fibrillation

Recommendation	COR	LOE
Rate control		
"AV nodal ablation with permanent ventricular pacing is reasonable to control heart rate when pharmacological therapy is inadequate and rhythm control is not achievable."	I	B
"AV nodal ablation with permanent ventricular pacing should not be performed to improve rate control without prior attempts to achieve rate control with medications."	III ^a	C
Rhythm control		
"AF catheter ablation is useful for symptomatic paroxysmal AF refractory or intolerant to at least 1 class I or III antiarrhythmic medication when a rhythm-control strategy is desired."	I	A
"Before consideration of AF catheter ablation, assessment of the procedural risks and outcomes relevant to the individual patient is recommended."	I	C
"AF catheter ablation is reasonable for some patients with symptomatic persistent AF refractory or intolerant to at least 1 class I or III antiarrhythmic medication."	IIa	A
"In patients with recurrent symptomatic paroxysmal AF, catheter ablation is a reasonable initial rhythm-control strategy before therapeutic trials of antiarrhythmic drug therapy, after weighing the risks and outcomes of drug and ablation therapy."	IIa	B
"AF catheter ablation may be considered for symptomatic long-standing (>12 months) persistent AF refractory or intolerant to at least 1 class I or III antiarrhythmic medication when a rhythm-control strategy is desired)."	IIb	B
"AF catheter ablation may be considered before initiation of antiarrhythmic drug therapy with a class I or III antiarrhythmic medication for symptomatic persistent AF when a rhythm-control strategy is desired."	IIb	C
"AF catheter ablation should not be performed in patients who cannot be treated with anticoagulant therapy during and after the procedure."	III ^a	C
"AF catheter ablation to restore sinus rhythm should not be performed with the sole intent of obviating the need for anticoagulation."	III ^a	C
"AF catheter ablation may be reasonable in selected patients with symptomatic AF and HF with reduced LV ejection fraction (HFrEF) to potentially lower mortality rate and reduce hospitalization for HF"	IIb	B-R

AF: atrial fibrillation; AV: atrioventricular ; COR: class of recommendation; HF: Heart Failure; HFrEF: heart failure with left ventricular ejection fraction; LOE: level of evidence; LV: left ventricular.

^a Not recommended.

Although the guidelines did not make a specific recommendation on the use of cryoablation, they did state that "Cryoballoon ablation is an alternative to point-by-point RFA to achieve pulmonary vein isolation."

U.S. Preventive Services Task Force Recommendations

Not applicable.

Ongoing and Unpublished Clinical Trials

Current Procedural Terminology © American Medical Association. All Rights Reserved.
Blue Cross and Blue Shield Kansas is an independent licensee of the Blue Cross Blue Shield Association

Some currently ongoing and unpublished trials that might influence this review are listed in Table 4.

Table 4. Summary of Key Trials

NCT No.	Trial Name	Planned Enrollment	Completion Date
<i>Ongoing</i>			
NCT04942171	EMOTIon and COgNitive Function After Atrial FibrillationCatheter Ablation vs. Medical Therapy; Randomized Clinical Trial (EMOTICON Trial)	320	Feb 2026
NCT02150902	Augmented Wide Area Circumferential Catheter Ablation for Reduction of Atrial Fibrillation Recurrence (AWARE)	396	Jan 2022
NCT03365700	Cryoballoon Versus Conventional Radiofrequency Ablation for Persistent Atrial Fibrillation With AF Duration < 2 Years: the IRON-ICE Trial	303	Aug 2020 (last updated Feb 2018)
NCT04037397	First Line Radiofrequency Ablation Versus Antiarrhythmic Drugs for Persistent Atrial Fibrillation Treatment (RAAFT-3)	120	Mar 2025
<i>Unpublished</i>			
NCT01420393	A Randomized Ablation-based Atrial Fibrillation Rhythm Control Versus Rate Control Trial in Patients With Heart Failure and High Burden Atrial Fibrillation (RAFT-AF)	411	Jun 2021
NCT02106663	Evaluating the Efficacy of Circumferential Pulmonary Vein Ablation (CPVA) Versus Segmental Pulmonary Vein Isolation (SPVI) in Paroxysmal Atrial Fibrillation	100	Dec 2021

NCT: national clinical trial.

CODING

The following codes for treatment and procedures applicable to this policy are included below for informational purposes. This may not be a comprehensive list of procedure codes applicable to this policy.

Inclusion or exclusion of a procedure, diagnosis or device code(s) does not constitute or imply member coverage or provider reimbursement. Please refer to the member's contract benefits in effect at the time of service to determine coverage or non-coverage of these services as it applies to an individual member.

The code(s) listed below are medically necessary ONLY if the procedure is performed according to the "Policy" section of this document.

CPT/HCPCS	
93655	Intracardiac catheter ablation of a discrete mechanism of arrhythmia which is distinct from the primary ablated mechanism, including repeat diagnostic maneuvers, to treat a spontaneous or induced arrhythmia (List separately in addition to code for primary procedure)
93656	Comprehensive electrophysiologic evaluation including transeptal catheterizations, insertion and repositioning of multiple electrode catheters with induction or attempted induction of an arrhythmia including left or right atrial pacing/recor 3-dimensional mapping and echocardiography when necessary, right ventricular pacing recording when necessary, and His bundle recording when necessary with intracardiac catheter ablation of atrial fibrillation by pulmonary vein isolation
93657	Additional linear or focal intracardiac catheter ablation of the left or right atrium for treatment of atrial fibrillation remaining after completion of pulmonary vein isolation (List separately in addition to code for primary procedure)
93799	Unlisted cardiovascular service or procedure

ICD-10 DIAGNOSES	
I48.0	Paroxysmal atrial fibrillation
I48.11	Longstanding persistent atrial fibrillation
I48.19	Other persistent atrial fibrillation
I48.20	Chronic atrial fibrillation, unspecified
I48.21	Permanent atrial fibrillation
I48.3	Typical atrial flutter
I48.4	Atypical atrial flutter
I50.21-I50.43	Congestive heart failure code range

REVISIONS	
03-30-2007	Previously this policy was an Experimental / Investigational policy under the title of Pulmonary Vein Isolation and Ablation as a Treatment of Atrial Fibrillation. The

REVISIONS	
	guideline changed on 03/30/07 considering the procedure medically necessary at the approval of the Medical Director with specific guidelines.
05-2-2007	The guideline was approved by Cardiology Liaison Committee with removal of the 93651 CPT code. The Medical Director approved the policy for placement on the web site.
11-17-2007	Changed Title from: "Transcatheter Radiofrequency Ablation as a Treatment of Atrial Fibrillation" To: "Radiofrequency Catheter Ablation of the Pulmonary Veins as Treatment for Atrial Fibrillation" Added Description section. In Policy Section: <ul style="list-style-type: none"> ▪ Liberalized #2 to require "Is resistant to one or more antiarrhythmic drugs..." instead of two or more antiarrhythmic drugs.
01-26-2010	Title: <ul style="list-style-type: none"> ▪ Changed From: Transcatheter Radiofrequency Ablation as a Treatment of Atrial Fibrillation To: Radiofrequency Catheter Ablation of the Pulmonary Veins as Treatment for Atrial Fibrillation Description Section updated. In Policy Section: <ul style="list-style-type: none"> ▪ Liberalized #2 requiring "one or more antiarrhythmic drugs" rather than "two or more antiarrhythmic drugs" Added Rationale Section Updated References Section
10-08-2010	In policy section: <ul style="list-style-type: none"> ▪ Remove "in the pulmonary vein" to read "Transcatheter radiofrequency ablation of arrhythmogenic foci is considered medically necessary as a treatment of atrial fibrillation when the patient..." In Rationale Section: <ul style="list-style-type: none"> ▪ Added August 2010 Updated Reference Section <ul style="list-style-type: none"> ▪ Added references 19-26 Updated Other References Section: <ul style="list-style-type: none"> ▪ Added Blue Cross and Blue Shield of Kansas Cardiology Liaison Committee, April 2010
03-28-2011	Description section updated. Reference section updated. Reference section updated.
06-06-2011	Incorrect effective date noted and corrected. Removed "January 26, 2010" and inserted correct effective dates "October 8, 2010" for the Professional side, "November 8, 2010" for the Institutional side.
08-24-2012	Description section updated. Rationale section updated. Reference section updated.
01-15-2013	In the Coding section: <ul style="list-style-type: none"> ▪ Removed CPT codes: 93651 (Effective 12-31-2012) ▪ Added new CPT codes: 93653, 93654, 93655, 93656, 93657 (Effective 01-01-2013)
06-14-2013	Rational section updated.

REVISIONS	
	Reference section updated.
	In Coding section: <ul style="list-style-type: none"> Added ICD-10 Diagnosis codes (<i>Effective October 1, 2014</i>)
07-10-2015	In Policy title: <ul style="list-style-type: none"> Changed from "Radiofrequency Catheter Ablation of the Pulmonary Veins as a Treatment for Atrial Fibrillation"
	Updated Description section.
	In Policy section: <ul style="list-style-type: none"> In Item A, removed "of atrial fibrillation when the patient" and added "for either of the following indications which have failed to respond to adequate trials of antiarrhythmic medications" to read "Transcatheter radiofrequency ablation of arrhythmogenic foci is considered medically necessary as a treatment for either of the following indications which have failed to respond to adequate trials of antiarrhythmic medications:" In Item A 1, removed "Has markedly symptomatic paroxysmal or persistent atrial fibrillation, and" and added "Symptomatic paroxysmal or symptomatic persistent atrial fibrillation; OR" In Item A 2, removed "Is resistant to one or more antiarrhythmic drugs (or has intolerance or a contraindication to appropriate antiarrhythmic drug therapy)" and added "As an alternative to atrioventricular nodal ablation and pacemaker insertion in patients with class II or III congestive heart failure and symptomatic atrial fibrillation" Added Item B, "Repeat radiofrequency ablations may be considered medically necessary in patients with recurrence of atrial fibrillation and/or development of atrial flutter following the initial procedure. (See Policy Guidelines)" Added Item C, "Transcatheter ablation of arrhythmogenic foci is considered experimental / investigational as a treatment for all indications except for specific cases of atrial fibrillation as noted above." Added Item D, "Transcatheter cryoablation of arrhythmogenic foci as a treatment for atrial fibrillation is considered experimental / investigational." In Policy Guidelines, added a new Item #2; the previous Item #2 is now Item #3.
	Updated Rationale section.
	In Coding section: <ul style="list-style-type: none"> Removed CPT Codes 93653, 93654, and 93655.
	Updated References section.
10-27-2015	Updated Description section.
	In Policy section: <ul style="list-style-type: none"> In Item A (formerly Item C), removed "of arrhythmogenic foci is," "experimental / investigational," and "as a treatment for all indications except for specific cases of atrial fibrillation" and added "radiofrequency," "or cryoablation to treat atrial fibrillation may be," "medically necessary as an initial treatment for patients with symptomatic paroxysmal atrial fibrillation in whom a rhythm-control strategy is desired" to read, "Transcatheter radiofrequency ablation or cryoablation to treat atrial fibrillation may be considered medically necessary as an initial treatment for patients with symptomatic paroxysmal atrial fibrillation in whom a rhythm-control strategy is desired." In Item B (formerly Item A), removed "of arrhythmogenic foci is" and added "or cryoablation to treat atrial fibrillation may be" and "(or has intolerance of or a contraindication to appropriate antiarrhythmic medications)" to read, "Transcatheter radiofrequency ablation or cryoablation to treat atrial fibrillation

REVISIONS	
	<p>may be considered medically necessary as a treatment for either of the following indications which have failed to respond to adequate trials of antiarrhythmic medications (or has intolerance of or a contraindication to appropriate antiarrhythmic medications):"</p> <ul style="list-style-type: none"> ▪ In Item C (formerly Item B), added "or cryoablation" to read, "Repeat radiofrequency ablation or cryoablation may be considered medically necessary in patients with recurrence of atrial fibrillation and/or development of atrial flutter following the initial procedure. (see Policy Guidelines)" ▪ In Item D, removed "of arrhythmogenic foci as a treatment for," and added "radiofrequency ablation or," "to treat," and "as a treatment for cases of atrial fibrillation that do not meet the criteria outlined above" to read, "Transcatheter radiofrequency ablation or cryoablation to treat atrial fibrillation is considered experimental / investigational as a treatment for cases of atrial fibrillation that do not meet the criteria outlined above." <p>In Policy Guidelines:</p> <ul style="list-style-type: none"> ▪ In Item 1, removed all prior verbiage and added "Transcatheter treatment of atrial fibrillation may include pulmonary vein isolation and/or focal ablation." <p>Updated Rationale section.</p> <p>Updated References section.</p>
10-01-2015	<p>Policy published 05-11-2016. Effective 10-01-2015 with ICD-10 coding implementation.</p> <p>In Coding section:</p> <ul style="list-style-type: none"> ▪ Added ICD-10 code I48.0
06-22-2016	<p>Updated Description section.</p> <p>Updated Rationale section.</p> <p>Updated References section.</p>
07-01-2017	<p>Updated Description section.</p> <p>In Policy section:</p> <ul style="list-style-type: none"> ▪ In Policy Guidelines Item 2, removed ", but several variations" to read, "There is no single procedure for catheter ablation." Removed "also" to read, "Electrical isolation of the pulmonary vein musculature (pulmonary vein isolation) is the cornerstone of most AF ablation procedures, but additional ablation sites may be included during the initial ablation." ▪ In Policy Guidelines Item 3, removed "because of", "of the", and "were" and added "due to", "to", "of", "may have been", and "in scope" to read "As many as 30% of patients will require a follow-up (repeat) procedure due to recurrence of atrial fibrillation or to development of atrial flutter. In most published studies, success rates may have been based on having as many as 3 separate procedures, although these repeat procedures may be more limited in scope than the initial procedure." <p>Updated Rationale section.</p> <p>In Coding section:</p> <ul style="list-style-type: none"> ▪ Updated nomenclature to CPT codes: 93656, 93657. <p>Updated References section.</p>
06-22-2018	<p>Updated Description section.</p> <p>Updated Rationale section.</p> <p>In Coding section:</p> <ul style="list-style-type: none"> ▪ Added CPT code: 93655. ▪ Removed ICD-9 codes. <p>Updated References section.</p>
08-28-2019	<p>Updated Description section.</p>

REVISIONS	
	In Policy section: <ul style="list-style-type: none"> ▪ In Item B, added "recurrent" to read, "Transcatheter radiofrequency ablation or cryoablation to treat atrial fibrillation may be considered medically necessary as an initial treatment for patients with recurrent symptomatic paroxysmal atrial fibrillation in whom a rhythm-control strategy is desired."
	Updated Rationale section.
	Updated References section.
10-01-2019	In Coding section: <ul style="list-style-type: none"> ▪ Added ICD-10 codes: I48.11, I48.19, I48.20, I48.21 ▪ Removed ICD-10 codes: I48.1, I48.2
03-23-2021	Updated Description section.
	Updated Rationale section.
	Updated References section.
07-02-2021	Rational section updated.
	Reference section updated.
01-03-2022	In Coding section <ul style="list-style-type: none"> ▪ Revised nomenclature CPT 93656: ▪ Additions to code descriptor to indicate that the service includes 3-dimensional mapping and echocardiography
07-01-2022	Updated Description Section
	Updated Rationale Section
	Updated coding Section <ul style="list-style-type: none"> ▪ Converted ICD-10 codes to ranges
	Updated References Section

REFERENCES

1. Lee MA, Weachter R, Pollak S, et al. The effect of atrial pacing therapies on atrial tachyarrhythmia burden and frequency: results of a randomized trial in patients with bradycardia and atrial tachyarrhythmias. *J Am Coll Cardiol.* Jun 04 2003; 41(11): 1926-32. PMID 12798559
2. Kay GN, Ellenbogen KA, Giudici M, et al. The Ablate and Pace Trial: a prospective study of catheter ablation of the AV conduction system and permanent pacemaker implantation for treatment of atrial fibrillation. *APT Investigators. J Interv Card Electrophysiol.* Jun 1998; 2(2): 121-35. PMID 9870004
3. Falk RH. Management of atrial fibrillation--radical reform or modest modification?. *N Engl J Med.* Dec 05 2002; 347(23): 1883-4. PMID 12466514
4. Van Gelder IC, Hagens VE, Bosker HA, et al. A comparison of rate control and rhythm control in patients with recurrent persistent atrial fibrillation. *N Engl J Med.* Dec 05 2002; 347(23): 1834-40. PMID 12466507
5. Wyse DG, Waldo AL, DiMarco JP, et al. A comparison of rate control and rhythm control in patients with atrial fibrillation. *N Engl J Med.* Dec 05 2002; 347(23): 1825-33. PMID 12466506
6. Gupta A, Perera T, Ganesan A, et al. Complications of catheter ablation of atrial fibrillation: a systematic review. *Circ Arrhythm Electrophysiol.* Dec 2013; 6(6): 1082-8. PMID 24243785

7. Shemin RJ, Cox JL, Gillinov AM, et al. Guidelines for reporting data and outcomes for the surgical treatment of atrial fibrillation. *Ann Thorac Surg.* Mar 2007; 83(3): 1225-30. PMID 17307507
8. Fuster V, Ryden LE, Cannom DS, et al. ACC/AHA/ESC 2006 guidelines for the management of patients with atrial fibrillation--executive summary: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines and the European Society of Cardiology Committee for Practice Guidelines (Writing Committee to Revise the 2001 Guidelines for the Management of Patients With Atrial Fibrillation). *J Am Coll Cardiol.* Aug 15 2006; 48(4): 854-906. PMID 16904574
9. Blue Cross and Blue Shield Association Technology Evaluation Center (TEC). Catheter ablation of the pulmonary veins as a treatment for atrial fibrillation. *TEC Assessments.* 2008;Volume 23:Tab 11.
10. Jais P, Cauchemez B, Macle L, et al. Catheter ablation versus antiarrhythmic drugs for atrial fibrillation: the A4 study. *Circulation.* Dec 09 2008; 118(24): 2498-505. PMID 19029470
11. Khan MN, Jais P, Cummings J, et al. Pulmonary-vein isolation for atrial fibrillation in patients with heart failure. *N Engl J Med.* Oct 23 2008; 359(17): 1778-85. PMID 18946063
12. Oral H, Pappone C, Chugh A, et al. Circumferential pulmonary-vein ablation for chronic atrial fibrillation. *N Engl J Med.* Mar 02 2006; 354(9): 934-41. PMID 16510747
13. Pappone C, Augello G, Sala S, et al. A randomized trial of circumferential pulmonary vein ablation versus antiarrhythmic drug therapy in paroxysmal atrial fibrillation: the APAF Study. *J Am Coll Cardiol.* Dec 05 2006; 48(11): 2340-7. PMID 17161267
14. Stabile G, Bertaglia E, Senatore G, et al. Catheter ablation treatment in patients with drug-refractory atrial fibrillation: a prospective, multi-centre, randomized, controlled study (Catheter Ablation For The Cure Of Atrial Fibrillation Study). *Eur Heart J.* Jan 2006; 27(2): 216-21. PMID 16214831
15. Wazni OM, Marrouche NF, Martin DO, et al. Radiofrequency ablation vs antiarrhythmic drugs as first-line treatment of symptomatic atrial fibrillation: a randomized trial. *JAMA.* Jun 01 2005; 293(21): 2634-40. PMID 15928285
16. Asad ZUA, Yousif A, Khan MS, et al. Catheter Ablation Versus Medical Therapy for Atrial Fibrillation: A Systematic Review and Meta-Analysis of Randomized Controlled Trials. *Circ Arrhythm Electrophysiol.* Sep 2019; 12(9): e007414. PMID 31431051
17. Marrouche NF, Brachmann J, Andresen D, et al. Catheter Ablation for Atrial Fibrillation with Heart Failure. *N Engl J Med.* Feb 01 2018; 378(5): 417-427. PMID 29385358
18. Nyong J, Amit G, Adler AJ, et al. Efficacy and safety of ablation for people with non-paroxysmal atrial fibrillation. *Cochrane Database Syst Rev.* Nov 22 2016; 11: CD012088. PMID 27871122
19. Forleo GB, Mantica M, De Luca L, et al. Catheter ablation of atrial fibrillation in patients with diabetes mellitus type 2: results from a randomized study comparing pulmonary vein isolation versus antiarrhythmic drug therapy. *J Cardiovasc Electrophysiol.* Jan 2009; 20(1): 22-8. PMID 18775050
20. Mont L, Bisbal F, Hernandez-Madrid A, et al. Catheter ablation vs. antiarrhythmic drug treatment of persistent atrial fibrillation: a multicentre, randomized, controlled trial (SARA study). *Eur Heart J.* Feb 2014; 35(8): 501-7. PMID 24135832

21. Shi LZ, Heng R, Liu SM, et al. Effect of catheter ablation versus antiarrhythmic drugs on atrial fibrillation: A meta-analysis of randomized controlled trials. *Exp Ther Med*. Aug 2015; 10(2): 816-822. PMID 26622399
22. Chen HS, Wen JM, Wu SN, et al. Catheter ablation for paroxysmal and persistent atrial fibrillation. *Cochrane Database Syst Rev*. Apr 18 2012; (4): CD007101. PMID 22513945
23. Ganesan AN, Shipp NJ, Brooks AG, et al. Long-term outcomes of catheter ablation of atrial fibrillation: a systematic review and meta-analysis. *J Am Heart Assoc*. Mar 18 2013; 2(2): e004549. PMID 23537812
24. Zhuang Y, Yong YH, Chen ML. Updating the evidence for the effect of radiofrequency catheter ablation on left atrial volume and function in patients with atrial fibrillation: a meta-analysis. *JRSM Open*. Mar 2014; 5(3): 2054270414521185. PMID 25057380
25. Wilber DJ, Pappone C, Neuzil P, et al. Comparison of antiarrhythmic drug therapy and radiofrequency catheter ablation in patients with paroxysmal atrial fibrillation: a randomized controlled trial. *JAMA*. Jan 27 2010; 303(4): 333-40. PMID 20103757
26. Kuck KH, Lebedev DS, Mikhaylov EN, et al. Catheter ablation or medical therapy to delay progression of atrial fibrillation: the randomized controlled atrial fibrillation progression trial (ATTEST). *Europace*. Mar 08 2021; 23(3): 362-369. PMID 33330909
27. Wu G, Huang H, Cai L, et al. Long-term observation of catheter ablation vs. pharmacotherapy in the management of persistent and long-standing persistent atrial fibrillation (CAPA study). *Europace*. May 21 2021; 23(5): 731-739. PMID 33367669
28. Hussein AA, Saliba WI, Martin DO, et al. Natural history and long-term outcomes of ablated atrial fibrillation. *Circ Arrhythm Electrophysiol*. Jun 2011; 4(3): 271-8. PMID 21493959
29. Teunissen C, Kassenberg W, van der Heijden JF, et al. Five-year efficacy of pulmonary vein antrum isolation as a primary ablation strategy for atrial fibrillation: a single-centre cohort study. *Europace*. Sep 2016; 18(9): 1335-42. PMID 26838694
30. Bunch TJ, May HT, Bair TL, et al. Atrial fibrillation ablation patients have long-term stroke rates similar to patients without atrial fibrillation regardless of CHADS2 score. *Heart Rhythm*. Sep 2013; 10(9): 1272-7. PMID 23835257
31. Weerasooriya R, Khairy P, Litalien J, et al. Catheter ablation for atrial fibrillation: are results maintained at 5 years of follow-up?. *J Am Coll Cardiol*. Jan 11 2011; 57(2): 160-6. PMID 21211687
32. Tzou WS, Marchlinski FE, Zado ES, et al. Long-term outcome after successful catheter ablation of atrial fibrillation. *Circ Arrhythm Electrophysiol*. Jun 2010; 3(3): 237-42. PMID 20335557
33. Bertaglia E, Tondo C, De Simone A, et al. Does catheter ablation cure atrial fibrillation? Single-procedure outcome of drug-refractory atrial fibrillation ablation: a 6-year multicentre experience. *Europace*. Feb 2010; 12(2): 181-7. PMID 19887458
34. Sawhney N, Anousheh R, Chen WC, et al. Five-year outcomes after segmental pulmonary vein isolation for paroxysmal atrial fibrillation. *Am J Cardiol*. Aug 01 2009; 104(3): 366-72. PMID 19616669
35. Anselmino M, Grossi S, Scaglione M, et al. Long-term results of transcatheter atrial fibrillation ablation in patients with impaired left ventricular systolic function. *J Cardiovasc Electrophysiol*. Jan 2013; 24(1): 24-32. PMID 23140485
36. Takigawa M, Takahashi A, Kuwahara T, et al. Long-term follow-up after catheter ablation of paroxysmal atrial fibrillation: the incidence of recurrence and progression of atrial fibrillation. *Circ Arrhythm Electrophysiol*. Apr 2014; 7(2): 267-73. PMID 24610740

37. Hunter RJ, Berriman TJ, Diab I, et al. A randomized controlled trial of catheter ablation versus medical treatment of atrial fibrillation in heart failure (the CAMTAF trial). *Circ Arrhythm Electrophysiol.* Feb 2014; 7(1): 31-8. PMID 24382410
38. Lellouche N, Jais P, Nault I, et al. Early recurrences after atrial fibrillation ablation: prognostic value and effect of early reablation. *J Cardiovasc Electrophysiol.* Jun 2008; 19(6): 599-605. PMID 18462321
39. Pokushalov E, Romanov A, De Melis M, et al. Progression of atrial fibrillation after a failed initial ablation procedure in patients with paroxysmal atrial fibrillation: a randomized comparison of drug therapy versus reablation. *Circ Arrhythm Electrophysiol.* Aug 2013; 6(4): 754-60. PMID 23748210
40. Packer DL, Kowal RC, Wheelan KR, et al. Cryoballoon ablation of pulmonary veins for paroxysmal atrial fibrillation: first results of the North American Arctic Front (STOP AF) pivotal trial. *J Am Coll Cardiol.* Apr 23 2013; 61(16): 1713-23. PMID 23500312
41. Su W, Orme GJ, Hoyt R, et al. Retrospective review of Arctic Front Advance Cryoballoon Ablation: a multicenter examination of second-generation cryoballoon (RADICOOOL trial). *J Interv Card Electrophysiol.* Apr 2018; 51(3): 199-204. PMID 29478173
42. Vogt J, Heintze J, Gutleben KJ, et al. Long-term outcomes after cryoballoon pulmonary vein isolation: results from a prospective study in 605 patients. *J Am Coll Cardiol.* Apr 23 2013; 61(16): 1707-12. PMID 23199518
43. Neumann T, Wojcik M, Berkowitsch A, et al. Cryoballoon ablation of paroxysmal atrial fibrillation: 5-year outcome after single procedure and predictors of success. *Europace.* Aug 2013; 15(8): 1143-9. PMID 23419659
44. Boho A, Misikova S, Spurny P, et al. A long-term evaluation of cryoballoon ablation in 205 atrial fibrillation patients: a single center experience. *Wien Klin Wochenschr.* Oct 2015; 127(19-20): 779-85. PMID 26142169
45. Davies AJ, Jackson N, Barlow M, et al. Long Term Follow-up of Pulmonary Vein Isolation Using Cryoballoon Ablation. *Heart Lung Circ.* Mar 2016; 25(3): 290-5. PMID 26621109
46. Andrade JG, Khairy P, Macle L, et al. Incidence and significance of early recurrences of atrial fibrillation after cryoballoon ablation: insights from the multicenter Sustained Treatment of Paroxysmal Atrial Fibrillation (STOP AF) Trial. *Circ Arrhythm Electrophysiol.* Feb 2014; 7(1): 69-75. PMID 24446022
47. Dagues N, Hindricks G, Kottkamp H, et al. Complications of atrial fibrillation ablation in a high-volume center in 1,000 procedures: still cause for concern?. *J Cardiovasc Electrophysiol.* Sep 2009; 20(9): 1014-9. PMID 19490383
48. Cappato R, Calkins H, Chen SA, et al. Prevalence and causes of fatal outcome in catheter ablation of atrial fibrillation. *J Am Coll Cardiol.* May 12 2009; 53(19): 1798-803. PMID 19422987
49. Haeusler KG, Koch L, Herm J, et al. 3 Tesla MRI-detected brain lesions after pulmonary vein isolation for atrial fibrillation: results of the MACPAF study. *J Cardiovasc Electrophysiol.* Jan 2013; 24(1): 14-21. PMID 22913568
50. Herm J, Fiebach JB, Koch L, et al. Neuropsychological effects of MRI-detected brain lesions after left atrial catheter ablation for atrial fibrillation: long-term results of the MACPAF study. *Circ Arrhythm Electrophysiol.* Oct 2013; 6(5): 843-50. PMID 23989301
51. Waldo AL, Wilber DJ, Marchlinski FE, et al. Safety of the open-irrigated ablation catheter for radiofrequency ablation: safety analysis from six clinical studies. *Pacing Clin Electrophysiol.* Sep 2012; 35(9): 1081-9. PMID 22817524

52. Shah RU, Freeman JV, Shilane D, et al. Procedural complications, rehospitalizations, and repeat procedures after catheter ablation for atrial fibrillation. *J Am Coll Cardiol*. Jan 10 2012; 59(2): 143-9. PMID 22222078
53. Ellis ER, Culler SD, Simon AW, et al. Trends in utilization and complications of catheter ablation for atrial fibrillation in Medicare beneficiaries. *Heart Rhythm*. Sep 2009; 6(9): 1267-73. PMID 19716081
54. Reddy VY, Dukkipati SR, Neuzil P, et al. Randomized, Controlled Trial of the Safety and Effectiveness of a Contact Force-Sensing Irrigated Catheter for Ablation of Paroxysmal Atrial Fibrillation: Results of the TactiCath Contact Force Ablation Catheter Study for Atrial Fibrillation (TOCCASTAR) Study. *Circulation*. Sep 08 2015; 132(10): 907-15. PMID 26260733
55. Nakamura K, Naito S, Sasaki T, et al. Randomized comparison of contact force-guided versus conventional circumferential pulmonary vein isolation of atrial fibrillation: prevalence, characteristics, and predictors of electrical reconnections and clinical outcomes. *J Interv Card Electrophysiol*. Dec 2015; 44(3): 235-45. PMID 26387117
56. Afzal MR, Chatta J, Samanta A, et al. Use of contact force sensing technology during radiofrequency ablation reduces recurrence of atrial fibrillation: A systematic review and meta-analysis. *Heart Rhythm*. Sep 2015; 12(9): 1990-6. PMID 26091856
57. Zhu M, Zhou X, Cai H, et al. Catheter ablation versus medical rate control for persistent atrial fibrillation in patients with heart failure: A PRISMA-compliant systematic review and meta-analysis of randomized controlled trials. *Medicine (Baltimore)*. Jul 2016; 95(30): e4377. PMID 27472728
58. Anselmino M, Matta M, Castagno D, et al. Catheter ablation of atrial fibrillation in chronic heart failure: state-of-the-art and future perspectives. *Europace*. May 2016; 18(5): 638-47. PMID 26857188
59. Vaidya K, Arnott C, Russell A, et al. Pulmonary Vein Isolation Compared to Rate Control in Patients with Atrial Fibrillation: A Systematic Review and Meta-analysis. *Heart Lung Circ*. Aug 2015; 24(8): 744-52. PMID 25890871
60. Jones DG, Haldar SK, Hussain W, et al. A randomized trial to assess catheter ablation versus rate control in the management of persistent atrial fibrillation in heart failure. *J Am Coll Cardiol*. May 07 2013; 61(18): 1894-903. PMID 23500267
61. Kuck KH, Merkely B, Zahn R, et al. Catheter Ablation Versus Best Medical Therapy in Patients With Persistent Atrial Fibrillation and Congestive Heart Failure: The Randomized AMICA Trial. *Circ Arrhythm Electrophysiol*. Dec 2019; 12(12): e007731. PMID 31760819
62. Packer DL, Piccini JP, Monahan KH, et al. Ablation Versus Drug Therapy for Atrial Fibrillation in Heart Failure: Results From the CABANA Trial. *Circulation*. Apr 06 2021; 143(14): 1377-1390. PMID 33554614
63. Turagam MK, Musikantow D, Whang W, et al. Assessment of Catheter Ablation or Antiarrhythmic Drugs for First-line Therapy of Atrial Fibrillation: A Meta-analysis of Randomized Clinical Trials. *JAMA Cardiol*. Jun 01 2021; 6(6): 697-705. PMID 33909022
64. Elsayed M, Abdelfattah OM, Sayed A, et al. Bayesian network meta-analysis comparing cryoablation, radiofrequency ablation, and antiarrhythmic drugs as initial therapies for atrial fibrillation. *J Cardiovasc Electrophysiol*. Feb 2022; 33(2): 197-208. PMID 34855270
65. Packer DL, Mark DB, Robb RA, et al. Effect of catheter ablation vs antiarrhythmic drug therapy on mortality, stroke, bleeding, and cardiac arrest among patients with atrial fibrillation: the CABANA randomized clinical trial. *JAMA*. 2019;Epub ahead of print.

66. Mark DB, Anstrom KJ, Sheng S, et al. Effect of catheter ablation vs medical therapy on quality of life among patients with atrial fibrillation: the CABANA randomized clinical trial. *JAMA*. 2019;Epub ahead of print.
67. Blomström-Lundqvist C, Gizurarson S, Schwieler J, et al. Effect of catheter ablation vs antiarrhythmic medication on quality of life in patients with atrial fibrillation: the CAPTAF randomized clinical trial. *JAMA*. 2019;Epub ahead of print.
68. Hakalahti A, Biancari F, Nielsen JC, et al. Radiofrequency ablation vs. antiarrhythmic drug therapy as first line treatment of symptomatic atrial fibrillation: systematic review and meta-analysis. *Europace*. Mar 2015; 17(3): 370-8. PMID 25643988
69. Morillo CA, Verma A, Connolly SJ, et al. Radiofrequency ablation vs antiarrhythmic drugs as first-line treatment of paroxysmal atrial fibrillation (RAAFT-2): a randomized trial. *JAMA*. Feb 19 2014; 311(7): 692-700. PMID 24549549
70. Cosedis Nielsen J, Johannessen A, Raatikainen P, et al. Radiofrequency ablation as initial therapy in paroxysmal atrial fibrillation. *N Engl J Med*. Oct 25 2012; 367(17): 1587-95. PMID 23094720
71. Nielsen JC, Johannessen A, Raatikainen P, et al. Long-term efficacy of catheter ablation as first-line therapy for paroxysmal atrial fibrillation: 5-year outcome in a randomised clinical trial. *Heart*. Mar 2017; 103(5): 368-376. PMID 27566295
72. Andrade JG, Wells GA, Deyell MW, et al. Cryoablation or Drug Therapy for Initial Treatment of Atrial Fibrillation. *N Engl J Med*. Jan 28 2021; 384(4): 305-315. PMID 33197159
73. Kuniss M, Pavlovic N, Velagic V, et al. Cryoballoon ablation vs. antiarrhythmic drugs: first-line therapy for patients with paroxysmal atrial fibrillation. *Europace*. Jul 18 2021; 23(7): 1033-1041. PMID 33728429
74. Pavlovic N, Chierchia GB, Velagic V, et al. Initial rhythm control with cryoballoon ablation vs drug therapy: Impact on quality of life and symptoms. *Am Heart J*. Dec 2021; 242: 103-114. PMID 34508694
75. Wazni OM, Dandamudi G, Sood N, et al. Cryoballoon Ablation as Initial Therapy for Atrial Fibrillation. *N Engl J Med*. Jan 28 2021; 384(4): 316-324. PMID 33197158
76. Wazni O, Dandamudi G, Sood N, et al. Quality of life after the initial treatment of atrial fibrillation with cryoablation versus drug therapy. *Heart Rhythm*. Feb 2022; 19(2): 197-205. PMID 34666139
77. Gopinathannair R, Chen LY, Chung MK, et al. Managing Atrial Fibrillation in Patients With Heart Failure and Reduced Ejection Fraction: A Scientific Statement From the American Heart Association. *Circ Arrhythm Electrophysiol*. Jun 2021; 14(6): HAE0000000000000078. PMID 34129347
78. Calkins H, Kuck KH, Cappato R, et al. 2012 HRS/EHRA/ECAS expert consensus statement on catheter and surgical ablation of atrial fibrillation: recommendations for patient selection, procedural techniques, patient management and follow-up, definitions, endpoints, and research trial design: a report of the Heart Rhythm Society (HRS) Task Force on Catheter and Surgical Ablation of Atrial Fibrillation. Developed in partnership with the European Heart Rhythm Association (EHRA), a registered branch of the European Society of Cardiology (ESC) and the European Cardiac Arrhythmia Society (ECAS); and in collaboration with the American College of Cardiology (ACC), American Heart Association (AHA), the Asia Pacific Heart Rhythm Society (APHRS), and the Society of Thoracic Surgeons (STS). Endorsed by the governing bodies of the American College of Cardiology Foundation, the American Heart Association, the European Cardiac

- Arrhythmia Society, the European Heart Rhythm Association, the Society of Thoracic Surgeons, the Asia Pacific Heart Rhythm Society, and the Heart Rhythm Society. *Heart Rhythm*. Apr 2012; 9(4): 632-696.e21. PMID 22386883
79. Calkins H, Hindricks G, Cappato R, et al. 2017 HRS/EHRA/ECAS/APHRS/SOLAECE expert consensus statement on catheter and surgical ablation of atrial fibrillation. *Europace*. Jan 01 2018; 20(1): e1-e160. PMID 29016840
80. January CT, Wann LS, Alpert JS, et al. 2014 AHA/ACC/HRS guideline for the management of patients with atrial fibrillation: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines and the Heart Rhythm Society. *J Am Coll Cardiol*. Dec 02 2014; 64(21): e1-76. PMID 24685669
81. January CT, Wann LS, Calkins H, et al. 2019 AHA/ACC/HRS Focused Update of the 2014 AHA/ACC/HRS Guideline for the Management of Patients With Atrial Fibrillation: A Report of the American College of Cardiology/American Heart Association Task Force on Clinical

OTHER REFERENCES

1. Cardiology Liaison Committee member with expertise in electrophysiology, 11/22/06.
2. MCOP consultant #1073-9683, 3/28/07.
3. Considine consultant #474, 3/29/07.
4. Medical Director Guideline, 3/30/07.
5. Cardiology Liaison Committee, May 2007 and Medical Advisory Committee (consent ballot), August 2007.
6. Blue Cross and Blue Shield of Kansas Cardiology Liaison Committee, April 2009; April 2010; April 2011; May 2018.
7. BCBSKS Medical Consultant, Practicing Board Certified Cardiologist (401), March 2013.