How effective is microwave ablation for atrial fibrillation during concomitant cardiac surgery?

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Summary

A best evidence topic in cardiothoracic surgery was written according to a structured protocol. The question addressed was whether performing microwave ablative procedures during concomitant cardiac surgical procedures is effective for the treatment of atrial fibrillation (AF). In total, 200 papers were found using the reported search, of which 12 represented the best evidence to answer the clinical question. The authors, journal, date and country of publication, patient group studied, study type, relevant outcomes and results of these papers are tabulated. Major exclusion criteria included studies exclusively using bipolar ablation, ambiguous or unspecified ablation technique, other energy modalities and studies with highly variable or undisclosed follow-up time. One study reported that 66% of patients were in sinus rhythm (SR) with follow-ups ranging from 1 to 14 months and suggested that the risk of AF recurrence was significantly increased with a larger left atrial diameter (OR = 1.21, P = 0.02) and an increased duration of preoperative AF (OR = 2.14, P = 0.03). A separate study found no significant difference in the success rate on the basis of the concomitant procedure (coronary artery bypass grafting or mitral valve surgery, P > 0.5). In the only randomized trial identified, microwave ablation delivered significantly inferior SR restoration rates to radiofrequency (RF) ablation at all time points from discharge to 24 months. There is a large degree of heterogeneity in the studies, with patients’ characteristics, for example type of AF, and patient management postoperatively, for example administration of anti-arrhythmias, being inconsistent. Of the 12 studies, nine assessed SR at a mean of 6–12 months and found postoperative success rates between 62 and 87%. One study looked at the medium range follow-up of 24 months with SR restoration at 71%. Two studies looked at the long-term follow-up (5 and 5.37 years) with SR restoration at 39 and 61%, respectively. We conclude that microwave ablation, as an intervention for the treatment of AF during concomitant surgery, is not currently recommended on the limited available evidence. This is because the success rates in the longer term are less clear and the only randomized study to date has found inferior outcomes compared with RF-based ablation.

Keywords: Atrial fibrillation • Microwave ablation • Mitral • Surgery

INTRODUCTION

A best evidence topic was constructed according to a structured protocol. This is fully described in the ICVTS [1].

THREE-PART QUESTION

In [patients undergoing concomitant cardiac surgery for atrial fibrillation (AF)] is [microwave ablation] compared to [no treatment, catheter based therapy, or other sources of energy] an effective procedure for returning the patient to [sinus rhythm (SR)].

CLINICAL SCENARIO

You have under your care a 58-year old patient with mitral regurgitation and paroxysmal AF. You would like to treat his AF during the procedure. You usually use a radiofrequency (RF) bipolar device to perform pulmonary vein isolation, but a colleague has a new microwave ablation device available today that you could use. You resolve to check from the literature that the results are broadly comparable to your usual method prior to embarking on using this device.

SEARCH STRATEGY


SEARCH OUTCOME

Two hundred papers were found using the reported Medline search. Major exclusion criteria included studies using only other energy modalities (such as RF or cryoablation), studies where the ablation technique was ambiguous or not directly specified and papers with highly variable or undisclosed follow-up time.
### Table 1: Best evidence papers

<table>
<thead>
<tr>
<th>Author, date and country, Study type (level of evidence)</th>
<th>Patient group</th>
<th>Outcomes</th>
<th>Key results</th>
<th>Comments</th>
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<tr>
<td>Maessen et al., 2002, Ann Thorac Surg, The Netherlands [3] Prospective cohort study (level III)</td>
<td>24 consecutive patients undergoing beating heart epicardial microwave ablation for either permanent or paroxysmal AF</td>
<td>Patients in SR at follow-up (mean 6.4 months, range 3–9 months)</td>
<td>87%</td>
<td>The authors concluded that epicardial microwave ablation is a successful alternative to the Cox-maze procedure in the treatment of atrial fibrillation. There were several study weaknesses. Small sample size. Mixed types of AFs. All patients on anti-arrhythmics and 2 patients cardioverted during follow-up. How SR was assessed was not stated. Wide range of time for follow-up may have influenced results.</td>
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<td>Wisser et al., 2004, Eur J Cardiothorac Surg, Austria [11] Prospective cohort study (level III)</td>
<td>23 consecutive patients undergoing endocardial MW ablation</td>
<td>Patients in SR at follow up (12 months)</td>
<td>81% (17/21) However, two patients were lost during follow up</td>
<td>Authors concluded that microwave ablation gave similar results to radiofrequency ablation in the treatment of AF. There were some study weaknesses. Small sample size. Wide range of preoperative AF duration. Unclear whether or not patients were taking anti-arrhythmics during follow-up.</td>
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<td>Kabbani et al., 2005, Asian Cardiovasc Thorac Ann, Syria [4] Cohort study (level II)</td>
<td>84 patients with permanent AF undergoing endocardial MW ablation using a rigid antenna or epicardial MW ablation using a flexible antenna Concomitant to open heart surgery between 2002 and 2004 Ablation system used was (AFx, Inc., Fremont, CA, USA)</td>
<td>Patients in SR at follow-up (6 months)</td>
<td>74.3% (52/70) However, 14 patients were lost during surgery or follow-up</td>
<td>The authors concluded that microwave ablation is a satisfactory and safe method of AF ablation. They also noted that preoperative LAD seemed to be an important factor in the conversion to SR with a mean diameter of 7.0 cm in non-responding patients compared with 5.7 cm in responding patients ( P = &lt; 0.001 ). The study was not randomized and patients were still taking anti-arrhythmic therapy during follow-up.</td>
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<td>Ahlsson et al., 2008, Scand Cardiovasc J, Sweden [9] Prospective cohort study (level III)</td>
<td>20 patients undergoing epicardial microwave ablation for persistent or paroxysmal AF concomitant to open heart surgery between 2003 and 2005 Performed with a flexible microwave energy ablation catheter (Flex IV, Guidant, Boston Scientific, Natick) The left and right pulmonary veins were isolated and connected to each other followed by amputation of the left atrial appendage</td>
<td>Patients in SR at follow-up (12 months) Presence and velocity of left and right A waves in patients in SR</td>
<td>74% (14/19) One patient was lost during follow-up All patients in SR postoperatively (6 months) display left and right A waves of equivalent velocity to those seen in patients in SR preoperatively A wave (m/s) right: Preop 0.34 ± 0.14, Postop 0.31 ± 0.08, ( P = 0.518 ) A wave (m/s) left: Preop 0.49 ± 0.15, Postop 0.75 ± 0.4, ( P = 0.179 )</td>
<td>Authors concluded that microwave ablation results in SR in a majority of patients and preserves atrial mechanical function. There were some study weaknesses. Small sample size. Risk of type II error in echocardiography. Patients had different forms and durations of AF.</td>
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<td>Topkara et al., 2006, Heart Surg Forum, USA [10] Prospective cohort study (level II)</td>
<td>85 patients undergoing endocardial MW ablation for AF, concomitant to heart surgery MW ablation was performed using the MW ablation system (Guidant, Santa Clara, CA, USA) which consists of a surgical ablation probe (FLEX 4) connected by a coaxial cable to an MW generator</td>
<td>Patients in SR at follow-up</td>
<td>71.4% at 6 months 66.7% at 12 months</td>
<td>The authors concluded that microwave ablation was an effective alternative to 'cut and sew' ablation techniques</td>
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<td>Patient survival at follow-up</td>
<td>87.9% at 6 months 86.5% at 12 months</td>
<td>Mean rhythm follow-up is stated as 0.8 ± 0.6 years. It is unclear how the authors drew conclusions about rhythm at 1 year. Study weaknesses included the high variability of follow-up and mixed types of AF. Duration of AF prior to ablation is not mentioned</td>
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<td>Knaut et al., 2007, Heart Surg Forum, Germany [5] Prospective registry study (level III)</td>
<td>42 patients undergoing endocardial microwave ablation for AF concomitant to isolated CABG</td>
<td>Patients in SR at follow-up (12 months)</td>
<td>72% (28/39) of the CABG group However three patients were lost during follow-up</td>
<td>The authors concluded that microwave ablation in combination with CABG or mitral valve surgery can be performed with comparable and acceptable success rates</td>
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<td></td>
<td>68 patients undergoing endocardial microwave ablation for AF concomitant to isolated mitral valve surgery</td>
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<td>63% (40/64) of the mitral group However four patients were lost during follow-up</td>
<td>However there was no significant difference in success rates between ablation concomitant to CABG or mitral valve surgery Results may have been influenced by the use of anti-arrhythmics, cardioversion and pacemakers during follow-up</td>
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<td>Performed with Guidant microwave surgical ablation devices Flex 2 and Flex 4 System (AFx, Fremont, CA, USA)</td>
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<td>Zembala et al., 2003, Heart Surg Forum, Poland [6] Prospective cohort study (level III)</td>
<td>42 consecutive patients undergoing endocardial microwave ablation for AF, concomitant to mitral valve surgery</td>
<td>Patients in SR at follow-up (mean 7.3 ± 3.7 months, range 1–14 months).</td>
<td>66%</td>
<td>The authors concluded that early and late success after surgical energy ablation may be associated with discrete patient characteristics, such as longer arrhythmia duration and greater left atrial diameter, both associated with increased AF recurrence</td>
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<td>Performed with the Microwave Ablation System (AFx, Fremont, CA, USA) and the Flex 2 ablation probe (AFx). Lesion lines made from the mitral annulus, directed up to the ostium of the left inferior vein, and then to the left superior, right superior and right inferior pulmonary vein ostia. All lesions were placed in the left atrium</td>
<td>Adjusted odds ratio for retrospective risk factors associated with AF recurrence</td>
<td>LAD: OR = 1.21 95%, CI = 1.01–1.46, P = 0.04 Preop AF duration: OR = 2.14 95%, CI = 1.09–4.19 P = 0.03</td>
<td>There were some study weaknesses. Small sample size. Type of AF, both pre and post operative not stated. Use of anti-arrhythmics, cardioversion and wide range of follow-up times may have influenced the results</td>
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<td>Knaut et al., 2006, Europace, Germany [7] Prospective registry study (level II)</td>
<td>96 consecutive patients with permanent AF undergoing endocardial microwave ablation, with CABG alone or CABG in combination with valve surgery between 1998 and 2003. The AFx microwave surgical ablation devices were used to produce linear lesions on the endocardial surface of the left atrium. The first 59 patients underwent ablation according to Allessie's lesion line concept. For the next 43 patients, the course of the lesion lines was modified to form a box lesion.</td>
<td>Patients in SR at follow-up (1 year)</td>
<td>64.7%</td>
<td>However 11.5% of the initial patients were lost to follow-up 88.5%</td>
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<td>Knaut et al., 2004, J Card Surg, Germany [8] Cohort study (level II)</td>
<td>202 consecutive patients with permanent AF undergoing microwave ablation concomitant to open heart surgery. The AFx microwave surgical ablation devices were used to produce linear lesions on the endocardial surface of the left atrium. Either Allessie's lesion line or box lesions were used.</td>
<td>Patients in SR at follow-up (6 months)</td>
<td>63% (85/135)</td>
<td>However, 67 patients were lost to follow up 62.2% (74/119) at 1 year</td>
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<tr>
<td>Kim et al., 2010, J Korean Med Sci, South Korea [12] Prospective cohort study (level II)</td>
<td>96 consecutive patients undergoing endocardial microwave ablation for permanent or paroxysmal AF, concomitant to mitral valve surgery with or without other heart surgery between 1999 and 2005. Microwave energy was applied endocardially using FLEX 4 microwave ablation probes (AFx Inc., Fremont, CA, USA), in a modified version of the Cox maze III procedure</td>
<td>Patients in SR at follow-up (3 years)</td>
<td>79.8 ± 4.9%</td>
<td>61.3 ± 1.2% at 5 years (Final mean follow up 46.1 ± 28.2 months)</td>
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<td>Patient survival at follow-up (3 years)</td>
<td>96.1 ± 1.1%</td>
<td>95.6 ± 1.2% at 5 years</td>
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RESULTS

Paucity of level 1 evidence (only one randomized trial [2] identified) was a major limitation to this analysis and many of the studies share similar methodological flaws. In several, patients were given anti-arrhythmic medication or were cardioverted during follow-up, making it difficult to determine whether microwave ablation had cured AF [2–8]. Evaluation of SR restoration was through 24–72 h Holter electrocardiogram monitoring at outpatient clinics. This method can miss recurrent or asymptomatic AF, as patients were not monitored continuously throughout the follow-up period. Some studies also included patient populations with a mixture of permanent and paroxysmal AF [3, 9, 10]. Furthermore, the follow-up time and preoperative AF duration of patients in many of the studies were often very variable.

Maessen et al. [3] reported that 87% of patients were in SR at a mean period of 6.4 months postoperation in a study of 24 patients. Wisser et al. [11] reported that 81% of the patients were free of AF at 12 months in a study of 23 patients, concluding that microwave ablation gave similar results to RF ablation.

Kabbani et al. [4] reported that 74% of the patients were in SR at 6 months in a study of 84 patients. Additionally, preoperative left atrial diameter (LAD) seemed to be an important factor in the conversion to SR, with a mean diameter of 7.0 cm in non-responding patients compared with 5.7 cm in responding patients (P < 0.001).

Ahlsson et al. [9] reported that 74% of the patients were in SR at 12 months in a study of 20 patients. They also noted that all patients in SR at 6 months postoperatively displayed left and right A waves of equivalent velocity to those seen in patients in SR preoperatively. Thus, they suggest that microwave ablation...
can restore SR in a majority of patients while also preserving atrial mechanical function.

Topkara et al. [10] reported that 67% of the patients were in SR at 1-year in a study of 85 patients. However, the mean follow-up was only 0.8 ± 0.6 years.

Knaut et al. [5] reported that 72% of the 42 patients who underwent microwave ablation concomitant to isolated coronary artery bypass graft (CABG) were in SR at 12 months, compared with 63% of the 68 patients who underwent microwave ablation concomitant to isolated mitral valve surgery. They concluded that microwave ablation in combination with CABG or mitral valve surgery can be performed with comparable success rates.

Zembala et al. [6] reported 66% of the 42 patients in SR at a mean period of 7.3 months postoperatively and suggested that the risk of AF recurrence was significantly increased with a larger LAD (OR = 1.21, P = 0.02) and an increased duration of pre-operative AF (OR = 2.14, P = 0.03).

Another study by Knaut et al. [8] reported 65% of the patients in SR at 1-year in a study of 96 patients. They also examined success rates between patients undergoing the ablation by two different techniques (described in Table 1), and between patients undergoing ablation with CABG alone, or CABG in combination with other procedures. They found a significant difference in success rates between CABG combined with the initial technique or combined with the box technique (52 vs. 74%, respectively, P = 0.0026).

Knaut et al. [8] published a further study showing 62% of the patients in SR at 1-year in a study of 202 patients, although many of these patients were lost during follow-up. The paper does not suggest why the attrition rate was so high. The Knaut group has published several papers investigating different factors affecting the rate of sinus conversion after microwave ablation. It is important to note that it is unclear whether the patients used for their studies overlap.

Over the longer time periods of 3 and 5 years, Kim et al. [12] demonstrated an 80% and a 61% freedom from AF, respectively (without anti-arrhythmic administration). Vicol et al. [13] showed that at a mean period of 5.37 years, only 39% of the patients who underwent ablation were in SR, a vastly lower proportion than noted in other studies assessing SR over shorter periods of time. They therefore concluded that microwave ablation is not a reliable method of achieving long-term conversion to SR.

Lin et al. [2] conducted a prospective trial in which patients were randomized to either undergo microwave (n = 94) or RF (n = 93) ablation. At all follow-up time points ranging from discharge to 24 months, there was a significant difference in the numbers of patients remaining in SR that favoured RF over MW ablation. The authors stated that the MW antenna in particular had to be repositioned two to three times to finish the circular lesion around the endocardial pulmonary veins. They postulated that the uncertainty in transmurality and continuity of the lesions might have contributed to the inferior success rates of MW relative to RF ablation.

**CLINICAL BOTTOM LINE**

It is apparent that there is a large degree of heterogeneity in studies that address the success of microwave ablation for AF during concomitant cardiac surgery, with patients’ characteristics, for example type of AF, and patient management postoperatively, for example the administration of anti-arrhythmics, being inconsistent. Of the 12 studies, nine assessed SR at a mean period of 6–12 months and found postoperative success rates between 62 and 87%. One study looked at the medium range follow-up of 24 months with SR restoration at 71%. Two studies looked at the long-term follow-up (5 and 5.37 years) with SR restoration at 39 and 61%, respectively. In the UK, NICE guidelines have concluded that microwave ablation is ‘safe enough and works well enough for use in the NHS’ (http://www.nice.org.uk/nicemedia/live/11172/31382/31382.pdf). We conclude that microwave ablation as an intervention for the treatment of AF during concomitant surgery is not currently recommended on the limited available evidence. This is because the success rates in the longer term are less clear and the only randomized study to date has found inferior outcomes to those of RF-based ablation.

**Conflict of interest:** none declared.

**REFERENCES**


