NATIONAL INSTITUTE FOR CLINICAL EXCELLENCE

INTERVENTIONAL PROCEDURES PROGRAMME

Interventional procedures overview of microwave ablation for atrial fibrillation as an associated procedure with other cardiac surgery

Introduction

This overview has been prepared to assist members of the Interventional Procedures Advisory Committee (IPAC) in making recommendations about the safety and efficacy of an interventional procedure. It is based on a rapid review of the medical literature and specialist opinion. It should not be regarded as a definitive assessment of the procedure.

Date prepared

This overview was prepared in July 2004.

Procedure name

- Microwave ablation for atrial fibrillation as an associated procedure with other cardiac surgery.

Specialty society

- Society of Cardiothoracic Surgeons in Great Britain and Ireland.
- British Pacing and Electrophysiology Group.

Description

Indications

Atrial fibrillation.

Atrial fibrillation is the irregular and rapid beating of the upper two chambers of the heart (the atria). It may be classified as paroxysmal, persistent or permanent. It is the most common type of arrhythmia, affecting approximately 0.5% of the adult population[1]. The incidence increases markedly with age. Patients with atrial fibrillation may be asymptomatic or they may have symptoms including palpitations, dizziness and breathlessness. They also have an increased risk of stroke, as a result of blood clots forming in the left atrium and then embolising to the brain.

Although atrial fibrillation may occur in the absence of other heart disease, it is particularly common in patients with mitral valve disease. Patients with a history of atrial fibrillation for longer than a year are less likely to be restored to normal sinus rhythm after mitral valve surgery alone than patients with intermittent atrial fibrillation or those who have had atrial fibrillation for less than a year.

Current treatment and alternatives

Conservative treatments include medications, electrical cardioversion to control the heart rhythm, and anticoagulants to prevent blood clots forming. A surgical treatment known as the Cox maze procedure was developed to treat atrial fibrillation. This is usually performed at the same time as open heart surgery for another indication, such as mitral valve disease. Multiple strategically placed incisions are made in both atria to isolate and stop the abnormal electrical impulses. All the incisions are then sutured and a 'maze' of scar tissue subsequently forms at the incision sites, which blocks the electrical impulses from travelling through the atrium. A single pathway is left intact for the impulse to travel between the chambers of the heart.

What the procedure involves

Microwave ablation of the atria can be performed via a catheter introduced through a femoral vein but surgical microwave ablation for atrial fibrillation is typically carried out in patients undergoing concomitant open-heart surgery, including mitral valve replacement or repair. A microwave probe is used to create lines of conduction block by thermal damage rather than the incisions created in the traditional Cox maze surgery. Ablation may be performed on both atria or on the left atrium only.

Mitral valve surgery is usually performed via a median sternotomy. The patient is connected to a cardiopulmonary bypass machine and an incision is made to enter the left atrium. Microwave ablation may be performed before or after the concomitant cardiac surgical procedure. A flexible microwave probe is used to create ablation lesions in the left atrium. The heat generated by the probe coagulates the heart tissue, forming scars along the ablation lines that disrupt the transmission of the electrical impulses. The procedure may then be repeated in the right atrium. The ablation can be performed from within or outside the atrium.

The Cox maze procedure is complex and time consuming. The microwave ablation approach takes less time and is reported to be easier to perform. A potential advantage of microwave heating is that it does not cause endocardial surface charring or coagulation.

Efficacy

The main outcome measure for efficacy was the conversion to sinus rhythm. In one randomised controlled trial, patients having open-heart surgery and microwave ablation were compared with those having open-heart surgery alone. Immediately after the surgery, 92% (22/24) of patients given microwave ablation were in sinus rhythm compared with 32% (6/19) of patients in the control group ($p < 0.05$). At 12 months 67% (12/18) of patients having microwave ablation were in sinus rhythm compared with 33% (3/9) of control patients ($p < 0.05$). A non-randomised controlled trial reported that 62% (84/136) of patients treated with microwave ablation were in sinus rhythm at 12 months, compared with 10% (5/51) of patients having heart surgery without microwave ablation ($p < 0.0001$). A second non-randomised controlled trial compared microwave ablation with radiofrequency ablation. At 12 months there was no significant difference between the two groups; 59% (13/22) of patients treated with microwave ablation were in sinus rhythm compared with 57% (8/14) of patients treated with radiofrequency ablation.

Two case series reported that between 61% (25/41) and 76% (32/42) of patients were in sinus rhythm immediately after the surgery. In a further case series, 62% (74/119) of patients were in sinus rhythm at the 12-month follow-up.

One Specialist Advisor noted that there was some uncertainty regarding whether the lesions created by microwave ablation would be "full thickness".

Safety

Because the microwave ablation is performed with concomitant cardiac surgery, it is sometimes difficult to differentiate those complications that are specifically related to the microwave ablation.

The main complications reported were in-hospital mortality and the requirement for a permanent pacemaker. In the randomised controlled trial, the in-hospital mortality was 4.2% (1/24) for patients having microwave ablation and heart surgery, compared with 5.3% (1/19) for patients treated with heart surgery only. This difference was not statistically significant. Four other studies reported in-hospital mortality rates, which ranged from 0% (0/42) to 4.3% (1/23). Four studies reported the proportion of patients who needed a permanent pacemaker and this ranged from 0% (0/41) to 22% (46/202). One study including 23 patients with microwave ablation reported additional complications of bleeding (2 patients), intra-aortic balloon pump (1 patient), transient low cardiac output (1 patient) and severe systemic inflammatory response syndrome (1 patient).

One Specialist Advisor stated that inappropriate application causing heart block or coronary problems was a potential adverse event.

Literature review

Rapid review of literature

The medical literature was searched to identify studies and reviews relevant to intraoperative microwave ablation for atrial fibrillation as an associated procedure with other cardiac surgery. Searches were conducted via the following databases, covering the period from their commencement to July 2004: MEDLINE, PREMEDLINE, EMBASE, Cochrane Library and Science Citation Index. Trial registries and the Internet were also searched. No language restriction was applied to the searches.

The following selection criteria (Table 1) were applied to the abstracts identified by the literature search. Where these criteria could not be determined from the abstracts the full paper was retrieved.

Table 1 Inclusion criteria for identification of relevant studies

Characteristic	Criteria
Publication type	Clinical studies included. Emphasis was placed on identifying good quality studies. Abstracts were excluded where no clinical outcomes were reported, or where the paper was a review, editorial, laboratory or animal study.
Patient	Patients with atrial fibrillation and requiring concomitant cardiac surgery.
Intervention/test	Intraoperative microwave ablation of the atria.
Outcome	Articles were retrieved if the abstract contained information relevant to the safety and/or efficacy.
Language	Non-English-language articles were excluded unless they were thought to add substantively to the English-language evidence base.

List of studies included in the overview

This overview is based on one randomised controlled trial, two non-randomised controlled trials and three case series studies. The randomised controlled trial compared patients given open heart surgery and microwave ablation with those having the open heart surgery only.[2] One non-randomised controlled trial compared microwave ablation with radiofrequency ablation and the other compared patients given open heart surgery and microwave ablation with those having the open heart surgery only.[3,4] Three case series studies have also been described in Table 2.[5,6,7]

References to other studies that are considered to be relevant to this overview are listed in Appendix A.

Table 2 Summary of key efficacy and safety findings on intraoperative microwave ablation for atrial fibrillation with concomitant cardiac surgery

Study Details	Key efficacy findings	Key safety findings	Comments
Schuetz A (2003)[2] Randomised controlled trial 2001 – 2002 Germany 43 patients • 56% (24/43) microwave ablation and open-heart surgery • 44% (19/43) open-heart surgery only Mean age: • microwave ablation and open-heart surgery = 65 years • open-heart surgery only = 70 years Mean diameter of left atrium: • microwave ablation and open-heart surgery = 55 mm (range 43 to 105 mm) • open-heart surgery only = 54 mm (range 35 to 95 mm) Mean duration of permanent atrial fibrillation: • microwave ablation and open-heart surgery = 3.8 years (range 0.08 to 8.2 years) • open-heart surgery only = 9.2 years (range 0.08 to 24 years), p = 0.05 Follow-up: 12 months Indications: permanent atrial fibrillation after unsuccessful previous treatment, in patients requiring surgery for valve disease and/or coronary artery bypass grafting	Sinus rhythm immediately after surgery: • microwave group = 92% (22/24) • control group = 32% (6/19), p < 0.05 Sinus rhythm at discharge: • microwave group = 61% (14/23) • control group = 16% (3/19), p < 0.05 Sinus rhythm at 6 months: • microwave group = 67% (12/18) • control group = 30% (3/10), p < 0.05 Sinus rhythm at 12 months: • microwave group = 80% (12/15) • control group = 33% (3/9), p < 0.05	**Complications** In-hospital mortality: • microwave group = 4.2% (1/24) • control group = 5.3% (1/19), p = not significant	Patients were randomised without any regard to the concomitant heart disease. Method of randomisation not described. Small patient numbers. Patients treated with microwave ablation also received atrial size reduction surgery. Ablation to left atrium only. Adjuvant antiarrhythmic therapy was given to patients if sinus rhythm was restored post surgery or if a clinical significant tachyarrhythmia occurred. AFx microwave ablation system, with a FLEX 2 surgical ablation probe was used.

Study Details	Key efficacy findings	Key safety findings	Comments
Wisser W (2004)[3] Non-randomised controlled trial 2001 – 2002 Austria 42 patients • 55% (23/42) microwave ablation • 45% (19/42) radiofrequency ablation Mean age: • microwave ablation = 66 years • radiofrequency ablation = 64 years Mean diameter of left atrium: • microwave ablation = 70 mm • radiofrequency ablation = 74 mm Mean follow-up: • microwave ablation = 24 months • radiofrequency ablation = 12 months, $p < 0.01$ Indications: chronic permanent atrial fibrillation > 6 months and heart valve disease, coronary artery disease or aortic aneurysm. Exclusions: paroxysmal atrial fibrillation Mean duration of permanent atrial fibrillation: • microwave ablation = 62 months • radiofrequency ablation = 54 months	Sinus rhythm immediately after surgery: • microwave ablation = 100% (23/23) • radiofrequency ablation = 100% (19/19) Sinus rhythm at 6 months: • microwave ablation = 59% (13/22) • radiofrequency ablation = 47% (9/19) Sinus rhythm at 12 months: • microwave ablation = 59% (13/22) • radiofrequency ablation = 57% (8/14) Freedom from atrial fibrillation at 12 months: • microwave ablation = 81% (18/22) • radiofrequency ablation = 80% (11/14), p = not significant	**Complications** In-hospital mortality: • microwave ablation = 4.3% (1/23) (not attributable to ablation procedure) Intra-aortic balloon pump: • microwave ablation = 4.3% (1/23) Transient low cardiac output: • microwave ablation = 4.3% (1/23) • radiofrequency ablation = 5.3% (1/19) Postoperative bleeding requiring rethoracotomy: • microwave ablation = 8.7% (2/23) • radiofrequency ablation = 0% (0/19) Severe systemic inflammatory response syndrome: • microwave ablation = 4.3% (1/23) • radiofrequency ablation = 5.3% (1/19) Permanent pacemaker insertion: • microwave ablation = 22% (5/23) • radiofrequency ablation = 21% (4/19)	No randomisation. Consecutive patients. Small patient numbers. There were no significant differences in baseline variables between the two groups. Biatrial ablation. No antiarrhythmic therapy was administered immediately after surgery. AFx microwave ablation system, with a FLEX 2 surgical ablation probe was used. Medtronic radiofrequency system was used.

Study Details	Key efficacy findings	Key safety findings	Comments
Spitzer S (2002)[4] Non-randomised controlled trial Germany 187 patients • 73% (136/187) surgery and microwave ablation • 27% (51/187) surgery only	Sinus rhythm at 6 months: • microwave ablation = 64% (87/136) • surgery only = 8% (4/51) Sinus rhythm at 12 months: • microwave ablation = 62% (84/136) • surgery only = 10% (5/51), p < 0.0001	**Complications** There were no serious complications during the ablation procedure	No randomisation. Article in German. Information from English abstract only. Likely to include some patients also reported by Knaut et al, 2004.
Knaut M (2004)[5] Case series 1998 onwards Germany 202 patients Mean age: 68 years (range 30 to 84 years) Mean duration of atrial fibrillation: 6.8 years (range 0.2 to 57.2 years) Mean diameter of left atrium: 52 mm (range 30 to 110 mm) Follow-up: 12 months Indications: permanent atrial fibrillation and concomitant cardiosurgical procedure (for mitral valve disease, coronary artery disease, aortic valve disease, tricuspid valve disease, atrial septal defects, and aortic aneurysms)	Sinus rhythm at 6 months = 63% (85/135) Sinus rhythm at 12 months = 62% (74/119)	**Complications** Perioperative mortality = 1.5% (3/202) Pacemaker implantation = 22% (46/202) No thromboembolic events occurred during the perioperative follow-up	Consecutive patients. Antiarrhythmic drugs were used postoperatively and terminated after 3 months if stable sinus rhythm was established. 67% (135/202) patients had reached the 6 month follow-up at the time of analysis. 59% (119/202) patients had reached the 12 month follow-up. Likely to include some patients also reported by Spitzer and Knaut, 2002. AFx microwave ablation system, with a FLEX 2 surgical ablation probe was used.

Study Details	Key efficacy findings	Key safety findings	Comments
Venturini A (2003)[6] Case series 2001 – 2002 Italy 41 patients Mean age: 61 years (range 45 to 76 years) Mean follow-up: 14 months (range 5 to 21 months) Indications: Mitral valve disease and permanent or paroxysmal atrial fibrillation Mean duration of atrial fibrillation: 24 months (range 2 to 324 months)	Sinus rhythm at discharge = 61% (25/41) Sinus rhythm at final follow-up = 83% (34/41) Patients in sinus rhythm at follow-up: Severe left atrial function impairment (atrial filling fraction <20%) = 15% (5/34) Mild to moderate left atrial function impairment (atrial filling fraction 20 – 29%) = 26% (9/34) Normal left atrial function (atrial filling fraction >30%) = 59% (20/34)	**Complications** No in-hospital deaths No reexplorations for bleeding or permanent pacemaker insertion	Patient selection not described. Small patient numbers. Antiarrhythmia therapy was maintained in patients who were free of atrial fibrillation at follow-up. AFx microwave ablation system, with a FLEX 2 surgical ablation probe was used.
Zembala M (2003)[7] Case series Poland 42 patients Age range: 39 to 73 years Mean follow-up: 7 months (range 1 to 14 months) Indications: Mitral valve disease and chronic atrial fibrillation for 6 months or longer	Sinus rhythm at discharge = 76% (32/42) Sinus rhythm at most recent follow-up = 67% (28/42)	**Complications** No in-hospital complications or deaths. One patient died 8 months postoperatively because of a cerebral thromboembolic event. Pacemaker implantation = 7% (3/42)	Consecutive patients. Ablation to left atrium only. For patients with persisting atrial fibrillation, prophylactic therapy was administered according to the discretion of the attending physician. Preoperative duration of atrial fibrillation and left atrial diameter were identified as risk factors for recurrence of atrial fibrillation. AFx microwave ablation system, with a FLEX 2 surgical ablation probe was used.

Table 3 Relevant literature identified during the consultation period

Study Details	Key efficacy findings	Key safety findings	Comments
Knaut (2004)[8] Case series Germany 249 patients • original lesion line = 137 • modified lesion line = 112 Mean age (years): • original lesion line = 68.4 • modified lesion line = 68.1 Mean duration of atrial fibrillation (years): • original lesion line = 6.5 • modified lesion line = 6.8 Indications: permanent atrial fibrillation and mitral valve disease, coronary artery disease or aortic valve disease. Exclusion criteria: paroxysmal atrial fibrillation, age < 18 years, emergency operations, congestive heart failure. Concomitant procedures: mitral valve repair/replacements, aortic valve replacement, coronary bypass grafting. Follow-up: 6 months	Survival rate: • original lesion line = 97.8% • modified lesion line = 96.4%, p > 0.05 Stable sinus rhythm at 6 months: • original lesion line = 65% • modified lesion line = 80%, p = 0.16 Stable sinus rhythm at 6 months in original lesion group by indication: • mitral valve disease = 62% • coronary artery disease = 68% • aortic valve disease = 78% Stable sinus rhythm at 6 months in modified lesion group by indication: • mitral valve disease = 88% • coronary artery disease = 78% • aortic valve disease = 85% All patients with stable sinus rhythm demonstrated good biatrial transport function in echocardiography. After 6 months, 26% of all patients had a pacemaker (5 patients had a pacemaker before the procedure).	2.8% (7/249) of patients died perioperatively; the causes of death were low cardiac output syndrome (n = 3), multi-organ failure (n = 2), right ventricular failure (n = 2). There were no cases of haemorrhage, perforation of the oesophagus or later stenosis of the pulmonary veins.	Retrospective review. Patients were divided into two groups; the first 137 patients were treated with the original ablation line concept and the next 112 were treated with a modified ablation line.

Validity and generalisability of the studies

- There are many aspects of the microwave ablation procedure that varied within and among studies, including the pattern of ablation lesions, the type of ablation probe, and the postoperative regimen of antiarrhythmic drugs. This needs to be taken into consideration when the safety and efficacy are compared among studies.

- The studies had different inclusion criteria with regards to duration and type of atrial fibrillation, and type of concomitant heart surgery.

- The one randomised controlled trial, comparing patients treated with open-heart surgery and intraoperative microwave ablation with patients treated with open-heart surgery only, was very small. The study included only 43 patients followed up for 12 months.

- Patients were treated with concomitant heart surgery and some of the reported complications would have been due to this surgery rather than to the microwave ablation procedure.

Specialist advisors' opinions

Specialist advice was sought from consultants who have been nominated or ratified by their Specialist Society or Royal College.

- Microwave is one of several energy sources that can be used to treat atrial fibrillation.
- There are a variety of lesion sets being used.

Issues for consideration by IPAC

None other than those described above.

References

1 Grubb NR, Furniss S. Radiofrequency ablation for atrial fibrillation. *British Medical Journal* 2001; 322: 777–80.

2 Schuetz A, Schulze CJ, Sarvanakis KK, et al. Surgical treatment of permanent atrial fibrillation using microwave energy ablation: a prospective randomized clinical trial. *European Journal of Cardio-thoracic Surgery* 2003; 24: 475–80.

3 Wisser W, Khazen C, Deviatko E, et al. Microwave and radiofrequency ablation yield similar success rates for treatment of chronic atrial fibrillation. *European Journal of Cardio-thoracic Surgery* 2004; 25: 1011–7.

4 Spitzer SG, Knaut M. Intraoperative microwave ablation for surgical treatment of atrial fibrillation. *Herzschrittmachertherapie und Elektrophysiologie* 2002; 13: 225–32.

5 Knaut M, Tugtekin SM, Matschke K. Pulmonary vein isolation by microwave energy ablation in patients with permanent atrial fibrillation. *Journal of Cardiac Surgery* 2004; 19: 211–5.

6 Venturini A, Polesel E, Cutaia V, et al. Intraoperative microwave ablation in patients undergoing valvular surgery: midterm results. *The Heart Surgery Forum* 2003; 6: 409–11.

7 Zembala M, Lenarczyk R, Kalarus Z, et al. Early and late outcomes after microwave ablation for chronic valvular atrial fibrillation. *The Heart Surgery Forum* 2003; 6: 403–8.

8 Knaut M, Tugtekin SM, Jung F, et al. Microwave ablation for the surgical treatment of permanent atrial fibrillation – a single centre experience. *European Journal of Cardio-thoracic Surgery* 2004; 26: 742–6.

Appendix A: Additional papers on microwave ablation for atrial fibrillation as an associated procedure with other cardiac surgery not included in the summary tables

Article title	Number of patients/ follow-up	Comments	Direction of conclusions
Chiappini B, Di Bartolomeo R, Marinelli G. The surgical treatment of atrial fibrillation with microwave ablation: preliminary experience and results. *Interactive Cardiovascular & Thoracic Surgery* 2003; 2: 327–30.	10 patients. Mean follow-up = 12 months.	Case series. Chronic atrial fibrillation and concomitant heart surgery.	Survival rate = 100%. Sinus rhythm at follow-up = 78%.
Knaut M, Tugtekin SM, Spitzer S, et al. Combined atrial fibrillation and mitral valve surgery using microwave technology. *Seminars in Thoracic and Cardiovascular Surgery* 2002; 14: 226–31.	105 patients. 12 month follow-up.	Case series. Mitral valve disease and chronic atrial fibrillation.	Survival rate = 99%. Sinus rhythm at 12 months = 58%.
Knaut M, Spitzer SG, Karolyi L, et al. Intraoperative microwave ablation for curative treatment of atrial fibrillation in open heart surgery – the MICRO-STAF and MICRO-PASS pilot trial. *Thoracic & Cardiovascular Surgeon, Supplement* 1999; 47: 379–84.	18 patients. Follow-up = 90 days.	Case series. Chronic atrial fibrillation and indication for open heart surgery.	No perioperative complications. Sinus rhythm at 90 days = 57% (4/7).
Maessen JG, Nijs JF, Smeets JL, et al. Beating-heart surgical treatment of atrial fibrillation with microwave ablation *Annals of Thoracic Surgery* 2002; 74: S1307–11.	24 patients. Follow-up = 3 to 9 months.	Case series. Paroxysmal and chronic atrial fibrillation.	Sinus rhythm at follow-up = 87%.
Manasse E, Medici D, Ghiselli S, et al. Left main coronary arterial lesion after microwave epicardial ablation. *Annals of Thoracic Surgery* 2003; 76: 276–7.	1 case.	Case report.	Left main coronary arterial lesion. The patient had an anterior myocardial infarction on day 90.
Manasse E, Colombo PG, Barbone A, et al. Clinical histopathology and ultrastructural analysis of myocardium following microwave energy ablation. *European Journal of Cardio-Thoracic Surgery* 2003; 23: 573–77.	15 patients.	Case series. Histological results.	In most of the cases, lesions were transmural.
Zembala M, Kalarus Z, Lenarczyk R, et al. Surgical microwave ablation of atrial fibrillation in mitral valve disease. *Kardiologia Polska* 2002; 57: 223–6.	32 patients. Mean follow-up = 8 months.	Case series. Mitral valve disease and persistent atrial fibrillation.	Sinus rhythm at discharge = 84% Sinus rhythm at follow-up = 75%

Appendix B: Literature search for microwave ablation for atrial fibrillation as an associated procedure with other cardiac surgery

The following search strategy was used to identify papers in Medline. A similar strategy was used to identify papers in EMBASE, Current Contents, PreMedline and all EMB databases.

For all other databases a simple search strategy using the key words in the title was employed.

Search History	Results
1	exp Atrial Fibrillation/
2	intraoperative.mp.
3	exp Microwaves/tu [Therapeutic Use]
4	exp Thoracic Surgery/
5	microwave.mp. or MICROWAVES/
6	1 and 5