



Navigating the mini-maze: Systematic review of the first results and progress of minimally-invasive surgery in the treatment of atrial fibrillation [☆]

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ABSTRACT

Background: In this paper we present a systematic literature overview and analysis of the first results and progress made with minimally-invasive surgery using RF energy in the treatment of AF. The minimally-invasive treatment for atrial fibrillation (AF) tries to combine the success rate of surgical treatment with a less invasive approach to surgery. It has the additional potential advantage of ganglion plexus (GP) ablation and left atrial appendage exclusion. Furthermore, additional left atrial ablation lines (ALAL) can be created in non-paroxysmal AF patients.

Methods: For the search query multiple databases were used. Exclusion and inclusion criteria were applied to select the publications to be screened. All remaining articles were critically appraised and only relevant and valid articles were included in our results.

Results: Twenty-three studies were included. In 15 studies GPs around the pulmonary veins were ablated. In four studies ALAL were performed. Single procedure success rate was 69% (95% CI, range 58%–78%) without antiarrhythmic drugs (AAD) and 79% (95% CI, range 71%–85%) with AAD at one year follow-up. Mortality was 0.4%, and various complications were reported (3.2% surgical, 3.2% post-surgical, 2.6% cardiac, 2.1% pulmonary, 1.7% other).

Conclusions: Twenty-three studies of minimally-invasive surgery for AF have been reviewed with success rates between that of the standard maze procedure and catheter ablation. These first combined results show promise; however, minimally-invasive surgery is still evolving, for instance by the recent inclusion of electrophysiological endpoints. Furthermore, the type of ALAL and the additional value of GP ablation have to be elucidated.

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1. Introduction

Treatment of AF, worldwide the most common supraventricular arrhythmia, is a challenge for the cardiologist, despite increasing pharmacological and technological options. Some patients experience no or few complaints during AF while others are adequately managed with pharmacologic rate or rhythm control. Unfortunately, there is a group of patients with AF who have debilitating symptoms during AF that cannot sufficiently be treated with AAD. The Cox–Maze procedure described by Cox et al. was the first invasive surgical procedure for the

treatment of AF [1,2]. It has a success rate of 75%–95% after up to 15 years of follow up. In 1998 Haïssageurre et al. published a landmark paper in which an endovascular approach was described to target pulmonary vein triggers [3]. Catheter based interventions have a lower single procedure success rate of 57% (95% CI, range 50%–64%) off AAD after a mean follow up of 14 months, but are less invasive than the Cox–Maze-III procedure, which requires open heart surgery. Indeed, a single procedure is not always enough to prevent AF recurrences and most patients require multiple procedures to achieve a success rate of 71% (95% CI, 65%–77%) off AAD [4]. In 2005 Wolf et al. described the first results of 21 patients treated with a minimally-invasive surgical approach to PVI [5]. The minimally-invasive procedure tries to combine the success rate of surgical treatment with a less invasive intervention for the patient akin to catheter ablation. Since the first publications, experience with the minimally-invasive procedure has increased, but the technique has not yet been established as a regular treatment option of AF. A potential advantage of the epicardial approach is the possibility of GP ablation, which may modulate the substrate for

Abbreviations: AAD, antiarrhythmic drugs; AF, atrial fibrillation; ALAL, additional left atrial lesion set; AT, atrial tachycardia; CI, confidence interval; GP, ganglionated plexus; LAA, left atrial appendage; LSP, long standing persistent; PVI, pulmonary vein isolation; RF, radiofrequency.

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AF-induction [6]. Furthermore, ALAL can be created to prevent AF recurrence and AT in patients requiring more extensive ablation. The risk of embolic events might be reduced through the possibility of excluding the LAA during surgery. Multiple energy sources have been investigated, including microwave [7–9] or high frequency ultrasound [10], but application of these energy sources results in a lower success rate than RF energy. In this paper we present an analysis of the first results and progress made with minimally-invasive surgery, using RF energy only, in the treatment of AF. Additionally we discuss the recent developments and the place of minimally-invasive surgery in the therapeutic options of AF-treatment.

2. Methods

2.1. Search query

For the search query the following databases were used; Pubmed and Embase on 07/07/2011. The search query is shown in Table 1. We have added the results of Pison et al. (Pison et al., submitted) to the analysis.

2.2. Search strategy

The exclusion criteria were chosen to make a selection based on title and/or abstract, hereby selecting the papers needed to screen. Inclusion criteria were applied on the full text of the selected articles. Exclusion and inclusion criteria are listed in Table 1. Studies using RF-energy were selected as this method of ablations shows superior results compared with other energy sources like high intensity focused ultrasound [10] and microwave ablation [7–9]. Doubles were filtered manually and all remaining articles were combined. All included full texts were screened on references.

2.3. Statistical analysis

Forest-plots to present an overview of the studies have been made using Meta-Analyst Beta 3.13 (Tufts Medical Center, Boston, MA) [11]. No individual patient data were available to perform a meta-analysis; however an overall freedom of AF curve was made to show the results of all studies. A freedom from AF analysis curve was chosen to estimate the combined effect of the different studies based on the reported proportions of success and number of patients. The analysis was performed with the Statistical Package for the Social Sciences, version 15.0 for Windows XP (SPSS, Chicago, IL, USA). The authors of this manuscript have certified that they comply with the Principles of Ethical Publishing in the International Journal of Cardiology.

3. Results

A total of 24 studies were found using our search query in Embase of whom 22 were also found in Pubmed [5,12–31]. Two studies on ≤ 10 patients were excluded [32,33]. An overview of the remaining 22 studies and the study of Pison et al. is presented in Table 2. All studies were observational in nature and 18/23 studies were performed in a single centre [5,13–18,20–23,26,27,29–31,34]. In total there were

five studies by the group of Edgerton et al. who report on overlapping patients [21–25]. Therefore their papers of 2007 and 2008 have been excluded from analysis in calculations of complications [21,22]. The paper of Wang et al. [31] describes an open-label randomized trial where patients received irbesartan after minimally-invasive surgery. For calculations of the cumulative results only the patients not receiving irbesartan were selected. There were two studies by the group of Speziale and Nasso, who performed a monolateral thoracotomy. As this procedure has different surgical approach, it has been excluded from the cumulative analysis, but the results of these studies can be found in Tables 2 and 3.

3.1. Surgery

In all but two studies bilateral thoracotomy or thorascopic approach to surgery was performed, only the group of Speziale and Nasso used a monolateral thoracotomy [12,16]. Two studies performed a hybrid procedure; Krul et al. [30] performed extensive electrophysiological measurements epicardially while Pison et al. performed simultaneous transvenous catheter measurements. There were differences in the execution of the minimally-invasive surgical procedure (Table 2). RF energy was used in all studies as this was a selection criterion in including the studies in this paper. GP ablation was performed in 14 of 22 studies in addition to PVI (Table 2). Irrespective of the choice of GP ablation the ligament of Marshall was divided in all but two studies [12,16]. ALAL were made in four studies as shown in Table 2 [17,23,30]. The LAA was excluded through suturing or stapling in 20 of 22 studies [5,13–15,17–31,34]. From studies of which procedure data were available, the mean procedure duration is 208 minutes ($n = 12$ studies [5,13,14,17–20,26,28,30,31]) and hospital admission is 5 days ($n = 17$ studies [5,13,14,17–20,23–28,30,31,34]).

3.2. Outcome

Definition of success varied between studies, but unfortunately not all studies report according to the HRS/EHRA/ECAS expert consensus statement on catheter and surgical ablation of AF (Tables 2 and 3) [35].

All papers present a total number of patients of 842 who underwent surgery. The reported population comprised of 752 patients. This number is lower because some patients were lost for follow-up or were still in the 3 months blanking period following the procedure at the time of publication.

In these studies a mean of 26% (range 5%–45%, $n = 15$ studies) of patients had a history of a previous catheter ablation (excluding Castella et al. [27], where all patients had a previous catheter ablation). Total follow up varied from 2 to 45 months, with a reported mean ranging from 5.7–18 months. Unfortunately 6 month and/or 12 month follow-up were not reported in all studies. It was not always possible to assess the success percentage at these times of follow up. Results in the different types of AF and the use of AAD were not specified in every study and as such not all studies could be included in the respective pooled analysis.

Given these restrictions, the overall single procedure success rate of minimally-invasive surgery without AAD is 64% (95% CI, range 55%–72%, $n = 7$ studies) at a follow-up of 6 months and 69% (95% CI, range 58%–78%, $n = 5$ studies) at 12 months follow-up.

With AAD the single procedure success rate was 75% (95% CI, range 70%–80%, $n = 5$ studies) the 6-months of follow up (Fig. 1). At 12-months success rate was comparable at 79% (95% CI, range 71%–85%, $n = 7$ studies) with AAD (Fig. 1).

In studies with GP ablation the overall success rate is 63% with AAD (95% CI, range 58%–69%, $n = 15$ studies) while in studies where the investigators refrained from GP ablation, the success rate was 83% with AAD (95% CI, range 63%–94%, $n = 6$ studies).

In studies with ALAL the overall success rate is 77% with AAD (95% CI, range 53%–92%, $n = 4$ studies) while in studies where the

Table 1
Search query.

Database	Search query	Search results
Pubmed	(atrial fibrillation[tiab] OR AF[tiab]) AND (epicardial ablation[tiab] OR endoscopic[tiab] OR thorascopic [tiab] OR videothorascopy[tiab] OR surgical ablation [tiab] OR minimally invasive[tiab] OR minimal invasive [tiab] OR mini-maze[tiab] OR VATS[tiab] OR epicardial pulmonary vein isolation[tiab] OR surgical pulmonary vein isolation[tiab])	Total: 538 Exclusion: 32 Inclusion: 21
Embase	("atrial fibrillation":ti,ab OR "AF":ti,ab) AND ("epicardial ablation":ti,ab OR "endoscopic":ti,ab OR "thorascopic": ti,ab OR "videothorascopy":ti,ab OR "surgical ablation": ti,ab OR "minimal invasive":ti,ab OR "minimally invasive": ti,ab OR "mini-maze":ti,ab OR "VATS":ti,ab OR "epicardial pulmonary vein isolation":ti,ab OR "surgical pulmonary vein isolation":ti,ab)	Total: 632 Exclusion: 43 Inclusion: 23

The search was performed on 07-07-2011.

Exclusion criteria: Animal studies, reviews, case reports, concomitant surgery, not atrial fibrillation, not minimally-invasive surgery, not English, no full-text availability.

Inclusion criteria: Studies with > 10 patients, follow-up of > 3 months, use of radio frequent energy, off-pump cardiac surgery.

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