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Seven years of experience in using the cryoMAZE intra-operative procedure in cardio-center

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ABSTRACT

Introduction: The authors carried out a retrospective assessment of the efficacy of cryoMAZE procedure employed between early 2004 and June 2011 jointly with performing other cardiac surgeries in patients suffering from permanent/persistent or paroxysmal atrial fibrillation (AF) and other supraventricular arrhythmias. Included in the set to be assessed were 383 patients. This paper aims to assess the effectiveness of the procedure in maintaining the sinus rhythm (SR).

Methods: Within one year following the discharge from the Center, the patients, then outpatients, underwent four follow-up checks – data obtained in the checks have been used to compile this assessment.

Conclusion: One year after the cryoMAZE therapy was given, 74% of the patients exhibited sinus rhythm. No complications attributable to the use of cryoenergy were observed. The best results in restoring and maintaining the sinus rhythm were achieved in the group of patients indicated for cryoMAZE because of their paroxysmal atrial fibrillation.

SOUHRN

Úvod: Retrospektivně jsme hodnotili účinnost procedury cryoMAZE provedené u pacientů s permanentní/perzistující nebo paroxysmální fibrilací síní (FS) a s jinými supraventrikulárními poruchami srdečního rytmu při kardiochirurgické operaci v období od začátku roku 2004 do června roku 2011. Do souboru bylo zařazeno celkem 383 pacientů. Cílem práce bylo posoudit účinnost provedeného výkonu při udržení sinusového rytmu (SR).

Metodika: Pacienti prošli po propuštění z kardiocentra postupně během jednoho roku čtyřmi ambulantními kontrolami, během kterých byla získána data pro toto hodnocení.

Závěr: Po roce od provedení cryoMAZE mělo sinusový rytmus 74 % pacientů. Nebyla zaznamenána komplikace spojená s užitím kryoenergie. Skupina pacientů indikovaných ke cryoMAZE pro paroxysmální fibrilaci síní měla nejlepší výsledky v nastolení a udržení sinusového rytmu.

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Atrial fibrillation is the most frequently encountered sustained cardiac arrhythmia. Its prevalence is constantly on the rise. The condition is characteristic of fast uncoordinated atrium activation translated into the deterioration of atrial

mechanical function and the increased risk of thromboembolic events [1]. Atrial fibrillation impairs the quality of life and raises both morbidity and mortality [2]. That is why the optimal treatment of AF patients is ceaselessly sought.

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Epidemiology

Prevalence of AF in adults is reported to keep between 0.95% and 2%. The figure oscillates from 0.1% in persons below 55 years of age to 3.8% in people over 60 and to 9.0% in the octogenarians and above. Atrial fibrillation is on the increase and for the next 50 years the number of AF patients is expected to multiply 2.5-fold to 5-fold. Approximately 85% of AF patients are older than 65. Males develop the condition more frequently than females (1.1% prevalence as compared to 0.8%) [3]. Patients with cardiac failure experience AF in dependence on the severity of the failure: it starts at about 5% for patients in NYHA I Class and finishes at almost 50% for NYHA IV Class patients [4]. Atrial fibrillation is most often associated with valvular defects, particularly the mitral defects, and the ischaemic heart disease; it is frequently seen in patients with heart failure and hypertension. Patients undergoing mitral valve surgery exhibit atrial fibrillation in as much as 50% of cases [5–8].

Mortality of AF patients is about twice as high as that observed in patients with the sinus rhythm. The higher rates of morbidity and mortality witnessed in AF patients can be ascribed primarily to the increased occurrence of thrombo-embolic events. In cases where the AF acts jointly with a valvular defect (especially the mitral regurgitation), the risk of ictus can be increased 17-fold [9].

Pathophysiology of atrial fibrillation

Theories formulated to explain the mechanism of AF development assume the existence of one or multiple ectopic foci and the presence of one or several re-entrant circuits. Often enough AF is triggered by impulses repeatedly transmitted from the ectopic foci. Such impulses can appear as single occurrences; in bursts; or, rarely, as impulses of very high frequency (the truly focal AF).

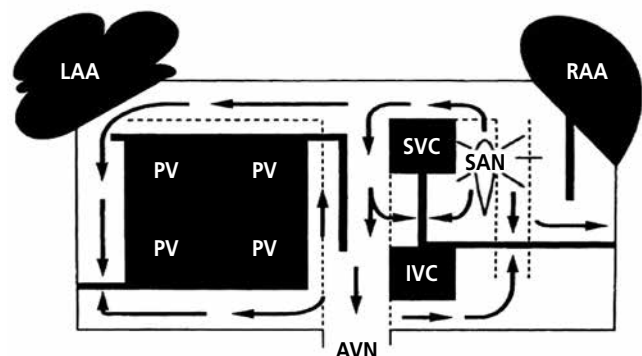


Fig. 1 – Electro-physiological representation of the Cox-MAZE III procedure

AVN – atrioventricular node; IVC – inferior vena cava; LAA – left atrial appendage; PV – pulmonary veins; RAA – right atrial appendage; SAN – sinoatrial node; SVC – superior vena cava.

Used from: Nitta T, Lee R, Schuessler RB, Boineau JP, Cox JL. Radial approach: A new concept in surgical treatment for atrial fibrillation I. Concept anatomic and physiologic bases and development of a procedure. *Ann Thorac Surg* 1999;67:27–35.

There can be a single focus or several foci – if several, the foci can take turns in activating. Most frequently the foci are located at the orifices of pulmonary veins, specifically in the “sleeves” of the atrial muscles extended over the veins [10]. As presumed, the triggering function of ectopy is at work at the early stages of the paroxysmal AF, while the remodeled atrium offers conditions favorable for maintaining re-entry. The theory of multiple re-entries suggests that AF is maintained by the action of several unstable circuits subdivided into sub-circuits of multiple levels, whose number will depend on the size and conductive properties of the atrium. If the AF is to be maintained, 4 to 7 circuits are considered a *sine qua non*. The greater the atrial dilatation, the higher the probability of AF (the reason being that more circuits can be “crammed” in the atrium and thus changed). Special importance can be attached to the left atrium which has circuits around the orifices of pulmonary veins. Both the catheter and the surgery methods of curing AF are applied to disintegrate the re-entrant circuits.

Therapy

Atrial fibrillation has to be treated in an individualized manner. Broadly stated, the treatment targets the arrhythmia proper and at the same time it endeavors to prevent the thrombo-embolic events. The AF therapy itself is oriented in two directions: the first one tries to restore and maintain the sinus rhythm (the rhythm control), while the other attempts to optimize the heartbeat frequency during the permanent AF (the frequency control).

Pharmacological therapy: rhythm/frequency control and thrombo-embolism prevention. Non-pharmacological therapy: electrical cardioversion; cardio-stimulation; catheter ablation and surgery ablation also known as the MAZE procedure.

MAZE (a labyrinthine network of pathways) – the first type of the MAZE procedure was developed in the late 1980s by professor Cox and his team whose Cut & Sew technique yielded very good results in maintaining the sinus rhythm. Since then the method has undergone several modifications finally resulting in the modified type of MAZE III as applied today. MAZE III is a system of transmural lesions carried out in heart atria and designed to make sure the impulse travels from the SA node to the AV node through the only route available, concurrently spreading into numerous blind branches. Such intervention should enable homogenous contraction of all areas of atrial myocardium, an action perceived as a fundamental prerequisite for recovery of their transportation function. Intervention in the left atrium: isolating the pulmonary vein orifices; joining the right-side and left-side pulmonary veins; making a line to the mitral annulus and across sinus coronarius, (eventually) resection of atrial appendage. Intervention in the right atrium: performing a series of linear incisions towards the superior vena cava and the inferior vena cava; making a line towards the cavotricuspid isthmus; and making a line towards the septum. Epi- or endocardial course depends on, if the atrium is opened (especially in the valvular surgery). Modified Cox-

-MAZE III with isolating the pulmonary vein orifices; joining the right-side and left-side pulmonary veins; making a line to the mitral annulus and across sinus coronarius, is nowadays used at most, because it leads to minimal decrement of effectivity of the procedure, but it reduces significantly the operation complexity (Fig. 1).

At present the Department of Cardiosurgery in České Budějovice performs these types of MAZE interventions:

- MAZE conducted while operating on cardiac blood vessels or valves from sternotomy – cryoablation;
- MAZE conducted while operating on mitral or mitral & tricuspid valve from right-handed minithoracotomy – cryoablation;
- MAZE conducted as an isolated surgery in the treatment of AF from right-handed minithoracotomy (possibly performed jointly with resecting/suturing the left atrium appendage and reducing the left atrium size) – cryoablation;
- endoscopic MAZE conducted as an isolated surgery in the treatment of AF is performed from right-handed minithoracotomy – radiofrequency (RF) ablation.

Patients who underwent the MAZE procedure together with another cardiosurgery between March 2004 and June 2011 were included in the statistical set – throughout the next year they were checked as outpatients in our Department.

Characteristics of the set of patients

The intraoperative cryoMAZE procedure was performed on 383 patients, 69 years of age on average, out of whom 152 (40%) were females.

Before the intervention 236 (61.6%) of the patients suffered from the permanent atrial fibrillation, the paroxysmal or persistent AF was observed in 115 (30.1%) patients

and the atrial flutter in 18 (4.7%) of the patients. As obvious from the transthoracic echocardiogram, the average systolic dimension of the left atrium (when measured in the parasternal projection onto the long axis) was 48.1 ± 7 mm, while the average ejection fraction of the left ventricle was 55% (table 1).

Surgeries performed jointly with the cryoMAZE procedure

Isolated aortic-coronary artery bypass was carried out in 153 patients (39.9% of the total number); the mitral valve was operated on in 80 patients (20.9%); 30 cases were treated with replacement therapy; and 50 cases were treated with plastic surgery of the mitral valve. Concurrent surgeries of the mitral and tricuspid valves were performed in 101 (26.4%) patients, while 106 (26.7%) persons underwent the isolated surgery of the aortic valve.

Table 2 shows the types of MAZE procedures, possibly applied together with the resection or suture of appendage; in 6 cases the MAZE procedure was accompanied by an intervention designed to reduce the left atrium.

Methodics of monitoring

With the cryoMaze performed and the patients discharged, Warfarin anticoagulation therapy is indicated for a period no shorter than 3 months; a beta blocker is used as an antiarrhythmic drug; if the postoperative relapse of AF is treated with amiodarone, propafenone and other antiarrhythmic drugs (digitalis, sotalol) are administered to a substantially reduced number of patients.

One month after the surgery all patients go through a follow-up examination wherein they have their ECG recorded and the therapy attuned to their condition. Patients subjected to cryoMAZE are then examined 3, 6 and 12 months after the surgery. Coming to be checked after 3 months, the patients bring in the results of 24-hour ECG monitoring, they have their clinical condition reexamined and the transthoracic echocardiogram recorded to see especially if the atrial A wave is present. With the sinus rhythm maintained, the AF obviously not relapsing, and the atria provably contracting, the anticoagulation therapy is terminated and the patients are put on anti-aggregation treatment.

Results

On discharge from hospital, the sinus rhythm (SR) was detected in 66% of patients; after 3 months the figure was 72%; after 6 months it was 68% and after 12 months 75%. The best results were achieved in a subgroup of patients suffering from the paroxysmal AF (82% on discharge and 89% after one year of monitoring); the worst results were obtained in a subgroup of patients having the left atrium preoperatively dilated (57% on discharge, 62% after one year).

As regards postoperative complications, 8 patients (2.09%) had to be revised for early postoperative bleeding. Twenty five patients (6.5%) were indicated for permanent cardiac stimulation early after the surgery (7th to 15th day). Eighteen hospitalized patients experien-

Table 1 – Characteristics of the set of patients.

	Number of patients	[%] of the entire set
Diabetes	320	83.5
Hypertension	353	92.2
Renal insufficiency	70	18.3
IHD	202	52.8
COPD	67	17.5
Previous cardiosurgeries	5	1.3

COPD – chronic obstructive pulmonary disease; IHD – ischaemic heart disease.

Table 2 – Types of the procedures.

Single left-sided cryoMAZE	143
Both-sided cryoMAZE	240
Endocardial cryoMAZE	124
Epicardial cryoMAZE	259
Resecting the left atrium appendage	60
Reducing the left atrium	6

ced a cerebrovascular event, out of whom 14 had a transient ischaemic attack (TIA) without any subsequent neurological deficit and 4 developed an ictus followed by a persisting neurological deficit. The average time spent at the Resuscitation Ward (RES) was 4.6 days, while the average time-to-discharge from the Department was 14.6 days. Twenty nine patients (7.5%) died at the early postoperative period (within 30 days of surgery).

When monitored as outpatients, 28 more patients were indicated for permanent cardiac stimulation. Throughout the one-year monitoring 4 patients underwent catheter radiofrequency ablation to treat atrial flutter; 2 patients to treat relapsing AF and 2 patients had to have their AV node ablated and then a pacemaker implanted. Another 9 patients died – the available documentation was not allowed to identify the causes (Fig. 2).

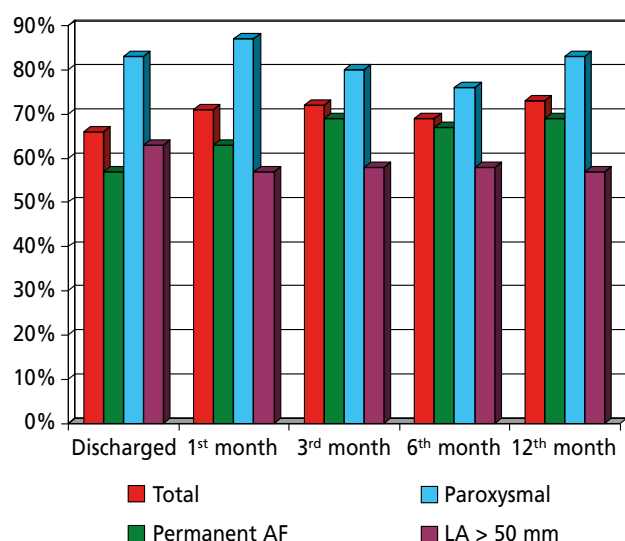


Fig. 2 – Success rate of restoring and maintaining the sinus rhythm: red column indicates total number of patients with sinus rhythm by each ambulant control (discharged from hospital, 1st month control, 3rd, 6th and after 12th month), green column patients with permanent AF before the operation, blue column with paroxysmal and purple column patients with dilated left atrium over 50 mm (measured from parasternal projection to long axis).

Discussion

Patients suffering from permanent or paroxysmal AF have not been investigated in many prospective randomized studies wherein the different cardiosurgery interventions accompanied by intraoperative ablation would be compared with a control group in which no form of ablation was performed. If available at all, the randomized data do not cover large groups of patients, and the patients actually included are exclusively those who have their mitral valves diseased [11–18].

The papers mentioned above testify quite unambiguously to the beneficial effect that surgical ablation has on maintaining the sinus rhythm (SR) after mitral valve interventions. The higher rate of SR maintained in the

intervened group then translated itself into a positive effect on thrombo-embolic events. The quoted papers report that the group of patients who underwent the ablation maintained SR in 44.4% to 95.2% of cases, while the not ablated group exhibited the SR maintenance in 4.5% to 42.9% of cases [19]. The differences were statistically significant in all sets of the patients.

Currently the left or right atrial appendage is resected or sutured while performing the cryoMAZE solely in cases where a thrombus is documentably contained in the appendage; a spontaneous echo-contrast is present; and/or a cerebrovascular event is recorded in the anamnesis.

Concerning the energy, in conducting intraoperative MAZE the authors rely exclusively on cryoenergy. The cryoablation, in contrast to radiofrequency, generally keeps the collagenous tissue integrated. During 48 hours after the procedure irreversible lesions develop in the form of hemorrhages, oedemas and inflammations. Throughout 12 weeks from the cryoablation the atrial wall develops a transmural homogenous and fibrotic lesion. A major benefit of the cryoenergy rests in its capability of maintaining the tissue structures integral and the thrombogenesis at a low level [20].

The herein presented set of patients with preoperatively diagnosed atrial fibrillation, who underwent cryoablation together with another cardiac surgery, exhibited long-term and high-level effectiveness in maintaining the sinus rhythm. Our results can be favorably compared with those published in literature.

In accordance with results published elsewhere, our set of patients also manifested marked improvement within the first six months after the intervention, whereas the later improvements were more moderate. Consequently, the subsequent interventions made with reliance on pharmacological or electrical cardioversions were most successful when completed during the first months after the operation.

The use of cryoablation did not heighten the perioperative risk, and the early mortality figure (7.5%) was comparable with that encountered after cardiosurgeries conducted without cryoMAZE. Analogously to what has to be done after catheter ablation for AF, some of the patients had to be kept on the antiarrhythmic therapy, primarily to suppress the early relapsing arrhythmias experienced before the atria were fully healed.

Residual arrhythmogenic substrate left after the surgical cryoablation may occasionally require that antiarrhythmic drugs be administered in the course of subsequent monitoring, but even in such cases the intervention will often make effective therapy which would otherwise be incapable of maintaining the sinus rhythm [21].

Limitations

Asymptomatic AF events not obvious in the electrocardiogram can now and then occur within the period of monitoring. The assessments of results relied on anamnesis focused on arrhythmia symptoms and standard ECG methods, including the 24-hour Holter ECG monitoring.

Conclusion

The surgical cryoablation has proved to be a safe method of long-term effectiveness available to treat atrial fibrillation in patients undergoing another cardiosurgery; the method offers a high probability of restoring the sinus rhythm and allows to reduce the subsequent antiarrhythmic and anticoagulation therapy. Currently surgical cryoablation is a standard therapy applicable both to permanent and to paroxysmal atrial fibrillation.

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