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Original Article / Özgün Makale

Application of cryoablation for the treatment of atrial fibrillation in patients undergoing cardiac surgery: Our mid-term results

Kalp cerrahisi yapılan hastalarda atriyal fibrilasyon tedavisinde kriyoablasyon uygulaması: Orta dönem sonuçlarımız

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ABSTRACT

Background: In this study, we aimed to present mid-term results of concomitant argon-based cryoablation in patients undergoing cardiac surgery.

Methods: Between August 2014 and May 2016, 33 patients (17 males, 16 females; mean age 63.9 years; range 45 to 82 years) underwent the Maze procedure using cryoablation for the treatment of atrial fibrillation during a concomitant open cardiac operation. Robot-assisted procedures were used in 12 patients. Biatrial or isolated left atrial ablation was performed according to the underlying pathology. The rhythm assessment with 12-lead electrocardiography and 24-hour Holter, and recordings of atrial fibrillation-related medications, stroke or other thromboembolic events were evaluated by the cardiologist at 3 and 12 months postoperatively.

Results: Thirty patients (90.9%) were in sinus rhythm and three (9.1%) were in atrial fibrillation at the time of discharge. Cryoablation failed in three patients (n=2, 8.3% in isolated left atrial and n=1, 11.1% in biatrial group) following the operation in the mid-term. Among the patients, there was no in-hospital mortality and no major postoperative complications such as stroke, sepsis, renal failure requiring dialysis, and prolonged respiratory failure.

Conclusion: Concomitant surgical cryoablation is an effective method for the treatment of atrial fibrillation, when performed concomitantly with other cardiac surgical procedures and results in very low atrial fibrillation recurrence, even in robotic surgery.

Keywords: Atrial fibrilation; cryoablation; robotic surgery.

ÖZ

Amaç: Bu çalışmada kalp cerrahisi yapılan hastalarda eşlik eden argon bazlı kriyoablasyonun orta dönem sonuçları sunuldu.

Çalışma planı: Ağustos 2014 - Mayıs 2016 tarihleri arasında 33 hastaya (17 erkek, 16 kadın; ort. yaş: 63.9 yıl; dağılım 45-82 yıl) eş zamanlı açık kalp cerrahisi sırasında atriyal fibrilasyon tedavisi için kriyoablasyon ile Maze işlemi uygulandı. On iki hastaya robotik cerrahi kullanıldı. Altta yatan patolojiye göre biatriyal veya izole sol atriyal ablasyon yapıldı. Ameliyat sonrası 3 ve 12. aylarda kardiyolog tarafından, ritim 12 derivasyonlu elektrokardiyografi, 24 saatlik Holter ile değerlendirildi ve atriyal fibrilasyon ile ilgili ilaçlar, inme veya diğer tromboembolik olaylar değerlendirildi.

Bulgular: Taburculuk sırasında 30 hasta (%90.9) sinüs ritminde, üç hasta (%9.1) ise atriyal fibrilasyonda idi. Ameliyat sonrasında orta dönemde, kriyoablasyon üç hastada (izole sol atriyal fibrilasyonda n=2, %8.3 ve biatriyal ablasyonda n=1, %11.1) başarısız oldu. Hastalarda hastane mortalitesi ve inme, sepsis, diyaliz gerektiren renal yetmezlik ve uzamış solunum yetmezliği gibi majör ameliyat sonrası komplikasyonlar gelişmedi.

Sonuç: Eş zamanlı cerrahi kriyoablasyon, diğer kardiyak cerrahi işlemler ile birlikte uygulandığında atriyal fibrilasyonun tedavisinde etkili bir yöntem olup, robotik cerrahi ile de çok düşük oranda atriyal fibrilasyon nüksü ile sonuçlanmaktadır.

Anahtar sözcükler: Atriyal fibrilasyon; kriyoablasyon; robotik cerrahi.

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Surgical ablation for atrial fibrillation (AF) has been under continuous development for more than three decades and is recommended at the time of concomitant cardiac operations to restore sinus rhythm (SR).[1] Despite good progress in the management of patients with AF, this arrhythmia remains one of the major causes of stroke, heart failure, sudden death, and cardiovascular morbidity worldwide. The Cox Maze III procedure is a precisely defined pattern of biatrial incisions to eliminate AF in patients undergoing open cardiac surgery. The reported SR conversion rate after the Cox-Maze III procedure is 97 to 99% and is, therefore, considered the golden standard.[2] However, due to its technical difficulty, only a few surgeons performed this procedure. Over the years, application of various energy sources such as radiofrequency or cryothermy and lesion sets have been used to create lines of conduction block, replacing the suture lines of the classic approach.[3-6] As a treatment for AF, the CryoMaze procedure creates linear frozen scars in the upper chamber of the heart by applying an Argon-powered cold probe to freeze the tissue. By freezing the tissue to very cold temperatures and creating electrical obstacles, electrical activity is permanently obstructed.[3,6,7]

In the present study, we aimed to present mid-term results of isolated left atrial (LA) or biatrial cryoablation technique for the treatment of AF as a concomitant procedure of open cardiac surgery and to report a structured local follow-up to one year postoperatively.

PATIENTS AND METHODS

This prospective, single-center study included a total of 33 patients (17 males, 16 females; mean age 63.9 years; range 45 to 82 years) who underwent open cardiac surgery concomitant endocardial cryoablation for the treatment of AF between August 2014 and May 2016. The demographic characteristics of the patients are presented in Table 1. The study protocol was approved by the ethics committee. An informed consent was obtained from each patient. The study was conducted in accordance with the principles of the Declaration of Helsinki.

Perioperative data were retrieved from the institutional database. Preoperative AF was defined as intermittent (paroxysmal, persistent) or permanent according to the Heart Rhythm Society/European Heart Rhythm Association/European Cardiac Arrhythmia Society. Additional rhythm related data were collected including presence of AF at the time of surgery, duration of AF, antiarrhythmic medications, and echocardiographic data such as LA size and left ventricular ejection fraction were all retrieved from database.

There was a heterogeneity for the type of procedures and the approach in terms of robotic assistance; however, uniform protocol for ablation and lesion set was used in all patients. If the LA was planned to open alone (n=24), this was achieved through interatrial groove following midsternal approach and central cannulation (ascending aorta and bicaval) in non-robotic assisted patients. The LA appendage was ligated in all patients using a double layered running suture from the inside of LA. Cryoablation was performed using a flexible argon-based device (cryoICE cryoablation probe, AtriCure Inc., West Chester, OH, USA; Cardioblate CryoFlex Surgical Ablation Probe, Medtronic Inc., Minneapolis, MN, USA) and starting with an ablation line extending from the atriotomy to the mitral valve annulus in the region P2/P3. The left and right pulmonary veins were isolated, an inferior and superior ablation line was placed to complete the box lesion for isolation of the posterior atrial wall, and an additional lesion was placed to connect the box to the closure line of the LA appendage. The cryoprobe can be fit to the shape of the atrial wall, either endocardial or epicardial, creating cryolesions of 1 to 10 cm in length. Principally, atrial cryolesions in this series were performed for 90 sec reaching local temperatures of -130°C. Biatrial ablation (n=9, 27.2%) was performed in the patients with atrial flutter or enlarged right atrium (RA) such as existence of atrial septal defect. An additional RA lesion set consisted of an intercaval lesion extending from the superior vena cava (SVC) to the inferior vena cava (IVC); from this lesion to tricuspid valve annulus and finally from the first lesion to RA appendage.

Twenty-four of the patients (72.7%) underwent mitral valve surgery. The types of the concomitant surgeries in addition to LA or biatrial cryoablation were summarized in Table 2.

Robotic assistance was used in 12 patients, and the operative technique was detailed previously.[8] Briefly, in robotic approach, cardiopulmonary bypass (CPB) was achieved via peripheral cannulation (femoral artery, femoral vein, internal jugular vein) under guidance of transesophageal echocardiography (TEE). The heart was arrested using cold crystalloid cardioplegia delivered into the aortic root with a transthoracic cannula through the thoracotomy. The inferior and superior venae cavae were occluded with

Table 1. Demographic characteristics

	n	Mean	Range
Age (year)		63.9	45-82
Gender			
Female	16		
Ejection fraction (%)			
Ejection fraction (50>)	30		
Ejection fraction (35-50)	2		
Ejection fraction (<35)	1		
Preoperative left atrium (>55)	7		
Cerebrovascular accident	1		
Peripheral vascular disease	1		
Prior myocardial infarction	1		
Hypertension	17		
Congestive heart failure (NYHA Class III-IV)	16		
Chronic obstructive pulmonary disease	3		
Diabetes mellitus (two of them insulin depended)	10		
Renal dysfunction (acute renal, no dialysis)	1		
Reoperation	0		
Coronary artery disease	16		
Atrial fibrillation			
Mean duration of atrial fibrillation (months)		38.6	1-180
Type of atrial fibrillation			
Intermittent (paroxysmal or persistent)	2		
Permanent	31		
Rhythm at time of surgery			
Atrial fibrillation	33		
Preoperative medication			
Calcium channel blocker	7		
Digoxin	3		
Acetylsalicylic acid	13		
Beta blocker	21		
Antiarrhythmic medication	3		
Warfarin sodium	2		

NYHA: New York Heart Association.

bulldog clamps in patients which the RA was opened. The cryoprobe is flexible and also suitable for creating ablation during robotic assistance.

The mean duration of follow-up was 18 (range 10 to 30) months among the discharged patients. Follow-up data were 100% complete for all patients, and no patients died during this period.

All patients received oral anticoagulation therapy with warfarin for three months regardless of postoperative rhythm. The continuation of oral anticoagulation therapy was decided according to the CHA2DS2-VASc score. The patients with mechanical valves received life-long anticoagulation. All patients were treated with β-blockers and amiodarone after surgery, unless postoperative bradycardia or junctional rhythm was detected.

Prospective follow-up protocol was started in August 2014, consisting of outpatient visits to the responsible surgeon at first month. The rhythm assessment with 12-lead electrocardiography (ECG) and 24-h Holter, and recordings of AF-related medication, stroke, or other thromboembolic events were evaluated by the cardiologist at three and 12 months, postoperatively. Definition of success for these patients was normal sinus or pacing rhythm, and freedom from AF at discharge and during follow-up. The patients were classified as free from AF, when they were in sinus rhythm, atrial paced without underlying AF, junctional rhythm or other regular rhythm. The patients who developed AF or atrial flutter, and those who were paced, but had underlying AF were classified as AF patients. The failure of the cryoablation procedure was defined as AF more than three months following the procedure.

Table 2. Operative characteristics of patients

Procedure		Non-robotic		Robotic	
	n	Endo LA	Biatrial	Endo LA	Biatrial
MVR	7			7	
MVR, TV repair	5	2		2	1
MVR + TVR	1				1
MVR + septal myectomy	1	1			
CABG + MV repair	2	1	1		
TVR	1		1		
AVR	2	2			
MVR, AVR	2		2		
MVR, AVR, TVR	1		1		
CABG	4	4			
Ascending aorta replacement	1	1			
CABG, coronary fistula ligation	1	1			
MVR + CABG + ascending aorta replacement	1	1			
MV repair	2	1		1	
David procedure, CABG	1		1		
Bentall procedure + MVR	1	1			
Atrial septal defect closure	1		1		
MVR + CABG	1	1			

LA: Left atrium; MVR: Mitral valve replacement; TV repair: Tricuspid valve repair; TVR: Tricuspid valve repair; CABG: Coronary artery bypass grafting; MV repair: Mitral valve repair; AVR: Aortic valve replacement

Statistical analysis

For the statistical analysis, the program NCSS (Number Cruncher Statistical System) 2007 Statistical Software (NCSS LLC, Kaysville, Utah, USA) (License No: 1675948377483; Serial No: N7H5-J8E5-D4G2-H5L6-W2R7) was used. The mean, standard deviation, minimum, maximum, range, median, frequency and ratio calculations from the descriptive statistical methods were used when the descriptive study data were evaluated.

RESULTS

Two patients (6%) had paroxysmal and 31 (94%) had persistent AF before operation. The mean duration of AF was 38.5 (range, 1 to 180) months, this was 36.6 (range, 14 to 60) months in recurrent AF group and 38.7 (range, 1 to 180) months in the treated AF group. The mean LA size was 50 mm (range, 39 to 68) mm. The mean CPB and mean cross-clamp time was 140.7 (range, 91 to 217) min and 99.5 (range, 31 to 171) min, respectively.

Cryoablation failed in three patients (n=2, 8.3 % in isolated LA and n=1, 11.1% in biatrial group) following the operation in the mid-term. Thirty patients (90.9%) were in sinus rhythm and three (9.1%) were in AF at the time of discharge. One of them became AF in the treated group and required permanent pacemaker implantation following cardioversion; however, this patient maintained sinus rhythm in the follow-up. One more patient required a permanent pacemaker implantation in the failure group due to slow-transition AF. During follow-up, 30 patients (90.9%) maintained their sinus rhythm. The patients with permanent AF at the time of surgery (n=31, 94%) had an increased rate of recurrence at discharge (n=3, 9.1%), compared to those with intermittent AF (n=0.0%).

The LA was larger than 55 mm in 1/3 (33.3%) of failure patients; however, by cryoablation 6/7 (85.7%) patients were converted to sinus rhythm among the patients who had LA larger than 55 mm.

Among the patients, there was no in-hospital mortality and no major postoperative complications such as stroke, sepsis, renal failure requiring dialysis, and prolonged respiratory failure.

DISCUSSION

Our results show that surgical cryoablation is an effective method for the treatment of AF, when performed concomitantly with other cardiac surgical procedures. This technique resulted in low AF recurrence rates in the mid-term follow-up (3/33; 9.1%).

There is a very limited number of studies showing the results of cryoablation procedure with robotic

assistance in the literature.[9] With the use of specialized robotic forceps, the probe can be molded to conform geometrically to an individual atrial anatomy. In our study, 12 patients underwent cryoablation with robotic assistance and 11 of them converted to sinus rhythm in the mid-term follow-up. The combination of dynamic LA retraction, improved dexterity using endowrist technology, and three-dimensional vision allows surgeon for precise placement of the cryoprobe and avoidance of skips caused by folds in the floor of the LA.

When analyzing the results, creating LA lesions in the setting of more chronic AF (long-lasting persistent AF) seems to be less effective, and these patients may derive greater benefit from a more extensive ablation procedure, such as creating biatrial lesion.

Our findings were consistent with Charitos et al.[10] suggesting that the preoperative duration of AF and the use of a box lesion only in patients with longer AF persistence history were independently associated with higher postoperative AF burden recurrence and many patients later required repeated catheter ablation interventions or the need for electrical cardioversion. In a study containing a large number of patients (n=503) with nine years period of observation, the statistically significant predictors for sinus rhythm continuation after one year were LA diameter, AF duration, preoperative paroxysmal AF, immediate postoperative sinus rhythm, and biatrial ablation for persistent AF.[11]

Our data showed that even in patients with large LA diameters, concomitant surgical AF ablation may restore sinus rhythm with negligible AF recurrence up to one year postoperatively, and enlarged LA diameters should not be considered as a contraindication for concomitant surgical ablation of AF.

The correction of severe mitral valve regurgitation was associated with lower AF burdens during the total observation period. In a similar manner, the patients with mild to moderate mitral valve regurgitation who did not undergo mitral valve repair had significantly higher AF burden during follow-up.[10] Similar conclusions have been obtained after catheter ablation which underscores the influence of coexisting mitral regurgitation on the outcomes of AF ablation procedures. In the case of the surgical patient, correction of mild-to-moderate mitral regurgitation in patients undergoing concomitant surgical AF ablation leads to lower rates of AF recurrence and should be strongly considered.[10]

On the other hand, due to the small number of patients and the resulting limited statistical power, none of the randomized trials was able to show a survival benefit for patients receiving concomitant ablation. However, in a recent propensity score-matched analysis by McCarthy et al.,[12] the mid-term survival of patients with AF receiving concomitant surgical ablation was statistically significantly higher, compared to the untreated patients and comparable to those of patients without preoperative AF.

There are several limitations of the present study, such as a non-randomized retrospective study design with a limited number of patients. Furthermore, the present study was a single center analysis, consisting of a wide spectrum of patients undergoing open cardiac surgery.

In conclusion, our study results suggest that the surgical treatment of atrial fibrillation using this flexible argon-based cryoablation device was safe and effective during a wide variety of concomitant cardiac procedures. This procedure takes 10 to 20 min which does not significant prolong the cardiopulmonary bypass duration. On the basis of our findings, all patients with any history of atrial fibrillation undergoing a cardiac surgical procedure may be considered for a concomitant ablation procedure.

Declaration of conflicting interests

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REFERENCES

1. Badhwar V, Rankin JS, Damiano RJ Jr, Gillinov AM, Bakaeen FG, Edgerton JR, et al. The Society of Thoracic Surgeons 2017 Clinical Practice Guidelines for the Surgical Treatment of Atrial Fibrillation. Ann Thorac Surg 2017;103:329-41.
2. Cox JL, Boineau JP, Schuessler RB, Kater KM, Lappas DG. Five-year experience with the maze procedure for atrial fibrillation. Ann Thorac Surg 1993;56:814-23.
3. Mack CA, Milla F, Ko W, Girardi LN, Lee LY, Tortolani AJ, et al. Surgical treatment of atrial fibrillation using argon-based cryoablation during concomitant cardiac procedures. Circulation 2005;112:1-6.
4. Luik A, Radzewitz A, Kieser M, Walter M, Bramlage P, Hörmann P, et al. Cryoballoon Versus Open Irrigated Radiofrequency Ablation in Patients With Paroxysmal Atrial Fibrillation: The Prospective, Randomized, Controlled, Noninferiority FreezeAF Study. Circulation 2015;132:1311-9.
5. Yılık L, Bayatlı K, Banu L, Emrecan B, Kestelli M, Karahan N, et al. Early and mid-term results of irrigated

radiofrequency left atrial ablation in chronic atrial fibrillation with concomitant mitral valvular pathology. Turk Gogus Kalp Dama 2006;14:185-8.

6. Akpinar B, Sağbaş E, Güden M, Sanisoğlu I. The surgical treatment of atrial fibrillation. [Article in Turkish] Anadolu Kardiyol Derg 2007;7:65-73.
7. Lee KH, Min J, Kim KH, Hwang HY, Kim JS. Efficacy of Cox Maze IV Procedure Using Argon-Based Cryoablation: A Comparative Study with N2O-Based Cryoablation. Korean J Thorac Cardiovasc Surg 2014;47:367-72.
8. Senay S, Gullu AU, Kocyigit M, Degirmencioglu A, Karabulut H, Alhan C. Robotic mitral valve replacement. Multimed Man Cardiothorac Surg MMCTS 2014;2014:2-5.
9. Nifong LW, Rodriguez E, Chitwood WR Jr. 540 consecutive robotic mitral valve repairs including concomitant atrial fibrillation cryoablation. Ann Thorac Surg 2012;94:38-42.
10. Charitos EI, Ziegler PD, Stierle U, Graf B, Sievers HH, Hanke T. Long-term outcomes after surgical ablation for atrial fibrillation in patients with continuous heart rhythm monitoring devices. Interact Cardiovasc Thorac Surg 2015;21:712-21.
11. Pecha S, Schäfer T, Subbotina I, Ahmadzade T, Reichenspurner H, Wagner FM. Rhythm outcome predictors after concomitant surgical ablation for atrial fibrillation: a 9-year, single-center experience. J Thorac Cardiovasc Surg 2014;148:428-33.
12. McCarthy PM, Manjunath A, Kruse J, Andrei AC, Li Z, McGee EC Jr, et al. Should paroxysmal atrial fibrillation be treated during cardiac surgery? J Thorac Cardiovasc Surg 2013;146:810-23.