Modified Maze lines plus pulmonary vein isolation created by radiofrequency catheter ablation on the atrial wall to treat atrial fibrillation in elderly

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Objective  To evaluate the effect of modified Maze lines plus pulmonary vein (PV) isolation created by radiofrequency catheter ablation (RFCA) on atrial wall guided by a novel geometry mapping system in the treatment of elderly patients with paroxysmal atrial fibrillation (PAF). Methods  After regular electrophysiological study, transseptal punctures were achieved twice with Swartz L1 and R1 sheaths. PV angiographies were conducted to evaluate their orifices and branches. A balloon electrode array catheter with 64 electrodes was put in the middle of the left atrium. Atrium geometry was constructed using Ensite 3000 NaviX system. Two RFCA lesion loops and three lines (modified Maze) were created on left and right atrial walls. Each lesion point was ablated for 30 seconds with preset temperature 50°C and energy 30W. The disappearance or 80% decrease of the amplitude of target atrial potential and 10 to 20, decrease of ablation impedance were used as an index of effective ablation. Results  A total of 11 patients (7 male and 4 female, mean age, 68.7±5.1 years) were enrolled. PAF history was 7.9±4.5 years. PAF could not be prevented by mean 3.1±1.6 antiarrhythmic agents in 6.3±3.4 years. None of the patients had complications with structural heart disease or stroke. Left atrial diameter was 41.3±3.6 mm and LVEF was 59.2±3.7 % on echocardiography. Two loops and three lines were completed with 67.8±13.1 (73-167) lesion points. Altogether 76-168 (89.4±15.3) lesion points were created in each patient. PAF could not be provoked by rapid burst pacing up to 600 beat per minute delivered from paroxysmal coronary sinus electrode pair. Complete PV electrical isolation was confirmed by three-dimensional activation mapping. Mean procedure time was 2.7±0.6 hours and fluoroscopy time was 17.8±9.4 minutes. Patients were discharged with oral aspirin and without antiarrhythmic agents. During follow up of 6.5±1.8 months, seven patients were PAF symptom free (63.6%). PAF attacks were decreased more than 70% in two patients (18.2%). PAF frequency did not change in another two patients (18.2%). Conclusions  Ensite 3000 NavX guided modified Maze lines plus PV isolation on the atrial wall is safe and feasible in the elderly patients. It has the advantages of exact procedural endpoint, shorter X-ray exposure, fewer complications and satisfied long-term effect PAF control. (J Geriatr Cardiol 2005;2(2): 95-100).

Key Words paroxysmal atrial fibrillation; electrophysiology; MAZE ablation; pulmonary vein ablation

Background  Paroxysmal atrial fibrillation (PAF) is one of the most frequent tachyarrhythmias in elderly patients. Its mechanism is believed to be triggered or driven by electrical foci originating mostly from pulmonary veins (PV).1 PAF could be cured either by ablating target focus or by isolating target PV electrically.2,3 Due to the difficult definition of the target foci, the electric isolation technique is frequently used now in interventional electrophysiology.4 Isolating target PV at its orifice by radiofrequency catheter ablation (RFCA) was first used in the cure of PAF, but this treatment has the complication of target PV stenosis.5,6 Recently, novel non-contact geometry mapping systems are used to guide the isolation of whole left and right PVs on the left atrial (LA) wall.6 In order to increase therapeutic efficacy and decrease complications of PAF treatment in the elderly, we used Ensite 3000 NavX, one of the non-contact mapping systems, to treat PAF by creating modified Maze lines on atrial walls plus isolating left and right PVs as two units on the LA wall.

Patient characteristics  Seven patients were male and four were female, with an average age of 68.7±5.1 years. PAF could not be prevented by a mean of 3.1±1.6 antiarrhythmic agents (including amiodarone, propafenone, propranolol, sotalol, quinidine, etc) for 6.3±3.4 years. No patients were complicated with structural heart disease or stroke. LA size was 41.3±3.6 mm and left ventricular ejection fraction (LVEF) was 59.2±3.7% on echocardiography. Repetitive P' on T atrial premature beats

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and PAFs were recorded by random ECG (Fig. 1) and/or Holter monitoring.

Two loops and three lines were completed with 67.8±13.1(73-167) lesion points. Altogether 76-168 (89.4±15.3) lesion points were created in each patient.

**Electrophysiological study**

After written informed consents were obtained, regular electrophysiological studies (EPS) were conducted to exclude supra- or intra-ventricular reentrant tachycardias. The methodology of standard EPS was reported elsewhere and briefly described as follows: A decapolar electrode catheter was placed in the distal coronary sinus via left subclavian vein. A tetrapolar electrode catheter (Josephson curve) was positioned at the His bundle branch for recording and another catheter (Courmand curve) was seated at the high right atrium (HRA) at first and then right ventricular apex (RVA) for pacing. Both programmed and non-programmed electrical stimulations were delivered via HRA and RVA electrode pairs with stimuli of two times of diagnostic threshold and 0.5 ms pulse width. Up-graded high rate burst pacing was used to induce atrial flutter and fibrillation at both HRA and coronary sinus.

Reentrant supraventricular and ventricular tachycardias were not induced in all patients. Atrial flutter was induced in two patients and atrial fibrillation was induced in another 6 patients.

**Pulmonary vein angiography and atrial geometry construction**

From the right femoral vein approach, the atrial septum
was punctured twice and L1 and R1 Swartz sheaths were positioned. A steerable large-tip ablation catheter (Bard Co., 7F) and a non-contact mapping catheter with 64 electrodes array mounted on an inflatable balloon were introduced into the left atrium (LA). The tip of the mapping catheter was positioned at the left superior PV orifice with a stiff 0.035 wire. PV angiographies were conducted to evaluate their orifices (Fig. 2A). LA geometry was constructed at either sinus rhythm or PAF using Ensite3000 Navx system (Fig. 2B) and with the large-tip ablation catheter as landmark in LA. On the three-dimensional geometry of LA, following loops and lines for electrical isolation were outlined (Fig. 2C and 2D): (1) Two loops encircled the left and the right-sided PV orifices. (2) A top line connected the two loops on the roof of LA. (3) A bottom line linked between the lower part of the left-sided loop and the lateral part of mitral valve ring.

After the mapping and ablating procedure in the LA, the balloon mapping catheter and the large-tip ablation catheter were withdrawn and put in the middle of RA. RA geometry was constructed and a shortest line (one of the three modified Maze lines) between interior vena cava orifice and tricuspid valve ring was outlined (Fig. 2D).

**Modified Maze lines plus pulmonary vein isolation guided by Ensite 3000 Navx**

Along with the described loops and lines on LA and RA geometry, radiofrequency energy was delivered point-by-point to form a continuous lesion guided by Ensite3000 Navx system. Each lesion point was ablated for 30 seconds with preset temperature 50°C and energy 30W. The disappearance or 80% decrease of the amplitude of target potential and 10 to 20° decrease of ablation impedance were used as index of effective ablation. Altogether 76-168 (89.4±15.3) lesion points were needed to complete the two isolation loops and

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Fig. 2. A. Left superior pulmonary vein angiography through a trans-atrial septal sheath positioned at the PV ostium. B. Configuration of Ensite 3000 Navx, a novel three-dimensional electro-anatomical mapping system. C. PV location on the left atrial wall from the view of posterior-anterior position. D. Two PV isolation circles and three modified Maze lesion lines.
Fig. 3. A total of 59 ablation points were used to complete two loops and two lines. The two loops encircled the left and the right sided PVs (A-G). The top line connected the two loops on the roof of LA (D,E,G) and the bottom line linked between the lower part of left loop and the lateral part of mitral valvar ring (C,D). A. Lesion on RAO view. B. Lesion on left lateral view. C. Lesion on mitral isthmas. D. Lesion on PA view. E. Lesion on right lateral view. F. Lesion on AP view. G. Lesion on crassial view.

Fig. 4. Posterior isthmus ablation. A. A radiofrequency ablation line between tricuspid ring and inferior vena cava was achieved with 6 lesion points B. Three dimensional activation mapping showed posterior isthmus conduction block.

three Maze lines (Fig. 3). Activation mapping on three-dimensional geometry at both sinus rhythm and coronary sinus pacing was repeated to confirm the electrical disconnection between pulmonary and LA and the activation block along three ablation lines. Up-graded high rate burst pacing up to 600 beat per minute was delivered from the distal coronary sinus electrode pair to provoke PAF. After that, the geometry of RA was constructed by withdrawing the balloon and ablation catheters. Radiofrequency lesion line between tricuspid ring and inferior vena cava was achieved with another 6 lesion points (Fig. 4). Mean procedure time was 2.7±0.6 hours and fluoroscopy time was 17.8±9.4 minutes. Altogether 10 mg morphine was injected intravenously in each patient during the period of energy delivery to resolve chest pain. There was no manipulation related death or complications.

Follow Up

The patients were discharged with long-term oral aspirin and without any antiarrhythmic agents. During the follow-up of 6.5±1.8 months, seven patients were free of PAF symptoms (63.6%). PAF attacks were decreased by more than 70% in two patients (18.2%). PAF frequency was not changed in another two patients (18.2%).

Discussion

Paroxysmal atrial fibrillation (PAF) is one of the most common arrhythmias seen in clinical practice. Its incidence increases with age and it is seen in up to 8.9% of individuals 80 years or older. Although many treatment modalities are available for PAF, curative therapy has recently become possible due to the improved understanding of the electrophysiology of PAF, availability of better mapping skills as well as advances in catheter technology.

Mechanism of PAF

In 1947, Scherf first revived the focal trigger theory of PAF. Later, Moe brought forward random reentry as the mechanism of PAF. Recently, Haissaguerre et al. reported that PVs are focal triggers in certain PAF cases. They believed that myocardial sleeves extended from the LA onto the PVs
are arrhythmogenic apparatus. These sleeves have important roles for both focal activity and reentry in the electrophysiology of PAF.

**Pulmonary vein and PAF.**

Nathan et al.\(^4\) found that the proximal portion of the PV has a sleeve of myocardium that is extended from the adjacent atrial tissue and is electrically coupled to the atrium in the human heart. Saito et al.\(^5\) observed that the peripheral zones of myocardial sleeves were associated with increasing connective tissue deposition between myocardial muscle groups. They suggested these were degenerative changes that fitted with progressive ischemia. Lin et al.\(^6\) reported that the ostia and proximal portion of superior PVs were nonspecifically dilated in AF patients and these significantly dilated PVs were frequently associated with ectopic beats initiating paroxysmal PAF.

**Coronary sinus and PAF.**

The coronary sinus (CS) may play roles in the origin and maintenance of AF. Gerkis et al.\(^7\) found that the proximal CS is surrounded with a spiral myocardial sheet that stops abruptly at or shortly beyond the CS orifices. Recently, Katritsis et al.\(^8\) recorded that double potentials are presented within the CS in many PAF patients, particularly the distal superoposterior part, near the left superior PV. They proposed that these are possible sources or substrate of PAF.

**Ligament of Marshall and PAF.**

The ligament of Marshall consists of multiple sympathetic nerve fibers, ganglia, blood vessels and multiple myocardial tracts (Marshall Bundles) insulated by fibrofatty tissue. Kim et al.\(^9\) found that the ligament of Marshall in the human heart is innervated by sympathetic nerve fibers and has multiple myocardial tract insertions into the left atrial wall and CS. They suggested that these could form a substrate of reentry. Polymeropoulos et al.\(^10\) recently recorded discrete electrical potential preceding the atrial electrogram (Marshall potential) from a 66-year-old woman with a history of PAF. Radiofrequency ablation was successfully performed. They found these Marshall potentials could be ablated by radiofrequency catheter ablation.

**Mapping of PAF.**

Due to the complex mechanisms and focal location of PAF, it is very important to achieve a three dimensional orientation and activation sequence of the focus to be able to overcome the disadvantage of traditional electrophysiological mapping techniques and to localize therapeutic targets. Besides electroanatomic or CARTO\(^\text{TM}\) mapping system, another novel noncontact mapping system consisting of a balloon mounted on multielectrode array, EnSite3000\(^\text{TM}\) (Endocardial Solutions, St Paul, MN), has been studied extensively. It is based on the principle that endocardial activation produces a chamber voltage field, which obeys Laplace’s equation. Noncontact electrode array on the balloon is used to detect the intracavity potential field. The activation points are displayed as isopotential maps. After establishing the geometry of the interested chamber, the focal area could be identified and the ablation catheter could be navigated to this area for precise mapping and treatment. Focal AF arising from both right atrium and PVs has been successfully ablated using this system and preliminary results are promising.

**Catheter ablation of PAF.**

**Radiofrequency catheter ablation of PAF:** The radiofrequency catheter ablation for RA or LA modification involves the creation of linear transmural atrial lesions. The RA modification has achieved good success in the treatment of driven or triggered PAF. On the other hand, LA modification has been not so rewarded because of faulty technique and increased risk of stroke. The LA is now frequently the ablation target for curative PAF since the introduction of PV isolation. One of the unsolved problems is the lack of good tissue contact between the electrode and the wall of atria or PVs. This will lead to the production of discontinuous lesions which could themselves be proarrhythmic. The development in catheter design and mapping system could overcome these shortcomings.

**Modified Maze procedure:** Most focal AFs could be cured by completely isolating target PV electrically.\(^11\)-\(^14\) PV isolation could be achieved by spike potential guided catheter ablation at its orifice or by geometry mapping guided circular isolation on the LA wall just near its orifice.\(^15\),\(^16\) Different procedures have different end points and long-term efficacies.\(^17,18\)

Spike potential guided ablation or segmental PV ostial ablation under x-rays suffered with technical challenges associated with identification of pulmonary potential, complete electrical isolation, long distance of PV-LA junction, focus mapping within target PV, irregular pulmonary orifice, long operation and x-ray exposure time, and potential pulmonary stenosis.\(^14\),\(^16\),\(^17\),\(^18\) In contrast, LA wall ablation near the pulmonary orifice guided by non-contact electroanatomical mapping,\(^3\) which includes two lesion loops around the left and right-sided pulmonaries, one lesion line on the roof of LA between two loops, and one lesion line from left loop to the mitral valular ring, can overcome the above disadvantages and achieve complete PV isolation. The two lesion lines also have the efficacy of atrial flutter prevention.

**Summary**

From these cases, it was found that Ensite 3000 Navx guided LA wall ablation near pulmonary orifice to cure AF is safe and feasible and has the advantages of clear procedure end point, shorter X-ray exposure, fewer complications and satisfied long-term effect. Long-term follow up data are needed to validate these primary results.

**References**


