

Surgical perspective on hybrid ablation for non-paroxysmal atrial fibrillation

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Atrial fibrillation (AF), the most common cardiac arrhythmia in the world, has an increasing incidence in general population (1). According to duration of episode, AF is divided into paroxysmal AF, persistent AF and long-standing persistent AF. To avoid stroke, arterial embolism and other critical complications, convert to normal sinus rhythm as soon as possible is the best strategy for AF management. Cox-Maze III procedure, also called as “cut and sew” Maze, is still the gold standard procedure of treating AF (2). Briefly, a series of scars were made by Cox-Maze III to interrupt or isolate reentry circuits by “cut and sew” of the atrium. Though the results of 5-year follow-up were very attractive (96.6–99% of patients free of AF), Cox-Maze III was replaced gradually by more simplified Cox-Maze IV due to development of new devices of ablation energy and procedure (2). On the other hand, percutaneous endocardial catheter ablation developed very fast thanks to endocardial electrophysiological activation mapping and different kinds of device. Catheter ablation shows its extraordinary effectiveness on suppressing paroxysmal AF (3), thus becomes the first line therapy for AF. Unfortunately, success rate (convert to sinus rhythm without antiarrhythmic drugs), either by Cox-Maze IV or catheter ablation is disappointed in long term follow-up in persistent and long-standing persistent AF patients.

Compare to catheter ablation, surgical ablation has proved transmural and durability with compromised higher complications and trauma which refused by the patients and electrophysiologists. Besides, catheter ablation

could create lesions easily that surgeon could not reach, such as mitral isthmus and coronary sinus where triggers atrial tachyarrhythmia (2). Meanwhile, endocardial electrophysiological activation mapping during catheter ablation could confirm circuits isolation. Hybrid ablation for AF, not only combines the strengths of epicardial surgical ablation and endocardial catheter ablation, but also minimizes each weakness. Compared to minimally invasive surgical ablation, hybrid ablation showed better 1-year results in a nonrandomized clinical study (4). Hybrid ablation might be an ideal therapy for AF. The goal of this article is to demonstrate the factors could impact the efficacy and safety of hybrid ablation.

There are three forms of hybrid ablation categorized with separation of both procedures. The first type is single-step ablation, surgical ablation and catheter ablation were performed during the same procedure and under the same general anesthesia. The second, catheter ablation apply following surgical ablation few days later in the same hospital admission. The third, Catheter ablation apply in a second hospital admission, maximum three months after surgical ablation, means two-step ablation or staged ablation.

Midterm clinical outcomes of concomitant thoracoscopic epicardial and transcatheter endocardial ablation for persistent and long-standing persistent atrial fibrillation: a single-centre experience (5), the paper by Dr. de Asmundis *et al.* published in *Europace*, showed us a clinical retrospective study about the single-step hybrid ablation procedure.

As a corresponding author of the paper mentioned above, Dr. La Meir is a pioneer surgeon of treating AF by means of minimally invasive totally thoracoscopic epicardial ablation. His team performed lots of live surgeries around the world and pushing the development of minimally invasive surgical treatment for AF. In the field of surgical capacity and volume, Dr. La Meir should be one of leaders.

de Asmundis and his colleagues presented 64 consecutive patients with symptomatic non-paroxysmal AF underwent the single-step hybrid ablation. Success was defined as free from atrial arrhythmias without antiarrhythmic drug therapy, recurrence was defined as paroxysmal AF, persistent AF or rapid atrial tachycardia occurs after hybrid ablation. At mean follow-up of 23.1 ± 14.1 months, the freedom of atrial arrhythmias without antiarrhythmic drugs was 67.2%. The procedure-related complications, including left atrium (LA) perforation, pericarditis, postoperative pericardial drainage were also reported.

We could find some innovations about this study. It has achieved the longest follow-up (23.1 ± 14.1 months) for a single-step hybrid ablation in consecutive series of patients with persistent and long-standing persistent AF. In addition, this article first mentioned the blanking period: patients with AF relapse during the blanking period were 4.60 times more likely to have AF recurrence after 3 months from the ablation procedure.

Interestingly, success rate report by de Asmundis and his colleagues was lower than other similar studies. Mahapatra *et al.* (6) reported the success rate of a sequential hybrid ablation in persistent and long-standing persistent AF who failed at least one percutaneous catheter ablation procedure was 86.7%. Pison *et al.* (7) reported the success rate of single-step hybrid ablation in paroxysmal and persistent AF was 90%, while the definition of recurrence was persistent AF occurs. Muneretto *et al.* (8) summarized the result of a sequential hybrid ablation in persistent and long-standing persistent AF. As a result, 91.6% of patients were in sinus rhythm with 77.7% of these patients off antiarrhythmic drugs. Kurfurst *et al.* (9) reported the result of a sequential hybrid ablation in persistent and long-standing persistent AF. Freedom from AF was 77% after surgical ablation and 93% after the completed hybrid ablation.

We found some factors could impact success rate of hybrid ablation through literatures review and our experience.

One of the most important factors in hybrid ablation is patient selection. According to 2016 ESC guideline for the management of AF, a hybrid ablation or a thoracoscopic surgical ablation can be performed in patients with

symptomatic AF after failure of catheter ablation, or in patients who are willing to accept a hybrid/surgical ablation. Concomitant diseases, like COPD, hyperthyroidism, have a negative effect on complication rate and recover from operation (10). Furthermore, recurrence and long-term success rate of hybrid ablation are negative influenced directly by left atrial dilatation, older age, longer than 10-year history of AF and non-paroxysmal AF (11).

Then, different surgical approaches deserve discussion. It is no doubt that the less trauma of thoracoscopic surgical approach compare to median approach. Bilateral thoracic approach, right/left thoracic monolateral approach, transdiaphragmatic approach are all regard as minimally invasive approach. Through right monolateral or transdiaphragmatic approach, reliable transmural and left atrial appendage (LAA) resection are difficult to achieve.

LAA resection remains lots of debate. As a potential fibrillation origin, LAA could contribute the AF recurrence. In our center, patients without LAA resection seem relapse more likely than who accepted LAA resection. More importantly, LAA is deemed to be the origin for more than 90% of emboli in nonvalvular AF (12). In nonpharmacological treatment strategy, routine LAA resection during surgical ablation will benefit for patients undergoing operation.

Lesion sets. Since the Cox-Maze I procedure, pulmonary vein isolation (PVI) was regarded as a core intervention. Actually, atrial electrical remodeling would be occurred in patients with long-term AF, thus PVI alone is not enough for long-standing persistent AF patients. In standard Cox-Maze IV procedure, lesions of inferior vena cava to superior vena cava, right atrial appendage and right atrial free wall directed towards the tricuspid annulus are created in right atrium, as well as a "box" lesion set for complete posterior left atrial isolation, lesions of mitral isthmus, connecting LAA to "box" lesion in LA (13). Create the lesions of standard Cox-Maze IV completely is the most ideal ablation strategy, especially for long-standing persistent AF patients with dilated atrium. Due to the limitation of surgical ablation device, some transmural lesions would be created difficultly, thereby induce reconnection or conduction gaps and AF relapse after ablation.

Another topic to highlight is the form of hybrid ablation. Compared to sequential or two-step hybrid ablation, single-step hybrid ablation could avoid the second anesthesia and admission. Besides, single-step hybrid ablation allows for immediate endocardial electrophysiological activation mapping with confirmation of isolation or incomplete

isolation with the possibility to add touch-up lesions endocardially, and it also allows for guiding surgical ablation accurately. By the way, surgical ablation in single-step procedure could provide protection and immediate response for catheter accident. Unfortunately, in fact, immediate electrophysiological mapping is not really reflecting surgical isolation. During surgical ablation, repeated mechanical clamping and transmural radiofrequency ablation might cause acute edema, inflammation and myocardium ischemia. Although electrophysiological mapping confirmed the isolation immediately, reconnection or conduction gaps will be recovered after stable lesions occur in 1 to 3 months. The incorrect intraoperative mapping might interfere operator's judgments. Research from On *et al.* (14) had proved this opinion to some extent. They reported the results of an electrophysiological study was performed 5 days after the surgical procedure. Interestingly, residual pulmonary vein potentials were observed in 19% patients. Sequential or two-step hybrid ablation could identify areas of early connection and small gaps that might be missed in an initial procedure. Furthermore, sequential and two-step hybrid ablation could avoid intra-operative bleeding and reduce post-operative pericardial drainage due to heparinize and over surgical or catheter ablation. Pericarditis would more likely occur after one-step hybrid ablation because creating lesions epicardial and endocardial simultaneously would stimulate pericardium and surrounding tissue.

Different rhythm monitoring and endpoints cause different success rate of clinical studies. Success was defined as absence of persistent and long-standing persistent AF basically, as well as absence of paroxysmal AF and/or rapid atrial arrhythmia, with or without antiarrhythmic drugs therapy in different studies. A 24-h Holter monitoring, 7-day Holter monitoring or an implantable loop recorder was used for confirming patients' rhythm.

According to paper from de Asmundis and his colleagues, success was defined as free from atrial arrhythmias without antiarrhythmic drug therapy, relapse of AF and rapid atrial arrhythmia was regarded as endpoint of the study. Severe dilated LA (mean LA diameter, 50.3 ± 7.1 mm; mean indexed left atrial volume, 40.2 ± 7.5 mL/m²), high proportion of long-standing persistent AF may reflect those were tough cases comparing with other studies. According to our experience, the surgical ablation device might difficult to clamp the pulmonary vein antrum completely on a severe dilated LA. It is reasonable why success rate was lower than other similar studies.

So far, hybrid ablation is a promising procedure for AF,

even still in infancy. How to choose hybrid ablation strategy would be debated continuously. The larger and prospective randomized studies with long-term follow-up are needed to clarify the efficacy and safety of single-step, sequential and two-step hybrid ablation for persistent and long-standing persistent AF. In the future, that hybrid ablation would become the first line strategy for AF, while advance devices and a heart team consist of surgeons, cardiologists and electrophysiologists are essential elements.

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Footnote

Conflicts of Interest: The authors have no conflicts of interest to declare.

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