EXPERT OPINION

Why the maze procedure is so effective. Let's get straight down into business!

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The maze procedure has been especially designed to surgically eliminate any type of atrial fibrillation or flutter. Given the fact that the maze procedure is a non-focal approach performed in one-single step, all possible macro reentrant circuits are broken up. A full bi-atrial lesion pattern is strongly recommended when using the maze procedure. When properly performed, the success rate can be as high as 90% at 5-year follow-up or even longer.

***Key words*: Arrhythmia; Atria; Atrial fibrillation; Macro reentrant circuit; Maze procedure.**

El procedimiento de maze ha sido especialmente diseñado para eliminar prácticamente cualquier tipo de fibrilación auricular o flutter. Dado que es un procedimiento no-focal en una sola intervención, todos los macrocircuitos pueden ser eliminados a la vez. Se recomienda encarecidamente siempre realizar el maze mediante un patrón de lesiones biauricular completo. Cuando se realiza correctamente, la tasa de éxito es de alrededor de 90% a 5 años o más de seguimiento.

***Palabras clave:* Arritmia; Aurícula; Fibrilación auricular; Macrocircultos de reentrada; prodecimento de Maze.**

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Atrial fibrillation (AF) is the most common cardiac arrhythmia all around the world. It is related to 5-fold increased risk for stroke [1], 3-fold increased risk for heart failure [2,3], 2-fold increased for dementia [4], and 2-fold increased for mortality [2]. For lone AF with no structural primary disease, once medical therapy and catheter-based techniques have failed, surgical approach is next step to eliminate AF [5]. For concomitant AF undergoing cardiac surgery, surgical approach is very precise since the very beginning [6].

Nonetheless, in order to understand how the maze procedure works, it is particularly crucial to know how AF is generated and sustained. Broadly speaking, the first prerequisite for generating AF are the triggers located into and around the pulmonary veins (PV), as demonstrated by Haissaguerre et al. in nearly 90% of cases [7]. Under certain conditions, these triggers shoot producing AF. This pathological condition is called "paroxysmal AF", which is lasting as long as less than seven days. This paroxysmal AF is trigger-dependent to exist. It can fade away on its own spontaneously, or be continued. At this point, it is quite understandable that the PV isolation (and antrum) is as effective as 90% as strategy for eliminating the "paroxysmal AF" [8]. However, PV isolation is not enough in order to eliminate the "non-paroxysmal AF" (persistent AF, long-standing persistent AF, permanent AF). García-Villarreal isolated by surgical methods the antrum containing all the four PV in 100 patients while undergoing mitral valve operation. After 5 years follow-up, less than 30% remained in normal sinus rhythm [9,10].

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The second condition in the AF genesis is the self-sustenance of the AF. Once AF has become longer than seven days, atrial myocardial remodeling appears. This is the main responsible for sustaining AF. Stated otherwise, once AF is self-sustained in both atria because of the electric atrial remodeling, it is turned out into persistent AF or "non-paroxysmal AF". Macro reentrant circuits, rotors, mother-rotors, or drivers additionality have the same meaning today. Drivers may be located anywhere in both atria. AF is a re-entry arrhythmia. In this framework, one of the most important concepts from Dr. Cox and his working group has been the discovery of the minimum size of the rotor to self-sustain AF is 6 cm in diameter or larger than this in human atria [11]. One or more macro reentrant circuits sustaining AF can coexist at the same time, being more complex, transient and variable the electric pattern of the AF. In such a way that if two separated incisions or burn lines are parallelly placed less than 6 cm one from the other in the atria, therefore there will never be enough space in the atrial tissue for the development of the macro reentrant circuit. The bottom line is that there will be no more AF (**Fig. 1**). This is the key point in order to understand how the maze procedure works. Moving from the theory into the practice, the maze procedure is a surgical technique which involves a series of surgical incisions or burn lines strategically placed throughout both atria [12]. PV isolation, left atrial appendage resection, as well as left and right atrial incisions are all of them part of the maze procedure (**Fig. 2**).

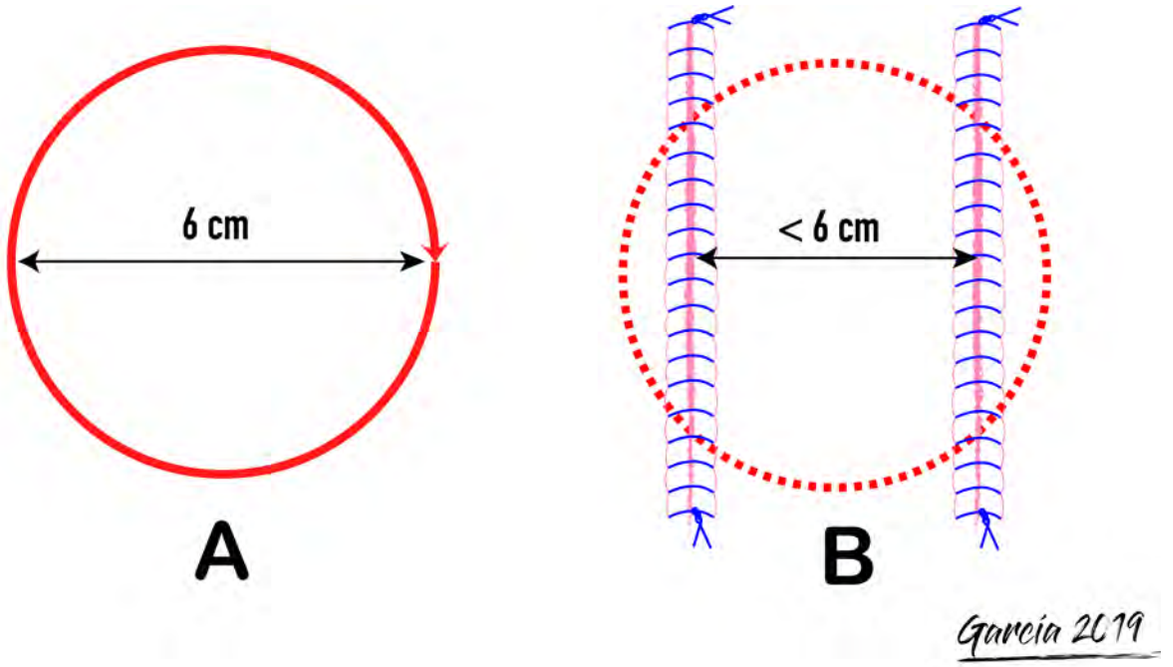

Figure 1. Schematic representation of the electrophysiological basis about how the maze procedure works. A: Minimum size of the macro reentrant circuit to sustain atrial fibrillation. B: Two separated surgical incisions parallelly less than 6 cm one from the other in the atrium breaking up the macro reentrant circuit.

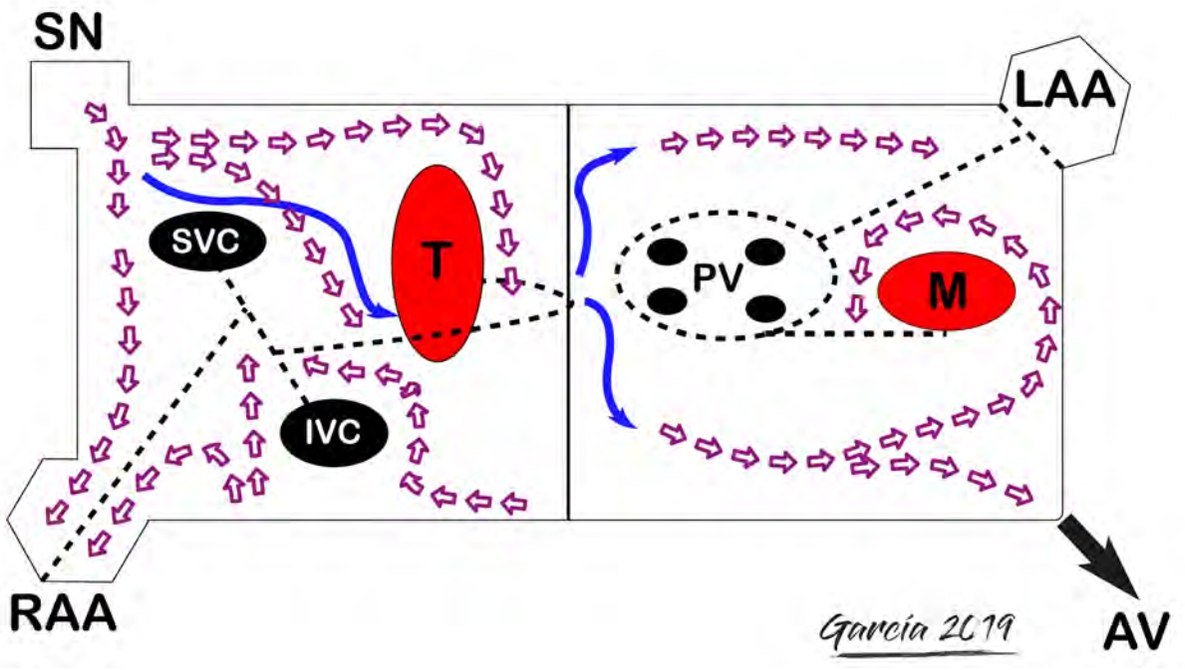

Figure 2. Schematic drawing showing the way of activation in the maze procedure. The electric impulse travels from to sinoatrial node (SN) to the atrioventricular node (AV). Dotted lines represent the surgical incisions or burn lines of the maze procedure as a true "maze". Violet arrows show all possible pathways of activation in the atrial myocardium. Blue arrows indicate the electric impulse going from the right atrium, crossing to the other side through the atrial septum reaching the left atrium. Left atrial appendage (LAA) is resected. Right atrial appendage (RAA) is preserved. IVC: inferior vena cava, M: mitral valve, PV: pulmonary veins, SVC: superior vena cava, T: tricuspid valve.

In this way, the normal electric impulse is guided from the sinus node to the AV node through both atrial "maze" while stimulating the entire atrial myocardium as a functional syncytium. The transport atrial function is also preserved. The maze procedure breaks up with all possible macro reentrant circuits in both atria on a permanent basis. Mapping-guided ablation strategies are not necessary under these circumstances, because this is a non-focal approach performed in "one-go", in "one-single step". This is why the maze procedure is highly effective. Because all possible causes are approached at the same time. When properly performed, the maze procedure can reach success rates higher than 90% at 5-year follow-up in normal sinus rhythm recovery [13].

The first maze procedure was performed in 1987 [14]. Over the time, several iterations have been implemented to improve the maze procedure. Hence, the maze I, maze II, and maze III have been properly described [15]. Time-consuming and technical difficulty have been the main limitations for the maze procedure worldwide. However, over the years, the surgical incisions have been replaced by burn lines utilizing alternative energy sources. It was from the year 2002 when the expansion accelerated at a breakneck speed [16]. Cryothermia as well as bipolar radiofrequency ablation have been the only energies creating consistent transmural burn lines [17]. Nevertheless, regardless the way of performing the maze procedure, the critical key is to preserve as far as possible the original full bi-atrial lesion pattern from the maze III procedure, originally described by Dr. Cox [12].

As a conclusion, when using the maze procedure, just one idea must be kept in mind: the more complete the lesion pattern, the higher the success rate.

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