

A Narrative Review on Comparison of Different Surgical Procedures like Cox-Maze IV, Cryo-Maze, and Electrocautery Maze Procedures for Atrial Fibrillation

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Abstract

Atrial fibrillation (AF) is a prevalent cardiac arrhythmia that increases the risk of stroke and heart failure. Surgical interventions such as the Cox-Maze IV, Cryo-Maze, and Electrocautery Maze procedures are effective in restoring sinus rhythm by creating conduction blocks in the atria. This review compares these procedures, highlighting their mechanisms, clinical outcomes, and advantages. Cox-Maze IV, utilizing radiofrequency or cryoablation, is the most widely adopted and effective, offering up to 90% success in long-term rhythm control. Cryo-Maze is less invasive and offers precise lesion formation, while Electrocautery Maze is a less commonly used but effective option for patients undergoing open-heart surgery. Each procedure's success is influenced by patient-specific factors, and the choice of technique depends on invasiveness and clinical context.

Keywords: Radiofrequency; Electrocautery; Cardiovascular; Surgery

Abbreviations

AF: Atrial Fibrillation; RF: Radiofrequency; CABG: Coronary Artery Bypass Grafting.

Introduction

Atrial fibrillation (AF) is the most common sustained cardiac arrhythmia and a major cause of morbidity and mortality worldwide. It is associated with a five-fold increase in the risk of stroke, heart failure, and overall cardiovascular complications. The surgical treatment of atrial fibrillation has evolved over the decades, with various techniques developed to restore normal sinus rhythm. Maze procedures are considered the gold standard for surgically treating AF, with several modifications such as the Cox-Maze IV, Cryo-Maze, and Electrocautery Maze being introduced to improve outcomes and reduce procedural complexity. This review

aims to provide an overview and comparison of these three prominent maze procedures, focusing on their mechanisms, clinical outcomes, and advantages or disadvantages [1].

Cox-Maze IV Procedure

The Cox-Maze IV procedure is a refined version of the original Cox-Maze procedure, developed by Dr. James Cox in 1987. The initial Maze procedure, known as Cox-Maze III, involved creating a series of precise surgical incisions in the atria to interrupt abnormal electrical pathways that cause AF. However, this procedure was highly invasive, requiring open-heart surgery, and had significant perioperative risks [2].

Cox-Maze IV simplified the original approach by using ablation technology instead of traditional incisions. The procedure involves applying radiofrequency (RF) ablation or cryoablation to create lines of conduction block in the atria.

The Cox-Maze IV procedure has shown high success rates in restoring sinus rhythm and preventing recurrent AF. It is often performed concomitantly with other cardiac surgeries, such as mitral valve repair or coronary artery bypass grafting (CABG), making it an effective option for patients with structural heart disease [3].

Advantages

- High efficacy in maintaining sinus rhythm (up to 90% success at long-term follow-up).
- Less invasive than the original Cox-Maze III due to the use of ablation.
- Suitable for patients undergoing other cardiac procedures.

Disadvantages

- Requires cardiopulmonary bypass and is more invasive compared to catheter-based interventions.
- Risk of complications such as bleeding, stroke, or infection.

Cryo-Maze Procedure

The Cryo-Maze procedure is another modification of the Maze technique, employing cryoablation to create lesions that block abnormal electrical circuits. Cryoablation works by applying extreme cold (typically -60°C to -80°C) to freeze and destroy the targeted cardiac tissue. This approach offers a more controlled and less traumatic method for creating lesions compared to traditional surgical incisions. Cryo-Maze is particularly useful in areas where precision is critical, such as near the coronary arteries or the atrioventricular node, as the cold application causes less collateral damage to surrounding tissues. It is also commonly used in combination with the Cox-Maze IV procedure or as a stand-alone intervention for patients with AF.

Advantages

- Precise lesion formation with minimal risk of damaging adjacent structures.
- Can be performed as a minimally invasive or

thoracoscopic procedure [4].

- Reduces the risk of arrhythmogenic gaps in the lesion set due to controlled application.

Disadvantages

- Longer lesion formation time compared to RF ablation.
- Requires specialized equipment and expertise.
- May not be as effective for long-standing persistent AF as other procedures.

Electrocautery Maze Procedure

The Electrocautery Maze procedure is a variant of the original Maze technique that uses electrocautery to create the desired lesion set in the atria. Electrocautery works by delivering thermal energy to burn and scar the targeted cardiac tissue, which prevents the propagation of erratic electrical signals responsible for AF [5]. This procedure is less commonly used in contemporary practice due to the development of more advanced ablation technologies.

While the Electrocautery Maze can be effective in treating AF, it is often associated with a higher risk of collateral tissue damage due to the less precise nature of thermal energy delivery. It also requires open-heart surgery and is typically performed in conjunction with other cardiac surgeries.

Advantages

- Established efficacy in creating conduction blocks and restoring sinus rhythm.
- Suitable for patients undergoing open-heart surgery for other conditions.

Disadvantages

- Increased risk of collateral damage to surrounding cardiac structures.
- Less controlled lesion formation compared to RF or cryoablation.
- Associated with longer recovery times and higher complication rates.

Comparison of the Procedures (Table 1)

Procedure	Technology Used	Invasiveness	Success Rate	Advantages	Disadvantages
Cox-Maze IV	Radiofrequency or Cryoablation	High (Open-heart surgery)	~90% at long-term follow-up	High efficacy, effective during concomitant surgery	Invasive, requires cardiopulmonary bypass
Cryo-Maze	Cryoablation	Moderate (Minimally invasive)	80-90%	Precise lesion formation, minimal tissue damage	Longer lesion creation time, equipment-intensive
Electrocautery Maze	Electrocautery	High (Open-heart surgery)	~80%	Effective for concomitant surgeries	Less precision, higher risk of collateral damage

Table 1: Comparison of the Procedures.

Clinical Outcomes and Considerations

All three procedures aim to restore sinus rhythm, but their success rates and associated risks vary depending on the patient's AF type (paroxysmal, persistent, or long-standing persistent), comorbidities, and whether the procedure is performed alongside other cardiac surgeries. Studies have shown that the Cox-Maze IV procedure offers the highest long-term freedom from AF, especially in patients undergoing concurrent cardiac operations. Cryo-Maze, while less invasive and precise, may have slightly lower success rates, especially for long-standing persistent AF. The Electrocautery Maze, though effective, is largely being replaced by RF and cryoablation techniques due to its higher complication rate and less precise lesion formation.

Conclusion

Surgical maze procedures continue to evolve as effective treatments for atrial fibrillation, offering patients significant improvements in rhythm control, quality of life, and stroke prevention. The Cox-Maze IV, Cryo-Maze, and Electrocautery Maze procedures each have their own merits and are suitable for different patient populations. The choice of procedure depends on factors such as invasiveness, the patient's overall health, and whether concomitant cardiac surgeries are required. While Cox-Maze IV remains the most effective and widely adopted approach, Cryo-Maze offers a minimally

invasive alternative, and Electrocautery Maze serves as an option in select surgical cases.

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