Catheter Ablation (General Principles and Advances)

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KEYWORDS

• Catheter ablation • 3D image integration • Remote navigation • 3D mapping
• Simultaneous mapping • Sequential mapping

KEY POINTS

- The underlying anatomy can be understood through three-dimensional reconstruction of tomographic imaging.
- Choosing the most appropriate acquisition system (simultaneous vs sequential) is necessary for the given arrhythmia.
- Recognizing the need for close collaboration with cardiac anesthesia ensures good hemodynamic support and adequate analgesia.

INTRODUCTION

Cardiac arrhythmias are typically encountered after cardiac surgery and can occur in the immediate postsurgical period or, more often, decades after surgery. In the postoperative period, arrhythmias may complicate the patient's course and prolong the stay in the intensive care unit.[1,2] Late after surgery, cardiac arrhythmias are thought to stem mainly from the unavoidable scars left behind (eg, after an atriotomy, the cannulation sites for the cardiopulmonary bypass, or other scars inherent to the specific cardiac surgery [patch sutures]).[3–5] However, age and progression of the structural/congenital heart disease, resulting in pressure increase and dilation, can lead to pronounced fibrosis, which in itself can promote focal and/or reentrant arrhythmia.[6] The presence of frequently recurrent or sustained arrhythmias is associated with reduced quality of life, risk of development of heart failure symptoms caused by tachycardiomyopathy, higher thromboembolic risk, and reduced survival.[7–9]

Catheter ablation of postsurgical arrhythmias in patients with congenital heart disease is currently feasible and successful with the use of advanced image integration and ablation tools. This article reviews the general steps of preparation for such a procedure and discusses the available techniques as an alternative to long-term antiarrhythmic therapy. Fig. 1 summarizes a stepwise approach that helps clinicians to perform even complex ablation procedure successfully.

GENERAL PREPARATION OF PATIENTS WITH CONGENITAL HEART DISEASE PRESENTING WITH ARRHYTHMIAS

In the first instance, 12-lead electrocardiogram (ECG) documentation is the key investigation to allow differentiation between atrial and ventricular, as well as regular (eg, atrial tachycardia) as opposed to irregular (eg, atrial fibrillation vs frequent atrial or ventricular ectopy or arrhythmias) arrhythmias. The 12-lead ECG allows a first localization of the origin of the documented arrhythmia,

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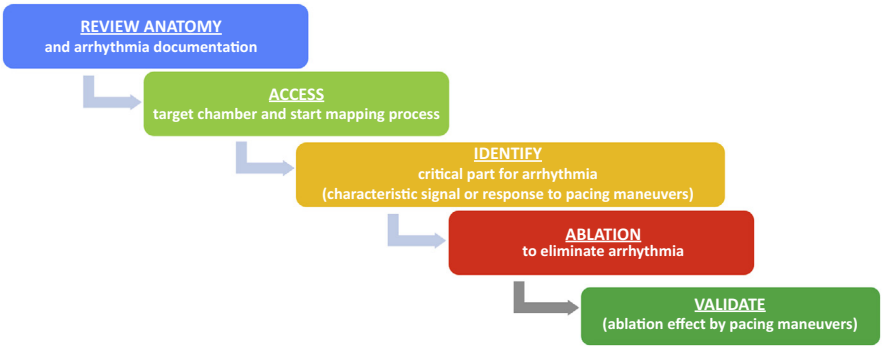

Fig. 1. Stepwise approach to plan and execute a successful catheter ablation procedure in patients with congenital heart disease.

but, because of the possibly distorted cardiac anatomy, common ECG algorithms may not be sufficient. Holter recordings are especially valuable in intermittent arrhythmias and also allow documentation of the arrhythmias when more than 1 type of arrhythmia is present. Correlation with symptoms and potential consequences (eg, prolonged pauses after tachycardia termination) can be identified. However, the duration of Holter recordings (typically up to 7–14 days) may limit the yield of this diagnostic test if patients experience rare palpitations.[10] Implantable loop recorder systems are an alternative, but lack the accuracy of P-wave detection and therefore differentiation of various atrial tachycardias may be based on cycle length analysis only.[11,12]

Standard Imaging Studies

Because the arrhythmia could be an expression of worsening of the underlying congenital condition, careful transthoracic and, if necessary, transesophageal echocardiography should be performed to understand the relevant hemodynamic issues (eg, increase in pulmonary valve regurgitation in tetralogy of Fallot). Invasive hemodynamic studies may need to be considered either as stand-alone investigations or as part of the ablation procedure.

PREPARATION OF THE ABLATION PROCEDURE

Detailed Knowledge of Individual Anatomy

Understanding the individual three-dimensional (3D) anatomy is the cornerstone of any successful ablation procedure, even in patients without congenital conditions.[13,14] Information on the dimensions of the cardiac chambers, the spatial relationship and angulations between different cardiac structures, and the presence of a patent foramen ovale are some examples of necessary information that may facilitate any procedure. In patients with congenital heart disease, this detailed understanding of the specific anatomy becomes vitally important, and is in the author's personal opinion an essential prerequisite for a successful ablation. Patients with congenital defects often have limited accessibility to their cardiac chambers because of complex intracardiac/extracardiac anomaly and/or presence of intraatrial baffles or artificial materials. With this detailed knowledge of the individual anatomy and the use of advanced tools, these obstacles can be overcome and procedures can be performed as safely and successfully as possible with minimal fluoroscopy exposure.[15]

Review of Surgical Procedure Note

Although knowing the underlying 3D anatomy is a necessary guide to insertion and navigation of the catheters, knowing the location and extent of surgical incisions and suture placement is of paramount importance in order to unveil the arrhythmia origin. Review of the surgical operation reports, if available, is valuable to understand the exact procedure performed in each individual and obtain information about the technique used (on/off pump, cannulation sites, location of patches). Cardiac surgeons have modified their technique over the years, so surgically created scars may be variable and, in the absence of surgical records, it may be difficult to reconstruct what has been done. This uncertainty is especially likely if preventive measures such as surgical mazelike ablations or incisions have been performed.[16,17]

ADVANCED TECHNIQUES

Three-Dimensional Image Reconstruction

In order to obtain a 3D reconstruction of the individual anatomy, the authors routinely perform a cardiac magnetic resonance (CMR) scan or, alternatively, a computed tomography (CT) scan when CMR is contraindicated.