Chapter 80
New Imaging and Computational Technology as a Guide for Catheter Ablation of Incessant Tachyarrhythmias

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ABSTRACT

Computational technology in the era of catheter ablation (RFA) has made it possible to experience relief from incessant atrial tachyarrhythmias (AT) by 3D electroanatomical mapping (EAM) systems. The Authors report the results of such technology in > 500 consecutive patients (57% males, mean age 56.9 years) with incessant refractory post-ablation left AT (mean cycle length 256 ms). Patients underwent electroanatomical-mapping systems, which combine electrophysiological and spatial information allowing accurate reconstruction of the whole atria with real-time activation sequence guiding RFA for continuous transmural linear lesions. Color-coded voltage and/or activation maps were successfully performed in all patients. Mapping distinguished clearly and rapidly between micro-macro-reentrant (>80%) and focal mechanisms. Acute success was obtained without major complications, with repeated procedures in about 5% of patients. EAM technology allows determining both mechanism and location of arrhythmia, ensuring successful elimination of complex arrhythmogenic substrates.

INTRODUCTION

An Epochal Change in the Management of Complex Tachyarrhythmias: Background

In the last two decades the rapid expansion of indications for catheter ablation from common supraventricular tachycardias to very complex tachyarrhythmias including atrial fibrillation, incessant atrial

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tachycardia and ventricular tachycardia led electrophysiologists to face more prolonged procedure times with excessive fluoroscopy exposure and, then the need for stable and reproducible catheter movement, all of which require a substantial improvement in the existing traditional 2D mapping technology, and new developments (Silka, Gillette, et al., 1985; Van Hare, Velvis, & Langberg, 1990; Kay, Chong, et al., 1993; Chen, Chiang, et al., 1994; Lesh, Van Hare, et al., 1994; Poty, 1996; Chen, Tai, et al., 1998; Haissaguerre, Jais, et al., 1998; Schilling, Peters, Davies, 1998; Gornick, Adler, et al., 1999; Jais, Shah, et al., 2000; Kottkamp, Hugl, et al., 2000; Willems, Weiss, et al., 2000; Saoudi, Cosío, et al., 2001). As a result, in the last years different electroanatomical mapping systems using different ablation catheters have been increasingly developed to definitively eliminate complex refractory tachyarrhythmias in many patients with or without structural heart diseases, (Nakagawa, Shah, et al., 2001; Dixit, & Callans, 2002; Friedman, 2002; Friedman, Asirvatham, et al., 2002; Kirchhof, Loh, et al., 2002; de Groot, Schalij, et al., 2003; Kopelman, Prater, et al., 2003; Macle, Jais, et al., 2003; Marrouche, Martin, et al., 2003; Oral, Scharf, et al., 2003; Pappone, Rosanio, et al., 2003; Schenider, Ndrepepa, et al., 2003; Pappone, Manguso, et al., 2004; Pappone, Santinelli, et al., 2004; Sporton, Earley, 2004; Ventura, Rostock, et al., 2004; Corrado, Basso, et al., 2005; Gurevitz, Glikson, et al., 2005; Packer, 2005; Rotter, Takahashi, et al., 2005; Earley, Showkathali, et al., 2006; Estner, Deisenhofer, et al., 2006; Kistler, Rajappan, et al., 2006; Oral, Pappone, et al., 2006; Pappone, Augello, et al., 2006; Pappone, & Santinelli, 2006; Roberts-Thomson, Kistler, et al., 2006; Chae, Oral, et al., 2007; Jais, Matsuo, et al., 2009; Martinek, Nesser, et al., 2007; Matsuo, Lim, et al., 2007; Medi, Kalman, et al., 2009; Del Carpio Munoz, Buescher, et al., 2010; Wilber, Pappone, et al., 2010; Khaykin, Oosthuizen, et al., 2011; Barbhaiya, Kumar, et al., 2014; Kang, Etheridge et al., 2014; Kapa, & Asirvatham, 2014; Sun, & Piccini, 2014Anter, Tschabrunn, & Josephson, 2015; Buch, & Shivkumar, 2015; Ceresnak, Nappo, & Janson, 2015; Scherr, Derval, et al., 2015; N Wang, Ouyang, et al., 2015; Winterfield, Jensen, et al., 2015; Zipes, Calkins, et al., 2015). Since 1990s catheter ablation has been commonly used to treat supraventricular tachyarrhythmias with a success rate of over 90 percent, a low risk of complications while the patient can resume the normal activities in a few days (Silka, Gillette, et al., 1985; Van Hare, Velvis, Langberg, 1990; Kay, Chong, et al., 1993; Kopelman, Prater, et al., 2003; Chen, Chiang, et al., 1994; Lesh, Van Hare, et al., 1994; Poty, 1996; Kopelman, Prater, et al., 2003). It causes little or no discomfort and is done under mild sedation with local anesthesia. In structural heart diseases, catheter ablation is usually performed for drug inefficacy or intolerance or as adjunctive therapy in patients with an implantable cardioverter-defibrillator, who are experiencing frequent DC schock discharges. Consensus groups from the European Society of Cardiology and the North American Society of Pacing and Electrophysiology have defined regular atrial tachycardia (AT) as either focal or macro-reentrant, classified according to electrophysiological mechanisms and anatomical structures (Saoudi, Cosío, et al., 2001). Focal ATs are characterised by a focal origin with subsequent centrifugal spread, with a mech- anism based in abnormal automaticity, triggered activity or micro re-entry (Chen, Tai, et al., 1998; Roberts-Thomson, Kistler, et al., 2006). Macro-reentrant ATs, by contrast, involve a larger re-entry circuit, conventionally defined by a diameter in excess of 2 cm. The most common form of macro-reentrant AT involves the cavo-tricuspid isth- mus (CTI) as a critical region and has traditionally been referred to as 'typical atrial flutter'. Since this classifi- cation, a third category of atrial tachycardia has been defined. This is termed small circuit re-entry and is "some- where between micro and macro". These circuits most commonly occur after atrial fibrillation (AF) ablation pro- cedures involving extensive left atrial ablation. Radiofrequency catheter ablation was first described in pediatric patients in the early 1990s (van Hare, Velvis, & Langberg, 1990). Since then, multiple advances in the technology and understanding of this procedure have allowed this technique to blossom into one of the