Cardiol Young 2002; 12: 294–297

ISSN 1047-9511

Brief Report

Non-contact mapping and ablation of tachycardia originating in the right ventricular outflow tract

Thomas Paul, Andrew T. D. Blaufox, J. Philip Saul

The Children's Heart Program of South Carolina, Medical University of South Carolina, Charleston, SC, USA

Abstract We performed an electrophysiological study, using non-contact mapping, in an 8-year-old girl weighing 39.9 kg who had suffered recurrent symptomatic episodes of exercise-induced non-sustained ventricular tachycardia. Color-coded isopotential maps of the ventricular tachycardia identified the area of earliest endocardial activation high and anterior in the right ventricular outflow tract. Although partial deflation of the balloon was required to position the ablation catheter at the earliest site of activation, this site was still identified accurately, as demonstrated by termination of the ventricular tachycardia and ectopy upon mechanical pressure, as well as application of radiofrequency current.

In this young patient, precise mapping of the earliest endocardial activation using the non-contact mapping system was safe and effective, allowing successful radiofrequency ablation of the tachycardia.

Keywords: Idiopathic right ventricular outflow tract tachycardia; non-contact mapping; radiofrequency catheter ablation

Radiofrequency catheter ablation is a successful and accepted therapy for treatment of idiopathic ventricular tachycardia originating from the right ventricular outflow tract in adults.[1] In young patients, idiopathic ventricular tachycardia is thought to be a generally benign disorder, with a significant chance of spontaneous resolution during follow-up.[2,3] In this age group, antiarrhythmic therapy or radiofrequency catheter ablation are indicated only in symptomatic patients. Accordingly, experience with radiofrequency catheter ablation of idiopathic ventricular tachycardia in young patients is limited.[3,4] Recently, novel mapping systems, using either electroanatomical or non-contact mapping, have been used in adults with sustained and non-sustained idiopathic ventricular tachycardia.[5,6] The aim of this report was to demonstrate the use of non-contact mapping in an 8-year-old girl with recurrent symptomatic ventricular tachycardia originating from the right ventricular outflow tract.

Correspondence to: Thomas Paul MD, The Children's Heart Program of South Carolina, Medical University of South Carolina, 165 Ashley Avenue, PO Box 250915, Charleston, SC 29425, USA. Tel: 843-7923279; Fax: 843-7923284; E-mail: pault@musc.edu

Accepted for publication 16 January 2002

Patient and methods

The patient was an 8-year-old girl, weighing 39.9 kg and measuring 127 cm, who had suffered frequent episodes of non-sustained ventricular tachycardia with left bundle branch morphology and inferior axis enhanced by exercise (Fig. 1). According to physical examination, surface electrocardiography, cross-sectional echocardiography, chest X-ray, and magnetic resonance imaging, no structural heart disease was present. After obtaining written informed consent, the patient underwent a complete intracardiac electrophysiological study under general anaesthesia. After cannulation of the femoral veins and femoral artery for continuous control of blood pressure, heparin was given repeatedly to keep the activated clotting time equal to or greater than 300 s. The 9 French multi-electrode balloon array, produced by Endocardial Solutions Inc., Minneapolis, was introduced into the right ventricular outflow tract over a stiff 0.035 inch

guide wire placed in the left pulmonary artery. A steerable 7 French mapping and ablation catheter was also placed in the right ventricle (Marinr®, Cardiorhythm/Medtronic, Minneapolis; Fig. 2). The anatomy of the right ventricle was reconstructed with the use of the Enguide™ signal during sinus rhythm.[6] Programmed atrial and ventricular stimulation, with and without infusion of isoproterenol, failed to induce any significant supraventricular or ventricular ectopy. Frequent spontaneous non-sustained episodes of ventricular tachycardia, with a cycle length of 340–380 ms, were observed. Non-contact mapping was used to localize the earliest endocardial activation during ventricular tachycardia. In the review mode, the color-coded isopotential map was tracked back in time to demonstrate the earliest endocardial activation high and anterior in the right ventricular outflow tract (Fig. 2). At that location, reconstructed unipolar electrograms showed a qs–morphology preceding the onset of the tachycardia QRS complex by 40 ms. In real time mode, attempts were made to steer the ablation catheter to the labelled target site using the Enguide™ signal. The focus could not be approached precisely with the ablation catheter as long as the balloon was in place because it overlaid the focus. Consequently, the balloon was partially deflated, allowing the ablation catheter to be placed at the precise area guided by the navigation signal. As soon as the area was touched with the tip of the ablation catheter, all ventricular tachycardia and ectopy stopped. Pacing at this location resulted in a QRS complex identical to the morphology of the ventricular tachycardia. Local bipolar electrograms recorded from the tip of the ablation catheter preceded the onset of the tachycardia QRS complex by 48 ms. A single application of radiofrequency current, at 500 kHz and 60 W, was delivered for 60 s at this location, with a target temperature of 70°C. The maximum temperature achieved was 54°C. Following that single application, no further ventricular ectopy or tachycardia was noted. The catheter was removed and the patient was observed for a further 30 min. Repeated provocation with isoproterenol did not reveal any ventricular ectopy. The duration of the

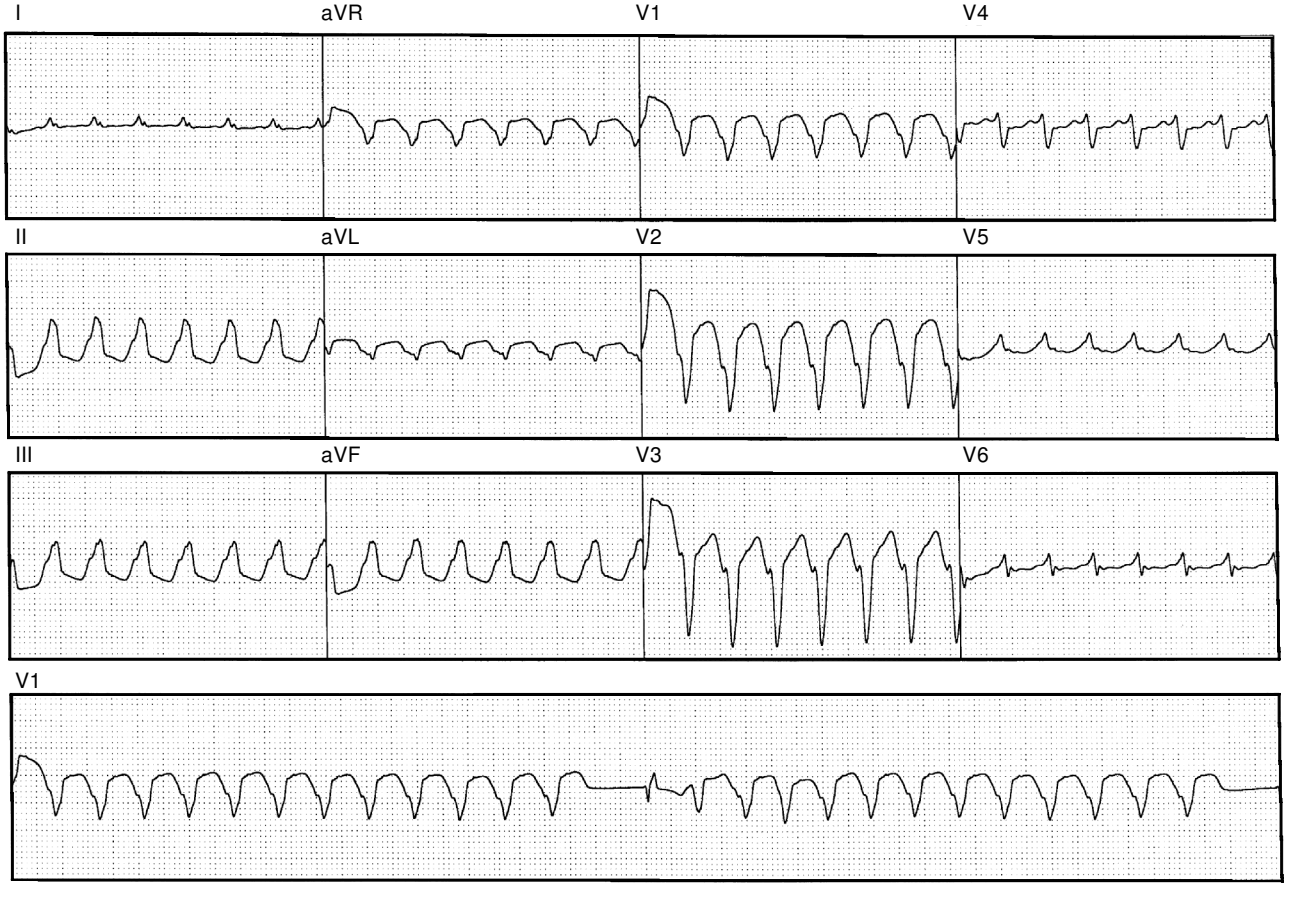

Figure 1.
12-lead electrocardiogram of spontaneous non-sustained ventricular tachycardia with a cycle length of 360 ms. Note the inferior axis and left bundle branch block pattern of the QRS complex.

https://doi.org/10.1017/S1047951102000641 Published online by Cambridge University Press

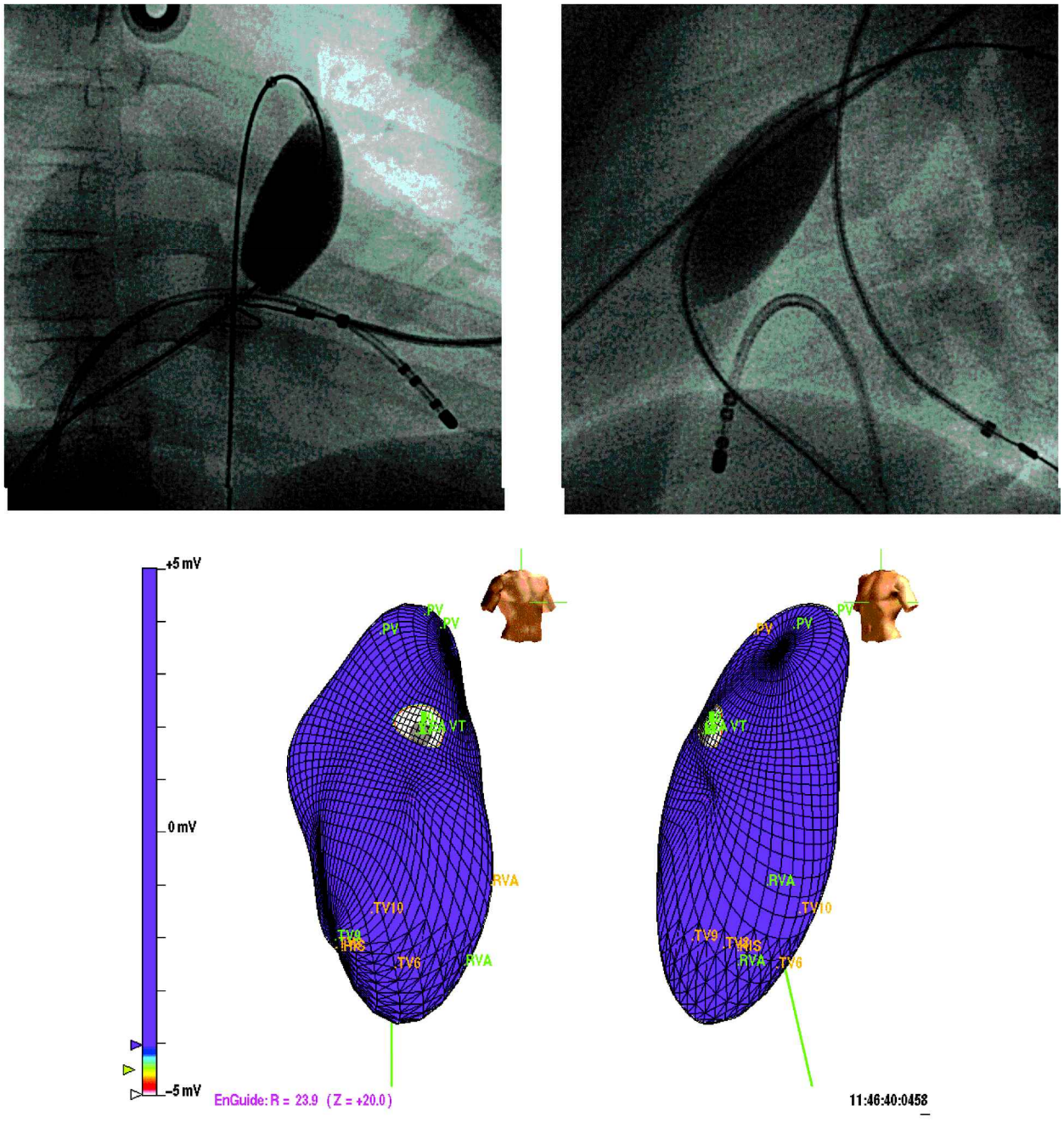

Figure 2.
Top panel: the multielectrode balloon array is placed in the right ventricular outflow tract, with the steerable ablation catheter at the right ventricular apex. The left panel shows the right anterior projection at 30° RAO, while the right panel is in left anterior oblique at 60°. The bottom panel shows the earliest endocardial activation during ventricular tachycardia as displayed on the non-contact isopotential map, using the same orientation. The coloured area represents endocardial activation on the isoelectric purple background. Earliest activation is evident anterior and high in the right ventricular outflow tract. Abbreviations: EAVT = earliest activation during ventricular tachycardia, His = His bundle location; PV: pulmonary valve; RVA: right ventricular apex; TV6/TV9/TV10: tricuspid valve annulus at 6, 9 and 10 o'clock position, respectively.

entire procedure was 5.2 h, and the time for fluoroscopy was 34 min. No complications were noted. The patient was in normal sinus rhythm two months later without any ventricular ectopy on the resting electrocardiogram, on Holter monitor, or during treadmill exercise testing.

Discussion

Treatment of idiopathic ventricular tachycardia in infants and children is indicated only for symptomatic patients and those developing tachycardia-induced cardiomyopathy. Idiopathic right ventricular tachycardia is thought to be triggered activity by

https://doi.org/10.1017/S1047951102000641 Published online by Cambridge University Press

adenyl cyclase-mediated delayed after depolarizations or cathecholamine-enhanced automaticity,[7] producing a focal arrhythmia.[8] Endocardial mapping and ablation are, therefore, directed by timing the local ventricular electrogram relative to onset of the QRS complex and by positive pacemapping with a short stimulus to the QRS interval.[3] These features make the arrhythmia very suitable for radiofrequency catheter ablation, with high rates of success even in young patients.[3,4,9] In the past, endocardial mapping was accomplished by contact mapping, necessitating significant times for the procedure and fluoroscopy. Further, the procedures were often frustrated by diminished ventricular ectopy in the sedated state. In addition, contact induced mechanical elimination of the focus occurred, as seen in this patient. Those problems may in part be overcome with the use of the modern systems using sequential contact mapping, such as the CARTO or LocaLisa systems, and those that provide continuous simultaneous multisite recordings, such as basket and non-contact mapping systems.[1,5,6,10] In general, experience with these technologies is limited in children, in part because of the issues of size. Mapping systems permitting simultaneous aquisition of data, like the Ensite 3000 system and the basket catheter, allow the display of the pattern of endocardial activation from just a single beat of tachycardia.[1,6]

To the best of our knowledge, this is the first report of mapping and ablation of a right ventricular tachycardia using the Ensite system. The report demonstrates that non-contact mapping is safe, and facilitates radiofrequency catheter ablation. Despite the age of the patient, the multielectrode balloon array inflated in the right ventricular outflow tract did not cause any hemodynamic compromise. Although the balloon was in tight contact with the anterior wall of the outflow tract, it allowed appropriate reconstruction of the individual endocardial anatomy. Subsequent simultaneous isopotential mapping permitted precise detection of the site of earliest endocardial activation even during non-sustained tachycardia. Although the balloon had to be partially deflated to reach the area of earliest endocardial activation during ventricular tachycardia, the Enguide™ signal, which is transmitted between two ring electrodes mounted on the balloon catheter and the tip of the mapping and ablation catheter, allowed precise identification of the focus of the tachycardia. In addition, although in this patient the very first contact of the tip of the catheter with the area of earliest endocardial activation immediately eliminated tachycardia, this area could safely be targeted with the navigation signal. This avoids the frustrating situation where radiofrequency energy cannot precisely be applied due to incomplete mapping after temporary elimination of the focus by contact mapping. As this is still a new technique, the findings of the non-contact mapping system were validated using standard mapping techniques.

Once an approximate endocardial anatomy of the right ventricle was identified with the Ensite system, the mapping and ablation catheter could be navigated without fluoroscopy, yielding a relatively low period of fluoroscopy of 34 min, compared to the long duration of the procedure, which lasted 5.2 h. The long procedural time may in part be explained by the intensive efforts undertaken to reach the area of earliest activation while the balloon was still in place, a problem specifically related to this technology.

This procedure does demonstrate a potential limitation of the non-contact balloon. It may limit access to some endocardial sites due to the presence of the balloon itself, which may not be encountered when a basket catheter is used.[1] In our patient, partial deflation of the balloon allowed access without significantly compromising identification of the site of tachycardia. Furthermore, despite the close proximity of the balloon to the site of activity, the focus remained active until the more direct contact with the mapping catheter itself.

References

1. Aiba T, Shimizu W, Tagushi A, et al. Clinical usefulness of a multielectrode basket catheter for idiopathic ventricular tachycardia originating from the right ventricular outflow tract. J Cardiovasc Electrophysiol 2001; 12: 511–517.
2. Pfammatter JP, Paul T. On behalf of the Working Group on Dysrhythmias and Electrophysiology of the Association for European Pediatric Cardiology: Idiopathic ventricular tachycardia in infancy and childhood. A multicenter study on clinical profile and outcome. J Am Coll Cardiol 1999; 33: 2067–2072.
3. O'Connor BK, Case CL, Sokoloski MC, Blair H, Cooper K, Gillette PC. Radiofrequency catheter ablation of right ventricular outflow tachycardia in children and adolescents. J Am Coll Cardiol 1996; 27: 869–874.
4. Coggins DL, Lee RJ, Sweeney J, et al. Radiofrequency catheter ablation as a cure for idiopathic tachycardia of both right and left ventricular origin. J Am Coll Cardiol 1994; 23: 1333–1341.
5. Stevenson WG, Delacretaz E, Friedman PL, Ellison KE. Identification and ablation of macroreentrant ventricular tachycardia with the CARTO electroanatomical mapping system. PACE Pacing Clin Electrophysiol 1998; 21: 1448–1456.
6. Betts TR, Roberts PR, Allen SA, Morgan JM. Radiofrequency ablation of idiopathic left ventricular tachycardia at the site of earliest activation as determined by noncontact mapping. J Cardiovasc Electrophysiol 2000; 11: 1094–1101.
7. Varma N, Josephson ME. Therapy of "idiopathic" ventricular tachycardia. J Cardiovasc Electrophysiol 1997; 8: 104–116.
8. Buxton DJ, Waxman HL, Marchlinski FE, Simson MB, Cassidy D, Josephson ME. Right ventricular tachycardia: clinical and electrophysiological characteristics. Circulation 1983; 68: 917–927.
9. Paul T. Radiofrequency catheter ablation of idiopathic ventricular tachycardia in young patients. In: Imai Y, Momma K (eds). The Proceedings of the Second World Congress of Pediatric Cardiology and Cardiac Surgery. New York: Futura Publishing, 1998, pp 607–610.
10. Wittkampf FH, Wever EFD, Derksen R, et al. LocaLisa. New technique for real-time 3-dimensional localization of regular intracardiac electrodes. Circulation 1999; 99: 1312–1317.

https://doi.org/10.1017/S1047951102000641 Published online by Cambridge University Press