*Case Reports*

# Nonfluoroscopic Imaging as Guidance for Radiofrequency Ablation

## of Atrioventricular Nodal Reentrant Tachycardia after Mustard Repair

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*Most tachycardias in the pulmonary venous atrium are inaccessible by direct means and require either a retrograde approach or a transseptal approach for ablation.*

*We present a case in which successful radiofrequency ablation of common atrioventricular nodal reentrant tachycardia was accomplished via a retrograde transaortic approach guided by nonfluoroscopic mapping with use of the NavX™ mapping system. The patient was a 49-year-old woman who at the age of 4 years had undergone Mustard repair for complete dextrotransposition of the great arteries. Three-dimensional reconstructions of the ascending aorta, right ventricle, systemic venous atrium, left ventricle, and superior vena cava–inferior vena cava baffle complex were created, and the left-sided His bundle was marked. After a failed attempt at ablation from the systemic venous side, we eliminated the atrioventricular nodal reentrant tachycardia by ablation from the pulmonary venous side.*

*This case is, to our knowledge, the first report of successful radiofrequency ablation of common atrioventricular nodal reentrant tachycardia after Mustard repair for this congenital cardiac malformation in which ablation was guided by 3-dimensional nonfluoroscopic imaging. This imaging technique enabled accurate anatomic location of the ablation catheters in relation to the His bundle marked from the systemic venous side.* ***(Tex Heart Inst J 2017;44(1):58-61)***

***Key words:*** *Catheter ablation/methods; electrocardiography; electrophysiologic techniques, cardiac; nonfluoroscopic imaging/methods; surgery/Mustard repair; tachycardia, atrioventricular nodal reentry; tachycardia, supraventricular; transposition of great vessels/complications; treatment outcome*

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Mustard repair for complete dextrotransposition of the great arteries (D-TGA) is associated with a 10% incidence of late recurrent atrial tachycardias.[1] Most of these tachycardias (localized, as they are, in the pulmonary venous atrium) are not directly accessible for ablation and require either a retrograde approach or a transseptal approach.[2-4] We present a case of successful radiofrequency (RF) ablation of common atrioventricular nodal reentrant tachycardia (AVNRT), guided by nonfluoroscopic mapping with use of the EnSite™ NavX™ cardiac mapping system (St. Jude Medical, Inc.; St. Paul, Minn) in a patient who long before had undergone Mustard repair for D-TGA.

## Case Report

In 2013, a 49-year-old woman with a 3-year history of recurrent supraventricular tachycardia at 175 beats/min (responsive to intravenous adenosine) was referred for catheter ablation. At the age of 4 years, she had undergone a Mustard repair for D-TGA. No detailed report of her surgical anatomy was available. Therefore, cardiac magnetic resonance imaging was performed before ablation: it showed the right and left pulmonary veins diverted to the right (pulmonary venous) atrium and the superior and inferior venae cavae (SVC and IVC) diverted by an atrial baffle to the left (systemic venous) atrium. A 12-lead electrocardiogram showed both sinus rhythm with criteria for right ventricular (RV) hypertrophy with right-axis deviation (Fig. 1A) and supraventricular tachycardia that suggested common AVNRT (Fig. 1B). During an electrophysiologic study performed after informed consent was obtained, diagnostic and ablation catheters were placed with use of fluoroscopy and were displayed on the screen of the EnSite NavX system. Via the right femoral vein, we deployed a 6F hexapolar catheter in the SVC for stimulation and recording from the pulmonary venous atrium, a 6F quadripolar catheter for stimulation and recording

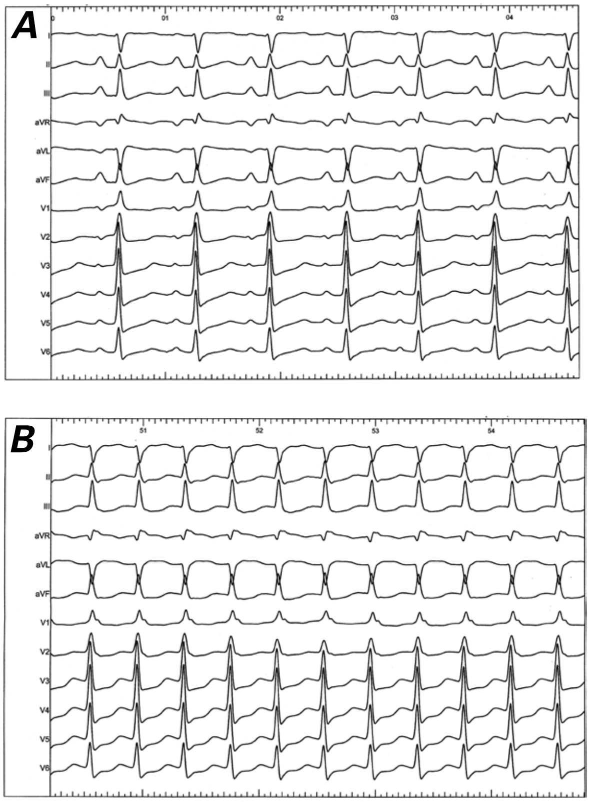

***Fig. 1*** *Surface 12-lead electrocardiograms during* ***A****) sinus rhythm and* ***B****) supraventricular tachycardia, the latter at 175 beats/min with no visible P waves.*

*Paper speed = 50 mm/s.*

in the left ventricle (LV), and a steerable 7F catheter for recording His-bundle potential and ablation in the systemic venous atrium. A second steerable 7F catheter was advanced from the retrograde transaortic approach, either for stimulation and recording from the RV or for mapping and ablation along the low midseptum of the pulmonary venous atrium (from the ventricular and atrial aspects). The hexapolar catheter in the SVC was used as a reference for the creation of the 3-dimensional (3D) geometry of the chambers. Using both ablation catheters, we created 3D reconstructions of the ascending aorta, the RV, the systemic venous atrium, the LV, and the SVC–IVC baffle complex (Fig. 2A and B). In addition, points were collected to mark the left-sided His bundle, the anterior and midseptal tip of a left-sided catheter, and the mitral annulus (Fig. 2C). The baseline atrial–His (AH) and the His–ventricular (HV) intervals were 115 and 40 ms, respectively. Both incremental pacing and extrastimulation performed from the right pulmonary venous atrium and the systemic RV revealed bidirectional single atrioventricular (AV) nodal pathway physiology. Sustained common AVNRT (Fig. 3) at a cycle length of 340 to 410 ms could be reproducibly induced 1) by incremental atrial pacing and extrastimulation after achieving critical atrial–His prolongation and 2) by incremental ventricular stimulation. Although the tachycardia could not be reset by ventricular extrastimuli elicited during His-bundle refractoriness, the tachycardia could be reproducibly entrained and terminated by ventricular overdriving at a cycle length of 300 ms, the latter because of 2nd-degree retrograde AV block.

We performed RF ablation with use of an anatomic stepwise approach guided simultaneously by fluoroscopic and electroanatomic means, with close electroanatomic monitoring of fluoroscopic positions of the ablation catheter (left- or right-sided) in relation to the tip of the left-sided His catheter positioned midseptally (Fig. 2C).

We first attempted RF ablation in the low atrial mid-posteroseptum of the left (systemic venous) atrium, ≥10 mm posterior to the marked anterior His bundle and ≥6 mm posterior to the midseptal left-His-bundle catheter, respectively—where the local electrogram showed no His-bundle deflection. After 5 RF applications promptly interrupted within 5 to 10 s, due to rapid junctional tachycardia at 3 sites (yellow tags), common AVNRT remained inducible (Figs. 2B and C). Therefore, using a retrograde transaortic approach, we attempted ablation in the low mid-posteroseptum of the right (pulmonary venous) atrium at the tricuspid annulus opposite the left ablation site (Figs. 2B–D). One long RF pulse for 60 s, with slow junctional tachycardia followed by additional RF applications for safety, rendered AVNRT noninducible. There was no damage to the normal AV conduction system, and the patient remained arrhythmia-free during a follow-up period of 2 years after ablation.

## Discussion

Radiofrequency ablation of intra-atrial reentrant tachycardia after the Senning or Mustard procedure for D-TGA requires detailed knowledge of the surgical anatomy, currently achieved by fluoroscopy alone or in combination with electroanatomic mapping by means of the CARTO® mapping system (Biosense Webster, Inc., a Johnson & Johnson company; S. Diamond Bar, Calif).[2-5] We are aware of only 2 reports[3,6] of successful RF ablation of AVNRT guided by fluoroscopic imaging alone, in a total of 6 patients with Mustard or Senning procedures for D-TGA. To avoid damage to the compact AV node in 3 patients with AVNRT, Kanter and colleagues[3] found it useful to obtain a His-bundle electrogram first, followed by catheter repositioning under fluoroscopic guidance—until the His-bundle potential no longer was present. (This is for slow pathway ablation along the tricuspid valve on the pulmonary venous side by using a retrograde transaortic approach.)

However, in 2 of their 11 patients, RF ablation of intra-atrial reentrant tachycardia (attempted from the

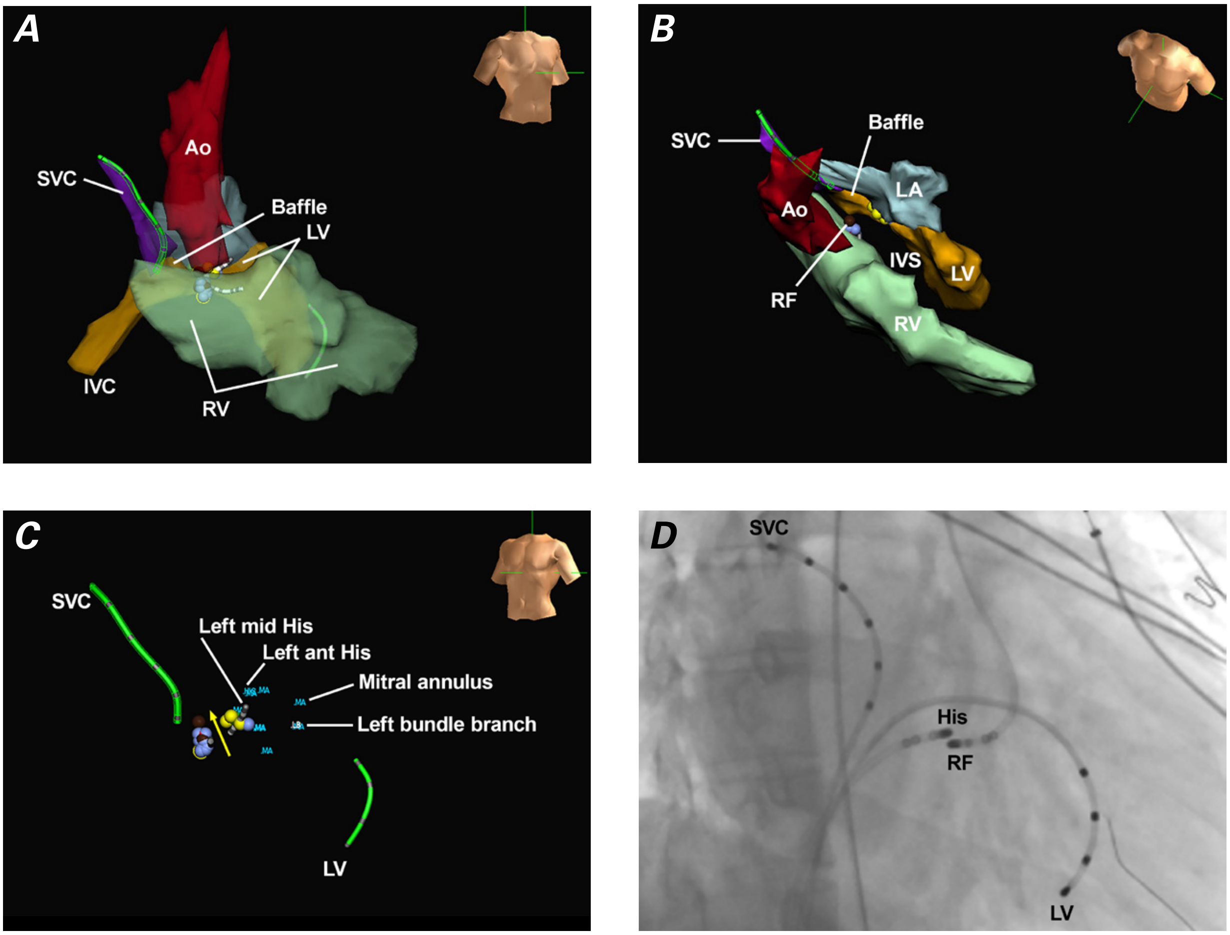


***Fig. 2*** *Radiofrequency (RF) ablation guided by nonfluoroscopic mapping (3-dimensional reconstruction) in **A**) right anterior oblique (RAO) and **B**) cranial left anterior oblique views show the ascending aorta (Ao), right ventricle (RV), left (systemic venous) atrium (LA), left ventricle (LV), superior vena cava (SVC), inferior vena cava (IVC), and SVC–IVC baffle complex. **C**) Left anterior oblique view of 3-dimensional map shows the left anterior His bundle (Left ant His), the tip of the left-sided His catheter (Left mid His), in the midseptal position, the mitral annulus (MA), the left bundle branch (LB), and 2 catheters, one in the SVC–IVC baffle complex (SVC) and one in the left ventricle (LV). With use of an anatomic stepwise approach (arrow), an initially unsuccessful ablation from the left atrial side (yellow and blue tags) followed by the successful retrograde transaortic approach from the right pulmonary venous side (red and blue tags) are shown (Figs. 2B and C). The red tag denotes an effective RF pulse that renders atrioventricular nodal reentrant tachycardia noninducible. **D**) A radiograph (RAO view) shows the ablation catheter (RF) positioned at the successful ablation site.*

*IVS = interventricular septum*

systemic side of the medial isthmus) resulted in 2nd- or 3rd-degree AV block associated with an inability to obtain a reliable His-bundle recording. In the other 3 patients with AVNRT in whom ablation was attempted, the application of RF energy to the low medial regions of the systemic venous atrium was unsuccessful, and a subsequent retrograde approach from the pulmonary venous side was required to eliminate the tachycardia.[6] Concordant with our findings, 2 of these 3 patients had bidirectional single-pathway physiology.

Our case, to our knowledge, is the first reported of successful RF ablation of common AVNRT guided by 3D nonfluoroscopic imaging in a patient with this congenital cardiac malformation. As a consequence of complex anatomy, it is technically challenging to determine the location of the ablation catheter by means of fluoroscopic imaging alone.[7] In our patient, 3D nonfluoroscopic imaging enabled accurate anatomic positioning of the ablation catheters in relation to the His bundle, the latter marked from the systemic venous side. In patients with a normal cardiac anatomy and unsuccessful right-sided ablation, successful slow pathway ablation for AVNRT via a retrograde transaortic left atrial approach has been reported.[8,9]

This case is illuminating: after Mustard repair, RF ablation attempted first from the systemic venous side did not eliminate AVNRT, although rapid and slow junctional tachycardias were observed during energy applications. Yet AVNRT could be eliminated opposite the unsuccessful site (the systemic venous atrium) by ablation from the pulmonary venous side, at the tricuspid annulus.

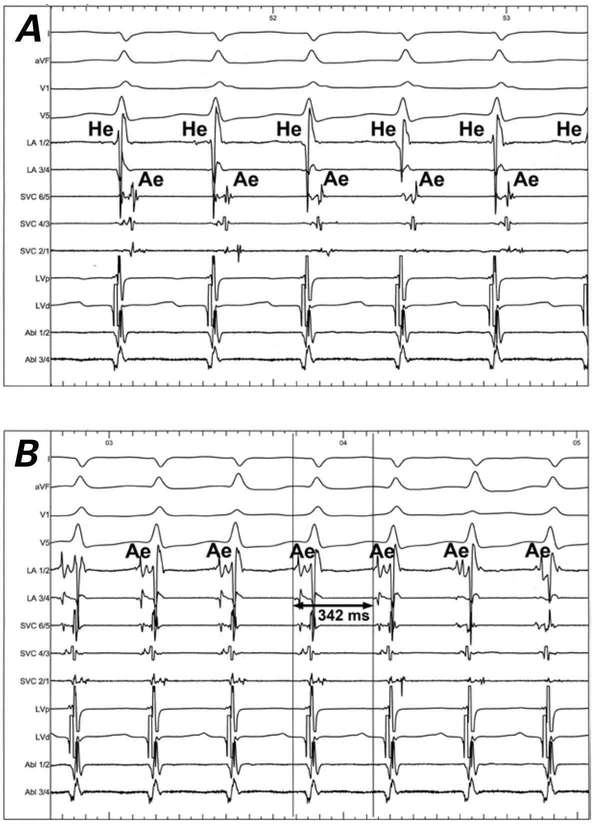


***Fig. 3*** *Intracardiac electrogram recording during common atrioventricular nodal reentrant tachycardia (AVNRT).* ***A****) Note a distinct His-bundle potential recordable in the left (systemic venous) atrium (LA 1/2) at an initial cycle length (CL) of 410 ms,* ***B****) merged into the atrial electrogram during progressive AVNRT-CL shortening to 340 ms with unmasked concentric retrograde atrial activity. Paper speed = 100 mm/s.*

*Abl 1/2 and 3/4 = right ventricle; Ae = atrial electrogram; He = His-bundle electrogram; LA 1/2 and 3/4 = distal and proximal basal septal recordings in the left atrium; LVd and LVp = distal and proximal left ventricle; SVC 2/1, 4/3, and 6/5 = distal, mid, and proximal superior vena cava baffle complex; Ve = ventricular electrogram.*

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