

# Delta wave automatic mapping and catheter ablation without fluoroscopy in patients with overt accessory pathway: A new workflow



Saverio Iacopino, MD,\* Jacopo Colella, MD,\* Francesca Pesce, MD,\* Paolo Artale, MD,†  
Gennaro Fabiano, BSc,\* Andrea Petretta, PhD, MD\*

From the \*Electrophysiology Unit, Maria Cecilia Hospital, Cotignola, Italy, and †Electrophysiology Unit, Città di Lecce Hospital, Lecce, Italy.

## Introduction

Accessory pathways (AP) are abnormal electrical connections between 2 parts of the heart, usually isolated one from the other. Atrioventricular AP may be responsible for atrioventricular reentrant tachycardia (AVRT), which accounts for about 30% of supraventricular tachycardias, being especially common in the pediatric population.<sup>1,2</sup> When an AP is visible on a resting electrocardiogram (ECG) (ie, overt or manifest AP), it results in the so-called pre-excitation, which leads to Wolff-Parkinson-White syndrome when associated to tachyarrhythmias.

According to current guidelines (ESC 2019),<sup>3</sup> catheter ablation of AP is recommended in patients with symptomatic and recurrent AVRT, or in asymptomatic patients with high-risk profile for specific electrophysiological (EP) AP properties (shortest pre-excited R-R interval  $\leq 250$  ms, AP effective refractory period [ERP]  $\leq 250$  ms, multiple APs, and an inducible AP-mediated tachycardia), or for certain patients' characteristics (dangerous occupation, competitive athletes).

In the last years, electroanatomical (EA) mapping systems have represented an alternative and an assistance to conventional EP study, permitting the reduction of fluoroscopy time and radiation dose.

Traditionally, before EA mapping, there have been multiple key factors for successful ablation of an AP: catheter technology, catheter stability, and careful analysis of the signals and intracardiac electrograms (EGM) measured by the distal electrodes of the ablation probe, as well as an essential element represented by the operator experience (particularly in recognizing a signal that leads to AP disruption if ablated).<sup>4</sup> Additional parameters are used for correct localization

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Funding Sources: The authors have no funding sources to disclose. **Address reprint requests and correspondence:** Dr Saverio Iacopino, Electrophysiology Unit, Maria Cecilia Hospital, Via Corriera 1, 48033, Cotignola (RA), Italy. E-mail address: [siacopino@gvmmnet.it](mailto:siacopino@gvmmnet.it).

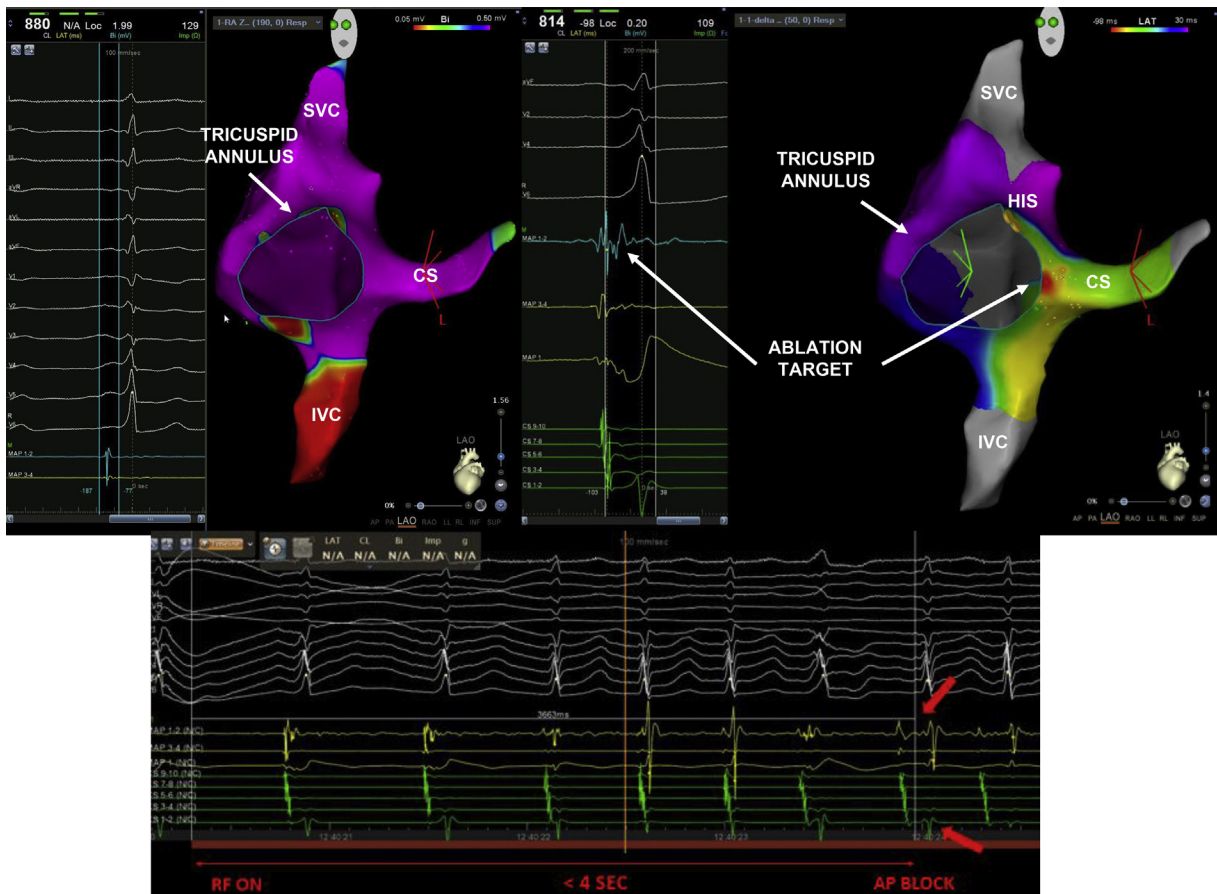
## KEY TEACHING POINTS

- Traditionally, careful analysis of the signals and intracardiac electrograms is required to address accessory pathways (AP). To correctly localize an overt AP, measurements of local AV time and time from local ventricular electrogram and delta wave at the surface electrocardiogram are required. These parameters can be inaccurate and manual annotation during electroanatomical mapping may lead to errors.
- With the CARTO 3 System (Biosense Webster) and an automatic mapping workflow that combines the Confidense module (Automatic Mapping, Wavefront Annotation, and Pattern Matching) and the CARTO Prime Parallel Mapping module, it is possible to precisely localize the AP, optimizing the radiofrequency applications and achieving a safe and successful endpoint, as demonstrated by the 3 cases presented.
- The proposed automatic workflow enables fast mapping and avoids inaccuracies that may occur during manual annotations of the signals.

of AP, such as measurement of local AV time and time from local ventricular electrogram and delta wave at the surface ECG. Nonetheless, these parameters can also be inaccurate, especially if used individually.

In this context, there is still a significant failure rate of AP ablation, with an average recurrence rate of 8%, which can increase up to 17% in particular cases such as septal AP.<sup>5</sup>

With the aim to improve diagnosis and treatment success of AP, we developed a new workflow based on EA mapping using the CARTO® 3 System (Biosense Webster, Johnson & Johnson Medical S.p.a., Irvine, CA).



**Figure 1** Case 1. Top left: CARTO 3 voltage map of the right atrium in a left anterior oblique (LAO) projection; top right: CARTO 3 activation map showing the target point in red in LAO. Both maps have 190 points. On the bottom the accessory pathway block is visible after <4 seconds of radiofrequency ablation. CS = coronary sinus; IVC = inferior vena cava; SVC = superior vena cava.

This workflow consists of a multiparametric evaluation and an automatic mapping process to localize the AP. The purpose is to achieve a fast and precise localization of the AP minimizing the radiofrequency (RF) applications and the total RF time, and eventually increasing the success rate of the ablation. Nevertheless, as already demonstrated in the literature,<sup>6</sup> using an EA mapping system enables to minimize or even eliminate fluoroscopy.

### Workflow description

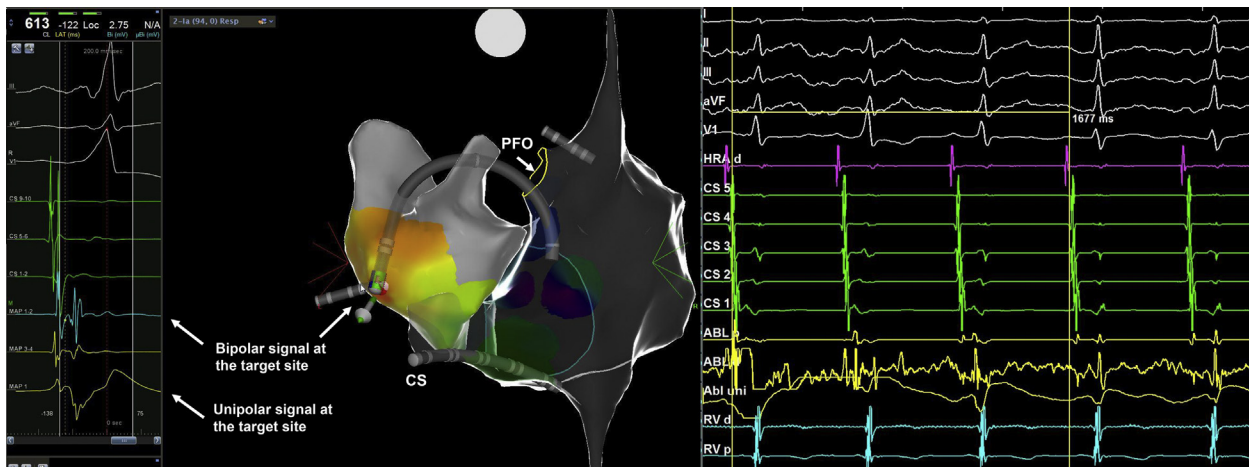
The workflow is based on the concomitant use of the following modules integrated in the CARTO Prime™ software of the CARTO 3 system version 7 (Biosense Webster): Confidense™ module (Automatic Mapping, Wavefront Annotation, and Pattern Matching) and CARTO Prime™ Parallel Mapping module. For EA mapping and arrhythmic substrate ablation, we used the ThermoCool SmartTouch® catheter (Biosense Webster, Inc), an irrigated catheter with contact force sensing and vector visualization.

By relying on this workflow, for some patients (when affected by right-sided manifest AP), it was possible to use only a ThermoCool SmartTouch catheter without employing other intracavitary references.

First, we acquired the basal ECG signal for Pattern Matching (beat-to-beat analysis on the 12-lead ECG derivation), setting the reference on the most stable QRS peak in 1 of the 12 ECG leads. This reference lead was expected not to change polarity after ablation.

Then, using the Parallel Mapping module, we acquired simultaneously 2 different EA maps. The first map (a bipolar map with 0.05–0.5 mV standard cut-off for atrial mapping) was aimed to the atrial signal, in order to define the precise localization of the annular plane and other anatomical structures (coronary sinus ostium, inferior and superior vena cava, etc). For this map the window of interest (WOI) was set excluding ventricular activity (WOI: -250/-50; reference: QRS peak). In the second map, information on the local activation time of the overt AP was acquired, excluding the atrial signals from the WOI; in this way, we always had only 1 signal in the reference window. Specifically, the WOI started at the end of the P wave, evaluated on every lead in sinus rhythm.

The annotation of the ventricular signal in the WOI is based on the Wavefront Annotation algorithm of the CARTO 3 system. This algorithm focuses on the automatic annotation of the maximum negative slope of the unipolar EGM within the window of interest defined on the bipolar EGM. All



**Figure 2** Case 2. From left to right: the electrocardiogram (ECG) and electrogram (EGM) signals at the target site; posteroanterior (PA) view of the CARTO 3 activation map; ECG and EGM signals during radiofrequency ablation showing accessory pathway block after 1677 ms.

the signals were annotated automatically by the algorithm, without any manual adjustment.

In the present report, we describe 3 clinical cases of overt AP ablation using this new workflow.

## Case report

### Case 1

A 31-year-old woman presented to outpatient visit for frequent episodes of undocumented palpitations. The 12-lead ECG showed a ventricular pre-excitation, and the EP study revealed the presence of a right posteroseptal AP, with easy induction of AVRT during ventricular stimulation (tachycardia cycle length = 280 ms). We mapped the right atrium with a ThermoCool SmartTouch catheter (Figure 1) and placed a decapolar and a tetrapolar catheter in the coronary sinus and in the right ventricle, respectively. We applied the proposed workflow, achieving a localization of the AP on the 3-D map, confirmed by the maximum AV fusion and the best QS signal on the unipolar derivation. After 1.2 seconds of RF delivery at 35 W with a contact force >10 g, AP disappearance was observed (time-to-effect = 4 seconds). No fluoroscopy was required during the entire procedure.

### Case 2

The second case involves a 17-year-old male patient. Delta waves were occasionally observed on the ECG during a sport medical visit. The patient was asymptomatic for palpitations or tachycardia. Nevertheless, being a competitive athlete, he underwent an EP study. An EA mapping of the right chambers and left atrium was created using only 1 mapping/ablation catheter (ThermoCool SmartTouch 3.5 mm D-F irrigated catheter, Biosense Webster). The left atrium was reached via patent foramen ovale (PFO). A decapolar catheter was placed in the coronary sinus, whereas 2 tetrapolar catheters were placed, 1 in the right ventricle and 1 in the right atrium, respectively. The EP study confirmed the

presence of a left posterior AP with high-risk properties (ERP of 250 ms).

Therefore, using the previously described workflow, we obtained a precise localization of the AP (Figure 2). After finding the maximum AV fusion and the best QS signal on the unipolar lead (which confirmed the localization), RF was delivered with a power of 35 W and a contact force >10 g, leading to the immediate disappearance of the pre-excitation (time-to-effect <2 seconds). No fluoroscopy was required for catheter placement or during ablation.

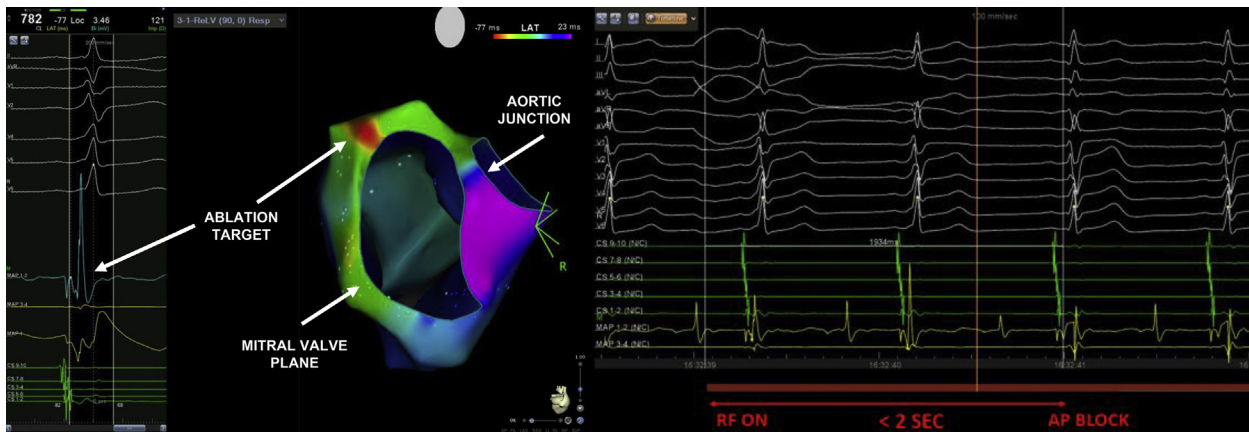
### Case 3

A 53-year-old woman, with a known diagnosis of ECG pre-excitation, symptomatic for dizziness and palpitations, underwent an EP study. The examination revealed the presence of an anterolateral left manifest AP, with an ERP of 290 ms, and induction of AVRT. A decapolar and a tetrapolar catheter were placed in the coronary sinus and in the right ventricle, respectively, whereas the ThermoCool SmartTouch catheter was used in the left ventricle for activation mapping. By applying the proposed workflow, we identified the location of the AP, which was confirmed by the maximum AV fusion and the best QS signal on the unipolar derivation (Figure 3). After 2 seconds of RF delivery at 35 W and with a contact force >10 g, AP disappearance was observed (time-to-effect = 2 seconds).

Fluoroscopy was only limited to catheter placement (especially for transaortic approach), with a total fluoroscopy time of 30 seconds and an effective dose of 0.07 mSv.

## Discussion and conclusions

As shown in the 3 cases reported, the proposed workflow allowed a fast and precise annotation of the signal of interest, increasing the precision of the EA mapping. A short time-to-effect (defined as AP disappearing) during ablation was also achieved, optimizing intraprocedural outcome. Specifically, we observed a time-to-effect  $\leq 5$  seconds.



**Figure 3** Case 3. At left, CARTO 3 activation map (posterior view) with red zone indicating the accessory pathway (AP) location where the AV signals recorded by the ablation catheter (MAP 1-2) show the maximum fusion. On the right, the signals during radiofrequency ablation with AP block after <2 seconds.

Nevertheless, an ablation index of 450 was always reached. Mean procedural time was 70 minutes, including 30 minutes of waiting time. For a map of approximately 200 points, the average mapping time was 5 minutes. When mapping was restricted to a smaller area with fewer acquired points, then the mapping time was even shorter.

In our experience, using this workflow, the mapping time was reduced by 5–10 minutes compared to the conventional approach.

For all the patients Holter ECG (7 days) was performed at 1 and 6 months after the procedure and no pre-excitation was observed, nor have symptoms of SVT been reported.

By using the pattern matching module, we do not have to rely on any intracavitary reference for the activation map and we can map using solely the SmartTouch catheter. Furthermore, no additional multielectrode catheters such as PentaRay® or DecaNav® were required to achieve successful endpoint, hence minimizing the number of catheters employed and the risk of complications.

The advantage of this workflow is that it excludes the first atrial signal and consistently annotates the second component using the automatic wavefront annotation algorithm. This algorithm considers the maximal negative slope of the unipolar signal within the window demarcated by the bipolar signal. Therefore, when on the annular plane, but distant from the AP location, the algorithm annotates the late ventricular signal. As the catheter is moved closer to the AP location, the ventricular signal appears earlier in time and, at the exact AP location, both the AP signal and the ventricular signal with the maximal precocity are seen. This is where the wavefront algorithm correctly annotates the maximal precocity corresponding to the AP location on the activation map (red focal area).

Overall, the use of EA mapping permitted to minimize the fluoroscopy time, which was zero in the right atrial procedures or when a PFO was present, and it was near zero in left atrial procedures with transaortic approach.

This workflow has been tested with the CARTO 3 system using wavefront annotation and pattern matching. As previously shown,<sup>7</sup> the wavefront annotation algorithm minimizes the variations that could be caused by low-quality signals, resulting in highly accurate maps. To our knowledge, the CARTO 3 system is the only EA mapping system with this feature.

Another feature used is the Parallel Mapping module, which enables simultaneous acquisition of 2 maps with different settings, such as 2 different windows of interest. With this feature we were able to acquire voltage and activation maps at the same time. The voltage map enables quick identification of the valve plane and any potential alteration in the substrate, whereas with the activation map we successfully localized the target ablation zone. Again, to our knowledge parallel mapping is available only with the CARTO Prime software version v7.

As illustrated by the case studies, the new workflow has great potential in the diagnosis and treatment of overt AP, for many reasons. It increases the precision of EA mapping, reducing dramatically the area of AP localization on the reconstructed map. This allows focusing the ablation to a smaller zone of cardiac tissue, shortening the time of RF delivery, and making the ablation safer (possibly lowering risk of complications such as pericardial effusion or tamponade). Moreover, it can reduce the number of catheters used during the procedure. In selected cases only 1 mapping and ablation catheter may be sufficient to localize the AP and perform the ablation, thus diminishing the risk of vascular complication, especially for young patients.

To conclude, the use of EA mapping helps reduce fluoroscopy time, if not avoiding it (for right-sided APs or in the presence of PFO), being useful in select categories such young patients and women of childbearing age. Additionally, the present workflow allows for fast mapping time with automatic signal annotation, avoiding manual annotations, which are more prone to inaccuracies.

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