Electrogram-based AF ablation –finally, reproducibility!

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August 1, 2022

Abstract

Abstract: After several years with sobering experiences with electrogram-based AF ablation approaches, Seitz et al present with the VX1 software a reliable tool to map and ablate spatio-temporal dispersion. The presented multicenter study in persistent AF patients was conducted in 1 expert and 7 satellite centers with a total of 17 operators, using the VX1 software to detect and subsequently ablate spatiotemporal dispersion. While the AF termination rate (88%) and the freedom from AF in 12 months FU (82%) was very encouraging, the VX1 software, using AI enhanced electrogram adjudication, achieved very similar results in all centers, regardless of the centre's or the operator's experience. Thus, the biggest criticism of electrogram-based ablation strategies, i.e. the lack of reproducibility in "non-expert" centers, seems to be finally addressed.

Editorial comment for

Artificial Intelligence Software Standardizes Electrogram based

Ablation Outcome for Persistent Atrial Fibrillation (JCE-22-0260.R1)

Title: Electrogram-based AF ablation –finally, reproducibility!

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Funding: none

Disclosures: None

Since the landmark publication of Koonlawee Nademanee in 2004 (1), electrogram based ablation (mostly) in addition to systematic PVI has been an often and most often controversially discussed ablation strategy for substrate modification in persistent atrial fibrillation. In most studies, complex fractionated atrial electrograms (CFAE) are detected using single bipolar recordings from ablation catheters or circular mapping catheters. These (singular) electrograms are then adjudicated to "CFAE" or "no CFAE" using the expertise of the operator aided by relatively simple mathematical algorithms (measuring e.g. the mean cycle length of the recorded electrogram); the subsequent ablation of CFAE aims at AF regularization and finally termination by eliminating the AF maintaining substrate. In several (single center) studies, the results of this approach were very encouraging, but it relied heavily on the experience of the operators, and the main criticism was its mediocre reproducibility (2-3). This limitation proved to be crucial in the multicenter STAR AF II trial, where the addition of CFAE ablation to PVI did not improve the ablation success (4).

A the same time, mapping technologies and tools that allowed the simultaneous analysis of adjacent electrograms and aimed at simultaneous representation of the meandering activation patterns in ongoing AF were developed. In contrast to the morphological description of singular bipolar electrograms, these technologies were designed to detect in a more comprehensive, "panoramic" way (either for both atria from surface ECG

or for a whole atrium with a large basket catheter) recurrent patterns of focal and reentrant activation in many (adjacent) electrograms (5-6). In these technologies, more complex mathematical algorithms and much more filtering and alteration of the recorded bipolar electrograms were used to determine activation directions/focal firing and to identify by this AF rotors or drivers as targets for ablation.

However, changing the field of view from single bipolar recordings (with high resolution) to whole chamber/whole heart mapping (with very low resolution) was maybe a step to far. At the same time, due to the important transformation of local ECGs by filtering and "recalculation" and the application of advanced mathematical algorithms, it was almost impossible for operators to "understand" the diagnosis of the mapping system: you had to trust the system blindly, because it is impossible to counter-check by looking at the recorded electrograms.

Eventually, it turned out that even by using these highly sophisticated systems, the reproducibility of results in multicenter studies including also non-expert centers is still low (7).

In a previous publication (8) Seitz e al introduced the concept of atrial substrate identification by mapping spatiotemporal dispersion, depicting an atrial area with local fractionated electrograms and/or special conduction properties as detected by the unfiltered, original bipolar recordings in one position of a multipolar mapping catheter (e.g. the Pentarray® catheter). It is important to note that (a) the electrograms remain unchanged and that (b) the relationship of the electrograms, i.e. the conduction timing and patterns, are an important point of the analysis. Since only one position of a multipolar mapping catheter is analyzed at a time, the total surface mapped simultaneously approaches 1-2cm^2..

The results regarding AF termination and long-term maintenance of sinus rhythm were very encouraging (95% termination; 85% sinus rhythm after 1.4 ablation procedures), but needed to be confirmed in a multicenter study including "non-expert" operators.

In this edition of the Journal, Seitz et al. present a multicenter study with one expert and 7 "satellite centers" that focusses exactly on the two major weaknesses of electrogram based approaches: (a)reproducibility and (b)an advanced electrogram analysis technology, that combines advanced mathematical algorithms with operators' experience – the latter enhanced by the addition of artificial intelligence (AI) (9).

The authors included 85 ablation-naïve patients with persistent AF in 8 centers (one primary center and 7 satellite centers) with a total of 17 operators performing the ablation. Of note, almost 30% of the patients suffered from long-lasting persistent AF, the mean age was 70 years, mean CHADSvasc score was 2.5 and mean LA volume was 165±31 ml, with a majority of patients suffering of at least one cardiovascular comorbidity – an overall challenging patients' cohort.

The used mapping tool – the VX1 system- provides an online, AI enhanced detection of spatio-temporal dispersion areas by evaluating the local EGM morphology but also the complex relationship of adjacent electrograms and thus analyzing conduction patterns between bipolar electrograms recorded in one position of a multipolar mapping catheter. The whole EGM adjudication process is enhanced by the use of AI that takes formerly adjudicated EGMs into account. Thus, the system improves in the going by addition of adjudicated EGMs.

Acute AF termination occurred in as many as 88% of patients and was similar high in the expert center as the satellite centers (92% vs. 84%). The very good intraprocedural results translated also in very satisfying numbers after a FU of 12 months: after a single ablation procedure, freedom from atrial fibrillation with/without AAD was reached in 86% of patients, whereas 54% of patients were free of any atrial tachyarrhythmia. After a mean of 1.3 procedures, the number of patients free from any atrial tachyarrhythmia increased to 73%.

Most importantly, no statistical difference could be found between expert center and the satellite centers, no matter which subgroup or FU was analyzed and the procedural safety was very high (one AV block).

Thus, Seitz and colleagues could demonstrate a high reproducibility of their electrogram-based approach of spatiotemporal dispersion using the VX1 software, even in non-expert hands and with a large number of

operators.

Furthermore, they could also reach very encouraging long-term success rates regarding the maintenance of sinus rhythm, moreover after a comparably low number of re-do procedures.

Regarding the procedures, there are also many very interesting points, that should lead to further research: Only 42% of patients underwent in the course of the ablation additional PVI and with 25% of patients, an unusual high number of patients converted directly to sinus rhythm without a transition via ATs. The mean RF time to reach SR was also very short with 27min, meaning this approach is no "carpet-bombing" and probably provides a maintained atrial transport function.

Regarding the long-term FU, the study confirms the finding that intra-procedural termination is a positive predictor for sinus rhythm in FU, with >60% of the terminated patients experiencing no atrial tachyarrhythmia anymore after a single ablation procedure.

In summary, Seitz and colleagues showed that their AI enhanced VX1 software is finally able to provide reliability and reproducibility in an EGM based approach – the holy grail of EGM based ablation approaches. Together with very encouraging success rates regarding long-term restoration of sinus rhythm, the Volta system has shown a high clinical usefulness for treating the complex persistent AF patients.

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