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High-density mapping-guided regional pulsed field ablation for atrial appendage tachycardia: a two-case report

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Case Report

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Abstract

Background

Focal atrial tachycardia (AT) arising from an atrial appendage is uncommon and technically challenging because the thin, trabeculated anatomy may impair catheter stability and tissue apposition. Experience with pulsed field ablation (PFA) for this indication remains limited.

Case presentation:

A 42-year-old man with recurrent right atrial appendage AT and a 38-year-old woman with left atrial appendage AT underwent high-density activation mapping. In both patients, a discrete region of earliest activation with centrifugal spread was identified. A mapping-guided regional lesion strategy was implemented using a VARIPULSE variable-loop circular catheter, with PFA delivered across the mapped region and selected appendage segments. In the first patient, AT terminated during PFA at the mapped distal RAA target and was subsequently non-inducible. In the second, a complete activation map was acquired before AT terminated without energy delivery and could not be reinduced. PFA was subsequently performed during sinus rhythm using the stored activation map and electroanatomical geometry. Both patients remained asymptomatic, with no documented AT recurrence during 6- and 3-month follow-up, respectively.

Conclusions

These cases illustrate the technical feasibility of high-density mapping-guided regional PFA for focal AT arising from either atrial appendage.

Introduction

Focal atrial tachycardia (AT) arising from the atrial appendages is uncommon but can be technically challenging to treat[1, 2]. The thin myocardial wall, extensive pectinate muscle trabeculation, and variable morphology may impair catheter stability and tissue apposition while increasing the risks associated with catheter manipulation and lesion delivery[3, 4]. Additional considerations arise from the proximity of the sinus node and right phrenic nerve to the right atrial appendage (RAA), and of the left phrenic nerve and circumflex coronary artery to the left atrial appendage (LAA)[4].

Radiofrequency ablation is effective in many patients with appendage-origin AT, although recurrent or refractory cases may require repeat procedures, alternative ablation strategies, or surgery[5, 6]. When high-density mapping identifies a discrete appendage source, the intended lesion extent remains an important procedural consideration. Treatment confined to a single earliest activation point may provide incomplete coverage in trabeculated anatomy, whereas complete appendage isolation exposes a larger

volume of appendage myocardium to ablation. In the LAA, electrical isolation has also raised concerns regarding appendage mechanical function and thromboembolic risk[7, 8].

Pulsed field ablation (PFA) induces myocardial injury predominantly through irreversible electroporation and has been used mainly for pulmonary vein isolation[9, 10]. Clinical experience with PFA for appendage-origin focal AT remains limited. Here, we report two cases of focal AT arising from the right and left atrial appendages treated with a high-density mapping-guided regional lesion strategy using the VARIPULSE variable-loop circular catheter. PFA was directed towards the mapped source and selected appendage segments rather than being planned as complete appendage isolation.

Case presentation

Case 1: Right atrial appendage tachycardia

A 42-year-old man was referred for catheter ablation because of recurrent symptomatic AT. An RAA origin had previously been diagnosed at another institution, but no ablation had been performed. Amiodarone and metoprolol initially provided partial symptom control; however, the episodes subsequently increased in frequency and duration. Transthoracic echocardiography showed normal cardiac chamber dimensions and ventricular function without relevant structural heart disease, and transoesophageal echocardiography excluded intracardiac thrombus.

The procedure was performed under deep intravenous sedation with spontaneous ventilation. Atrial burst pacing during isoprenaline infusion reproducibly induced sustained AT with a cycle length of 350 ms. High-density activation mapping with a PentaRay catheter using the CARTO 3 system (Biosense Webster, Irvine, CA, USA) demonstrated centrifugal activation from the distal RAA near the apex on the free-wall aspect. The earliest local activation preceded the selected mapping reference by 80 ms (Fig. 1).

A VARIPULSE variable-loop circular catheter was advanced into the RAA through a VIZIGO steerable sheath. Two PFA delivery sets were applied at the RAA ostium, followed by two at the distal RAA encompassing the mapped source; each set comprised three applications, resulting in 12 applications in total (Fig. 2). Tissue proximity guidance was used before energy delivery, and the catheter was rotated between delivery sets to improve spatial coverage. Complete RAA isolation was not a procedural endpoint. Saline irrigation at 30 mL/min was maintained during PFA delivery.

The AT terminated during the third delivery set, the first delivered at the mapped distal RAA target, with immediate restoration of sinus rhythm. The final planned delivery set was subsequently completed. Repeated atrial burst pacing with isoprenaline infusion failed to reinduce AT. No sinus node dysfunction or other procedure-related complication was observed.

The patient was discharged the following day. Aspirin 100 mg once daily was prescribed for 1 month, and antiarrhythmic medication was discontinued. At 6-month clinical follow-up, he remained asymptomatic, with no documented recurrence of AT.

Case : Left atrial appendage tachycardia

A 38-year-old woman with a 1-year history of recurrent paroxysmal palpitations was referred for repeat electrophysiological assessment. A previous electrophysiological study at another institution had failed to induce the tachycardia, and no ablation had been performed. Her symptomatic episodes subsequently increased in frequency despite medical therapy. Transthoracic echocardiography showed preserved left ventricular systolic function without relevant structural heart disease, and transoesophageal echocardiography excluded LAA thrombus.

The procedure was performed under local anaesthesia with intravenous fentanyl for analgesia. After transseptal access, intravenous unfractionated heparin was administered, and the activated clotting time was monitored throughout left atrial instrumentation according to the institutional anticoagulation protocol.

Atrial burst pacing during isoprenaline infusion induced sustained AT with a cycle length of 360 ms. A complete high-density activation map was acquired with a PentaRay catheter using the CARTO 3 system while the AT remained sustained. The map demonstrated centrifugal activation from the LAA ostium adjacent to the LAA–left pulmonary vein ridge, where the earliest local activation preceded the selected mapping reference by 40 ms (Fig. 3).

Immediately after completion of activation mapping, the AT terminated without energy delivery and could not be reinduced despite repeated atrial burst pacing during isoprenaline infusion. Because the complete activation map had already been acquired and stored, PFA was subsequently performed during sinus rhythm using the stored activation map and corresponding electroanatomical geometry.

A VARIPULSE variable-loop circular catheter was initially positioned at the ostial ridge-side region and subsequently advanced to selected more distal sites along the ridge-facing aspect of the LAA. Two PFA delivery sets were applied at each region; each set comprised three applications, resulting in 12 applications in total (Fig. 4). Tissue proximity guidance and catheter rotation were used to support apposition and spatial coverage. Complete LAA isolation was not a procedural endpoint. Saline irrigation at 30 mL/min was maintained during PFA delivery.

After completion of the planned lesion set, AT remained non-inducible during repeated atrial burst pacing with isoprenaline infusion. No procedure-related complication occurred, and the patient was discharged the following day. Rivaroxaban 15 mg once daily was prescribed for 2 months, and antiarrhythmic medication was discontinued. At 3-month clinical follow-up, she remained asymptomatic, with no documented recurrence of AT.

Discussion

These cases illustrate the technical feasibility of using high-density activation mapping to guide regional PFA for focal AT arising from either atrial appendage. In Case 1, AT terminated during PFA at the mapped

distal RAA target and was subsequently non-inducible. In Case 2, a complete activation map was acquired before the AT terminated without energy delivery, allowing PFA to be performed during sinus rhythm using the stored activation pattern and electroanatomical geometry. The two cases therefore demonstrate complementary applications of the same workflow: lesion delivery during sustained AT with direct termination and map-guided lesion delivery after loss of the induced tachycardia.

Published experience with PFA for atrial appendage arrhythmias remains limited and has included LAA-origin AT treated with PFA and transcatheter LAA occlusion, combined superior vena cava and RAA isolation, and premature atrial complexes arising from the RAA apex[6, 11, 12]. These reports used different catheter configurations and procedural endpoints. The present cases add experience with mapping-guided regional PFA for focal AT arising from both atrial appendages, with lesion delivery guided by the mapped source and corresponding appendage geometry.

The regional lesion strategy was intended to balance focal targeting with spatial coverage in a highly trabeculated structure. Treatment confined to a single earliest activation point may be affected by variable catheter orientation and tissue apposition between pectinate muscles. PFA applications were therefore distributed across the mapped source and selected appendage segments, with catheter rotation used to improve spatial coverage across the electrode array. This approach differed from both single-point ablation and a predefined appendage isolation strategy. Complete appendage isolation was not a procedural endpoint, although broader lesion sets or appendage isolation may remain appropriate in patients with multiple foci, a more extensive arrhythmogenic substrate, or recurrence after targeted treatment.

Case 2

highlights the practical value of completing and storing an activation map while the induced AT remains sustained. Although the AT could not be reinduced before PFA, lesion delivery remained guided by the activation pattern acquired during tachycardia rather than by anatomical estimation alone. Because inducibility had already been lost before energy delivery, this case does not provide a direct electrophysiological measure of the acute effect of PFA. It should therefore be interpreted primarily as demonstrating the feasibility of using a previously acquired activation map to guide lesion delivery during sinus rhythm. The absence of documented recurrence during short-term follow-up is encouraging but cannot establish treatment efficacy.

The variable-loop catheter permitted positioning at selected ostial and distal appendage sites, while integration with the electroanatomical mapping system supported display of catheter position and PFA tags within the reconstructed geometry[13].These technical features facilitated implementation of the planned lesion strategy but do not establish superiority over focal radiofrequency ablation or other PFA catheter designs. Furthermore, PFA does not eliminate the mechanical and thromboembolic risks associated with catheter manipulation within the atrial appendages. Potential effects on adjacent coronary and neural structures also remain relevant when energy is delivered within the appendages[8–10].

These observations are limited by the two-patient sample, the absence of a comparator, and short-term clinical follow-up. Further studies are needed to define the appropriate lesion extent and dosing, evaluate longer-term arrhythmia outcomes, and systematically assess appendage conduction and mechanical function.

Conclusion

High-density mapping-guided regional PFA was technically feasible in two patients with focal AT arising from the right and left atrial appendages. PFA applications were distributed across the mapped source and selected appendage segments; complete appendage isolation was not a procedural endpoint. Further study is needed to determine the appropriate lesion extent and assess longer-term clinical outcomes

Declarations

Author Contributions

Lijun Zeng and Xiaobo Pu conceived and designed the study. Lijun Zeng collected and analyzed the clinical data, prepared the figures, and drafted the initial manuscript. Xiaobo Pu performed the procedures, supervised the study, critically revised the manuscript for important intellectual content, and validated the final version. Both authors reviewed, approved, and agreed to be accountable for all aspects of the work.

Patient consent

The authors confirm that written informed consent for the publication of this case report, including the accompanying images, was obtained from both patients in accordance with COPE guidance.

Funding

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Conflict of interest

None declared.

Data availability

The data underlying this article are available from the corresponding author upon reasonable request, subject to applicable patient privacy and institutional requirements.

Ethics approval and consent to participate

The work was conducted in accordance with the Declaration of Helsinki and applicable institutional requirements. The Biomedical Research Ethics Committee of West China Hospital, Sichuan University confirmed that this retrospective case report is exempt from ethics review.

Consent for publication

Written informed consent was obtained from both patients for publication of this case report and the accompanying clinical information and images.

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Figures

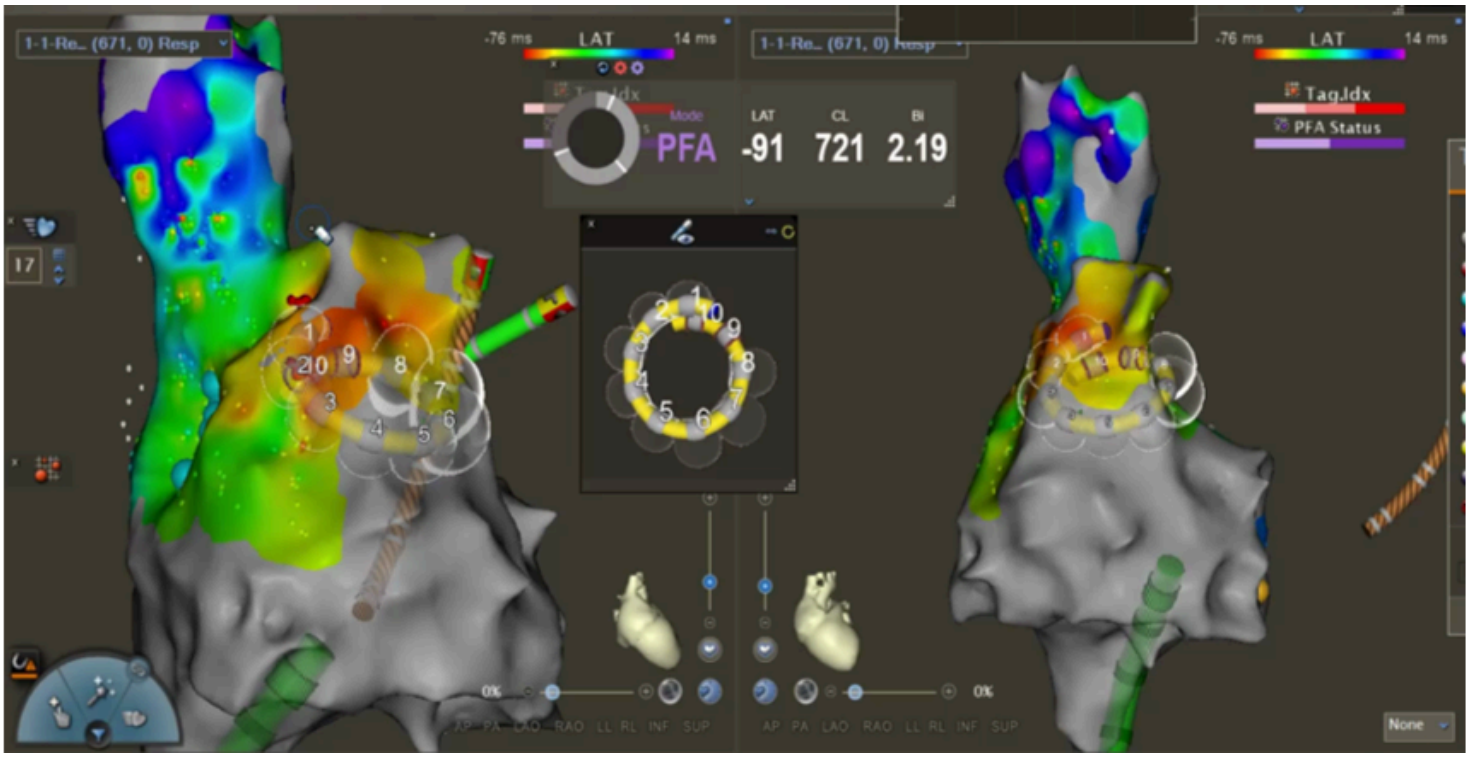


Figure 1

High-density activation mapping and subsequent PFA catheter positioning in Case 1. Two views of the reconstructed RAA geometry show centrifugal activation from the distal free-wall region. The activation map was acquired with a PentaRay catheter.

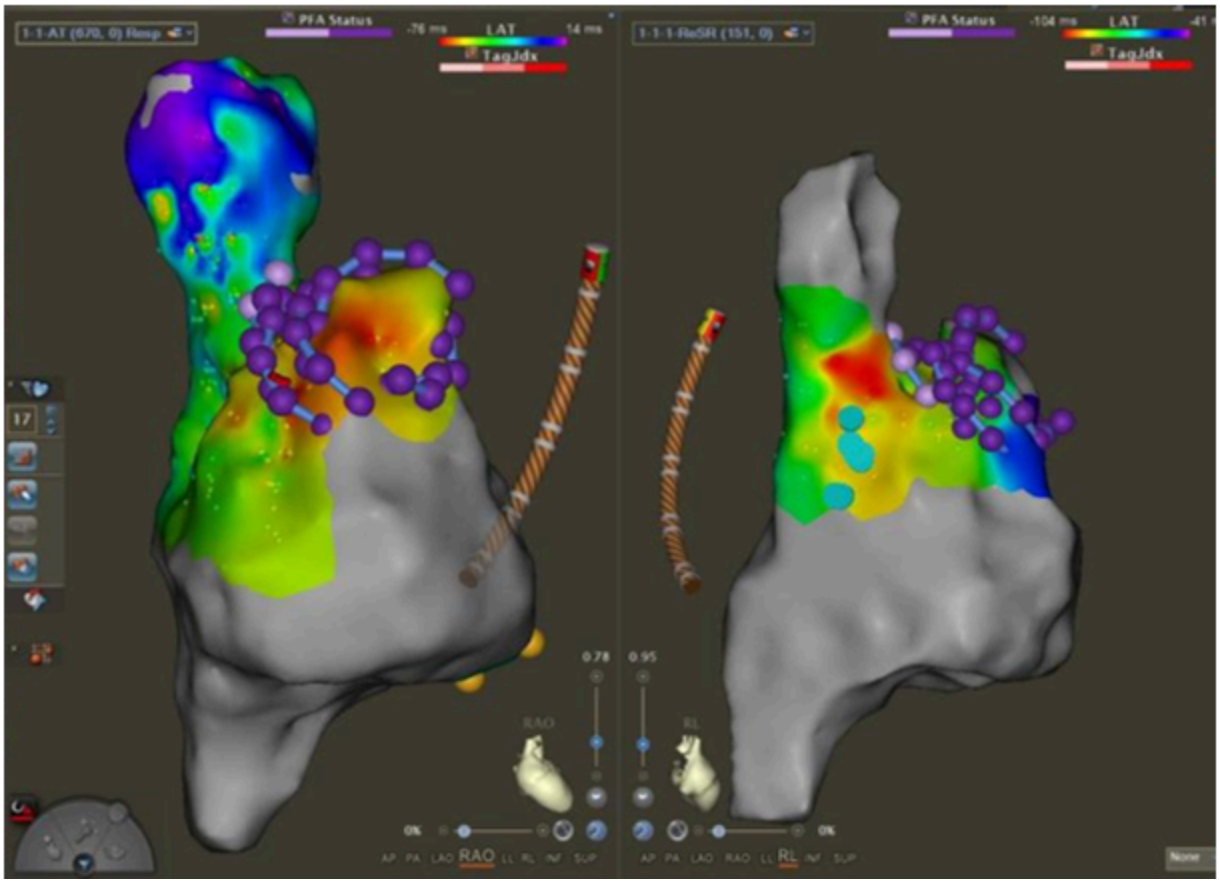


Figure 2

Distribution of regional pulsed field ablation applications in Case 1. Two views of the reconstructed RAA geometry show PFA tags at selected ostial and distal positions. The mapped earliest activation region was located in the distal RAA near the apex, where AT terminated during the first distal delivery set.

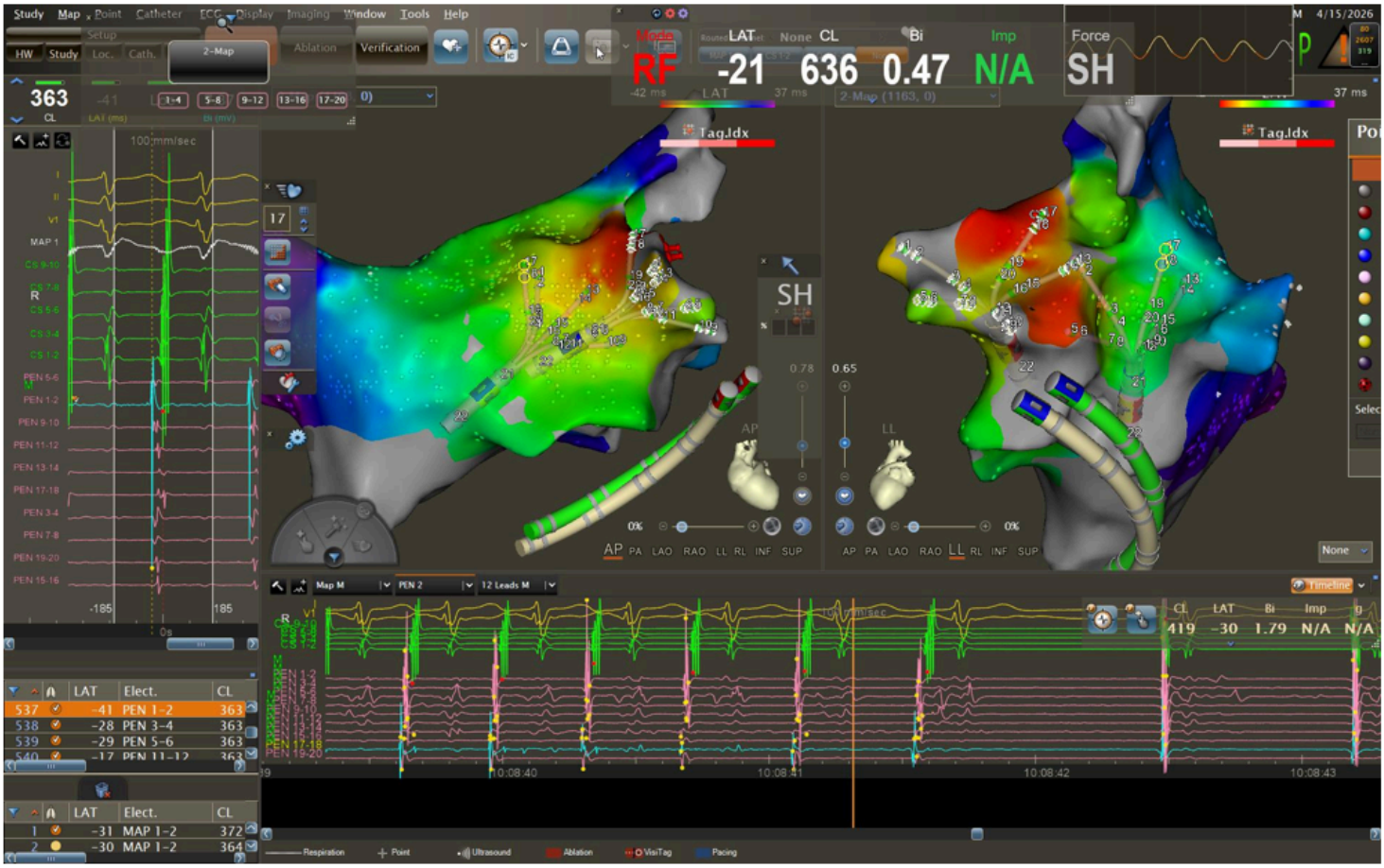


Figure 3

High-density activation mapping of LAA tachycardia in Case 2. Two views of the reconstructed left atrial geometry demonstrate centrifugal activation from the LAA ostium adjacent to the LAA–left pulmonary vein ridge. The red region denotes the earliest activation, with progressively later activation represented by yellow, green, blue, and purple. The PentaRay catheter is displayed within the reconstructed geometry.

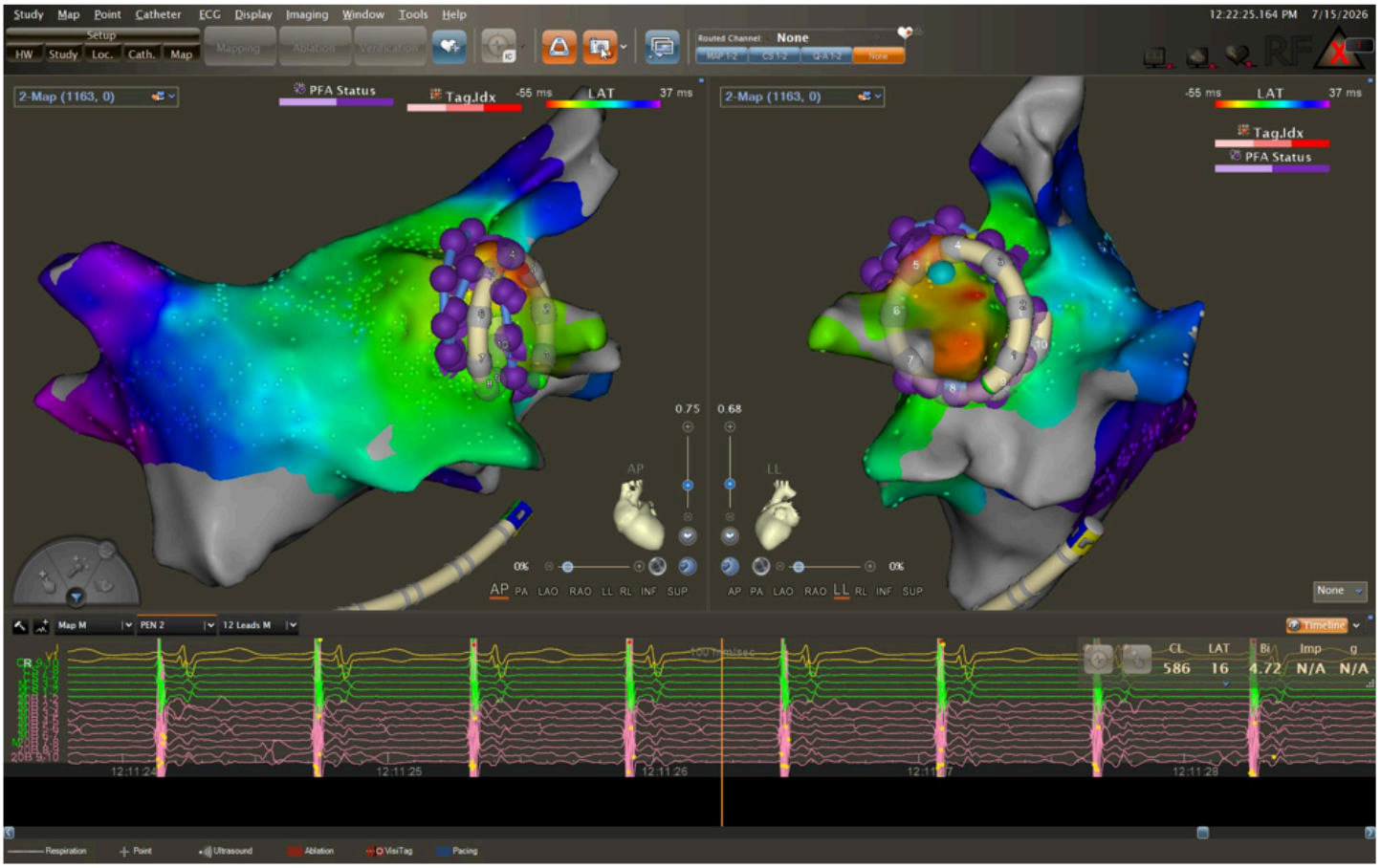


Figure 4

Regional pulsed field ablation guided by the stored activation map in Case 2. Two views of the reconstructed left atrial geometry demonstrate positioning of the VARIPULSE variable-loop circular catheter at the ostial ridge-side region and at selected more distal sites along the ridge-facing aspect of the LAA.