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Role of Epicardial Connections in persistent and Recurrent Left Atrial Tachyarrhythmias

Short Title: Role of Epicardial Connections in Left Atrial Tachyarrhythmias

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Abstract:

Background:

Catheter ablation is a primary treatment for atrial fibrillation (AF), yet 30% of patients experience recurrence due to epicardial connections. This study investigates the role of these connections in left atrial tachyarrhythmias.

Methods:

We retrospectively analyzed 204 patients undergoing radiofrequency ablation (RFA) for persistent or recurrent atrial tachyarrhythmias between January 2020 and December 2022. Epicardial connections were identified in 40 patients (19.6%) using high-density (HD) mapping, with missing isochrones and specific activation patterns. Patient demographics, echocardiographic parameters, and mapping results were analyzed. Epicardial connections were mapped to the Vein of Marshall (VOM), Bachman Bundle, Septoatrial Bundle, and Septopulmonary Bundle.

Results:

The cohort had a mean age of 74±6.4 years, predominantly male (95%). The most common epicardial connection was the VOM (52.5%), followed by the Bachman Bundle (22.5%), Septoatrial Bundle (15%), and Septopulmonary Bundle (10%). Recurrence of atrial fibrillation or atrial tachyarrhythmias occurred in 47.5% of patients' post-ablation. Hospitalization within three months occurred in 22.5% of patients, and 12.5% experienced mortality within the same period.

Conclusions:

Epicardial connections are an important substrate for persistent and recurrent left atrial tachyarrhythmias and should be considered when conventional endocardial mapping findings do not fully explain arrhythmia mechanisms. In this cohort, the Vein of Marshall and Bachmann

Bundle were the most frequently identified epicardial connections. Recognition and targeted ablation of these pathways may facilitate arrhythmia termination and improve procedural success in selected patients undergoing catheter ablation.

Abbreviation List

- AF – Atrial Fibrillation
- RFA – Radiofrequency Ablation
- VOM – Vein of Marshall
- LVEF – Left Ventricular Ejection Fraction
- HD Mapping – High-Density Mapping
- PVI – Pulmonary Vein Isolation
- ECG – Electrocardiogram
- CTI – Cavotricuspid Isthmus
- BMI – Body Mass Index
- CHADS2-VASc – Congestive Heart Failure, Hypertension, Age, Diabetes, Stroke Score
- LAVI – Left Atrial Volume Index

Introduction

Catheter ablation has become an established therapy for atrial fibrillation, earning a class I indication as the treatment of choice for a selected group of patients, according to the 2023 ACC/AHA/ACCP/HRS guidelines (1). Pulmonary vein isolation remains the primary target for catheter-guided intervention in most patients (2-4). However, despite advancements in ablation techniques, approximately 30% of patients experience a recurrence of atrial arrhythmias (1-2,5). Notably, even after successful pulmonary vein isolation and intervention on additional targets, recurrent atrial arrhythmias have been associated with concomitant epicardial connections (6-8). One of the most common epicardial connections linked to atrial arrythmias is the bundle of Marshall (9). The Vein of Marshall, a vestigial remnant of the left venous horn, extends between the left atrial appendage and left pulmonary veins, terminating in the coronary sinus (6-9). Within the Vein of Marshall lies a parallel-aligned muscular bundle composed of epicardial fibers, which act as a barrier to achieving bidirectional block during mitral isthmus line ablation (7). The anatomy and distribution of this bundle structure can serve as a conduit for recurrent atrial arrhythmias (6-8).

Additional epicardial connections, including the Bachman Bundle, the Septopulmonary Bundle and the Septoatrial Bundle, have also been implicated in atrial arrhythmias (10-13). Over the past two years, we have focused on mapping and ablating these pathways, resulting in a reduction in the reoccurrence of left atrial arrythmias in patients with concomitant epicardial connections. The purpose of our study is to examine the nature of these epicardial connections using high density (HD) mapping and activation patterns based on a single center experience. Additionally, we seek to explore the echocardiographic and anatomical characteristics associated with an epicardial connections.

Methods:

Patient Cohort

This study examined 204 patients with persistent or recurrent atrial tachyarrhythmias who underwent radiofrequency (RF) ablation between 2020 to 2022. Among these, 40 patients (19.6%) were identified as having epicardial connections, as determined by HD mapping, isochronal gap, and activation patterns.

Mapping and Ablation Technique

All patients provided written informed consent for ablation. The study was approved by the institutional review board. Procedures were typically performed under moderate conscious sedation or general anesthesia, with an anesthetist present in the procedure room during each case. Mapping was conducted using either the CARTO-3 (Biosense Webster, Diamond Bar, CA) or Ensite™ (Abbott Medical, Chicago, USA) systems. A coronary sinus catheter, intracardiac echocardiography, esophageal temperature monitor, and an Agilis steerable sheath (Abbott, Chicago, IL, USA) were used in all procedures.

RF ablation was performed with parameters set at a temperature of 43°C and a power of 30-35Watts 30 seconds. Pulmonary veins isolation was performed in all first-time ablation patients, with confirmation of intact isolation for those undergoing redo ablation procedure. Bidirectional antral-pulmonary vein block was achieved in all patients. Additional ablations, including mitral isthmus line, posterior wall isolation, roof line, complex fractionated potentials ablation, and cavotricuspid line ablation, were performed at the operator's discretion.

Establishing Epicardial Connections

In this study, epicardial connections were suspected during atrial fibrillation ablation when pulmonary vein conduction persisted despite circumferential pulmonary vein isolation and electrical isolation could only be achieved by delivering ablation lesions at a site located more than 5 mm from the intended pulmonary vein isolation line. In patients with atrial flutter or atrial tachycardia, epicardial connection participation was suspected when activation mapping demonstrated discontinuous propagation, characterized by an endocardial breakthrough site and a spatial mismatch between the earliest activation site and the location of arrhythmia termination. Additional evidence included the presence of an isochronal activation gap or activation patterns inconsistent with continuous endocardial conduction, suggesting conduction through an intervening epicardial pathway. These criteria were based on electrophysiologic observations including activation sequence discrepancies, spatial separation between earliest activation and successful ablation sites, and evidence of activation breakthrough patterns inconsistent with endocardial conduction alone as described in previously described reports (14,15). When CARTO-3 mapping system was used, local potential morphology, local activation timing, pacing based activation mapping and coherent map visualization were used to identify epicardial connections that are more than 5 mm from pulmonary vein isolation line or point of arrhythmia termination or pulmonary vein isolation. In cases where Ensite™ was used, omnipolar technology near field algorithm was used during high-density mapping to differentiate epicardial connections by analyzing peak frequency of local electrograms. Epicardial (far-field) signals typically exhibit dull, low-frequency components, whereas endocardial (near-field) signals display sharp, high-frequency components. Activation vectors and annotated electrograms are compared, and the emphasis map feature (which overlays peak frequency values onto voltage

maps) helps localize residual endocardial gaps by highlighting regions with elevated peak frequency signals. When RF ablation eliminates these sharp, high-peak frequency components while low-frequency epicardial signals persist, selective endocardial isolation is confirmed, enabling targeted ablation of endocardial conduction gaps that may otherwise be obscured by overlapping epicardial activity.

Epicardial connections were mapped to four specific sites: 1) bundle of Marshall, 2) Bachman Bundle, 3) Septoatrial Bundle, and 4) Septopulmonary Bundle. Figure 1 represents a structured stepwise flowchart algorithm in diagnosing and mapping epicardial connections. Supplement 1 includes comprehensive activation maps videos demonstrating the participation of epicardial connections in atrial arrhythmias.

Follow-Up

Patient were typically followed for up to two years post-ablation. Follow-up clinic visits occurred within three months of the initial ablation, with some patients undergoing Holter monitoring or device interrogation to assess for arrhythmia recurrence. Anti-arrhythmic medications were continued for three months post ablation and then stopped. Patients who maintained a quiescent rhythm without evidence of atrial tachyarrhythmias were often discharged from follow-up.

Outcomes:

Statistical Analysis

Statistical analysis was conducted using SPSS software (version XX.0, IBM Corp., Armonk, NY, USA). Continuous variables were presented as mean ± standard deviation (SD), while categorical variables were expressed as percentage (%).

Results

Baseline Characteristics

Out of 204 patients screened for atrial tachyarrhythmias undergoing RF ablation from 2020 to 2022, 40 (19.6%) had arrhythmias dependent on epicardial connections. The cohort was predominantly male (95%, n=38) with a mean age of 74±6.4 years (Table 1). The mean body mass index (BMI) was 33.5±5.8 kg/m². A significant portion of the cohort had comorbid conditions, including hypertension (87.5%, n=35), coronary artery disease (42.5%, n=17), and diabetes mellitus (32.5%, n=13). Paroxysmal atrial fibrillation was present in 57.5% (n=23) of patients, while 42.5% (n=17) had persistent atrial fibrillation. Systolic heart failure was observed in 22.5% (n=9) of the patients, and 17.5% (n=7) had valvular heart disease. The average CHADS2VA2SC score was 3.2±1.2. Regarding pharmacological treatment, 25% (n=10) of patients were on amiodarone, and 32.5% (n=13) were on beta blockers, with minimal usage of other antiarrhythmic agents such as dofetilide (2.5%, n=1) and flecainide (2.5%, n=1).

Echocardiographic Parameters

Echocardiographic evaluation revealed an average left ventricular ejection fraction (LVEF) of 44.7±10.5%. The left ventricular end-diastolic diameter (LVEDD) and left ventricular end-systolic diameter (LVESD) were 49.8±14.3 mm and 36.1±12.9 mm, respectively. The left atrial

volume index (LAVI) averaged 43.0±20.6 ml/m2. The E/A ratio was 2.1±1.1, with a septal E/e' of 12.9±6.5 and lateral E/e' of 10.1±4.9.

Procedural Characteristics

Most patients (87.5%, n=35) underwent pulmonary vein isolation, while cavotricuspid isthmus ablation was performed in 60% (n=24) of cases. Additionally, 47.5% (n=19) of patients had a mitral isthmus line, and 42.5% (n=17) had a roof line ablation.

Epicardial Connections in Atrial Tachycardia Circuits

The Vein of Marshall was the most prevalent epicardial connection, significantly contributing to atrial tachyarrhythmias and identified in 52.5% (n=21) of patients (Table 2). Other important epicardial connections included the Bachman Bundle (22.5%, n=9), the Septoatrial Bundle (15%, n=6), and the Septopulmonary Bundle (10%, n=4).

In some cases, patients presented with two concurrent epicardial connections (example in figure 2A and 2B), while in most cases patients had a single culprit epicardial connection (example in figure 2C). For the study, patients were categorized based on the epicardial connection most likely responsible for their atrial tachyarrhythmia.

Outcomes After Ablation

Within three months post-ablation, 22.5% (n=9) of patients were hospitalized, and 12.5% (n=5) died. The reason of death was not investigated in this study. Sinus rhythm was maintained in 52.2% (n=21) of the cohort over two years of follow up (Table 3 and Figure 3).

Discussion:

Our study exploring the role of epicardial connections in atrial tachyarrhythmias demonstrated that the Vein of Marshall Bundle was the most common epicardial connection, identified in 52.5% of our patients. Other notable epicardial connections included the Bachman Bundle,

Septoatrial Bundle, and Septopulmonary Bundle. Almost half of patients with epicardial connections had recurrence of atrial tachyarrhythmia during follow-up period, signaling that these connections may play a crucial role in the persistence and recurrence of arrhythmias. Epicardial connections play an important role in atrial arrhythmia recurrence, with Pathick et al. linking epicardial-endocardial breakthroughs to right atrial tachyarrhythmias (16). In their study of 26 patients, 14 (53.8%) showed evidence of endocardial-epicardial breakthrough conduction, defined by presence of focal endocardial activation with radial spread despite cavotriscuspid isthmus ablation. Focal breakthrough occurring within 5 milliseconds of the earliest activation on bipolar electrograms, along with the presence of an rS pattern on bipolar electrograms, further confirmed this breakthrough (16). Additionally, Groot et al. reported that in patients with longstanding atrial fibrillation, the frequency of epicardial breakthroughs was four times higher than during acute atrial fibrillation (17). Schuessler et al. demonstrated discordance between the endocardial and epicardial activation using isolated canine right atria. This discordance correlated with the atrial architecture and was largest in areas with pectinate muscles ran below the epicardial surface (18).

Over time, the role of epicardial connection has been increasingly recognized with the advent of high-resolution mapping (19). Neyak et al. identified evidence of endo-epicardial breakthrough by noting discontinuous endocardial activation, with a gap in activation corresponding to a missing amount of cycle length greater than 5% of the total cycle length resulting in focal endocardial breakout distally and activation back toward the gap (19). These activation gaps occurred in 37% of left atrial flutters and were linked to epicardial bridges found in the Bachman Bundle, Coronary Sinus, Bundle of Marshall, and Septopulmonary Bundles (19). A study by

Takigawa et al. further highlighted the significant contribution of epicardial connections in patients with atrial fibrillation ablation-related atrial tachycardias, accounting for 75% of peri-mitral flutters, 28.6% of roof-dependent macroreentrant atrial tachycardias, and 28.6% of non-anatomic macroreentrant atrial tachycardias (20). Furthermore, Barrio-Lopez et al. demonstrated a higher risk of atrial tachyarrhythmia recurrence post-atrial fibrillation ablation and lower rate of acute pulmonary vein isolation during ablation (21).

Marshall Bundle

The Marshall bundle is a myocardial sleeve within the bundle of Marshall (22). Encircling the Vein of Marshall, the Marshall bundle inserts into the coronary sinus or the posterior wall of the left atrium. The Marshall bundle then transitions into multiple muscle fibers, which insert into the left inferior pulmonary vein. The Marshall Bundle is an embryological remnant of the obliterated left anterior cardinal vein. (23). The vein of Marshall is present in up to 95% of individuals (23). In our patient cohort, the Marshall Bundle was the most common epicardial bridge, accounting for 53% of cases. The Marshall bundle accounts for approximately half of the mapped epicardial connections in patients undergoing atrial fibrillation ablation and is associated with a higher risk of atrial tachycardia recurrence post-ablation (21).

Targeting the vein of Marshall with retrograde ethanol injection was first described in humans when five patients undergoing pulmonary vein antral isolation had successful vein of Marshall cannulation and ethanol infusion (24). Voltage mapping in these patients demonstrated infero-posterior left atrial wall extension toward the left pulmonary vein (24).

In a randomized clinical trial (the VENUS trial), ethanol injection into the vein of Marshall in conjunction with catheter ablation was associated with higher freedom from atrial arrhythmia recurrence as compared with catheter ablation alone (49% vs. 38% at both 6 and 12 months) (8).

Derval et al. found that ethanol injection into the Vein of Marshall, combined with ablation in the coronary sinus, Vein of Marshall musculature, pulmonary vein isolation, and anatomical isthmuses, resulted in 72% freedom from atrial tachycardia/atrial fibrillation over 12 months (7).

Bachmann Bundle

The Bachman Bundle is a muscular bundle composed of parallel-aligned fibers connecting the right and left atrial walls (25). It serves as the primary pathway for interatrial conduction (25). It is observed as a thickening of the superior part of the left atrial anterior wall and is confluent with the precaval bundle of the crista terminalis. The Bachman Bundle stretches subepicardially across the interatrial groove and continues to the fold between the left atrial appendage and left pulmonary veins. Unlike other conduction tissues, it is not surrounded by a fibrous sheath (26). The bundle's body has median measurements of 4mm thickness and 9mm height, with a trapezoidal shape (27). The Bachmann Bundle is invariably supplied by the sinoatrial node artery, originating from the right coronary artery 55% of the time, from the circumflex in 40% of the time, and 5% from both (28). Electrophysiologically, Bachmann Bundle exhibits specialized properties resembling Purkinje fibers, including significantly faster conduction velocities (1.7 m/s) and distinct action potential morphology compared to surrounding atrial myocardium (29-31). Damage to the Bachman Bundle structure can sequentially lead to the development of atrial tachyarrhythmias (32). Mechanisms linking Bachmann Bundle dysfunction to atrial fibrillation include longitudinal dissociation facilitating re-entry circuits, while therapeutic Bachmann Bundle pacing has been shown to reduce atrial fibrillation incidence by shortening atrial activation time (33-35). Conduction blocks across the Bachman bundle have been associated

with a high risk of post-operative atrial fibrillation, as assessed by high-resolution epicardial mapping during coronary artery bypass (36). Consequently, while Bachman bundle abnormalities may reflect broader atrial electropathology, the bundle remains a critical anatomical substrate in the initiation and perpetuation of atrial tachyarrhythmias (37). Although Bachmann bundle-mediated conduction and roof-dependent atrial flutter may involve similar anatomical regions, Bachmann bundle participation is suggested by activation discontinuities and epicardial breakthrough patterns, whereas roof-dependent flutter is characterized by a continuous macro-reentrant circuit traversing the left atrial roof.

Septoatrial and Septopulmonary Bundle

The Septoatrial bundle arises from fibers running sub-endocardially from the interatrial raphe over the anterior wall to the lateral and superior dome of the left atrium and into the posterior wall (38). The Septopulmonary bundle emerges from the interatrial groove beneath the Bachmann bundle and runs anterior to the right superior pulmonary vein. Both bundles are separated by interposed adipose tissue, which may ‘protect’ the Septopulmonary bundle from the thermal ablation energy (39). The atrial Septopulmonary bundle constitutes a well-defined muscular structure within the posterior left atrium, characterized by parallel-aligned myocardial fibers that traverse superiorly and branch around the pulmonary vein ostia, with abrupt transitions in fiber orientation and myocardial thickness at its boundaries (40-41). It fans out over the dome of the left atrium before descending through the posterior wall and branching over the right and left pulmonary veins (38). The Septopulmonary bundle is confluent with the subepicardial circumferential band surrounding the inferior part of the left atrial posterior wall.

Electrophysiologically, while sinus impulses propagate uniformly through the Septopulmonary, high-frequency pulmonary vein-originating impulses encounter conduction delay and wave-break at specific Septopulmonary bundle boundaries - particularly the posterior left atrial septum transition and the left Septopulmonary bundle border (42-43). Experimental evidence demonstrates that these structural discontinuities facilitate reentry formation, with 42% of first atrial fibrillation wave-breaks localizing to the posterior left atrial septum boundary following pulmonary vein pacing, and subsequent atrial fibrillation waves consistently emerging along Septopulmonary bundle edges regardless of initiation site (44-45). Pambrum et al. investigated the frequency of Septopulmonary bundle bypass in roof line ablation, where epicardial connections were mapped in all cases with a residual gap during roof line ablation (39). The Septopulmonary bundle represents a critical anatomic substrate where pulmonary vein triggered impulses undergo wave-break and reentry, providing a mechanistic link between focal pulmonary vein activity and the initiation of vagally mediated atrial fibrillation in the structurally normal heart (40, 44, 46). Given the close anatomical relationship between the septoatrial and septopulmonary bundles, definitive differentiation between these structures may not always be possible with endocardial mapping alone. Therefore, classification was based on activation patterns and anatomical location, and some degree of overlap may exist.

Cardiac Anatomy and Relation to Epicardial Connections

Barrior Lopez et al. established an association between certain anatomical factors and epicardial connections (21). The appearance of a Patent Foramen Oval, increased left atrial size, and appearance of left common trunk were frequently associated with epicardial connections (21).

Structural heart disease has also been linked to be associated with epicardial connections (47). Previous cardiac surgeries, such as coronary artery bypass grafting, mitral valve surgery, aortic valve replacement, or tricuspid valve interventions has also been associated with an increased risk of endocardial-epicardial dissociation (48-49).

In our study we found reduced left ventricular ejection fractions was associated with an increased risk of atrial tachyarrhythmia recurrence in patients with epicardial connections. Diastolic function was not found to have significant clinical impact on patients with atrial tachyarrhythmias, likely due to the difficulty of assessing diastolic function in patients with atrial tachyarrhythmias.

Limitations

Our study has several limitations that should be considered when interpreting the findings. First, this study was had a predominantly male study population. Consequently, the findings may be subject to gender-related selection bias and may not be fully generalizable to female patients or non-VA populations. Another important limitation is the lack of a control group for patients without an identified epicardial connection. With such limitation, this study remains descriptive in nature. It is also important to acknowledge that there are no universal criteria in identifying the presence of epicardial connections. Furthermore, the study did not account for potential confounding factors such as medication changes, comorbid conditions, or variations in post-

ablation care, which could influence recurrence rates. Additionally, detailed cause-of-death information was not consistently available for all deceased patients, limiting our ability to determine whether mortality was related to arrhythmia recurrence, underlying cardiovascular disease, procedural factors, or unrelated causes. We also acknowledge that follow-up was not protocolized and rhythm surveillance varied among patients, including clinic ECGs, ambulatory monitoring, and device interrogation. Consequently, asymptomatic recurrences may have been under-detected. An additional limitation is that detailed procedural data, including lesion number, lesion set characteristics, intracardiac electrograms and case-specific ablation strategies, were not available at the time of manuscript revision. Consequently, we were unable to perform a more granular analysis of ablation techniques or provide detailed procedural comparisons among the various epicardial connection subtypes. Future studies should consider using high-resolution mapping or imaging modalities to validate these findings and explore the mechanisms of epicardial connections in more detail.

Conclusions:

Epicardial connections play an important role in the maintenance of left atrial tachyarrhythmias and should be considered when conventional endocardial mapping findings are insufficient to explain arrhythmia mechanisms. Targeted ablation of these connections frequently resulted in acute arrhythmia termination; however, recurrence remained common during follow-up, suggesting that these pathways represent one component of a complex arrhythmogenic substrate

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Tables and figures:
Table 1. Baseline characteristics (continuous variables mean ±SD; categorical n (%)

Variable	All Patients (n=40)
Age, years	74±-6.4
Male	95% (38)
Body Mass Index, kg/m^2	33.5 ±5.8
Hypertension	87.5% (35)
Paroxysmal Atrial fibrillation	57.5% (23)
Persistent Atrial Fibrillation	42.5% (17)
Coronary Artery Disease	42.5% (17)
Diabetes Mellitus	32.5% (13)
Sick Sinus Syndrome	5% (2)
Valvular Heart Disease	17.5% (7)
Systolic Heart Failure	22.5% (9)
Stroke	7.5% (3)
CHADSVASC	3.2 ±1.2
Amiodarone	25% (10)
Beta Blocker	32.5% (13)
Calcium Channel Blocker	0% (0)
Dofetilide	2.5% (1)
Sotalol	0% (0)
Flecanide	2.5% (1)
Pulmonary Vein Isolation	87.5% (35)
Cavotriscuspid Isthmus ablation	60% (24)
Mitral Isthmus Line	47.5% (19)
Roof Line	42.5% (17)
Left Ventricular Ejection Fraction	44.7±10.5
Left Ventricular End Diastolic Diameter(mm)	49.8±14.3
Left Ventricular End Systolic Diameter(mm)	36.1±12.9
Left Atrial Volume Index(ml/m2)	43.0±20.6
E/A	2.1±1.1
Septal E/e’	12.9±6.5
Lateral E/e’	10.1±4.9

Table 2. Epicardial Connection Participating in Atrial Tachycardia Circuits

Epicardial Connection	All Patients (n=40)
Vein of Marshall Bundle	52.5% (21)
Septopulmonary Bundle	10% (4)
Septoatrial Bundle	15% (6)
Bachman Bundle	22.5% (9)

Table 3. Outcomes After Ablation

Outcome	All Patients (n=40)
Hospitalization within 3 months	22.5% (9)
Death within 3 months	12.5% (5)
Atrial Fibrillation or Atrial Tachyarrhythmia Recurrence	47.5% (19)

Figure 1: Stepwise flowchart to diagnose and map epicardial connections during atrial arrhythmia ablation procedure

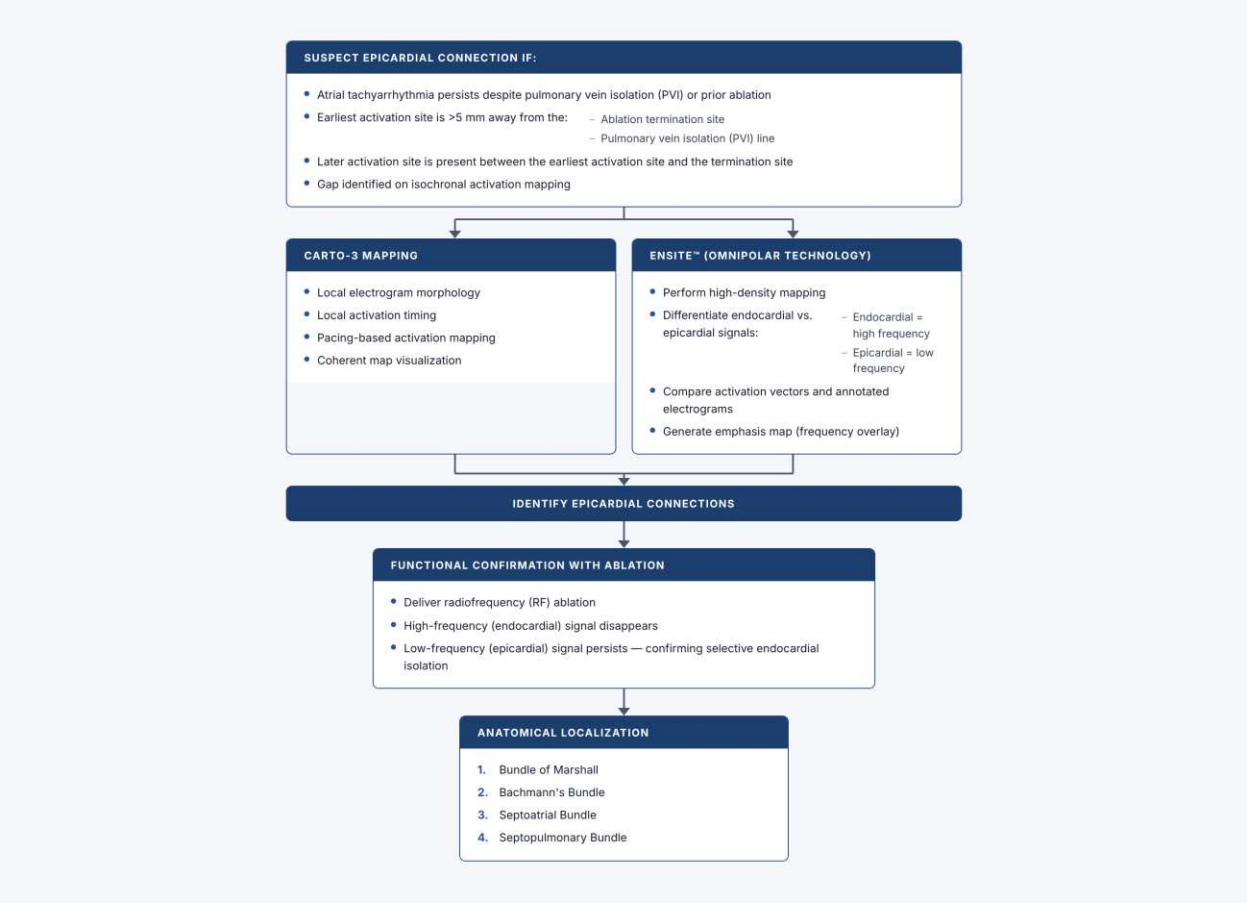


Figure 2: Activation Mapping of various Epicardial connections.

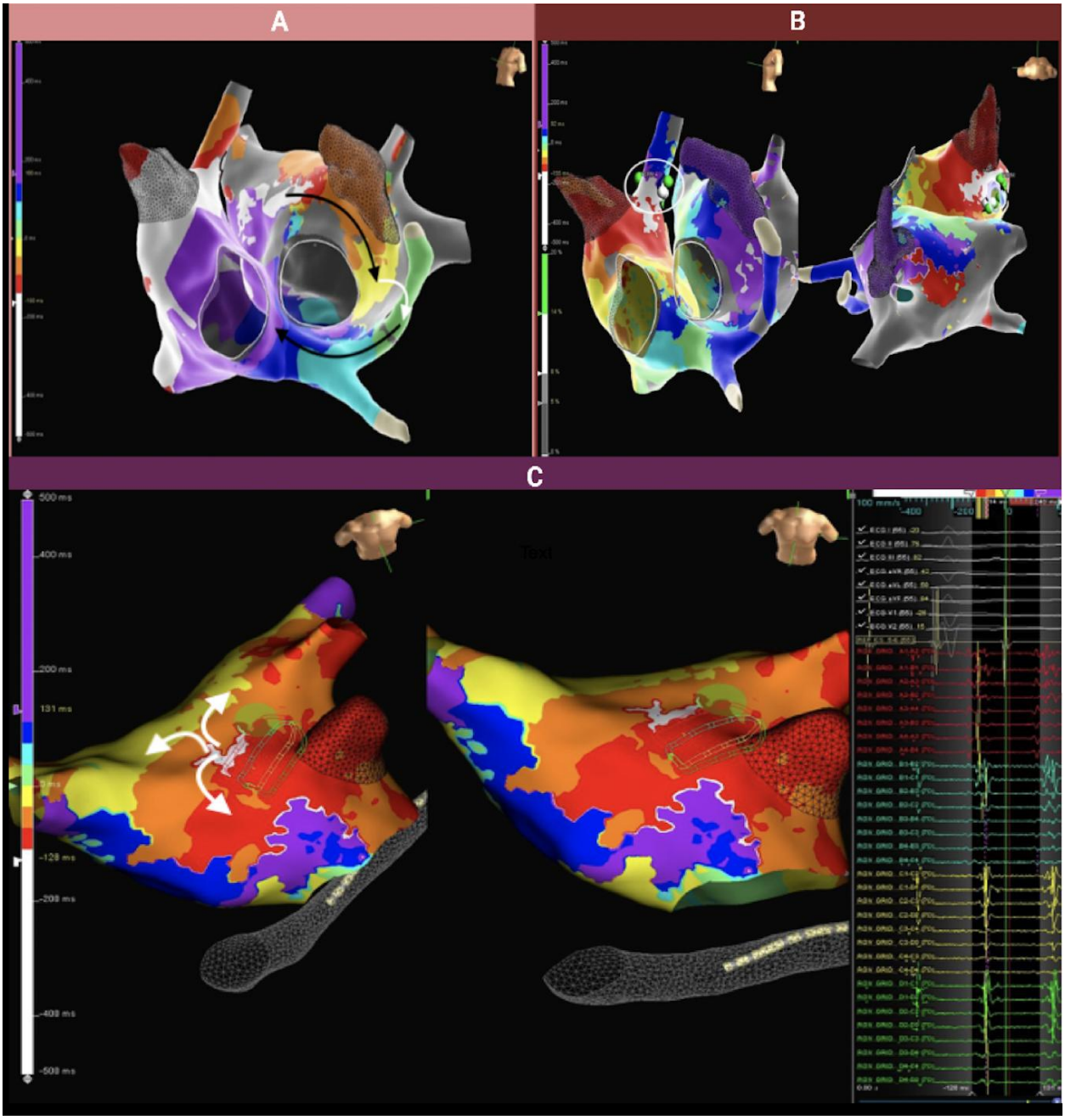


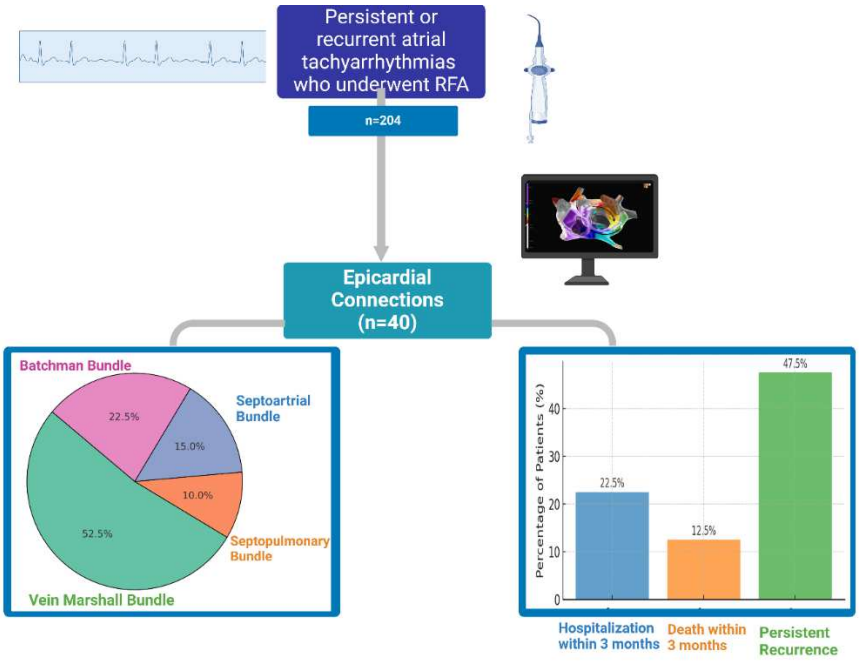
Figure 2A demonstrates activation mapping of a 73-year-old patient who underwent three prior radiofrequency ablations and returned with an episode of atypical bi-atrial flutter. Prior atrial flutter ablation necessitated ethanol injection into the Vein of Marshall and ablation of a focal atrial tachycardia in the superior portion of the ridge between the left atrial appendage and left

superior pulmonary vein. An epicardial connection between both atria was identified at the Marshall Bundle location, as suggested by an epicardial jump in the area inferior to the left inferior pulmonary vein and the left atrium (white arrow). Successful ablation led to the cessation of the rhythm.

Figure 2B shows activation mapping of the same patient as in Figure 2A. In addition to the epicardial connection in the Marshall Bundle, an additional atrial flutter that was mapped. A macroreentrant arrhythmia was found to loop at the junction of the right atrium and the Superior Vena Cava, with an epicardial jump through the Bachman Bundle into the left atrium. Ablation of the SVC and RA junction successfully terminated the atrial flutter.

Figure 2C depicts the activation map of a 70-year-old male with a history of atrial fibrillation with two prior pulmonary vein isolation procedures. The patient returned with an atrial flutter. Activation mapping revealed an atrial flutter propagating between the left superior pulmonary vein and left atrial appendage, with an anterior epicardial jump through the roof of the left atrium (white arrows). Ablation of the Septoatrial bundle terminated the atrial flutter.

Figure 3: Role of Epicardial Connections in persistent and Recurrent Left Atrial Tachyarrhythmias



Supplementary Files

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