Correlation of UniPolar Electrogram modification with Ablation Index during Atrial Fibrillation ablation: a pilot study (COUPE–AF)

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Abstract

Introduction Pulmonary vein isolation using radiofrequency catheter ablation is the standard of care for patients with drug-refractory atrial fibrillation. The purpose of this pilot study was to examine the local unipolar electrogram (UEGM) modification characteristics of the different target areas of left atrium and the associated ablation index parameters during pulmonary vein isolation procedure. Methods The study analyzed ten patients who underwent pulmonary vein isolation using radiofrequency energy at our Centre in 2021. The local electrophysiological properties and ablation parameters of 15 designated areas of interest in the left atria targeted by radiofrequency catheter ablation were collected. Results Out of the ten patients, six were men (mean age 66 years) and the majority (n=8) had paroxysmal atrial fibrillation. UEGM modification was observed in every studied RF ablation lesion. The mean time to achieve the UEGM modification in the posterior wall was shorter than that of the anterior wall(8.9 seconds vs 11.1 seconds, respectively). The time to achieve the UEGM modification for every target was significantly shorter than delivered ($p<.001$). Conclusion This study demonstrated that during pulmonary vein isolation using radiofrequency energy, local UEGM modification, representing a real-time surrogate of transmural lesion creation, is achieved in significantly shorter time reaching the conventional Ablation Index-guided approach in current practice.

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Abstract

Introduction

Pulmonary vein isolation using radiofrequency catheter ablation is the standard of care for patients with drug-refractory atrial fibrillation. The purpose of this pilot study was to examine the local unipolar electrogram (UEGM) modification characteristics of the different target areas of left atrium and the associated ablation index parameters during pulmonary vein isolation procedure.

Methods

The study analyzed ten patients who underwent pulmonary vein isolation using radiofrequency energy at our Centre in 2021. The local electrophysiological properties and ablation parameters of 15 designated areas of interest in the left atria targeted by radiofrequency catheter ablation were collected.

Results

Out of the ten patients, six were men (mean age 66 years) and the majority (n=8) had paroxysmal atrial fibrillation. UEGM modification was observed in every studied RF ablation lesion. The mean time to achieve the UEGM modification in the posterior wall was shorter than that of the anterior wall(8.9

seconds vs 11.1 seconds, respectively). The time to achieve the UEGM modification for every target was significantly shorter than delivered (p<.001).

Conclusion

This study demonstrated that during pulmonary vein isolation using radiofrequency energy, local UEGM modification, representing a real-time surrogate of transmural lesion creation, is achieved in significantly shorter time reaching the conventional Ablation Index-guided approach in current practice.

Keywords:

Radiofrequency ablation, Atrial fibrillation ablation, unipolar electrogram modification, ablation index

1 Introduction:

Pulmonary vein isolation (PVI) using radiofrequency catheter ablation (RFCA) is the standard of care for selected patients with drug-refractory, symptomatic

Atrial Fibrillation (AF)(1). RFCA strategies have evolved to obtain transmural atrial lesions safely. Ablation index (AI) used in the CARTO platform (CARTO® Biosense Webster. Inc) is a widely adopted RFCA guidance tool that incorporates contact force (CF), ablation time, and power, which helps to estimate transmurality of RFCA lesions and predict PVI- RFCA success (2).

Unipolar electrogram (U-EGM) signal modification correlates with the achievement of transmural RFCA lesions in the canine and porcine models. (3, 4). Elimination of the negative component of the local electrogram in the distal electrode of the ablation catheter is associated with transmural lesions on histology. Bortone et al., in a human study, compared using UEGM modification as the endpoint during PVI-RFCA with standard PVI-RFCA approach and noticed that the UEGM group had significantly lower procedural and ablation times and better long-term clinical outcomes compared to conventional strategy (5).

Excessive RF application may result in potentially severe complications like perforation and atrio-esophageal fistula. In addition, an extension of ablation beyond ten seconds after successful UEGM modification is associated with atrial wall necrosis and perforation (3). As LA target substrate is unique (muscle thickness and scar), customization of RF delivery guided by real-time physiological parameters, is desirable for every lesion.

Although currently recommended AI targets are functionally proven, they do not address inter-patient or substrate variability. Therefore, combined AI and

UEGM signal modification, providing real-time physiological data during PVI RFCA, will be potentially safer, but it has not been studied.

The purpose of this pilot study was to examine the local UEGM characteristics of the different target areas of LA during PVI-RFCA. In addition, we also studied the AI parameters achieved and required for UEGM modification during PVI-RFCA.

2 Methods:

This retrospective study analyzed ten patients who underwent PVI- RFCA at our Centre in 2021. The demographic data are shown in Table 1. We studied the local electrophysiological properties and ablation parameters of 15 designated areas of interest in the target areas of PVI-RFCA substrate (**Figure-1**).

2.1 Patient groups

Ten adult patients with documented paroxysmal or persistent AF refractory/intolerant to at least one Class I–IV anti-arrhythmic drug were included.

2.2 Exclusion criteria

The patients were excluded from the study if there was a history of previous surgical or cryoablation in the LA, valvular AF, hypertrophic cardiomyopathy, congenital heart disease or cardiac amyloidosis.

2.3 RF ablation procedural details

PVI-RFCA procedures were performed using standard- technique guided by CARTO 3® (Biosense Webster, CA, USA). A multipolar catheter was used to create initial LA geometry. An open-irrigated 3.5-mm tip ablation catheter (*THERMOCOOL SMARTTOUCH*® SF) was used with a steerable sheath. RFCA lesions were delivered in a contiguous point-by-point manner, with a in power-controlled mode. In the LA, RF duration was 30 seconds per lesion for the posterior wall at 20 Watts and 40 seconds per lesion for the anterior wall and ridge area at 35 Watts. 10-20 grams of contact force were used for each lesion. The targeted AI for the LA posterior wall was 350-400 and was 450-500 for the anterior wall.

2.4 Electrogram set up and analysis.

Standard surface ECGs and intracardiac electrograms were displayed on a real-time monitor during the procedure.

Bipolar electrograms were recorded from the distal bipole of the RF ablation catheter and bandpass filtered between 30 and 500 Hz. UEGMs were recorded from the distal electrode as cathode and the Wilson Central Terminal as the anode with bandpass filtered between 0.5 and 100 Hz .

UEGMs, AI, contact force and impedance data from each designated ablation site (**Figure-2**) before, during and after RF ablation were analyzed offline after the procedure was performed.

During the analysis of UEGM morphology, the first and second positive deflections were defined as R and R', respectively, and the first and second major negative deflections were defined as Q and S, respectively. The morphology of each local UEGM before and after ablation were classified into

one of the following patterns: QS, QR, QRS, R, RS, or RSR'. Each parameter and electrogram morphology before, during and after ablation were compared.

2.5 Statistical analysis

All continuous variables are expressed as mean (SD). T-test and Wilcoxon signed-rank test have been used to compare paired and unpaired variables. P <.05 was considered statistically significant.

3 Results

Out of the ten patients, six were men (mean age 66 years). The majority (n=8) had paroxysmal AF (**Table-1**). One hundred and fifty lesion points were analyzed (15 per patient). UEGM modification-elimination of the negative component of UEGM- was observed in every studied RF ablation lesion. The mean time to achieve the UEGM modification in the posterior wall and the anterior wall was 8.9 seconds and 11.1 seconds, respectively.

The time to achieve the UEGM modification for every target was significantly shorter than delivered (p<.001).

4 Discussion

We studied the RF delivery time to achieve target UEGM modification (surrogate of the transmural lesion) to achieve targeted AI-guided RFCA in contemporary practice with a contact force and steerable sheath-guided PVI-

RFCA. To the best of our knowledge, this correlation has never been reported previously.

The main findings are:

1. The time to achieve transmural lesions guided by UEGM modification was achieved in significantly less than the time delivered by the conventional AI-guided approach.
2. The mean times to achieve UEGM adjudicated LA posterior wall transmural RF lesion was significantly shorter than the LA anterior wall.
3. Current AI-guided PVI RFCA lesions successfully achieve transmural lesions but result in consistent excess energy delivery than what is optimally required.

4.2 UEGM modification during PVI-RFCA

Otomo et al. demonstrated that UEGM modification during PVI-RFCA defined by eliminating the negative deflection of UEGM was associated with the creation of transmural lesions in a porcine model(4). Subsequently, Bortone et al. found that UEGM modification guided human AF-RFCA procedures had significantly shorter ablation time and better long-term outcome of maintaining sinus rhythm (88% versus 70%)(5).

4.3 Clinical implication

UEGM provides opportunity to access real-time local electrophysiological information to optimize lesion delivery to ensure transmurality of the RF

lesions. Our observations have the potential impact on the contemporary practice of PVI- RFCA, which include:

1. Reduction of total RF delivery time and procedure duration of PVI-RFCA while confirming transmurality of delivered RF lesions.
2. Reduction of collateral thermal injury to adjacent structures like the esophagus and phrenic nerve.
3. Develop new real-time local UEGM based algorithms to inform PVI-RFCA operators or automize termination of RF delivery when the local transmural ablation lesion is created.

5 Limitations

Our small observational pilot study has several inherent limitations. However, the observations are overwhelmingly positive. We did not include any overt abnormal substrate, and abnormal atrial tissue (e.g. scar or atrial myopathy) may likely have different UEGM characteristics, which needs examination in a more extensive study.

6 Conclusion

This pilot study demonstrated that during PVI-RFCA, local UEGM modification, representing a real-time surrogate of transmural lesion creation, is achieved in significantly shorter time reaching the conventional AI-guided approach in current practice. Incorporating real-time UEGM data has excellent

potential to make future PVI-RFCA procedures shorter and safer, with fewer risk complications due to direct and collateral thermal injury.

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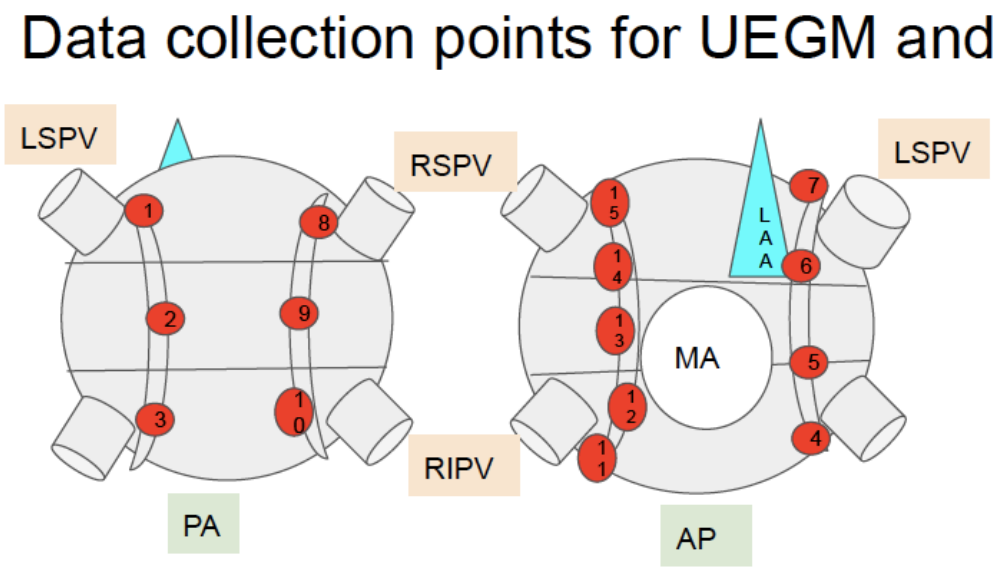

Figure-1 :The diagram shows 15 areas of interest in the left atrium where RF energy was applied during PVI.

1: LSPV antrum high posterior 2: LPV carina antrum mid posterior 3:LIPV antrum posterior 4: LIPV antrum floor 5: LPV antrum lower ridge 6: LPV antrum high ridge 7: LSPV antrum roof 8: RSPV antrum posterior 9: RPV antrum posterior 10: RIPV antrum posterior 11:RIPV antrum floor 12: RIPV antrum anterior 13:RPV carina antrum anterior 14: RSPV antrum anterior 15: RSPV antrum roof

AP : Anteroposterior view, LAA: LA appendage , LSPV: Left Superior Pulmonary Vein, MA: Mitral Annulus, RIPV: Right Inferior Pulmonary Vein, RSPV: Right Superior Pulmonary vein

Figure-2 UEGM (MAP-1 Channel) at baseline (left image) shows an rS pattern but 6 seconds after ablation (right image) the negative deflection is eliminated representing formation of a transmural lesion.

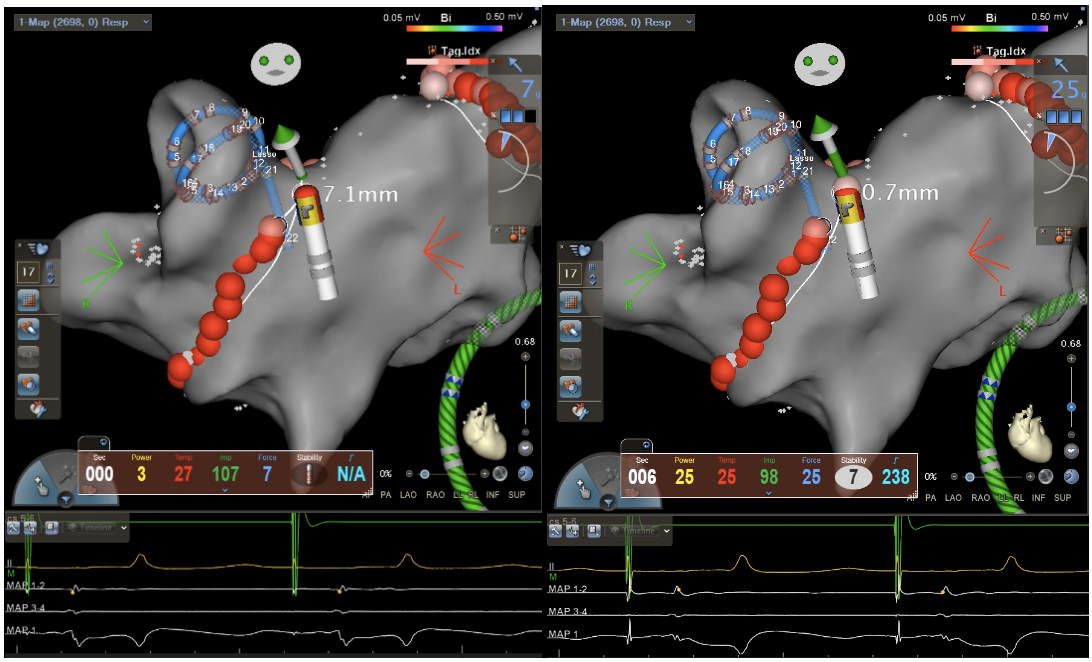

Table-1A clinical Characteristics

Patient #	age	gender	Type of AF	LVEF (%)	LA volume Index(ml/m^2)	Antiarrhythmic drugs
1	54	M	Persistent	60	28	HTN, DM, OSA
2	56	M	Paroxysmal	60	58	HTN
3	52	M	Paroxysmal	57	48	HTN, OSA
4	72	F	Persistent	30	19	HF, Age
5	75	F	Paroxysmal	68	29	HTN, Age
6	61	M	Paroxysmal	56	19	-
7	77	M	Paroxysmal	55	48	Age
8	71	F	Paroxysmal	45	60	HTN,HF,OSA,Age
9	70	F	Paroxysmal	60	50	HTN, Age
10	72	M	Paroxysmal	58	47	Age

HTN: Hypertension, HF: Heart failure, OSA: Obstructive sleep apnea, LVEF: left ventricular ejection fraction, LA: left atrium

Table-1B Electrophysiological characteristics

Lesion #	RF power (W)	Mean time to UEGM modification (sec)	Mean total ablation duration (sec)	Mean AI at UEGM Modification	Mean AI at end of ablation
1	20	8.7	24.5	270.2	388.9
2	20	9.3	26.4	272.4	383
3	20	9.4	28.4	252.9	377.4
4	30	10.8	29.7	314.3	454.7
5	30	13.6	28.8	360.3	486.9
6	30	12	29.5	337.2	469.9
7	30	10.8	28.8	302.2	421.3
8	20	8.6	28.2	248.5	390.2
9	20	8.3	25.6	269.9	411.8
10	20	8.9	26	278.8	396.1
11	25	10	28.6	294.6	434.4
12	30	10.9	26.9	333.7	465.5
13	30	9.8	28.1	322	468.5
14	30	11.8	27.1	347.5	465.6
15	30	10.2	29.8	298.8	435.1

Table-1C Electrophysiological characteristics

Lesion #	Mean impedance at start of ablation(ohm)	Mean impedance at UEGM modification point(ohm)	Mean impedance at end of ablation (ohm)
1	135.3	127.8	126.2
2	137.4	130	126.7
3	130.8	125.9	122.5
4	128.9	120.9	118.4
5	134.4	121.3	117.3
6	130.6	123.2	120.7
7	136.6	127.3	124.5
8	136.3	130.8	128.6
9	129.8	125.5	123.7
10	131.1	126.1	122.6
11	131.1	125.2	122.3
12	131.5	124.1	121.4
13	131.4	123.5	120.4
14	127.6	120.5	117.6
15	130.4	124.9	122.1