

BRIEF REPORT

Utility of a cloud-based lesion data collection software to record, monitor, and analyze an ablation strategy



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Background

Catheter radiofrequency (RF) ablation-based pulmonary vein isolation is the predominant approach to ablation of atrial fibrillation (AF). Attempts to improve success rates have included real-time monitoring of factors related to lesion formation, such as contact force (CF), power, impedance changes, lesion duration, and calculated indices such as ablation index (AI) (SURPOINT, Biosense Webster, Diamond Bar, CA). Data created from each lesion typically are lost because of logistical challenges related to storage, retrieval, and analysis. Cloud storage and analysis may alleviate some of these difficulties and enhance the use of these data for research, clinical quality improvement, and clinical reporting. We sought to describe our experience with this technology. We used CARTONET, a new cloud storage and analysis software (Biosense Webster), to evaluate our adherence to an ablation protocol (demonstrating clinical use) and to examine the predictors of additional ablation in a segment (research potential) (Figure 1).

Methods

This study was approved by the institutional review board (IRB) of Brigham and Women's Hospital.

Single-operator first-time AF RF ablations performed between June 3, 2018, and December 9, 2020, were included. Procedural data were uploaded to the CARTONET cloud analysis software. AF ablation was performed with trainee participation using a standardized zero fluoroscopy workflow.¹ CF between 5 and 40 g was targeted. Anteriorly, power of 40–50 W and AI between 450 and 500 were

targeted. Posteriorly, power of 40–50 W and AI of 350–400 were targeted.

Cartonet

During ablation, VISITAGs were generated when RF applications exhibited stability for up to 3 mm for at least 3 seconds with respiratory phase adjustment (Figure 1). Location at end of expiration was used for anatomic coordinates. Information from generated VISITAGs for all cases was uploaded to CARTONET for automated analysis. Procedural data were securely transferred from CARTO 3 workstations (Biosense Webster) to the Siemens teamplay gateway (Siemens, Malvern, PA). Files were scrubbed of patient identifiers, and the anonymized data were transmitted to the Microsoft Azure cloud (Microsoft Corp., Redmond, WA), where storage and machine learning-based lesion location assignment is performed. Lesion parameters included maximum power, average CF, stability, RF duration, force-time integral, AI, baseline impedance, and impedance drop. Stability was defined as the 90th percentile of catheter deviation from a mean position during RF delivery.

A Web site was used to review a timeline of ablation lesions. The machine learning-based lesion locations were adjusted as needed. Ablations performed after an initial full encirclement of the veins were deemed additional ablation sites labeled as touchup lesions retrospectively (Figure 2). Data were downloaded in bulk for review.

Statistical analysis

Statistical analysis was performed using Python and SPSS Version 21 (IBM Corp., Armonk, NY). Proportions across groups were compared using χ^2 analysis.

We classified lesions by adherence to the ablation strategy targets outlined earlier. For AI, we allowed for a 25-unit flexibility so that anteriorly lesions were within target between 425–525 of AI and posteriorly the values were 325–425. Intermediate locations were allowed to fall within the anterior and posterior defined ranges.

KEYWORDS Atrial fibrillation; Atrial fibrillation ablation; Big data; CARTONET; Cloud storage; Quality improvement (Heart Rhythm 0² 2022;3:319–322)

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KEY FINDINGS

- A cloud-based AI/machine learning system can be used to analyze detailed ablation data obtained during catheter ablation.
- This strategy allowed demonstration of predictors of need for "touch up" ablation during pulmonary vein isolation.
- This approach may be applied to a broad range of ablation procedures and parameter analysis in the future.

Results

A total of 62 patients and 6391 pulmonary vein isolation lesions were analyzed.

Adherence to ablation strategy targets

CF targets were met by 97.7% of ablation lesions, AI targets by 78.3%, power targets in 87.7%, impedance drop $\geq 10 \Omega$ in 26.4%, and impedance drop $\geq 7 \Omega$ in 52.0%. Regional differences were common (Table 1).

Relation between lesion parameters and additional ablation

Parameters related to the need for additional ablation included segment length, *minimum* CF, *minimum* duration, *minimum* force–time integral, *minimum* AI, *minimum* power,

and worse stability. Conversely, *mean* values were similar between segments that required additional ablation and those that did not (Table 2).

Discussion

We present the first description of using a cloud-based storage and analysis system in cardiac electrophysiology with the following key findings: (1) Lesion-specific data can be stored and downloaded in bulk for facile clinical and research assessments. (2) Stored data are clinically relevant and were related to the need for additional ablation.

The adoption of cloud storage and computing in medicine has been concentrated in the genomic and metabolomic fields, whereas applications related to health information exchange have lagged.² Ablation procedures offer an ideal application for such systems because of the amount of complex data generated. An ideal storage solution is secure, efficient, and easy to use, and stores clinically relevant information.

In our report, we demonstrated a simple example of how to use one such tool to compile and review ablation data, which can be used for clinical assessments, quality improvement, or research. We successfully assessed adherence to our target strategy and identified predictors of touchup ablation in a segment. Ideally, indication of first-pass isolation would be stored prospectively in future iterations. Alternative use cases may rely on impedance drop stored for each lesion as a surrogate of lesion

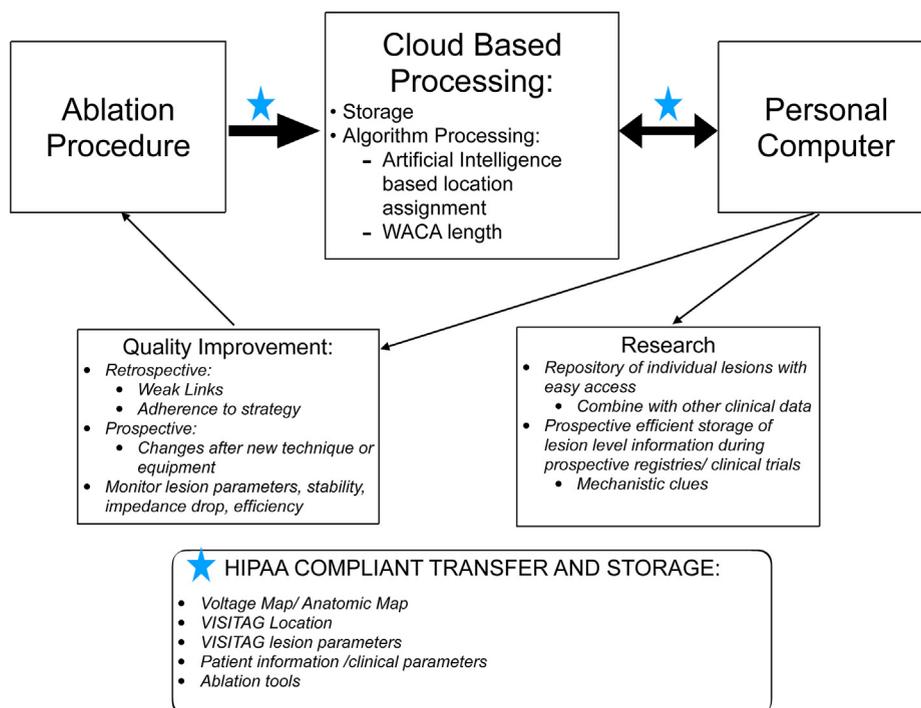


Figure 1 Suggested utility of cloud-based storage and analysis. HIPAA = Health Insurance Portability and Accountability Act; WACA = wide area circumferential ablation.

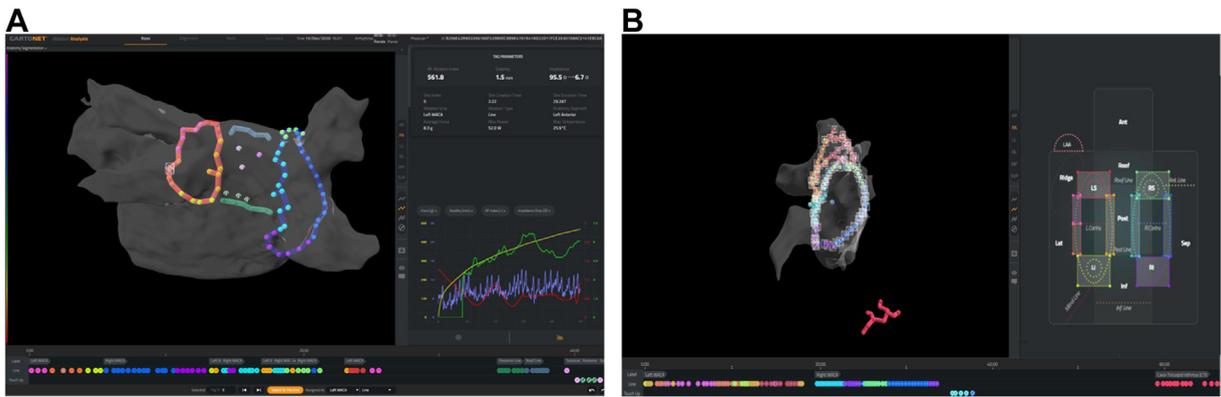


Figure 2 A: CARTONET screenshot. For each ablation site that is selected on the left map, stored data are visualized on the right side of the screen and can be downloaded in bulk. B: The viewing angle can be manipulated to review the accuracy of automated location assignment. The time of first encirclement can be determined, and lesions following this point can be labeled “touchups.”

formation. Ongoing challenges to advancement of this technology include information security, system interoperability, and legal constraints.

Despite current limitations, cloud-based analysis and storage has the potential to impact clinical care significantly by enabling physicians to assess and review their performance more easily. Adjustments to the ablation strategy or the adoption of new technologies can be

systematically reviewed to detect signals of altered lesion parameters or impedance drops. Incorporation of these tools into trials and registries can alleviate logistical difficulties and allow for comprehensive lesion-based analysis. Lastly, the compilation of large amounts of lesion-specific procedural data will allow for greater power to detect subtle effects that otherwise would be difficult to study.

Table 1 Ablation target compliance by region

	CF target achieved	<i>P</i> value compared to all other segments	AI target achieved	<i>P</i> value compared to all other segments	Power target achieved	<i>P</i> value compared to all other segments	Impedance drop target 10 Ω achieved	<i>P</i> value compared to all other segments	Impedance drop target 7 Ω achieved	<i>P</i> value compared to all other segments	
No.	(%)		(%)		(%)		(%)		(%)		
Left PVI lesions											
Left ridge	737	94.0	<.01	76.7	.26	84.4	.01	28.2	.24	55.0	.10
Left anterior	520	96.0	.01	64.0	<.01	70.6	<.01	27.1	.72	58.7	<.01
Left inferior	282	98.9	.23	84.0	.02	97.2	<.01	25.5	.80	49.6	.44
Left posterior	783	99.2	<.01	68.1	<.01	86.1	.17	25.7	.67	52.7	.70
Left roof	577	96.9	.21	93.4	<.01	97.6	<.01	33.3	<.01	57.0	.01
Left carina	50	96.0	.73	84.0	.42	100	<.01	20.0	.40	48.0	.67
Total	2949	96.8	<.01	76.1	<.01	86.2	.01	28.0	.01	54.9	<.01
Right PVI lesions											
Right anterior	1157	99.0	<.01	77.3	.35	81.7	<.01	37.9	<.01	65.1	<.01
Right inferior	310	98.1	.82	90.0	<.01	97.1	<.01	17.1	<.01	44.2	<.01
Right posterior	1241	98.8	.01	73.7	<.01	88.4	.40	15.5	<.01	35.1	<.01
Right roof	617	98.5	.19	92.2	<.01	95.9	<.01	23.5	.10	52.2	.97
Right carina	117	91.5	<.01	85.4	.08	100	<.01	28.2	.66	52.1	.95
Total	3442	98.7	<.01	80.0	<.01	88.3	.01	25.0	.01	49.6	<.01

Bold values are statistically significant.
 AI = ablation index; CF = contact force; PVI = pulmonary vein isolation.

Table 2 Ablation parameters in RFPI and those with additional ablation

	CF (g)		Duration (s)		FTI (g s)		Impedance drop (Ω)		AI	
	Mean	Min	Mean	Min	Mean	Min	Mean	Min	Mean	Min
Touchup segment	13.8 ± 3.5	6.2 ± 2.4	12.4 ± 3.2	7.0 ± 1.7	161 ± 47	64 ± 31	8.2 ± 2.4	0.8 ± 4.5	412 ± 47	310 ± 47
RFPI	14.1 ± 4.1	8.0 ± 3.6	11.9 ± 3.4	7.7 ± 2.2	157 ± 47	86 ± 42	8.1 ± 2.7	2.7 ± 3.3	411 ± 50	343 ± 43
<i>P</i> value	.37	<.01	.09	<.01	.33	<.01	.68	<.01	0.85	<.01

	Power (W)		Stability (mm)	
	Mean	Min	Mean	Max
Touchup segment	44.9 ± 4.6	41.1 ± 4.5	2.5 ± 0.6	5.4 ± 1.2
RFPI	45.4 ± 4.6	42.5 ± 4.8	2.4 ± 0.7	4.4 ± 1.4
<i>P</i> value	.30	<.01	.20	<.01

Bold values are statistically significant.

FTI = force–time integral; RFPI = regions of first-pass isolation; other abbreviations as in Table 1.

Study limitations

Future studies should validate the accuracy of machine learning–based lesion location assignment and the clinical impact from using such systems. Additional ablation sites were identified when ablations followed encirclement and occasionally may represent reinforcement of a wide area circumferential ablation despite first-pass isolation. Experience of other operators/centers or newer software versions may differ.

Conclusion

We describe a novel cloud-based storage system that utilizes machine learning to analyze ablation data obtained during catheter ablation for atrial fibrillation. Using this system, we demonstrate key ablation-related parameters that predict the need for additional ablation beyond initial first pass encirclement to achieve pulmonary vein isolation. There is significant potential for this system as a tool to analyze mapping and ablation procedure data and as a result improve procedural outcomes.

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Patient Consent: All patients provided written informed consent.

Ethics Statement: This study was approved by the Institutional Review Board of Brigham and Women's Hospital and adhered to the Helsinki Declaration guidelines.

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