Post Ablation Voltage By Pure EP™ As A Marker Of Transmural Lesion

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Background

With atrial fibrillation ablation, recurrence is observed in up to 50% of patients. The inability to create transmural and durable lesions resulting in pulmonary vein reconnection is a major contributor to ablation failure. Reduction in EGM amplitude has been shown to correlate with lesion trans-murality.[1]

A more accurate measurement of the post-ablation, low-amplitude fractionated signal can be used to determine the end-point of ablation. The PURE EP™ System is a signal acquisition and processing platform that collects analog, unfiltered intra-cardiac signal and addresses disruptive signals such as environmental lab noise, slow signal recovery and inaccurate display of fractionated potentials (Figure 1).

Accurate measurement of post ablation voltage could be used as an ablation end-points that correspond to transmural lesion formation and its electrophysiologic surrogate of loss of pace-capture.[2]

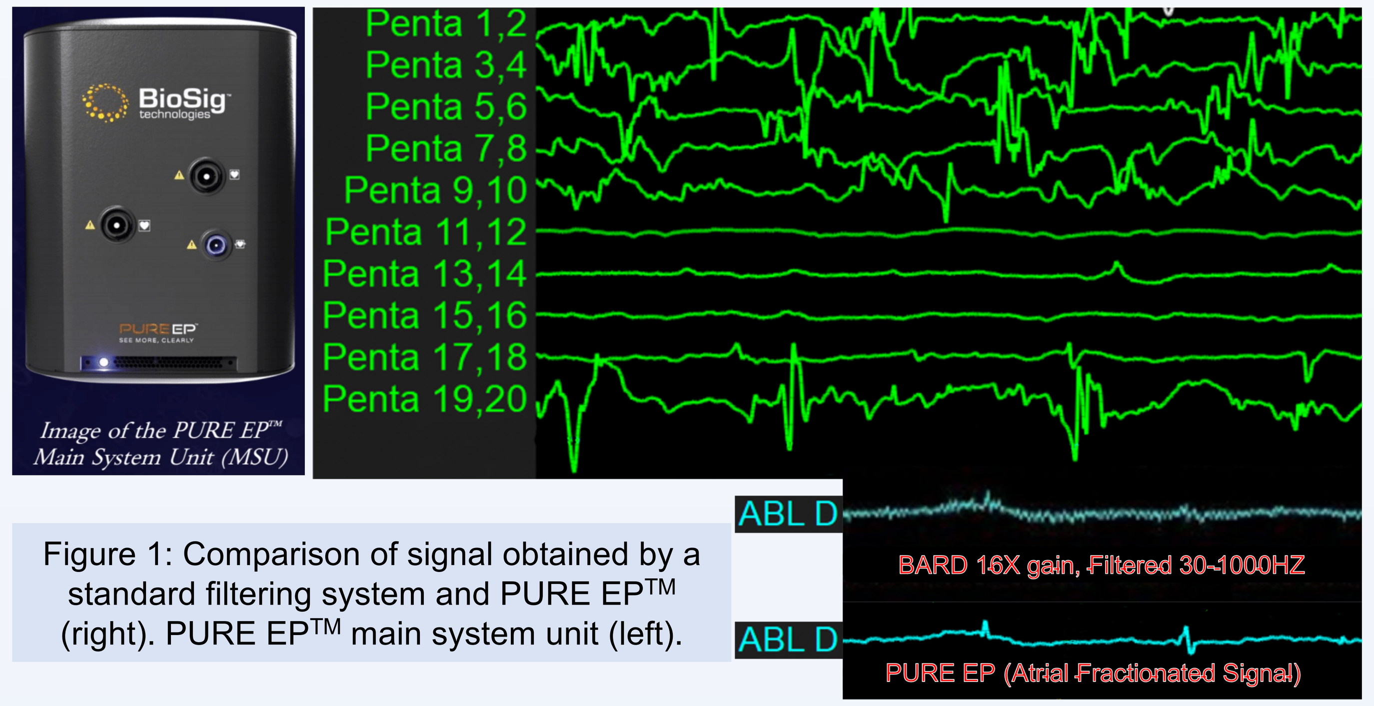

Figure 1: Comparison of signal obtained by a standard filtering system and PURE EP™ (right). PURE EP™ main system unit (left).

Objective

This study was aimed at determining post-ablation signal parameters in the left atrium obtained by PURE EP™ system that would determine adequacy of ablation and transmural lesion formation.

Methods

Ablation data (n=74) were collected from 11 patients undergoing atrial fibrillation ablation (Age 69±10, 46% Male) using remote navigation (n=9) or manual catheters (n=2). Baseline and post ablation parameters for each ablation point including impedance, bipolar and unipolar voltages, EGM morphology, duration of ablation, ablation energy and location (left atrial anterior, posterior and roof) were collected.

"Pace and ablate" method was used for each ablation point.[2,3] The end points of ablation were 10 seconds after loss of capture (LOC) from the ablating catheter while being paced at 10 mA and 2 msec output or a maximum duration of 60 seconds if no loss of capture was observed or a rise in esophageal temperature by 1 degree Celsius. A logistic regression model of parameters with significant predictive power for identifying LOC was created. The discriminatory performance of the model was tested using the area under a receiver operating curve (AUC).

Subsequently, machine learning techniques including Naïve Bayes, Random Forest, Logistic regression, and neural network were used to develop predictive models for ablation points with LOC. Cross validation method was used to calculate classifier performance measures such as Area Under the Curve (AUC), Classification Accuracy (CA), weighted harmonic mean of precision and recall (F-1), Precision, Recall and Specificity and to select the best performing classifier.

Figure 2: Post ablation bipolar voltage is significantly lower in points with LOC .

Results

Of 74 ablation points, 62 demonstrated loss of capture with an average ablation duration of 26±11 sec. Bipolar voltages recorded by PURE EP system but not Carto mapping system were significantly lower at sites with LOC compared to those without LOC (0.48±0.29 vs 0.58±0.21, P=0.04) (Figure 2).

Univariate screening showed ablation energy and post ablation bipolar voltage by PURE EP™ system to be significant determinants of sites with LOC.

Using machine learning algorithm, post ablation uni- and bi-polar voltages as well as ablation energy were used to develop predictive models. Neural network and logistic regression had very good discriminatory power with AUC and Precision of close or above 80% as summarized in table 1 and Figure 3.

Table 1: Discriminatory power of various machine learning algorithms to predict LOC at various ablation points using post ablation voltage (bipolar and unipolar) and ablation energy obtained by PURE EP™ system.

Model	AUC	CA	F1	Precision	Recall
Neural Network	0.84	0.84	0.81	0.80	0.85
Logistic Regression	0.76	0.85	0.78	0.87	0.85
Random Forest	0.74	0.84	0.80	0.80	0.84
Naive Bayes	0.53	0.81	0.78	0.76	0.82

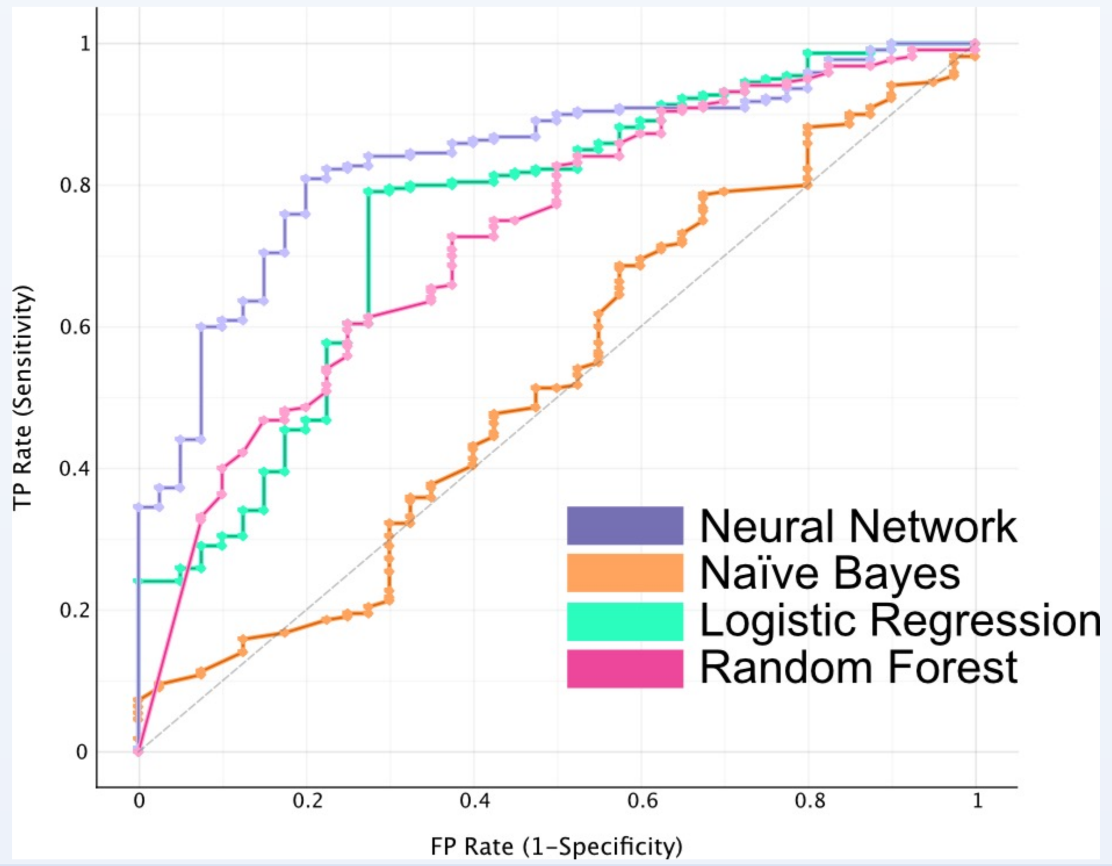

Figure 3: AUC of various machine learning algorithms for prediction of ablation sites with LOC.

Conclusion

Accurate unfiltered left atrial voltage after ablation is significantly lower at sites with transmural lesion. Machine learning algorithms can utilize post ablation voltage and ablation energy to predict ablation sites which are rendered non-excitable after ablation and likely correspond to transmural lesions with relatively high accuracy.

Further studies are needed to prospectively confirm these findings in larger number of patients.

If confirmed, dynamic voltage measurement during ablation can provide a surrogate end-points for ablation during PVI.

References

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