Circulation: Arrhythmia and Electrophysiology

RESEARCH LETTER

High-Frequency, Low-Tidal-Volume Mechanical Ventilation Safely Improves Catheter Stability and Procedural Efficiency During Radiofrequency Ablation of Atrial Fibrillation

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Atrial fibrillation (AF) ablation is the most performed electrophysiological procedure. Improved catheter stability is crucial for proper lesion formation and correlates with durable pulmonary vein isolation.[1] Studies have documented the profound impact that anesthesia management can have on catheter stability.[2,3] Improved catheter stability and long-term clinical outcomes are important rationales behind the widespread use of general anesthesia during catheter ablation of AF.

Nonetheless, during general anesthesia, significant changes in contact force and catheter stability are observed with each breath when utilizing a standard ventilation (SV) protocol. High-frequency jet ventilation has been used to suppress this respiratory-related cardiac and catheter motion, improving clinical outcomes by improving catheter stability.[4] However, high-frequency jet ventilation represents a complex ventilation modality, with higher cost and potential complications. High-frequency, low-tidal-volume (HFLTV) ventilation may be a simpler and safer alternative to improve catheter stability by decreasing respiratory excursion while maintaining adequate ventilation through frequent, low-volume respiration in the anesthetized patient, improving radiofrequency AF procedural efficacy, efficiency, and safety.

In the current study, prospective data were collected from the REAL-AF (Real-World Experience of Catheter Ablation for the Treatment of Paroxysmal and Persistent Atrial Fibrillation) registry (https://www.clinicaltrials.gov; Unique identifier: NCT04088071). Before the use of HFLTV ventilation, the ventilation parameters were set by the anesthesia team, traditionally using a tidal volume of 6 to 8 mL/kg with respiratory rates of 10 to 12 breaths/min (SV, control group). Ventilatory and anesthetic management was otherwise identical in both groups using our previously published protocol.[5] HFLTV protocol was accomplished by using a respiratory rate of 30 breaths/min and a tidal volume of 200 mL (≈3 mL/kg) only during the ablation part of the procedure to minimize the duration and potential of CO_2 retention. If needed, hyperventilation (or so-called recruitment breaths) was employed until a decrease in the end-tidal CO_2 was achieved. An end-tidal carbon dioxide CO_2 of <50 mm Hg was maintained. This study only reports acute procedural data since patients in the HFLTV group have not completed 1-year follow-up. The primary end points of this analysis were pulmonary vein first-pass isolation, radiofrequency, and total procedural times. Severe adverse events up to 3 months postprocedure were also analyzed (ie, cardiac tamponade, death, stroke within 7 days, atrioesophageal fistula pneumothorax, atelectasis, pneumonia).

The study was approved by Western Copernicus Group Institutional Review Board, which waived the need for informed consent; this approval does not permit sharing of data. Analyses were performed using SPSS version 25. Means and SDs were calculated for continuous variables, whereas frequencies and percentages were calculated for categorical variables. Independent *t* tests were used to test differences between SV and HFLTV on continuous variables (2-tailed). Pearson χ^2 tests

Key Words: atrial fibrillation ■ catheter ablation ■ high-frequency jet ventilation ■ pulmonary vein ■ tidal volume

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For Sources of Funding and Disclosures, see page 263.

Circulation: Arrhythmia and Electrophysiology is available at www.ahajournals.org/journal/circep

Nonstandard Abbreviations and Acronyms

AF	atrial fibrillation
HFLTV	high-frequency low-tidal-volume
SV	standard ventilation

were used to examine the relationship between ventilation method and categorical variables (2-tailed). For all analyses, $P<0.05$ was consider significant. Five hundred ninety-eight consecutive patients were prospectively enrolled in the registry from January 2018 to December 2020. Conventional ventilation was used up until April of 2020 (SV group). Thereafter, HFLTV was implemented during catheter ablation of AF.

Among the studied population, 112 patients underwent ablation using the HFLTV protocol, and 462 patients were in the SV group. Patients in the HFLTV and SV groups had similar age, body mass index, and sex distribution. Left ventricular ejection fraction and left atrial size were also similar between groups. First-pass pulmonary vein isolation rates were higher in the HFLTV group when compared with the SV group (85% versus 77%, $P=0.01$). Return of conduction after adenosine bolus in the HFLTV group was nonsignificantly lower (8% versus 15%, $P=0.06$), and the rates were similar during isoproterenol infusion (20% for both). There were no clinically important events of CO_2 retention. Procedural times were significantly shorter among patients in the HFLTV group (71.4±25.4 versus 79.6±31.4 minutes, $P=0.01$). There was also a significant reduction in the pulmonary vein radiofrequency time (11.9±3.8 versus 17.1±6.5 minutes, $P<0.001$) in the HFLTV group. Adverse Events up to 30 days were similar. No patients required prolonged mechanical ventilation after the procedure or reintubation. The main limitation of this study is the implementation of the ventilation protocols sequentially, rather than in a randomized study design. Our analysis, however, did not show a training effect.

This study demonstrates HFLTV mechanical ventilation during radiofrequency AF ablation was associated with a significantly higher first-pass pulmonary vein isolation rate (Figure). As first-pass pulmonary vein isolation requires the adequate and predictable delivery of radiofrequency energy consistently throughout the entire wide area circumferential ablation lesion set, it stands to reason that the observed improvement in our data represents improved catheter stability and resultant lesion delivery. The study also proved shorter total procedural and radiofrequency times without an increase in complications. As power settings and target contact force values were unchanged between the 2 groups, the decrease in radiofrequency time can only be explained by improved catheter stability and ability to achieve desired contact force. Further studies are indicated to better understand the impact of HFLTV on catheter stability and long-term outcomes in AF ablation.

ARTICLE INFORMATION

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Acknowledgments

None.

Sources of Funding

None.

Disclosures

Dr Osorio is a paid consultant for Biosense Webster, Inc, Philips/EPD, and Boston Scientific. Dr Rajendra is a paid consultant for Biosense Webster, Inc, Abbott, Medtronic, Boston Scientific, and Philips. Dr Morales is a paid consultant for Biosense Webster, Inc, Abbott, Medtronic, and Boehringer Ingelheim. Dr Romero has received grant support from Biosense Webster (BWI-IIS-535) for an investigator-initiated study (Posterior Wall And Left Atrial Appendage Empiric Electrical Isolation for Non-Paroxysmal Atrial Fibrillation Trial; https://www.clinicaltrials.gov; Unique identifier: NCT04216667). Dr Silverstein is a paid consultant for Biosense Webster, Inc. Dr Zei is a paid consultant for Biosense Webster, Inc, Abbott, Affera, and Varian, and is an expert witness for Boehringer Ingelheim. Neither honoraria nor payments were made for authorship. The other authors report no conflicts.

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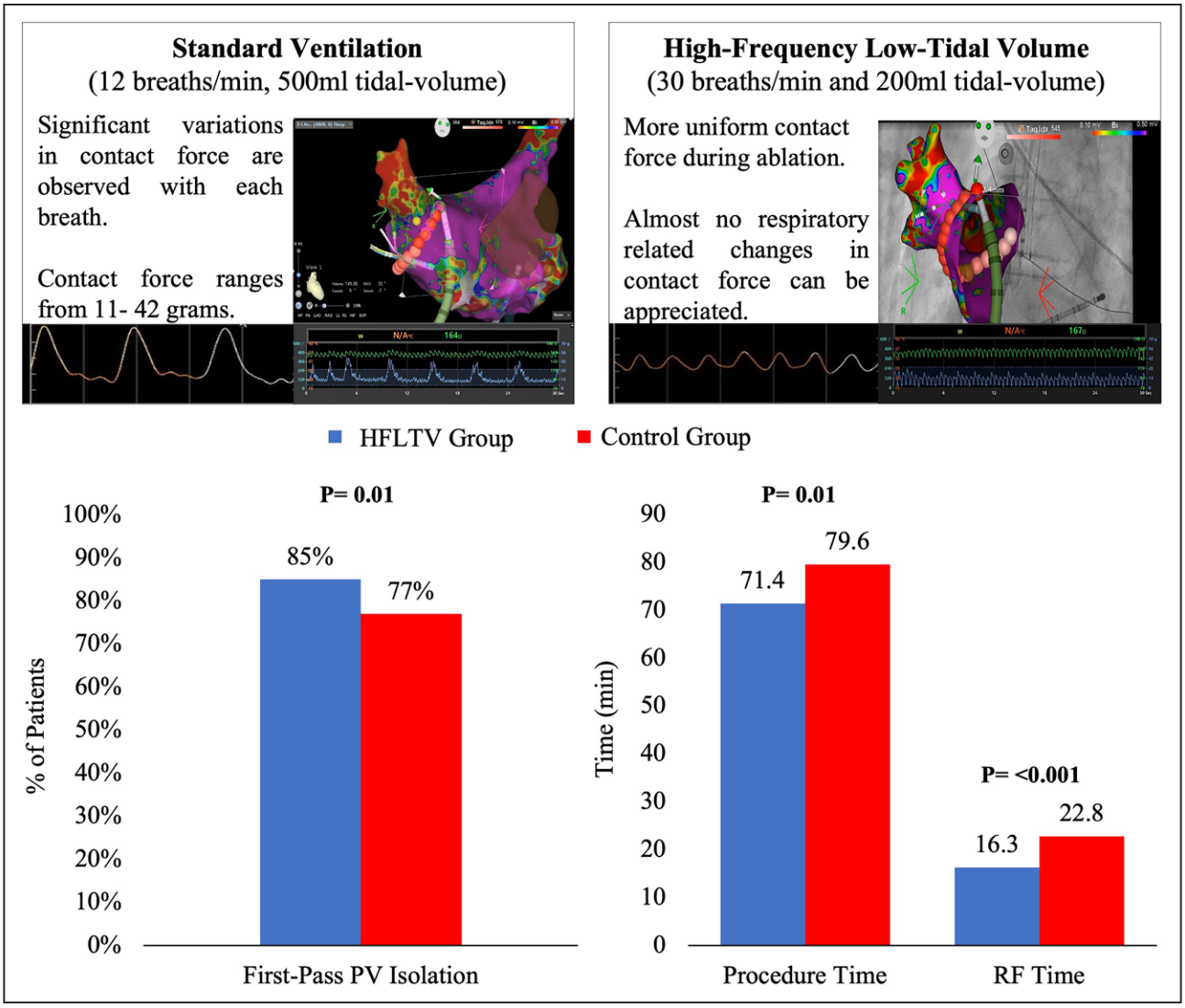

Figure. Electroanatomic map of the left atrium of a patient undergoing catheter ablation of paroxysmal atrial fibrillation using HFLTV.

Ablation catheter is located at the anterosuperior aspect of the right superior pulmonary vein (PV), which is commonly known as the most difficult anatomic area to obtain appropriate catheter stability. Standard ventilation (SV; **top left**) yields significant variations in catheter stability and contact force (ie, 11–42 g) with each breath. High-frequency low-tidal ventilation (HFLTV; **top right**) provides almost perfect catheter stability and contact force with minimum respiratory-related changes. The percentage of patients with first-pass PV isolation was higher in the HFLTV group (85%) vs the SV group (77%; *P*=0.01). Procedure time (minutes) was lower in the HFLTV group (71.4) vs the SV group (79.6; *P*=0.01). Similarly, radiofrequency time (minutes) was lower in the HFLTV group (16.3) vs the SV group (22.8; *P*<0.001).