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Visualization of Acute Edema in the Left Atrial Myocardium after Radiofrequency Ablation: Application of a Novel High-Resolution 3-Dimensional Magnetic Resonance Imaging Sequence:

Visualization of Post-Ablation LA Edema using T2-SPACE

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Abstract

Background—Ablation-induced left atrial (LA) edema may result in procedural failure due to reversible pulmonary vein (PV) isolation. Conventional T2-weighted magnetic resonance edema imaging is limited by low spatial resolution.

Objective—In this pilot study, our goal was to 1) optimize and validate a 3D-SPACE sequence for quantification of T2-signal in the LA and 2) apply in recently ablated patients, comparing myocardial edema on T2-SPACE to tissue damage on late gadolinium-enhancement (LGE) imaging.

Methods—Phantom studies were performed to identify 3D-SPACE parameters for optimal contrast between normal and edematous myocardium. Fourteen AF patients were imaged with both 3D-SPACE and DB-TSE to compare image quality and signal intensity between the two techniques. Eight patients underwent pre- and post-ablation 3D-SPACE and 3D-LGE imaging. Ablation points were co-registered with corresponding myocardial sectors and ablation-induced changes in T2 and LGE signal-intensities were measured.

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Results—SNR and CNR were higher on SPACE vs DB-TSE (65.5 ± 33.9 vs 35.7 ± 17.9 , $p=0.01$; and 59.4 ± 33.0 vs 32.9 ± 17.7 , $p=0.04$; respectively). T2-signal correlated well on 3D-SPACE and DB-TSE such that each unit-increase in TSE-intensity correlated with a 0.69-unit increase in SPACE-intensity (95%CI [0.56; 0.82], $p<0.001$). T2- and LGE-signal intensities were acutely increased at ablation sites. The extent of post-ablation edema was higher compared to LGE, although spatial distribution of hyper-enhancement around PVs appeared similar in both modalities.

Conclusions—T2-SPACE can be used to map, with improved resolution and lower artifact compared to traditional DB-TSE, the extent of acute post-ablation edema in the thin LA myocardium.

Keywords

Atrial fibrillation; T2-weighted imaging; left atrial imaging; late gadolinium enhancement; left atrial edema; left atrial fibrosis; radiofrequency ablation

INTRODUCTION

Pulmonary vein isolation (PVI) by radiofrequency ablation (RFA) has emerged as an effective treatment of AF by interrupting signal conduction from the pulmonary vein ostia to the left atrial (LA) myocardium. Radiofrequency ablation has been shown to cause both reversible (edema) and irreversible (necrosis/fibrosis) myocardial injury.¹ Since the permanence of conduction block cannot be assessed during the procedure, reversible injury has been proposed as an important reason for AF recurrence, as resorption of edema within weeks allows electrical conduction between the PVs and LA to be reestablished.

T2-weighted MRI has been used to identify ablation-induced tissue edema.¹ To date, conventional dark-blood turbo-spin echo (DB-TSE) sequences are artifact-prone with long acquisition times and limited spatial resolution. Hence, there is a need for high-resolution techniques to evaluate the thin LA wall.

In this pilot study, we seek to: 1) optimize and validate a high resolution T2-weighted imaging technique - Sampling-Perfection with Application-optimized Contrasts using different flip-Angle Evolution (SPACE)² - with comparison to the standard DB-TSE sequence, 2) quantify pre- and post-ablation T2-SPACE and late gadolinium-enhancement (LGE) signal changes at ablated regions of the LA, using registered electro-anatomic ablation maps as the standard of reference and compare the extent and distribution of high signal on T2-SPACE (edema) and LGE (necrosis/fibrosis), to assess the extent of ablation-induced reversible and irreversible myocardial injury.

METHODS

3D-SPACE TECHNICAL EVALUATION

We performed validation studies to determine optimal parameters for detection of edema within the myocardium. We used eleven in-house phantoms, consisting of different concentration of Agarose and CuSO₄ in water. T1 and T2 values of each phantom were

measured by a conventional spin-echo sequence and ranged from 187–1200 msec for T1 and 13 – 223 msec for T2. To optimize T2 signal, we focused on identifying the optimal TE for maximal contrast between phantoms with T1 and T2 values similar to normal and edematous myocardium. Phantoms with T2 values within the range for normal myocardium (45ms) and edema range (69ms) were selected for calculation of the maximum contrast-to-noise ratio (CNR).^{3,4} Subsequently, the selected phantoms were imaged 13 times using SPACE with different TEs ranging between 11 and 144 msec. CNR at each configuration was defined as difference in mean-T2 signal intensity between edema and normal myocardium phantoms divided by standard deviation of background signal intensity. TE time of 66 msec displayed the highest CNR with regards to edema sensitivity and was adopted for SPACE sequence.

STUDY POPULATION

To validate our optimized-SPACE against traditional DB-TSE sequence, 14 patients undergoing an initial AF-ablation were imaged with both SPACE and DB-TSE sequences. Clinical feasibility was then tested in a cohort of 8 patients undergoing an initial AF-ablation who underwent SPACE and LGE-imaging pre- and post-procedure. The Institutional Review Board approved the study and all patients provided written informed consent.

MRI ACQUISITION

Images were acquired using a 1.5 Tesla MR scanner (Aera, Siemens, Erlangen, Germany) with a phased array cardiac coil. A 3D-SPACE sequence with ECG and respiratory gating was obtained TE of 66 msec, in plane spatial resolution of 0.6×0.6 , slice thickness of 1.5 mm, and field of view of 30×40 cm with axial image covered the entire LA. Typical acquisition time was 10–12 minutes. Axial T2 dark blood FSE images were also acquired through the LA with the following parameters: Inversion time of 790 msec, TE of 60 msec, ^{3–5} in-plane spatial resolution of 1.3×1.3 mm, and slice thickness of 5 mm. LGE-MRI scans were acquired approximately 18 minutes following a total of 0.2 mmol/kg gadolinium injection (gadopentetate dimeglumine; Bayer Healthcare Pharmaceuticals, Montville, NJ, USA). For LGE, we utilized a three-dimensional inversion recovery prepared fast spoiled gradient recalled sequence that is respiratory and ECG gated with fat suppression (echo time of 1.52 ms, flip angle at 10 degrees, in-plane resolution of 1.3×1.3 , slice thickness of 2.0 mm, and inversion time of 240–290 ms). The entire LA was covered with approximately 20–25 slices.

COMPARISON OF 3D-SPACE AND DB-TSE

Multipanar reconstruction of the SPACE images was performed to generate an image with 5 mm slice thickness to match the DB-TSE images. Quantitative analysis included signal-to-noise ratio (SNR) and CNR. A 1.0×1.0 mm region of interest (ROI) was placed in the posterior wall of the left atrium on both DB-TSE as well as 3D-SPACE images and an additional ROI was placed outside the body for background-noise measurement. SNR for each sequence was defined as the ratio of mean LA signal intensity (SI_{LA}) to the standard deviation of background noise (SI_{AIR}). CNR was defined as difference in mean signal intensity between SI_{LA} and SI_{AIR} divided by standard deviation of SI_{AIR} . Subsequently, the posterior wall of the LA was used to draw ROIs at identical positions on twelve contiguous

slices covering the entire LA. SI_{ROI} was normalized to para-spinal muscle signal in the same slice and compared between the two sequences.

ABLATION PROCEDURE

All patients underwent wide area circumferential PVI. A double trans-atrial septal puncture was performed under fluoroscopic guidance. An endocardial map of the left atrium was created with an electroanatomic mapping system (CARTO, Biosense Webster, Diamond Bar, California) and superimposed on the pre-existing MR images. With routine hemodynamic and electrocardiographic monitoring, a 3.5-mm irrigated tip catheter (NaviStar, ThermoCool or Thermocool Smarttouch, Biosense Webster Inc, Diamond Bar, CA) was advanced to the LA. Circumferential radiofrequency ablation lesions were applied surrounding the pulmonary veins. PVI was performed using real-time automated display of RF application points (VISITAG; Biosense-Webster Inc) with predefined catheter stability settings. A maximum RF energy of 35 Watts was used for delivery of lesions with decrease in energy to 25 Watts on the posterior wall. Contact force targets were left to the discretion of the operators, and for the group were between 10–30g. Entrance block into the pulmonary veins was confirmed in all patients as the primary procedural endpoint. If conduction from PV to LA persisted, additional lesions were delivered along the original ablation line at sites of earliest activation.

ABLATION-INDUCED CHANGES IN T2-SPACE AND LGE

Pre-and post-ablation SPACE and LGE-MRI images were processed off-line on QMass MR software (version 7.2, Leiden University Medical Center, Leiden, The Netherlands). Epicardial and endocardial contours were manually drawn around the LA myocardium. The reference point was placed at the anterior base of the LA septum, and the LA myocardium in each axial plane was divided into 100 sectors (Figure 1). The image intensity ratio (IIR), a previously described LGE-MRI technique that normalizes myocardial pixel intensities by the mean intensity of the entire blood pool, was calculated for each chord.⁶ T2-signal was normalized to mean SI from an ROI placed in the para-spinal muscles^{5,7} (Suppl. Fig. 1). For LGE sequences, we chose an IIR threshold of >1.22 to define fibrosis as it correlated with bipolar voltage of 0.3 mV.⁹ Areas of edema on SPACE were defined by estimating the mean SI value and standard deviation of non-enhanced atrial myocardium. The T2-edema threshold was then calculated for two to four standard deviations above the mean of the non-enhanced area, covering from 95% to 99.994% of a Gaussian distribution. The final threshold that corresponds to T2-edema was determined by two experts (radiologist experienced in cardiac MRI and electrophysiologist experienced in AF ablation), by comparison of pre- and post-ablation 3D-rendering of edema maps to the original T2 images for appropriateness (Figure 2). The cutoff by consensus was pixels with SI 4 standard deviations greater than mean SI of non-enhanced myocardium. Three-dimensional maps of LGE were also generated for each sequence at both time periods (pre and post-ablation). Pulmonary veins were analyzed as ipsilateral pairs as no anatomical variants were reported in our cohort. The extent of circumferential PV ostia encirclement (at the site of PV isolation ablation line) by LGE and edema was determined visually on the 3D maps by an operator experienced in LA-LGE analysis (>150 cases/year). The presence or absence of edema and

LGE was also noted in each of the ipsilateral PV quadrants. LA volume was automatically extracted from image segmentations.

ABLATION MAP REGISTRATION

Ablation points were then extracted from the CARTO workstation and imported into LGE and SPACE images using the registration matrix defined during the procedure on MASS Research Software (Medis, Leiden, The Netherlands) (Figure 1). An intermediate registration step, performed on ParaView (Kitware, Clifton Park, NY), was needed to reconcile the CARTO coordinate system to the MR coordinate system. Mean normalized T2, LGE-SI, and wall thickness at the closest chord to each ablation point were extracted in pre- and post-ablation scans.

STATISTICAL ANALYSIS

Continuous variables were expressed as mean $\pm$ SD. We used non-parametric tests (Wilcoxon rank-sum test) to compare CNR and SNR due to small sample size and data skew. We used Bland-Altman analysis to study the agreement between T2-SPACE and DB-TSE intensities. The point-by-point correlation was examined using generalized estimating equations (GEE) linear regression models, clustered by patient. The GEE model approach utilized here recognizes the existence of within-subject data clustering via modeling within-subject correlations. We used mixed-effects linear regression models, clustered by patient, to examine ablation-induced change in T2- and LGE-SI, adjusting for wall thickness. The Wilcoxon signed rank test for paired data was used to compare the pre- and post-ablation LGE and edema burden around PVs. Pairwise chi-square test was used to analyze post-ablation spatial distribution of LGE and edema. Two-sided P values less than 0.05 were considered statistically significant. Statistical analysis was performed using STATA software (version 12, StataCorp, College Station, TX).

RESULTS

COMPARISON OF DB-TSE WITH T2-SPACE

Fourteen patients (11 men; mean age, 64 $\pm$ 8 years), presenting for an initial AF ablation, were imaged with both 3D-SPACE and DB-TSE (Table 1).

Mean SNR as well as CNR were higher on SPACE vs DB-TSE on non-parametric analysis (65.5 $\pm$ 33.9 vs 35.7 $\pm$ 17.9, $p=0.01$; and 59.4 $\pm$ 33.0 vs 32.9 $\pm$ 17.7, $p=0.04$, respectively) (Figure 3). On patient-clustered GEE analysis, each unit-increase in TSE-T2 intensity correlates with a 0.69-unit increase in SPACE-T2 intensity (95% CI [0.56; 0.82], $p<0.001$). On a pooled Bland-Altman analysis (Figure 4), mean difference was 0.206 [95% CI: 0.15–0.26] with only 6% of the points lying outside the area of agreement.

ABLATION-RELATED CHANGES IN LGE AND T2-SPACE

Eight patients (5 (63%) males, 57.5 $\pm$ 5 years, 5 (63%) paroxysmal AF) underwent pre-ablation MRI up to one week prior to ablation as well as within 24-hours post-ablation. Individual patient characteristics are summarized in Table 2. All scans were performed in sinus rhythm.

At baseline, mean LGE as a percentage of the total LA myocardium was $8.5 \pm 6.9\%$ while mean edema was $2.4 \pm 1.4\%$. High signal was observed at the ablation sites at the PV ostia on both LGE as well as T2-SPACE images (Figure 5). A pattern of dark, low-signal in the LA wall around ablation sites was also observed on LGE images corresponding to 'no-reflow' zones from necrosis-induced micro-vascular obstruction (Figure 6).

In total, 2172 ablation points (272 points/patient) were imported, registered with the LA myocardial sectors, and analyzed. Ablation at a particular site was significantly associated with increase in normalized-T2 signal intensity such as $[SI(\text{post-ablation})-SI(\text{pre-ablation})]/SI(\text{pre-ablation}) = +0.69$, $p < 0.001$) after adjusting for wall thickness at that site. Similarly, ablation at a particular site was significantly associated with increase in myocardial LGE-IIR such as $[SI(\text{post-ablation})-SI(\text{pre-ablation})]/SI(\text{pre-ablation}) = +0.03$, $p < 0.001$) (Supplemental Fig 2).

The extent of encirclement of the right PVs by edema was significantly greater than that of LGE ($68 \pm 19\%$ vs $43 \pm 26\%$, $p = 0.049$). We observed a similar trend for the left PVs (edema: $72 \pm 13\%$ vs LGE: $51 \pm 17\%$, $p = 0.12$). There was no significant difference in the circumferential extent of LGE or edema around the left PVs versus the right PVs ($p = 0.44$ for LGE, 0.78 for edema) (Figure 2).

There was no statistical difference in the presence of LGE and edema around the PVs for each of the eight quadrants (Supplemental Figure 3).

DISCUSSION

In this study, we introduced the use of a T2-weighted cardiac SPACE sequence to delineate, with high resolution, acute edema in the left atrial wall after ablation procedures. The main findings of this study are 1) 3D-SPACE correlates well to conventional DB-TSE while providing improved signal-to-noise and contrast-to-noise ratios in a 3D acquisition, 2) both T2 and LGE signal-intensities are increased acutely at ablation sites, 3) the extent of encirclement of the PVs is higher with edema than LGE signal, but the spatial distribution of both around the PV antra is similar.

COMPARISON OF DB-TSE WITH T2-SPACE

To the best of our knowledge, this is the first study comparing SPACE and DB-TSE for imaging of the LA. We performed a head-to-head signal intensity correlation analysis at identical positions on the LA posterior wall. Our study shows good correlation between the two techniques with improved signal-to-noise and contrast-to-noise ratios with SPACE, thus allowing better visualization of the thin myocardium. Indeed, for DB-TSE, spatial resolution must be sacrificed to image the LA in a reasonable number of breath-holds. Previous human studies have used a slice thickness of 5 mm, which results in volume averaging that is particularly troublesome in evaluation of the left atrium due to its complex anatomical structure and thin wall.¹ This pilot study clearly demonstrates the potential of SPACE to offer more accurate imaging of the LA with better anatomical delineation than currently available sequences.

EARLY POST-ABLATION IMAGING

High-resolution LGE-MRI has been used to evaluate the extent and location of RFA-related scar tissue after ablation.⁸ The extent and location of enhancement on post-ablation scans have been shown to correlate with the rate of recurrence.⁹ However, it remains unclear whether acute post-ablation LGE-MRI is sufficient to evaluate the extent of myocardial damage.

T2-weighted imaging has long been established as a reliable method for differentiation of acute from chronic myocardial infarct due to better evaluation of the edema associated with acute ischemia.^{5,10} Applying the same principles from acute myocardial infarction, some authors have investigated the role of T2 weighted imaging in identifying post-ablation changes. Arujuna et al evaluated 25 patients undergoing AF-ablation with both LGE-MRI and conventional T2-weighted imaging.¹ They demonstrated that recurrence-free patients had higher extent of LGE and lower extent of edema within the LA, representing more irreversible RFA-induced damage. Although the results of this study suggest a prognostic role for T2-weighted imaging, current techniques (T2-weighted double-inversion recovery turbo-spin echo) are limited for detailed evaluation of edema. Other than low spatial resolution, these sequences are acquired during breath-holds, which subject the acquired images to motion artifacts and gating problems in patients with arrhythmia. Therefore, there is a need for an improved technique for evaluating the atrial wall with a high resolution T2 weighted sequence to demonstrate the extent of LA edema.

SPACE FEATURES

SPACE is a turbo spin-echo pulse-sequence featuring a refocusing pulse train consisting of variable flip-angle pulses of less than 180°. Unlike standard 2D dark-blood spin echo techniques, SPACE can be used for high-resolution 3D imaging (resolution of 0.6×0.6×1.5mm). These datasets can be reconstructed in any imaging plane, which is advantageous for assessment of the complex anatomy of the LA. Scans are performed without breath-holding using cardiac and respiratory navigation. Signal voids from the flowing blood provide the necessary blood suppression. The image quality of SPACE was superior to our conventional free breathing DB-TSE with more accurate delineation of the edge of the myocardial wall and areas of wall thickening. This is in line with prior studies for evaluation of the heart, brain, CSF and musculoskeletal system.^{2,11–13}

CLINICAL APPLICATION

Electrical block, the measurable acute procedural end-point of most AF ablations, is caused by necrosis but may also be transiently observed due to edema around the PVs.^{14,15} Peri-procedural edema resolves within weeks, thus restoring electrical conduction with the PVs, potentially leading to AF recurrence.¹⁶ Current available technology does not allow the electrophysiologist to assess the cause of electrical isolation and to distinguish sites of tissue necrosis from areas of edema. Therefore, a combination of high-resolution MR-based sequences, such as SPACE and LGE, has the potential to accurately assess the composition of ablated tissue acutely after lesion placement with the goal of detecting gaps in the ablation patterns.

In our reported experience, we observed variability in terms of T2 vs LGE signal at each ablation site (Fig. 5–6). As an example, there was increased T2 signal around right PV anteriorly rather than posteriorly (Fig. 5). We hypothesize that varying ablation parameters on anterior vs. posterior wall (such as reducing ablation power and contact force to prevent esophageal or phrenic nerve injuries) may affect the differential nature of the ablation lesions at those two sites. Therefore, our group is currently studying the determinants of edema vs. LGE in patients receiving catheter-based ablation. In a prospective cohort with acute and long-term post-ablation imaging, we aim to extract ablation parameters from each ablation point to establish determinants of change in T2 and LGE intensities, among the ablation parameters (contact force, temperature, ablation time, power, etc), at each ablation site; and the optimal ablation parameters for a chronic LGE lesion representing durable pulmonary vein isolation.

LIMITATIONS

This study has a small patient population. Larger studies, with repeat mapping to examine the association of SPACE/LGE with permanence of lesions will refine our results. Although MRI characterizes the entirety of atrial tissue within each axial slice, the thickness of the slices, and its non-isotropic dimensions adds error and interpolation as well. Given this, and the fact that IIR has not been validated against tissue samples as of yet, the results of this study should be interpreted as three methods in relative agreement rather than against a gold standard. Our results may be affected by positional errors when registering ablation points to MRI; however, the extent of positional errors appears to be very low based upon prior validation studies of our technique.¹⁷ PVI was performed using real-time automated display of RF application points with operator-dependent predefined catheter stability settings. Although this standardizes the process by which ablation points are recorded on the EAM, there is inevitable operator-based variability in pre-defined catheter stability. SPACE-specific TR was derived by phantom-based methodology. Given this is the first application of SPACE for post-ablation LA edema, the selected parameters need to be validated using histological data.

CONCLUSION

T2-SPACE can be used to map, with high-resolution, the extent of edema in the LA. In good correlation with traditional DB-TSE, SPACE allows better visualization of the thin LA myocardium. Both T2 and LGE-signal intensities were increased at ablation sites. Acutely, the extent of lesions appears to be under-estimated on LGE in comparison to known ablation sites and SPACE but the spatial distribution of both signals around the PVs seems similar.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Figure 1. SPACE and Ablation Map registration. **A:** Manually drawn endo- and epicardial contours on T2-SPACE. **B & C:** Ablation points imported onto MRI, signal intensity at the nearest image sector was automatically recorded.

Figure 2.

Three-dimensional distribution of signal hyper-enhancement, generated from LGE and T2-SPACE pre and post-ablation. Patient 1 displays hyper-intense signal at ablation points. In Patient 2, ablation at the right veins led to more edema than LGE; suggesting ablation was insufficient to create necrotic injury. PVI: Pulmonary Vein Isolation.

Figure 3. Head-to-head comparison between DB-TSE (A) and SPACE (B) images. LA: Left Atrium, LV: Left Ventricle, RPV: Right Pulmonary Vein, LPV: Left Pulmonary Vein, Ao: Aorta.

Figure 4. Bland-Altman analysis illustrating the agreement between SPACE and DB-TSE intensities at corresponding LA segments.

Figure 5. Illustration of LGE (**A and B**) and SPACE (**C and D**) before (**A and C**) and after (**B and D**) ablation. Hyper-enhancement is indicated by white arrows at ablation sites. The “no-reflow” pattern, indicating irreversible micro-obstructive injury, is seen as non-enhancement at ablation sites (black arrows).

Figure 6.

Illustration of post-ablation SPACE-T2, DB-TSE and LGE at the same site from two patients. Patient 1 shows diffuse post-ablation edema around the RIPV and lateral LIPV (bold white arrows), with “no-reflow” on LGE (black arrows). LGE signal is seen around LIPV (asterisk). Patient 2 exhibits less edema and more LGE. Visual interpretation of LGE and T2-based sequences should be done cautiously as normalization of signal is needed for proper delineation of edema/fibrosis.

Table 1

Baseline characteristics of patient population for SPACE/DB-TSE Analysis.

Patient	Age	Sex	BMI	CHF	DM	CVA	CAD	HTN	OSA	CHA ₂ DS ₂ -VASc	AF Type	AF Duration (y)	LA Volume (mL)
1	64	F	31.5	No	No	No	No	No	No	1	PAF	3	79
2	60	M	27.2	Yes	No	Yes	No	Yes	No	4	NPAF	0.3	98
3	66	F	35.9	No	No	No	No	No	No	2	PAF	12	123.8
4	63	M	27.1	No	No	No	No	Yes	Yes	1	NPAF	0.3	81.7
5	62	M	30.3	No	No	No	No	No	No	0	PAF	4	93.6
6	75	M	30.1	No	No	No	No	Yes	No	2	NPAF	4	121
7	79	M	28.8	Yes	Yes	No	Yes	Yes	Yes	6	NPAF	8	113.8
8	84	M	28.4	No	No	No	No	Yes	No	3	PAF	10	87.3
9	62	F	26.8	No	No	Yes	No	No	No	3	PAF	3	103.6
10	69	M	22.9	Yes	No	No	No	No	No	2	NPAF	19	172.4
11	60	M	31.8	No	No	No	No	No	No	0	NPAF	1	129.9
12	67	M	28.2	No	No	No	No	Yes	No	2	PAF	10	77.1
13	51	M	35.3	No	Yes	No	No	No	No	1	PAF	2	104
14	41	M	24.2	No	No	No	No	No	No	0	NPAF	0.5	89.9

BMI: Body Mass Index, CHF: Congestive Heart Failure, DM: Diabetes Mellitus, CVA: Cerebro-Vascular Accident, CAD: Coronary Artery Disease, HTN: Hypertension, OSA: Obstructive Sleep Apnea, AF: Atrial Fibrillation, LA: Left Atrium, NPAF: non-paroxysmal (persistent) AF, PAF: paroxysmal AF

Table 2

Baseline characteristics of patient population for SPACE/LGE Analysis.

Patient	Age	Sex	BMI	CHF	DM	CVA	CAD	HTN	OSA	CHA ₂ DS ₂ -VASc	AF Type	AF Duration (y)	LA Volume (mL)
1	62	F	22.6	Yes	No	No	No	Yes	No	3	NPAF	1	62.96
2	62	M	27.3	No	No	No	No	Yes	Yes	1	NPAF	0.3	81.7
3	40	M	24.3	No	No	No	No	No	No	0	NPAF	0.5	89.9
4	62	F	38.9	No	No	No	No	Yes	No	2	PAF	2	67.98
5	55	M	35.6	No	No	No	No	Yes	Yes	1	PAF	2	90.9
6	61	F	36.0	No	No	No	No	No	Yes	1	PAF	2	135.2
7	60	M	21.7	No	Yes	No	No	Yes	No	2	PAF	3	67.8
8	58	M	25.7	No	Yes	No	No	Yes	No	2	PAF	20	71.2

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