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Left Atrial Appendage Eccentricity and Irregularity Are Associated With Residual Leaks After Percutaneous Closure

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ABSTRACT

OBJECTIVES Predictors of residual leak following percutaneous LAA closure were evaluated.

BACKGROUND Left atrial appendage (LAA) closure aims to exclude this structure from the circulation, typically using a circular occluder. A noncircular orifice is frequently encountered however, and fibrous remodeling of the LAA in atrial fibrillation may restrict orifice deformation. Noncircularity may thus be implicated in the occurrence of residual leak despite an appropriately oversized device.

METHODS Pre-procedural multislice computerized tomography was used to quantify LAA orifice eccentricity and irregularity. Univariate predictors of residual leak were identified with respect to the orifice, device, and relevant clinical variables, with the nature of any correlations then further evaluated.

RESULTS Eccentricity and irregularity indexes of the orifice in 31 individuals were correlated with residual leak even where the device was appropriately oversized. An eccentricity index of 0.15 predicted a residual leak with 85% sensitivity and 59% specificity. An irregularity index of 0.05 predicted a significant residual leak ≥3 mm with 100% sensitivity and 86% specificity. Orifice size, device size, degree of device oversize, left atrial volume, and pulmonary artery pressure were not predictors of residual leak.

CONCLUSIONS Eccentricity and irregularity of the LAA orifice are implicated in residual leak after percutaneous closure even where there is appropriate device over-size. Irregularity index in particular is a novel predictor of residual leak, supporting a closer consideration of orifice morphology before closure. (J Am Coll Cardiol EP 2015;1:478–85)

The prevention of stroke is a key consideration in the management of atrial fibrillation. The left atrial appendage (LAA) is a major site of thrombus formation in atrial fibrillation, and as such is frequently implicated in cardioembolic events (1). Percutaneous closure of the LAA has an emerging role in those individuals for whom the attendant bleeding risks of oral anticoagulation (OAC) are prohibitive (2). The efficacy of LAA closure is based on an exclusion of this cul-de-sac structure from the circulation, and persistent communication may not adequately prevent the passage of emboli from the LAA. An accurate sizing of the LAA for the purpose of device size selection is paramount in this regard, but residual leaks occur in more than 40% of cases post-procedure despite meticulous multimodality imaging (3).

Current closure devices are circular in shape and are deployed at relatively low pressure. Computerized tomographic (CT) evaluation of the LAA has

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shown a highly variable shape of the orifice however, with significant eccentricity and irregularity shown in the majority of individuals (4). Moreover, a remodeling of the LAA has been reported in chronic atrial fibrillation that is likely to alter wall compliance and elasticity (5). A mismatch between orifice shape and circular occluder in the setting of a less pliable orifice may thus be implicated in the occurrence of residual leaks. Parallels can be drawn to procedures such as transcatheter aortic valvular implantation (TAVI) for example, where excessive eccentricity has been shown to predict perivalvular leak (6). We evaluated the associations of residual leak after LAA closure with eccentricity and irregularity of the orifice as assessed by pre-procedural CT.

METHODS

PATIENT SELECTION. All consecutive individuals with atrial fibrillation in whom an intra-appendage occluder device had been implanted at our institution were identified from a prospectively established registry. Eligibility for LAA closure required a confirmed indication for anticoagulation as determined by a CHA_2DS_2VASc risk score ≥2, and either a prohibitive risk associated with long-term OAC or the occurrence of embolic events despite therapeutic OAC. Pre-procedural contrast-enhanced CT imaging of the LAA was routinely acquired to exclude left atrial / LAA thrombus and to complement intraprocedural evaluation of LAA size and morphology by transesophageal echocardiography (TEE) and fluoroscopy.

LAA OCCLUSION PROCEDURE. All procedures were conducted via femoral venous access under general anesthesia. Fluoroscopy, 2-dimensional (2D) TEE, and more recently 3D TEE were used for real-time guidance of trans-septal puncture and LAA occlusion. Closure device size was determined by consideration of orifice diameters derived from all imaging modalities including CT, TEE, and fluoroscopy. Deployment was in accordance with manufacturer guidance, and heparin was used to achieve an activated clotting time of >250 s. Comprehensive evaluation of the closure device by TEE was routinely conducted across all transducer-array planes immediately after final deployment to detect and thoroughly assess the magnitude of any residual leaks. All patients received aspirin 100 mg and clopidogrel 75 mg for 1 month post-procedure, which was then followed by aspirin monotherapy.

CT IMAGING. Pre-procedural evaluation of the left atrium, LAA, and neighboring structures was by multislice CT (dual source flash spiral 2 × 128 slice, Siemens Definition). Temporal resolution was 75 ms with a gantry rotation time of 0.28 s, detector collimation of 128 × 0.6 mm, pitch of 3.4, and tube voltage of 100 to 120 kV according to body habitus. Fifty milliliters of contrast (Omnipaque 350, GE Healthcare, Buckinghamshire, United Kingdom) was delivered via the antecubital vein with 50 ml saline flush at 5 ml/s. Automated contrast bolus tracking with a region of interest placed in the left atrium was triggered at 100 Hounsfield units. Delayed phase images were also acquired where LAA opacification was suboptimal to aid in the distinction of slow filling versus thrombus.

RETROSPECTIVE EVALUATION OF LAA ORIFICE. Blinded assessment of the LAA orifice on CT was conducted retrospectively by a single investigator (A.R.). Multiplanar reconstruction was used to obtain orthogonal views of the LAA and to prescribe a double-oblique en face view of the orifice (**Figure 1**). The orifice was defined as the plane between the circumflex artery and a point 15 ± 5 mm from the tip of the limbus, reflecting as closely as possible the site where the proximal aspect of the closure device would be expected to lie. Thin-slab views were used for measurements, typically at 0.15- to 0.18-mm thickness. Measurements were made of the maximal diameter and orthogonal minor diameter, and freehand planimetry was used to obtain orifice circumference, area, and thus mean diameter. Occluder device circumference could be determined by [π × uncompressed device diameter], to determine whether an appropriate oversizing had been achieved in relation to orifice circumference. Left atrial volume on CT was calculated by the biplane area-length method [0.85 × 4-chamber area × 2-chamber area / atrial length] (7). Pulmonary artery pressure was estimated noninvasively from pre-procedural transthoracic echocardiogram. Blinded quantification of residual leak on procedural 2D TEE was conducted separately (M.G.S., P.D.). Color and spectral Doppler were used to identify the presence of residual peri-device leak, and leak width was measured at its waist.

ECCENTRICITY AND IRREGULARITY INDEXES. Eccentricity refers to the distortion of a circular orifice along a major axis. Eccentricity index of an elliptical orifice was quantified by the magnitude of difference between major and minor axes (Online Figure), and calculated as: [1 − (minor diameter/major diameter)]. A perfectly circular orifice thus has an eccentricity index of 0, but approaches 1 with

ABBREVIATIONS AND ACRONYMS

AF = atrial fibrillation
AUC = area under the curve
CCF = congestive cardiac failure
CI = confidence intervals
CT = computed tomography
LA = left atrial
LAA = left atrial appendage
OAC = oral anticoagulation
ROC = receiver-operating characteristic
SD = standard deviation
SEM = standard error of the mean
TAVI = transcatheter aortic valve implantation
TEE = transesophageal echocardiography