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Atrial fibrillation ablation in patients with known sludge in the left atrial appendage

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Abstract
Purpose Transesophageal echocardiography (TEE) is routinely used to assess for thrombus in the left atrium (LA) and left atrial appendage (LAA) in patients undergoing atrial fibrillation (AF) ablation. However, little is known about the outcome of AF ablation in patients with documented LAA sludge. We hypothesize that AF ablation can be performed safely in a proportion of patients with sludge in the LAA and may have a significant benefit for these patients.
Methods We performed a retrospective analysis of all patients undergoing AF ablation at New York University Langone Medical Center (NYULMC) from January 1st 2011 to June 30, 2013. Patients with sludge found on their TEE immediately prior to AF ablation were identified and followed for stroke, AF recurrence, procedural complications, major bleeding, or death.
Results Among 1,076 patients who underwent AF ablation, 8 patients (mean age 69±13 years; 75 % men) with sludge were identified. Patients with sludge in their LAA had no incidence of early or late occurrence of stroke during mean follow-up of 10 months. One patient had a left groin hematoma, and two patients had atrial tachycardias that needed a repeat ablation. TEE at the time of repeat ablation demonstrated the presence of spontaneous echo contrast (smoke) and resolution of sludge. There were no deaths.
Conclusion In a cohort of eight patients with LAA sludge who underwent AF ablation, no significant thromboembolic events occurred during or after the procedure. AF ablation can be performed safely and may be beneficial in these patients. Larger studies are warranted to better determine the most appropriate management route.

Keywords Atrial fibrillation · Ablation · Sludge · Left atrial appendage

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1 Background

Atrial fibrillation (AF) is considered the most common arrhythmia in clinical practice [1] with high morbidity and mortality [2]. Findings of a thrombus in the left atrium (LA) or left atrial appendage (LAA) is considered a contraindication to rhythm control of AF, based on the most recent AF management guidelines [3, 4]. Persistent severe smoke or spontaneous echo contrast (SEC) in the left atrium on TEE is associated with later thrombus formation and systemic embolization [4]. The LAA is determined to contain sludge if there is an echo-dense lesion which is more viscid than smoke but less dense than thrombus. While, the finding of "sludge" is somewhat subjective, it is considered to be a stage further along the spectrum of thrombus formation compared to smoke/SEC [5]. At our institution, we routinely perform AF ablation procedures on patients with LAA smoke or SEC on preoperative TEE. The feasibility and safety of performing AF ablation on patients with LAA sludge is not well known. The aim of this study is to assess safety and long-term outcomes of AF ablation for patients with sludge in their LA or LAA.

2 Methods

2.1 Patients

A total of 1,076 patients underwent AF ablation at NYULMC from January 1, 2011 through June 30, 2013. Of that number,

there were eight patients who were found to have sludge on transesophageal echocardiography (TEE) prior to their procedure. These patients proceeded with AF ablation and were followed for acute and long-term complications. All patients were in AF at the time of their procedure. There were no patients in the cohort who had sludge on TEE that did not undergo AF ablation. There were no patients with sludge on TEE that underwent AF ablation prior to 2011.

2.1.1 TEE

2D and 3D TEE were performed with a commercially available ultrasound system (Phillips iE33; Philips Medical Systems, Andover, MA) using a matrix-array 3D TEE probe (X7-2t; Philips Medical Systems). All TEEs were performed no more than 24 h prior to the AF ablation procedure. Smoke was defined as dynamic, "smoke-like" echoes with swirling motion using optimal gain setting during the cardiac cycle (Fig. 1). Sludge was defined as a dynamic gelatinous, precipitous echo density similar to a meniscus level, without a discrete mass, present throughout the cardiac cycle, and appearing more dense and layered than severe smoke (Fig. 2). Thrombus, on the other hand, was defined as a circumscribed and uniformly echo-dense intracavitary mass distinct from the underlying LA or LAA endocardium and the pectinate muscles and is less heterogeneous and dynamic than sludge [5, 6] (Fig. 2). Two independent readers were asked to interpret the TEE studies. The second reader was blinded to the interpretation by the first reader.

2.1.2 Computed tomography (CT) scan

CT angiogram was performed in all patients through the chest from the level of the aortic arch to the hemidiaphragms after the administration of intravenous contrast in association with prospective ECG triggering. Off-line 3D post processing techniques were performed on an independent workstation. This allowed visualization of the LA and LAA and reconstruction of the LA, LAA, and pulmonary veins. Findings on CT scan were compared to TEE finding of smoke, sludge, and thrombus. Two independent radiologists were asked to interpret the scans. The second radiologist was blinded to the results of the first interpretation.

2.1.3 Atrial fibrillation ablation

AF ablation was performed aided by Ensite™ Velocity™ Cardiac Mapping System (St. Jude Medical, Sylmar, CA) imported CT scan and fluoroscopy. Mapping was performed using a 10-pole 20-mm lasso catheter, and an electro-anatomic geometry of the LA was created. A7 Fr Celsius ThermoCool irrigated tip ablation catheter with a 3.5-mm tip (Biosense Webster; Diamond Bar, CA) was used to deliver circumferential lesions around the right and left pulmonary veins to achieve isolation. Additional lesions were delivered along the roof of the atrium between the right and left encircling lesions and along the right and left carina in all patients. In patients with persistent AF, additional lesions were delivered to the endocardial and epicardial mitral isthmus, LA septum, LA floor, and anterior base of the LAA. During the AF ablation procedure, care was taken to avoid entry to the LAA. Our activated clotting time (ACT) goal was between 350 and 400. Pulmonary vein isolation was achieved in all patients. As per our routine institutional protocol, post procedure patients who were not on warfarin were bridged with enoxaparin (0.5 mg/kg twice daily) for 2 days and were restarted on oral anticoagulation 1 day following their procedure.

3 Results

3.1 Demographics

Among 1,117 patients, there were 8 patients with documented sludge on TEE in the LAA undergoing AF ablation. The patients were followed over a mean of 10±5 months. The mean age was 69±13 years. There were six male and two

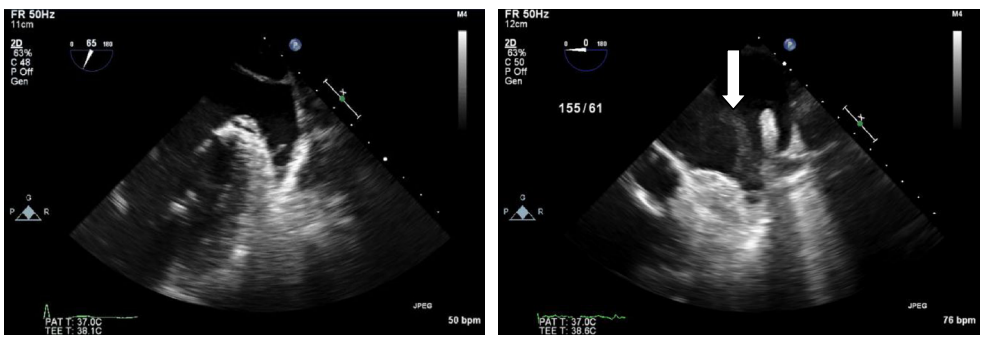

Fig. 1 *Left*: normal LAA on TEE. *Right*: TEE demonstrates appearance of spontaneous echo contrast in a patient with "smoke" (*arrow*) but without thrombus. There is no apparent boundary and no meniscus level

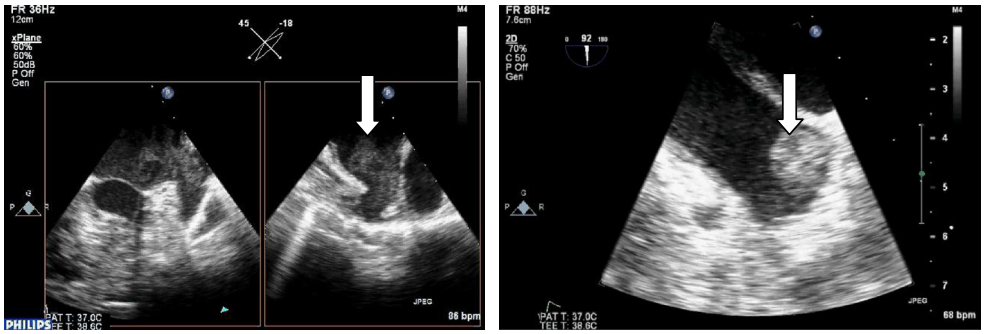

Fig. 2 *Left*: biplane TEE demonstrates sludge in the LAA (*arrow*). It appears as a non-uniform mass with a meniscus level and an echo density between that of smoke and frank thrombus. Sludge lacks clear boundaries. *Right*: 2D TEE shows presence of intracardiac thrombus (*arrow*) in the LAA which appears as a clearly discrete mass more dense and uniform than smoke or sludge

female patients. CHADS-VASC score was used in our patient population to direct anticoagulation. Mean score was 2.3± 1.06. Of note, no patient had a history of thromboembolic incident prior to the procedure.

3.1.1 Anticoagulation profile

All patients were adequately anticoagulated (>1 month) prior to and post procedure. Six patients were anticoagulated with warfarin (INR≥2), one patient with an oral direct factor Xa inhibitor, and one patient with an oral direct factor IIa inhibitor. Patients who were not on warfarin were asked to stop oral anticoagulation 5 days prior to procedure and were bridged with fractionated heparin (1 mg/kg twice daily). The patients on warfarin had therapeutic INR 1 month pre and post procedure on follow-up. At our institution, the post-procedure anticoagulation strategy is as follows: patients who are on the novel oral anticoagulant agents are given three doses of half-dose (by weight) subcutaneous fractionated heparin starting postoperative day #1 and resume their anticoagulant agent on the evening of the same day. A lower dose of fractionated heparin is chosen to reduce the incidence of access-related complications (e.g., hematoma). For patients on warfarin, the strategy is to anticoagulate with full-dose subcutaneous fractionated heparin until their INR is therapeutic (≥2).

3.1.2 Imaging

Among the eight patients with sludge, there were seven who underwent CT angiogram. CT scans were all interpreted by two independent radiologists as having thrombus in the LAA. Notably, routine contrast CT protocols cannot resolve thrombus vs. sludge. The TEE images were also read by two independent cardiologists. In 7/8 patients, there was concordant interpretation of sludge between the two readers. However, in one patient, the second reader interpreted the TEE as severe smoke. As there is no accepted definitive TEE criterion for classification of smoke/SEC vs. sludge, this patient was included in the study cohort. The average LA volume in the study cohort was 40±15 ml. Six patients had normal left ventricular ejection fraction (LVEF) whereas 2 had LVEF <40 % (Table 1). In the 8 patients with sludge, LAA Doppler flow velocity was 23.7+/−6 cm/s. Flow velocity of <20 cm/s is commonly accepted as a major risk factor for formation of LAA thrombus [5].

3.1.3 Outcome

Among all patients who underwent AF ablation, there were no incidents of death, stroke, or major bleeding within 30 days of the procedure. One patient developed a left groin hematoma but without need for transfusion or mechanical repair. During

Table 1 Patient demographics

Variable	Patient
Mean age (mean±SD)	69±13
Men *n* (%)	6 (75)
Women *n* (%)	2 (25)
LVEF <40 *n* (%)	2 (25)
Hypertension *n* (%)	4 (50)
Diabetes Mellitus *n* (%)	1 (12.5)
Stroke/TIA	*n* (%)
Chronic anticoagulation *n* (%)	8
Warfarin	6 (75)
Rivaroxiban	1 (12.5)
Pradaxa	1 (12.5)
Peripheral vascular disease *n* (%)	0
GFR<60 *n* (%)	1 (12.5)
Persistent AF *n* (%)	7 (87.5)
Paroxysmal AF *n* (%)	1 (12.5)

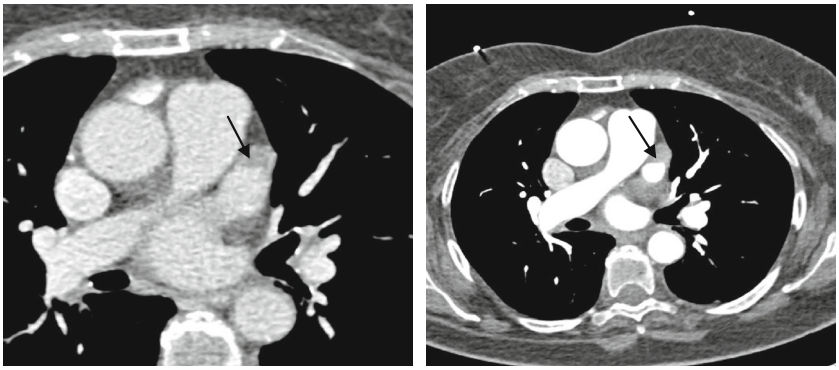

Fig. 3 Cardiac CT of a patient with sludge on TEE. LAA showing sludge that is read as thrombus (*arrows*) in the delayed contrast enhancement (*left*) and immediate contrast enhancement images (*right*). LAA thrombus is typically defined as a filling defect with an oval or convex shape. There is currently no standard CT protocol to differentiate thrombus vs. sludge vs. smoke

the AF ablation, all patients remained in AF and failed to convert to sinus requiring direct current cardioversion at the end of the procedure. All patients were maintained on anticoagulation indefinitely.

Recurrence in the form of atrial tachycardia occurred in two patients post procedure, requiring a repeat ablation. The follow-up TEE performed prior to the second ablations showed resolution of sludge and presence of smoke only. No patient experienced a thromboembolic event at last follow-up.

4 Discussion

TEE has been the gold standard of assessing presence of thrombus in the LA and LAA since the ACUTE trial [7]. CT scanning, on the other hand, can identify LAA thrombi with good sensitivity and moderate specificity [8]. In our observation, all CT scans of patients with sludge reported presence of thrombus, but none of the studies correlated with TEE findings which showed sludge in LAA without thrombi. The 2012 HRS/EHRA/ECAS expert consensus statement on catheter ablation of AF considers presence of LA thrombus as a contraindication to catheter ablation of AF [4]. However, the guidelines do not make the distinction between thrombus and sludge. Currently, the task force does not recommend that CT imaging be used to screen for LA thrombi in patients who are at high risk of stroke (Fig. 3). Some authors have considered sludge as a contraindication to direct current cardioversion and pulmonary vein isolation given the preliminary data suggesting a high rate of death or thromboembolism [9]. However, others have performed cardioversion in patients with sludge without any incidence of stroke [8].

This is the first hospital-based study to report on outcomes of a cohort of patients with LAA sludge undergoing AF ablation. In this cohort, there were no major adverse events related to thrombus acutely or during follow-up. Current management strategies for AF consider sludge to be a contraindication to AF ablation or cardioverison [10], equivalent to the presence of thrombus. However, AF ablation, when performed successfully, has long-term rates of death, stroke, and dementia similar to those without AF [11]. We hypothesize that AF ablation in patients with sludge may improve LA contraction and possibly prevent progression to thrombus. This is supported by the follow-up TEEs in two patients that demonstrated resolution of sludge after ablation.

AF ablation has been performed safely in these patients with no acute or long-term morbidity or mortality. Our findings are provocative that an aggressive approach may be more beneficial in these patients than conservative medical therapy.

Additionally, all patients had to be cardioverted with direct current at the end of the procedure to restore sinus rhythm. This may have been due to avoidance of entry to LAA which may have caused limitations in mapping. However, we believe that sludge may be a marker for the severity of LA myopathy in AF patients.

4.1 Limitations

The main limitations of our study are the small number of patients. Additionally, there is limited follow-up data with TEE in these patients on the status of the sludge after restoration of sinus rhythm. Brain imaging with MRI post procedure could also be helpful in diagnosing silent events. We avoided entry to the LAA which may have caused limitations in mapping of the LA.

5 Conclusion

AF ablation may be performed safely in a proportion of patients with sludge in the LAA and may have significant benefit for these patients. AF ablation in patients with sludge may prevent progression to thrombus. Further studies are warranted with larger number of patients to better determine the most appropriate management approach in these patients.

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