Transition from Transesophageal Echocardiography to Cardiac Computed Tomography for the Evaluation of Left Atrial Appendage Thrombus Prior to Atrial Fibrillation Ablation and Incidence of Cerebrovascular Events During the COVID-19 Pandemic

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June 2, 2021

Abstract

Background Transesophageal echocardiography (TEE) is variably performed before atrial fibrillation (AF) ablation to evaluate left atrial appendage (LAA) thrombus. We describe our experience with transitioning to the pre-ablation cardiac computed tomography (CT) approach for the assessment of LAA thrombus during the COVID-19 pandemic. Methods We studied consecutive patients undergoing AF ablation at our center. The study cohort was divided into pre- vs. post-COVID groups. The pre-COVID cohort included ablations performed during 1 year before the COVID-19 pandemic; pre-ablation TEE was used routinely to evaluate LAA thrombus in high-risk patients. Post-COVID cohort included ablations performed during the 1 year after the COVID-19 pandemic; pre-ablation CT was performed in all patients, with TEE performed only in patients with LAA thrombus by CT imaging. The demographics, clinical history, imaging, and ablation characteristics, and peri-procedural cerebrovascular events (CVE) were recorded. Results A total of 637 patients (pre-COVID n=424, post-COVID n=213) were studied. The mean age was 65.6 ? 10.1 years in the total cohort, and the majority were men. There was a significant increase in pre-ablation CT imaging from pre to post-COVID cohort (74.8 vs. 93.9%, p=<0.01), with a significant reduction in TEEs (34.6 vs. 3.7%, p=<0.01). One patient in the post-COVID cohort developed CVE following negative pre-ablation CT. However, the incidence of peri-procedural CVE between both cohorts remained statistically unchanged (0 vs. 0.4%, p=0.33). Conclusion Implementation of pre ablation CT-only imaging strategy with selective use of TEE for LAA thrombus evaluation is not associated with increased CVE risk during the COVID- 19 pandemic.

Transition from Transesophageal Echocardiography to Cardiac Computed Tomography for the Evaluation of Left Atrial Appendage Thrombus Prior to Atrial Fibrillation Ablation and Incidence of Cerebrovascular Events During the COVID-19 Pandemic

Short Title: Utility of pre-ablation CT only approach to LAA thrombus evaluation before AF ablation during COVId-19 pandemic

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Funding: (None)

Conflict of Interest

Dr. Arbab-Zadeh discloses research grant support from Canon Medical Systems. All other authors have reported that they have no relationships relevant to the contents of this paper to disclose.

Data Availability Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Word count: 2729

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Abstract

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Transesophageal echocardiography (TEE) is variably performed before atrial fibrillation (AF) ablation to evaluate left atrial appendage (LAA) thrombus. We describe our experience with transitioning to the pre-ablation cardiac computed tomography (CT) approach for the assessment of LAA thrombus during the COVID-19 pandemic.

Methods

We studied consecutive patients undergoing AF ablation at our center. The study cohort was divided into pre- vs. post-COVID groups. The pre-COVID cohort included ablations performed during 1 year before the COVID-19 pandemic; pre-ablation TEE was used routinely to evaluate LAA thrombus in high-risk patients. Post-COVID cohort included ablations performed during the 1 year after the COVID-19 pandemic; pre-ablation CT was performed in all patients, with TEE performed only in patients with LAA thrombus by CT imaging. The demographics, clinical history, imaging, and ablation characteristics, and peri-procedural cerebrovascular events (CVE) were recorded.

Results

A total of 637 patients (pre-COVID n=424, post-COVID n=213) were studied. The mean age was 65.6 $\pm$ 10.1 years in the total cohort, and the majority were men. There was a significant increase in pre-ablation CT imaging from pre to post-COVID cohort (74.8 vs. 93.9%, p=<0.01), with a significant reduction in TEEs (34.6 vs. 3.7%, p=<0.01). One patient in the post-COVID cohort developed CVE following negative pre-ablation CT. However, the incidence of peri-procedural CVE between both cohorts remained statistically unchanged (0 vs. 0.4%, p=0.33).

Conclusion

Implementation of pre ablation CT-only imaging strategy with selective use of TEE for LAA thrombus evaluation is not associated with increased CVE risk during the COVID- 19 pandemic.

Keywords:

Atrial fibrillation ablation, Left atrial appendage thrombus, Peri-procedural cerebrovascular event, Cardiac computed tomography, Transesophageal echocardiography

Introduction

The COVID 19 pandemic has significantly affected health care delivery across cardiac specialties, including cardiac electrophysiology (EP). Infection prevention efforts mandate reallocation of resources with the postponement of the elective procedures and minimization of invasive pre-procedural investigations[1]. Catheter ablation of atrial fibrillation (AF) is a commonly performed procedure in the EP lab and carries a risk of peri-procedural thromboembolic cerebrovascular events (CVEs)[2]. Left atrial appendage (LAA) thrombus is the most common source of embolism in such patients. To minimize the peri-procedural risk of CVEs, current guidelines recommend at least 3 weeks of effective anticoagulation or pre-procedural transesophageal echocardiographic (TEE) evaluation of LAA for patients who present for their ablation procedure in AF[2]. TEE is variably employed in other populations of patients undergoing AF ablation based on their stroke risk profile and physician preferences. Previous studies have suggested the utility of pre-procedural cardiac computed tomography (CT) in place of TEE for evaluation of LAA thrombus[3-9]. In the current study, we describe our institutional experience of transitioning from pre-procedural TEE to cardiac CT for evaluation of LAA thrombus during the COVID-19 pandemic (part of an effort to reduce COVID transmission risks to healthcare providers), and the risk of peri-procedural CVEs among patients undergoing pulmonary vein isolation (PVI) with minimally interrupted peri-procedural anticoagulation before and after this practice change.

Methods

Study Cohort

We conducted a single-center, retrospective cohort study comprising patients derived from an IRB-approved, prospectively populated clinical database of AF ablation patients. All patients underwent either first or repeat AF ablation between February 2019 to March 2021 at the Johns Hopkins Hospital. All patients underwent a preprocedural cardiac CT scan or cardiac magnet resonance imaging (MRI) to assess the left atrium (LA) and pulmonary vein (PV) anatomy in detail. The total patient cohort was divided into pre-COVID and post-COVID cohorts based on the Spring 2020 peak of the COVID-19 pandemic (when ablation procedures were temporarily halted in our hospital) and pre-procedural imaging for LAA thrombus evaluation. The pre-COVID cohort consisted of ablations performed between February 2019 to January 2020, and the post-COVID cohort included ablations performed between April 2020 to March 2021. All patients signed written informed consent at the time of the procedure. Demographics, clinical history, imaging data, procedural data, and complications were recorded for each procedure.

Anticoagulation Protocol

All patients in the pre-and post-COVID epochs were treated with a minimally interrupted anticoagulation strategy. Patients treated with warfarin continued uninterrupted therapy throughout the ablation period. Patients treated with direct oral anticoagulants (DOACs) underwent cessation of anticoagulation for 12–24 hours prior to the ablation procedure, with resumption 4 hours post-procedure. Adherence to a prescribed anticoagulation regimen was assessed by international normalized ratio (INR) for warfarin-treated patients or by verbal confirmation (for NOAC-treated patients) pre-and post-procedure. During the ablation procedure itself, activated clotting time levels were maintained above 350s with intravenous heparin during LA access. Anticoagulation was continued for a minimum of 3 months following the ablation procedure for all patients unless contraindicated.

Pre-ablation imaging protocol for LAA thrombus evaluation

In the pre-COVID cohort, pre-procedural TEE was performed routinely for all the patients presenting in AF or atrial flutter (AFL) on the day of ablation, and ablation was conducted after LAA thrombus was ruled out. CT scans in the pre-COVID cohort were not analyzed for the presence or absence of LAA thrombus but were used solely for assistance in electroanatomical mapping during the ablation itself. In the post-COVID cohort, we implemented a cardiac CT-based protocol for LAA thrombus evaluation, with TEE used selectively only in patients with findings suggestive of LAA thrombus on CT imaging. All patients underwent CT imaging

with first- and second-pass image acquisition to assess for LAA thrombus. TEE imaging was triggered only in patients with positive CT scan findings. If CT imaging was negative, or if triggered TEE imaging was negative, patients underwent ablation as planned. If triggered TEE was positive for LAA thrombus, the ablation procedure was canceled.

Echocardiography

LA size and left ventricular ejection fraction (LVEF) were assessed by transthoracic echocardiography (TTE) when available prior to the ablation. All TEEs were performed immediately before the planned ablation procedure. LA size and LAA velocities were assessed, and the LA and LAA were examined for the presence of thrombus or spontaneous echo contrast (SEC). In addition, the presence of patent foramen ovale (PFO) or atrial septal defect was assessed with color Doppler and/or injection of agitated saline. TEEs were interpreted independently by experienced cardiologists specializing in echocardiography.

Cardiac Computed Tomography

CT images were obtained on the day of ablation using a 320-detector scanner (Aquilion ONE, Canon Medical Systems) and prospective scan acquisition targeted at 40% of the R-R cycle (end-systole) without padding. Computed tomographic angiography (CTA) of the heart and great vessels was performed with intravenous iodinated contrast, including 3D iterative reconstruction of the cardiac chambers at 40% of the R-R interval. Prospective ECG-gating was performed to reduce the effective radiation dose. CTA was optimized for imaging the cardiac chambers and great vessels but not to visualize the complete course of the coronary arteries. A second acquisition was performed 30 seconds after the primary acquisition to assess for adequate filling of the left atrial appendage. A LA/LAA thrombus was defined as an intracavitary contrast filling defect with attenuation values similar to non-enhanced tissue. Intracavitary thrombi were differentiated from normal pectinate muscles and from filling, motion, and acquisition artifacts.

Outcomes

Peri-procedural CVE was defined as the acute onset of a new neurological deficit between the start of the procedure and up to 30 days after ablation. Stroke was defined as an acute infarct on imaging with the neurological deficit; transient ischemic attack (TIA) was defined as the absence of an acute infarct on imaging with an acute neurological deficit that resolved within 24 hours[10].

Post-Procedure Follow-Up

All patients were monitored overnight in the hospital and clinically evaluated before discharge the following day. Patients in whom neurological deficits were reported or observed underwent brain magnetic resonance imaging for evaluation of CVA. Clinical follow-up was performed routinely at 3 months, 6 months, and 1 year or earlier if the patient reported any symptoms.

Ablation Strategy

All ablation procedures were performed under general anesthesia. Femoral site access was

obtained, and intravenous heparin was administered to maintain activated clotting times >350 s.

Radiofrequency (RF) ablation :

After performing a double transseptal puncture, a Lasso or Penta Ray mapping catheter (Biosense-Webster, Diamond Bar, California) was positioned in the left atrium. An electroanatomic map of the left atrium was obtained using the CARTO system (Biosense-Webster) and superimposed on a pre-acquired CT scan. A 4-mm open-tip irrigated RF catheter with a contact force sensor (Thermocool SmartTouch, Biosense-Webster) was then positioned in the left atrium: PVI was performed using a real-time automated display of RF application points (Visitag, Biosense-Webster) with predefined catheter stability settings. Starting energy delivery parameters were 25 to 40 W on the posterior wall and 35 to 45 W at other sites. Target contact force was between 5 and 20 g at all sites. Esophageal temperature was monitored, and the RF delivery paused if the esophageal temperature increased by 0.5°C.

Cryoballoon (CB) ablation:

After a trans-septal puncture at the fossa ovalis, a long deflectable sheath (FlexCath Advance sheath; Medtronic, Inc, Minneapolis, MN) was introduced into the LA using intracardiac echocardiographic guidance. Pulmonary venous angiograms were obtained for each of the four PVs to serve as a fluoroscopic reference. An endocardial map of the LA was created via a CARTO-Biosense (Carto [R] 3; Biosense Webster, Inc, Diamond Bar, CA) or Ensite system (NavX, St. Jude Medical, Inc, St. Paul, MN). Right-sided phrenic nerve (PN) pacing was performed during the ablation of the right PVs. A second-generation CB catheter with a 23- or 28-mm balloon (Arctic Front Advance, Medtronic) and a PV mapping catheter were passed into the LA via the long sheath. Cryo lesions were targeted to the PVs after the demonstration of balloon occlusion with contrast injection. Goal temperatures were between -35 to -55C. Freezes were aborted if the esophageal temperature fell below 28˚C or if phrenic nerve pacing showed diminution of diaphragmatic excursion during right-sided PV lesion delivery. Following the delivery of at least two lesion sets per vein, electrical isolation of each PV was reassessed, and additional applications of cryotherapy were delivered with either a 23- or 28-mm second-generation CB as necessary.

Statistical Analysis

Statistics were calculated using SPSS Statistics Software for Windows version 23.0 (IBM Corporation, Armonk, New York). Normality was tested with the Shapiro-Wilks test. Continuous data was analyzed using the Student's t-test for normally distributed data and the Mann-Whitney test for non-normally distributed data. Categorical data was analyzed using the $\chi 2$ test. Values are presented as mean ±standard deviation or median and interquartile range (Q1-Q3) according to distribution for continuous data and count and percentage for categorical data, unless otherwise stated.

Results

Our study included a total of 637 patients undergoing AF ablation, of which 136 (21.4%) were undergoing repeat ablation. The pre-COVID cohort included 424 patients, and the post-COVID cohort included 213 patients. The mean age was 65.6 ± 10.1 years in the total population, and the majority were male (Table 1). The median body mass index (BMI) was 29.1 (26.0 – 34.1) kg/m^2, and the median CHA2DS2-VASc score was 2 (1–3), with no significant difference between cohorts. A higher proportion of patients with paroxysmal AF (PAF) (70.4 vs. 62.3 %, p=0.04) were included in the post-COVID cohort. A higher proportion of the patients included in the pre-COVID cohort had hyperlipidemia (29 vs. 17.4 %, p=<0.01) and a history of smoking (31.6 vs. 1.9 %, p=<0.01). Other comorbidities remained comparable between the two groups. Pre-procedure anticoagulation was used in 604 (94.8%) patients, with either uninterrupted warfarin therapy (n=45; 7.1%), or minimally interrupted dabigatran (n=45; 7.1%), rivaroxaban (n=175; 27.5%), or apixaban (n=339; 53.2%). The use of rivaroxaban was higher in the pre-COVID cohort (30.7 vs. 21.1 %, p=0.01), whereas apixaban was more commonly prescribed in the post-COVID cohort (61 vs. 49.3 %, p=<0.01).

Pre ablation imaging modality and ablation characteristics

A total of 517 (81.2%) pre-procedural CT scans were performed (Table 2). Following the implementation of CT-only protocol for LAA thrombus evaluation, we observed a significant increase in pre-procedural CT scan from pre-COVID to post-COVID cohorts (74.8 vs. 93.9%, p=<0.01). In contrast, a significant reduction was observed in the number of TEEs performed in the pre- to post-COVID groups (34.6 vs. 3.7%, p=<0.01). LA diameter (4.4 ± 0.9 vs. 4.2 ± 0.6 mm, p=<0.01) and LA volume index [90.9 (74.1-103.1) vs 74.2 (61.9-85.3) mL/m2, p=0.02] were significantly higher in the pre-COVID cohort. A total of 412 (64.7%) patients presented in normal sinus rhythm (NSR), 178 (21.9%) patients presented in AF, and 39 (6.1%) patients presented in AFL on the day of ablation.

In the pre-COVID cohort, out of a total number of 147 TEEs, 120 were performed for presentation in AF, and 24 were performed for presentation In AFL (Figure 1). While 5 TEEs showed spontaneous echo contrast (SEC), none of the TEEs showed LAA thrombus, and therefore all the ablations were carried out as scheduled. In the post-COVID cohort, a total of 8 patients were found to have CT findings concerning

for LAA thrombus and underwent TEE on the same day (Figure 2). TEE excluded the LAA thrombus in 6 of these patients, and ablation was performed as planned without any peri-procedural CVE. In 2 patients, TEE confirmed LAA thrombus leading to the cancellation of the ablation procedure (Figure 3). LAA thrombus resolved after 8 to 12 weeks of continued anticoagulation in both of these patients. Apixaban was replaced with warfarin in one patient, and warfarin therapy was continued in the other patient. Both patients underwent ablation subsequently.

Peri-procedural CVE

The incidence of peri-procedural CVE in the total cohort was 0.1% (1/637). While none of the patients in the pre-COVID cohort had CVE, 1 patient in the post-COVID cohort developed CVE. This patient presented in AF at the time of ablation and pre-ablation CT was unremarkable; therefore, TEE was not performed prior to ablation (Figure 4; clinical and procedural details are provided in Table 3). He underwent CB ablation for persistent AF, with minimally interrupted DOAC therapy (single dose of apixaban held) and developed stroke on the day after ablation. Brain MRI revealed an acute infarct in the posterior cerebral arterial territory. The proportion of CVE between pre vs. post-COVID cohort remained comparable (0 vs. 0.4%, p=0.33) (Figure 5).

Discussion

Infection prevention strategies during the COVID-19 pandemic have impacted the workflow significantly at high volume centers performing catheter ablation of AF. Omission of routine pre-ablation TEE use in appropriately selected patients is associated with improved workflow efficiency in the EP laboratory and promotes cost-effective utilization of health care resources. Additionally, it may reduce the risk of viral transmission to health care providers. We investigated the safety of a pre-ablation CT-only imaging protocol for the evaluation of LAA thrombus at our center to minimize the use of pre-procedural TEE. The following are the main findings of our study: 1) Implementation of pre ablation CT-only imaging strategy with selective use of TEE for LAA thrombus evaluation does not lead to significantly increased CVE risk; 2) Incidence of peri-procedural CVE is low; 3) Patients with CT imaging suggestive of LAA thrombus may have TEE imaging that is negative for thrombus.

Previous studies have investigated the sensitivity and specificity of pre-ablation CT by comparing it with TEE and reported conflicting findings[3-6,8,11-13]. Our study design precluded head-to-head comparison of pre-ablation CT with TEE for LAA thrombus evaluation. Nevertheless, our study provides data for the utility of pre-ablation CT-only approach to LAA thrombus assessment during the COVID-19 pandemic and supports the findings of previous reports[7-9]published during the non-COVID era. Bilchick et al[7], demonstrated the safety of the pre-ablation CT-only approach to assessment of LAA thrombus in low-risk patients undergoing AF ablation[7]. However, unlike the current study, they restricted the use of pre-ablation CT-only protocol for LAA thrombus evaluation to patients with PAF, without a history of prior CVE/LAA thrombus and CHA_2DS_2-VASc score <4. In contrast to previous studies[7-9], which included patients with low to intermediate stroke risk based on a younger age of the study cohort, lower CHA_2DS_2-VASc score and lower burden of comorbidities, our study included patients at a high stroke risk given a higher burden of comorbidities, older age, and a higher CHA_2DS_2-VASc score. Moreover, in our study, the pre-ablation CT-only protocol for LAA thrombus evaluation was offered to all the patients regardless of the previous history of stroke/TIA, type of AF, and CHA_2DS_2-VASc score. Additionally, we followed the current practice of minimally interrupted peri-procedural anticoagulation protocol with DOAC.

Similar to the previously published reports, our results suggest that the incidence of peri-procedural stroke following atrial fibrillation ablation remains low[8,14]. However, an interesting finding of our study is the development of peri-procedural stroke in a patient with unremarkable pre-ablation CT. Previous investigations[4,5,7-9,11]suggest that pre-ablation CT has a high sensitivity for LAA thrombus detection. Nevertheless, it is possible that our patient had a false-negative CT result, or that he had an embolic event from a different source (air embolism from a transseptal sheath; char at the catheter tip; non-LAA cardiac thrombus)[15,16]. Previously published reports suggest an increased propensity for LAA thrombus forma-

tion in patients with PsAF, and high CHA_2DS_2-VASc scores[3,13,17]. Whether patients with PsAF and high CHA_2DS_2-VASc scores would benefit from the routine use of pre-ablation TEE regardless of pre-ablation CT findings is a topic worthy of further investigation.

The findings of our study should be interpreted with attention to the associated limitations, including: 1) Those limitations inherent to a single-center, retrospective, and observational study; 2)We could not perform the adjusted predictor analysis for CVE given the low event rates; 3) The anticoagulation protocol at our center may be different from other centers, limiting the generalization of our findings; 4) There may be an underestimation of subclinical CVE or silent cerebral infarcts given the fact that not all the patients underwent post-procedural cardiac magnetic resonance imaging evaluation.5) We cannot exclude the possibility of a significant difference in a larger patient cohort.

In conclusion, based on our experience, implementation of pre ablation CT-only imaging strategy with selective use of TEE for LAA thrombus evaluation does not lead to significantly increased CVE risk during the COVID- 19 pandemic, has greater physician acceptance, and improved workflow efficiency. Further prospective randomized studies are required to identify the patients deriving the maximum benefit from pre-ablation TEE.

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Table 3.docx available at https://authorea.com/users/384507/articles/524649-transition-from-transesophageal-echocardiography-to-cardiac-computed-tomography-for-the-evaluation-of-left-atrial-appendage-thrombus-prior-to-atrial-fibrillation-ablation-and-incidence-of-cerebrovascular-events-during-the-covid-19-pandemic