

## Prevalence and Risk Factors of Incomplete Surgical Closure of the Left Atrial Appendage on Follow-up Transesophageal Echocardiogram

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### Abstract

**Objectives:** In patients with atrial fibrillation, incomplete left atrial appendage (LAA) closure is associated with an increased risk for cardioembolic events compared to complete closure. In this study, we aimed to determine the prevalence and risk factors for incomplete surgical closure of the LAA in the modern surgical era.

**Methods:** Records of 74 patients with surgical LAA closure who underwent follow-up transesophageal echocardiogram for any reason between 2010 and 2016, were assessed for incomplete closure. Complete closure was defined by absence of Doppler or color flow between the left atrial appendage and the left atrial body in more than 2 orthogonal views.

**Results:** Surgical LAA closure was incomplete in 21 patients (28%) and complete in 53 patients (72%). All included cases were completed via oversewing method with a double layer of running suture with or without excision of the LAA. While no individual demographic, echocardiographic, or surgical feature was significantly different between groups, incomplete closure of the LAA was more prevalent in patients with two or more of the risk factors; female sex, hypertension, and hyperlipidemia (OR 5.1, 95%CI 1.5–17).

**Conclusion:** A significant rate of incomplete surgical LAA closure still exists in the modern surgical era, and the presence of multiple risk factors associate an increased risk of incomplete closure.

### Introduction

Surgical closure of the left atrial appendage (LAA) has been performed for over two decades to prevent embolic events in patients with atrial fibrillation (AF)<sup>1</sup>. While recent data for catheter-based and device-based LAA closure has been promising, there remains a relative paucity of contemporary data regarding surgical closure.

In the past, older studies have demonstrated a high rate of incomplete surgical closure of the LAA, with a related increase in cardio-embolic events<sup>2,3</sup>. Risk factors for incomplete surgical closure

of the LAA have not been clearly identified. However, because patients who undergo surgical LAA closure as a whole have a reduced risk of stroke and systemic embolization<sup>4</sup>, current Society of Thoracic Surgeons guidelines advocate a Class IIa indication for surgical intervention of the LAA during concomitant cardiac surgery in patients with AF<sup>5</sup>.

The goal of our study is to provide a more contemporary assessment of the prevalence and risk factors for incomplete LAA surgical closure in the cardiac surgery population.

### Methods

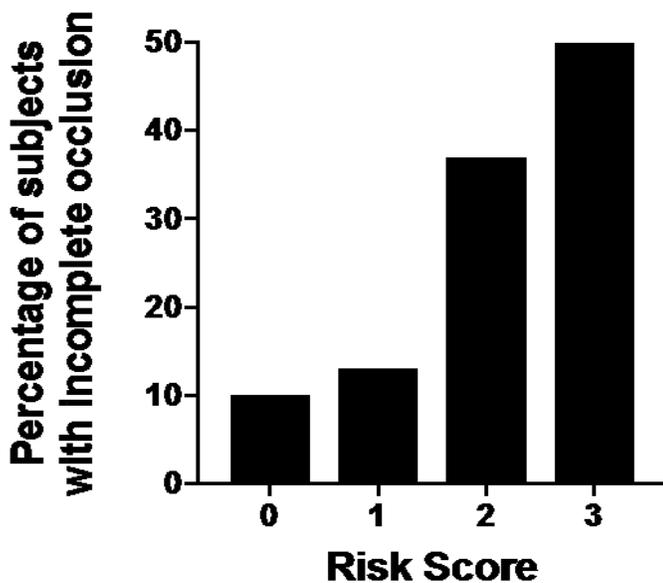
We linked the NYU Langone Health clinical and transesophageal echocardiogram (TEE) databases between 2010 and 2016 to identify patients who had undergone cardiac surgery and had a follow-up TEE for any reason noting LAA closure (n=193). Patients were excluded if they had transcatheter-based closure, a history of heart transplantation, poor study quality on TEE, or lacked a record of surgical LAA closure

### Key Words

Left Atrial Appendage, Left Atrial Appendage Thrombus, Left Atrium, Transesophageal Echocardiography, TEE, Cardiac Surgery, Atrial Fibrillation

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**Figure 1: Risk Score Distribution**

Graph indicates for patients with a certain risk score, the percentage with incomplete surgical closure of LAA on TEE. Risk score consists of the number of factors amongst female sex, hypertension, and hyperlipidemia

in their electronic medical record by operative reports or notes. Seventy-four patients were included as the final cohort for analysis. Study was approved by NYU School of Medicine Institutional Review Board with waiver for informed consent.

Indications for TEE consisted of prior to cardioversion ( $n = 24$ ), prior to ablation ( $n = 19$ ), assessment of the mitral valve ( $n = 20$ ), assessment of the aortic valve ( $n = 3$ ), possible endocarditis ( $n = 7$ ), and stroke or transient ischemic attack ( $n = 1$ ).

Demographics, medical history, and cardiac surgical history were obtained from chart review of notes, operative reports, and ICD-10 codes defined at the time of TEE. Complete or incomplete surgical LAA occlusion was determined by review of the TEE by two American Society of Echocardiography board-certified cardiologists. Complete closure of LAA was defined by absence of Doppler color flow at a reduced Nyquist limit between the LAA and the LA body in more than 2 orthogonal views. Other parameters of interest were collected from the official echocardiographic report.

To assess risk factors for incomplete LAA occlusion, we created a risk score of patient factors and used logistic regression to determine the odds ratio of incomplete closure in patients with multiple risk factors. Continuous data were expressed as mean  $\pm$  SD or median (IQR) and were compared using 2-tailed independent sample T-tests or Wilcoxon rank-sum test as appropriate. Categorical data were expressed as  $n(\%)$  and compared using chi-squared tests. Statistical significance was determined using a two-tailed  $\alpha < 0.05$  with all analyses performed in Stata v.14 (College Station, TX: StataCorp LP).

## Results

All surgical LAA closures were completed via oversewing method with a double layer of running suture with or without excision of the

LAA. The median time from surgery to TEE was 6.5 months (IQR 71). On TEE, occlusion of the LAA was incomplete in 21 patients (28%) and complete in 53 patients (72%).

Demographic characteristics were similar between each group with no individual parameter reaching statistical significance and are listed in Table 1. Furthermore, none of the echocardiographic features including ejection fraction, LA volume/dilatation, or mitral/aortic valve regurgitation predicted incomplete LAA closure at the time of TEE. Operative and surgical characteristics were similar between groups including type of surgery and elapsed time between LAA occlusion surgery and TEE (Table 1).

In the risk score analysis, we identified three factors with trends toward significance ( $p$ -value  $< 0.10$ ) for incomplete LAA closure: female sex, hypertension, and hyperlipidemia (Table 1). The percentage of patients with incomplete closure increased with increasing number of these risk factors (Figure 1). Logistic regression demonstrated statistically significant odds ratio for incomplete closure of the LAA in patients with two or more of these risk factors (OR 5.1, 95%CI 1.5–17).

## Discussion

In this study, we found the incidence of incomplete occlusion of the LAA after surgical closure to be 28%, in line with previous studies, which reported incidences ranging from 10.3% to 36%<sup>2,3,6-8</sup>. In addition, we identified three possible risk factors for failure of LAA closure. We noted an increased incidence of incomplete LAA closure with the presence of at least two of the following: female sex, hypertension, and hyperlipidemia.

While some prior studies reporting demographic characteristics of patients with complete versus incomplete closure of the LAA have not found significant differences<sup>6,8</sup>, others have demonstrated significantly higher rates of coronary artery disease and lower rates of heart failure in patients with incomplete closure of the LAA<sup>7</sup>. In addition to patient characteristics, echocardiographic features including left atrial size and degree of mitral regurgitation have also been of interest as possible predictors of incomplete LAA closure. However, these variables have not borne out in other analyses<sup>2,3,6</sup> and our own. Given the persistently high rates of incomplete LAA closure, future investigation into predictive models of incomplete surgical closure of the LAA will be important, especially when determining in which patients it is appropriate to stop therapeutic anticoagulation.

Different surgical techniques have been used to achieve LAA closure with variable rates of success<sup>6,8-10</sup>. Stapler exclusion, for example, has previously been associated with high rates of failure and stroke risk<sup>6</sup>. Surgical devices have also met with variable success, as well as the possibility of serious adverse events. Among devices, the AtriClip™ (AtriCure, Mason, OH) has shown significant promise<sup>11</sup>. Our finding of high rates of incomplete surgical suture closure in the modern era underscores the need for continued pursuit of these newer devices and techniques.

Our study has several limitations. As our study draws from patients that underwent follow-up TEE, it is possible our sample is biased toward those who had worse outcomes or comorbidities that would

**Table 1: Demographic, Echocardiographic, and Surgical Characteristics**

n (%) unless otherwise noted	LAA Incomplete Closure (n = 21)	LAA Complete Closure (n = 53)	p-value
Age (years), mean ± SD	67 ± 11	65 ± 11	0.38
Female sex	12 (57%)	19 (36%)	0.09
Hypertension	18 (86%)	34 (64%)	0.07
Hyperlipidemia	14 (67%)	22 (42%)	0.05
Obesity	2 (10%)	8 (15%)	0.5
Type II Diabetes Mellitus	3 (14%)	7 (13%)	0.9
Smoking History	8 (38%)	18 (34%)	0.74
Prior Stroke	3 (14%)	9 (17%)	0.75
Atrial Fibrillation	17 (81%)	48 (91%)	0.25
Rheumatic Heart Disease	4 (19%)	17 (32%)	0.26
Endocarditis	1 (5%)	2 (4%)	0.8
Anticoagulant Use	12 (57%)	40 (75%)	0.3
Aspirin Use	11 (52%)	27 (51%)	0.76
Statin Use	10 (48%)	20 (38%)	0.37
CHA <sub>2</sub> DS <sub>2</sub> -VASc score, mean ±SD	3.3 ±1.7	2.9 ±1.7	0.37
Ejection Fraction, % ±SD	53 ±10	53 ±13	0.89
LA Volume (mL/m <sup>2</sup> ), mean ±SD	45 ±20	48 ±24	0.66
LA Dilatation	13 (62%)	36 (68%)	0.51
Aortic Regurgitation	11 (52%)	23 (43%)	0.48
Mitral Regurgitation	18 (86%)	38 (72%)	0.97
Time from surgery to TEE (months), mean ±SD	54 ±81	47 ±64	0.73
Age at surgery (years), mean ±SD	63 ±9	60 ±16	0.43
Mitral Valve Repair	12 (57%)	33 (62%)	0.17
Mitral Valve Replacement <sup>1</sup>	9 (43%)	17 (32%)	0.77
Aortic Valve Replacement <sup>2</sup>	2 (10%)	13 (25%)	0.14
Coronary Artery Bypass Graft	2 (10%)	4 (8%)	0.8
Maze Procedure	7 (33%)	17 (32%)	0.96

CHA<sub>2</sub>DS<sub>2</sub>-VASc = age, sex, heart failure, hypertension, diabetes, stroke or transient ischemic attack, vascular disease

LA = left atrium, TEE = transesophageal echocardiography

138.5% mechanical

233.3% mechanical

warrant a TEE. Although, it should be noted that stroke/TIA was the indication for TEE in only one patient. Additionally, as our study did not collect information on rates of stroke during the intervening time between surgical LAA closure and TEE, we are unable to confirm prior reports linking increased incidence of stroke with incomplete closure. Lastly, we did not quantify the degree of leak into the LAA, or residual LAA stump size, which may or may not have impact on embolic risk in patients with incomplete LAA closure.

## Conclusion

Our study found a significant rate of incomplete surgical LAA suture closure still exists in the modern surgical era. We also found a composite of female sex, hypertension, and hyperlipidemia to be predictive of incomplete surgical LAA closure. Our data support utility of newer surgical techniques and devices for LAA closure and suggests future studies are needed to identify factors for incomplete surgical LAA closure.

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