

Optimizing Stroke Prevention after AtriClip Left Atrial Appendage Occlusion: A Narrative Review of Anticoagulation Dilemmas and Imaging Needs

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Abstract

Background: Atrial fibrillation (AF) is a major risk factor for ischemic stroke, with the left atrial appendage (LAA) being the predominant source of thrombi. Surgical LAA occlusion (LAAO) with devices like the AtriClip offers a mechanical alternative to long-term oral anticoagulation (OAC), particularly for patients at high bleeding risk or with OAC contraindications.

Purpose: Despite the increasing use of surgical LAAO, optimal post-procedural management—specifically regarding the necessity and duration of anticoagulation and the role of surveillance imaging—remains a subject of debate and practice variability. This comprehensive review examines current anticoagulation strategies, risk stratification tools (CHA₂DS₂-VASc, HAS-BLED), the efficacy and challenges associated with AtriClip LAAO, and the critical role of postoperative imaging modalities (transesophageal echocardiography [TEE] and cardiac computed tomography angiography [CTA]).

Findings: Current guidelines offer divergent recommendations on anticoagulation following surgical LAAO. While LAAO significantly reduces thromboembolic risk, a residual risk persists due to potential incomplete LAA exclusion, thrombus formation on remnant stumps, or non-LAA embolic sources. The CHA₂DS₂-VASc score remains crucial for risk assessment guiding anticoagulation decisions. Postoperative imaging is vital for confirming complete LAA occlusion, detecting device-related thrombus or residual leaks, and guiding individualized antithrombotic therapy. However, robust long-term data on thromboembolic events post-AtriClip and direct comparisons with contemporary DOAC therapy are limited.

Conclusion: Management following surgical LAAO with AtriClip requires a personalized approach, integrating baseline thromboembolic and bleeding risks with imaging-confirmed procedural success. Routine postoperative imaging is essential. Further research, including randomized controlled trials, is needed to standardize post-LAAO anticoagulation protocols, define optimal imaging surveillance strategies, and clarify the management of incomplete LAA occlusion to improve long-term outcomes in AF patients.

Keywords: Atrial fibrillation, Left atrial appendage occlusion, AtriClip, Anticoagulation, Stroke prevention, Transesophageal echocardiography, Computed tomography angiography

Introduction

Atrial fibrillation (AF) is the most prevalent sustained cardiac arrhythmia, posing a significant public health burden due to its association with thromboembolic stroke. The incidence of AF is escalating, with projections indicating that 6–16 million

individuals in the United States will be affected by 2050 [1]. AF is characterized by disorganized atrial electrical activity, leading to ineffective atrial contraction and blood stasis, primarily within the left atrial appendage (LAA). Notably, in nonvalvular AF, approximately 90% of stroke-causing emboli originate from the LAA [2,3]. Patients with AF face a fivefold

increased risk of stroke compared to the general population; these strokes are often more severe, resulting in extensive neurological damage and higher rates of disability and mortality [4].

For decades, oral anticoagulation (OAC) has been the cornerstone of stroke prevention in AF, with treatment decisions guided by risk stratification tools such as the CHA₂DS₂-VASc score [5]. However, a substantial proportion of patients cannot tolerate long-term OAC due to a high risk of bleeding, as assessed by scores like HAS-BLED, or other contraindications. This has spurred the development of alternative strategies, including percutaneous LAA occlusion (LAAO) devices (e.g., PLAATO, LARIAT, Amplatzer, Watchman) and surgical LAAO techniques such as LAA excision, epicardial clipping (e.g., AtriClip), and endocardial suture ligation. Surgical LAAO, often performed concomitantly with other cardiac surgeries like coronary artery bypass grafting or valve repair, offers a mechanical solution to exclude the LAA from systemic circulation. The AtriClip device is a widely used epicardial tool for this purpose.

Despite the compelling rationale for LAAO, considerable uncertainty persists regarding optimal anticoagulation management following the procedure. Current guidelines offer conflicting or incomplete recommendations, leading to significant variability in clinical practice. While the Society of Thoracic Surgeons (STS) endorses LAAO in non-emergent cardiac surgeries, it provides no specific guidance on postoperative anticoagulation [6]. Conversely, the 2023 American College of Cardiology (ACC)/American Heart Association (AHA) guidelines suggest that patients with a CHA₂DS₂-VASc score of ≥ 2 should receive both LAA exclusion and continued anticoagulation to mitigate stroke risk [7]. This discrepancy highlights a critical knowledge gap, particularly for patients at high risk for both thromboembolism and bleeding. This review aims to comprehensively examine current anticoagulation strategies, the role of risk stratification, the efficacy and challenges of LAAO with the AtriClip device, and the importance of postoperative imaging, to inform the development of evidence-based guidelines for managing these complex patients.

Anticoagulation Therapy for Atrial Fibrillation

Oral anticoagulants have long been pivotal in preventing thromboembolic stroke in AF. Warfarin, a vitamin K antagonist, has demonstrated a significant reduction in stroke risk (64%) and mortality (26%) in AF patients, particularly those with moderate-to-high CHA₂DS₂ [4,8]. However, warfarin therapy requires meticulous management, including regular International Normalized Ratio (INR) monitoring, due to its narrow therapeutic window and numerous drug and dietary interactions.

The advent of direct oral anticoagulants (DOACs)—including dabigatran, rivaroxaban, apixaban, and edoxaban—has revolutionized anticoagulation management. Pivotal clinical trials (e.g., ROCKET AF, ARISTOTLE, RE-LY, ENGAGE AF-TIMI 48) have shown that DOACs are at least as effective as warfarin in preventing ischemic stroke and are associated with a significantly lower risk of intracranial hemorrhage (by approximately 50%) [9]. DOACs offer several advantages, including predictable pharmacokinetics, fewer drug-food interactions, and no requirement for routine coagulation monitoring, which can enhance patient adherence and quality of life. Consequently, DOACs are now preferred over warfarin for eligible AF patients, balancing effective stroke prevention with an improved safety profile [4,9].

Risk Stratification: CHA₂DS₂-VASc and HAS-BLED Scores

Effective management of AF hinges on accurate risk stratification to tailor stroke prevention strategies while minimizing bleeding complications. The CHA₂DS₂-VASc score is a validated tool that estimates the annual risk of stroke in patients with nonvalvular AF. Points are assigned for **C**ongestive heart failure, **H**ypertension, **A**ge (≥ 75 years [2 points] or 65–74 years [1 point]), **D**iabetes mellitus, prior **S**troke or transient ischemic attack or thromboembolism (2 points), **V**ascular disease, and **S**ex category (female). The CHA₂DS₂-VASc score provides a more refined risk assessment than the older CHADS₂ score, particularly for patients at low to intermediate risk, and is integral to guiding anticoagulation decisions [10]. Recent guidelines have removed the sex category component from CHA₂DS₂-VASc, reflecting emerging evidence that female sex alone does not confer additional stroke risk in the absence of other risk factors.

Concurrently, the HAS-BLED score (**H**ypertension, **A**bnormal renal/liver function, **S**troke, **B**leeding history or predisposition, **L**abile INR, **E**lderly [e.g., >65 years], **D**rugs/ alcohol concomitantly) assesses the 1-year risk of major bleeding in AF patients on anticoagulation [11]. This score aids clinicians in identifying patients at higher bleeding risk, allowing for more cautious anticoagulation strategies, dose adjustments, or consideration of non-pharmacological stroke prevention approaches. The integrated use of CHA₂DS₂-VASc and HAS-BLED scores, as emphasized in current ACC/AHA guidelines, facilitates a personalized approach to stroke prevention, critically balancing thrombotic and hemorrhagic risks [7,12,13].

Antithrombotic Treatment Following LAAO with the AtriClip Device

Given the inherent bleeding risks associated with long-term anticoagulation, LAAO has emerged as a compelling alternative for stroke prevention in AF, especially for patients

with contraindications to OAC [14,15]. Surgical LAAO with devices like the AtriClip aims to mechanically exclude the LAA, the primary site of thrombus formation in non-valvular AF [16]. Postoperative imaging is crucial for assessing the success of LAAO.

Several studies have investigated the efficacy of AtriClip LAAO. The ATLAS trial, a randomized study, demonstrated a 2.2% absolute risk reduction in thromboembolism at one year in patients with AF undergoing prophylactic LAAO during cardiac surgery compared to no LAAO. In this trial, 44.3% of patients experienced postoperative AF, and OAC was used in 32.5% [17]. More recently, Rose *et al.* (2024), in an observational study, reported that minimally invasive AtriClip placement significantly reduced thromboembolic events by 4.8% in high-risk AF patients compared to those without LAA exclusion, underscoring its potential efficacy and favorable safety profile, often without the need for long-term anticoagulation in their selected cohort [18]. However, the observational nature of such studies means patient selection and unmeasured confounders could influence outcomes.

Multimodality Imaging Following LAAO with the AtriClip Device

Transesophageal echocardiography (TEE) and cardiac computed tomography angiography (CTA) are commonly employed to evaluate the completeness of LAA occlusion, detect any residual communication or peri-device leak, and identify thrombus formation. Such imaging is particularly important before considering cardioversion or alterations in antithrombotic therapy, as thrombus on or near the device/stump can have serious embolic consequences [19].

Studies assessing closure success with AtriClip have reported varying rates, partly due to differing imaging modalities,

follow-up durations, and definitions of "success." Kiankhooy *et al.* found successful closure in 96% of 97 patients at 1-year follow-up using TEE, defining failure as a residual pouch >1 cm or flow into the LAA [20]. Ellis *et al.* using CTA in 65 patients followed for a mean of 2.82 years, reported successful complete exclusion in 94%, with success defined as no exposed trabeculations and the clip within 1 cm of the left circumflex artery [21]. Kurfirst *et al.* observed 98% successful perioperative clip implantation in 92 patients followed for a mean of 18 months with TEE/CTA, reporting no clip migration, leakage, or clot formation near any remnant cul-de-sac [22]. A systematic review by Toale *et al.* (2019), encompassing 922 patients from largely observational data, found an overall AtriClip procedural success rate of 98% [23].

However, some studies highlight challenges. Ahmed *et al.* in a retrospective study of 78 AtriClip patients, found a remnant stump (defined as any LAA tissue distal to the clip) in 20% at 3-6 months follow-up with CTA [24], emphasizing the need for clear and standardized definitions of what constitutes a clinically significant remnant. Yoshimoto *et al.* reported small clots at the stump site in approximately 7.9% of 102 patients followed for 1.5 years with CTA [25]. Conversely, Emmert *et al.*, in a longer-term prospective device trial of 36 patients (mean follow-up 3.5 years) using TEE/CTA, reported no residual stump and only one unrelated TIA, with only 8.3% of patients on anticoagulation at follow-up [26].

AtriClip LAAO outcomes across multiple series shows variability in reported failure rates and thromboembolic events but confirming an overall favorable safety profile (Table 1). These findings underscore the importance of meticulous surgical technique and comprehensive postoperative imaging. Case reports have documented thrombus formation in remnant pouches or stumps even after apparently successful AtriClip deployment, as these areas can be highly

Table 1. AtriClip LAA occlusion studies: procedural success, complete closure rates, thromboembolic outcomes and imaging modality used to detect LAA closure.						
Study	Sample size	Follow up Duration	Failure rate (Pouch still open)	Thromboembolic events/ clots at stump site	Anticoagulation	Imaging modality
Kiankhooy <i>et al.</i> [20]	97	1.87 yrs	4%	none reported	5.1%	TEE
Ellis <i>et al.</i> [21]	65	2.82 yrs	6.2%	1.6%	>20%	CTA
Toale <i>et al.</i> [23]	922	NA	2.2%	2%	40.3%	TEE/CTA
Kurfirst <i>et al.</i> [22]	101	1.5 yrs	2%	4.3%	52%	TEE/CTA
Yoshimoto <i>et al.</i> [25]	102	1.5 yrs	1%	7.9%	38.2%	CTA
Emmert <i>et al.</i> [26]	36	3.5 yrs	0%	2.7%	8.3%	TEE/CTA
Gerdisch <i>et al.</i> [17]	376	1yr	1%	3.4%	23.7%	TEE
Rose <i>et al.</i> [18]	243	3 yrs	NA	7.3%	0	TEE/CTA
Ahmed <i>et al.</i> [24]	78	1 yr	46.2%	3.84%	NA	CTA

thrombogenic [19]. This necessitates imaging surveillance, particularly TEE before cardioversion, to prevent embolic complications. The Society for Cardiovascular Angiography & Interventions (JSCAI) recommends intraprocedural echocardiography for transcatheter LAAO and follow-up imaging at 45-90-day intervals if thrombus is identified, guiding decisions on anticoagulation discontinuation [19]. While these recommendations are for transcatheter approaches, the principles of vigilant imaging surveillance are undoubtedly relevant to surgical LAAO.

Discussion

Antithrombotic treatment following LAAO with the AtriClip device

The left atrial appendage (LAA) is recognized as the primary source of thrombus formation in approximately 90% of patients with non-valvular AF, significantly elevating their risk of systemic embolism and stroke. This understanding has led to the development and endorsement of LAAO procedures, particularly as an adjunct to non-emergent cardiac surgeries, a strategy supported by the 2024 STS guidelines [6]. Despite the established efficacy of LAAO in reducing thromboembolic risk, the optimal strategy for continued anticoagulation post-procedure remains a subject of considerable debate and variability in clinical practice. This uncertainty forms a key challenge for clinicians managing these patients.

Current guidelines offer differing perspectives on this matter. The 2023 ACC/AHA guidelines, for instance, recommend LAAO in conjunction with continued anticoagulation for patients undergoing cardiac surgery who possess a CHA₂DS₂-VASc score of ≥ 2 . This dual approach aims to comprehensively reduce stroke risk [7], acknowledging that LAAO addresses only one, albeit major, source of thrombi. The CHA₂DS₂-VASc score remains a cornerstone for assessing overall stroke risk in individuals with AF; a score of 6, for example, correlates with an annual stroke risk of approximately 9.8%, escalating to 15.2% for those with a score of 9 [27] (**Supplementary Table 1**).

Decisions regarding post-LAAO anticoagulation should be individualized, primarily guided by the patient's CHA₂DS₂-VASc score and bleeding risk (e.g., HAS-BLED score). Higher CHA₂DS₂-VASc scores may justify lifelong anticoagulation to mitigate the persistent systemic risk of embolism, irrespective of LAAO status. This approach is supported by large population-based studies suggesting that for patients at higher intrinsic stroke risk, the benefits of anticoagulation generally outweigh the associated bleeding risks. The key message is that LAAO modifies one aspect of stroke risk, but the overall patient risk profile, as captured by validated scores, must continue to drive anticoagulation decisions.

Multimodality imaging following LAAO with the AtriClip device

The AtriClip device, a widely utilized LAAO technique with extensive global application, has demonstrated promising outcomes in achieving LAA closure; manufacturer data indicate that over 600,000 devices have been implanted. The majority of patients achieve successful LAA exclusion. However, a subset of patients may exhibit residual LAA flow or develop remnant stumps post-procedure. Such remnants can be highly thrombogenic, posing a significant ongoing risk of thromboembolism. While existing short-term studies have investigated the incidence of early clot formation, comprehensive long-term data on the evolution of these remnants and late thromboembolic events are limited. This knowledge gap underscores the critical importance of routine, high-quality follow-up imaging, typically employing CTA or TEE, to confirm complete and durable LAA exclusion.

It is crucial to acknowledge that despite the substantial reduction in thromboembolic events afforded by AtriClip placement, the procedure does not entirely eliminate stroke risk. Consequently, a strategy of regular imaging surveillance is advisable, particularly between 6 to 12 months post-procedure, and potentially longer in select individuals. This allows for the evaluation of remnant stumps, residual flow, or *de novo* thrombus development. Such vigilance is paramount, as organized thrombi can form over extended periods, necessitating long-term follow-up imaging to ensure optimal patient outcomes and to inform ongoing antithrombotic management.

Several factors contribute to the residual thromboembolic risk following AtriClip LAAO. Firstly, while the device effectively addresses the LAA—the origin of approximately 90% of AF-related emboli—a baseline risk of about 10% from non-LAA sources (e.g., carotid disease, aortic arch atheroma, left ventricular thrombus) persists. Secondly, incomplete surgical exclusion can result in residual LAA stumps, which themselves can act as highly thrombogenic foci. Thirdly, the reported incidence of remnant stumps and what constitutes AtriClip "failure" can be variable. This variability is influenced not only by surgical expertise but also by the rigor of imaging interpretation during both intraoperative and postoperative assessments, and the lack of universally standardized definitions for a "significant" remnant or leak across studies. Collectively, these elements contribute to a notable ongoing thromboembolic risk, even after technically successful AtriClip deployment. This risk is further amplified in patients with higher baseline CHA₂DS₂-VASc scores and in instances where LAA closure is ultimately incomplete.

Therefore, a clear take-home message is that all patients who have undergone AtriClip placement should be considered for

follow-up assessments with TEE or CTA to confirm successful and complete LAA closure. If a remnant stump or significant peri-device leak is identified, continuation of anticoagulation is generally recommended. Further imaging evaluations may be warranted to assess the stability or resolution of such findings before any consideration of discontinuing anticoagulation. Although the AtriClip device demonstrates high initial success rates, there is a paucity of robust, long-term studies specifically designed to evaluate thromboembolic risk beyond the initial years post-implantation. Furthermore, head-to-head randomized controlled trials comparing surgical LAAO with AtriClip (with or without various post-procedural antithrombotic regimens) against contemporary DOAC therapy alone are notably absent from the current evidence base.

Conclusion and Future Directions

Surgical LAAO with the AtriClip device represents an effective intervention for reducing thromboembolic risk in appropriately selected patients with AF, particularly those undergoing concomitant cardiac surgery. However, it is imperative to recognize that LAAO does not entirely eliminate the risk of stroke. The decision to continue or discontinue anticoagulation post-LAAO must be meticulously individualized. This requires a careful synthesis of the patient's baseline thromboembolic (CHA₂DS₂-VASc) and bleeding (HAS-BLED) risks, the confirmed completeness and durability of LAA occlusion as assessed by high-quality postoperative imaging (TEE or CTA), and other evolving clinical factors and patient preferences.

Current evidence strongly supports the necessity of routine postoperative imaging to ensure complete and durable LAA exclusion and to identify potential complications, such as remnant stumps or device-related thrombus, which may warrant ongoing anticoagulation. A CHA₂DS₂-VASc score of ≥ 2 , particularly in the context of documented incomplete LAA occlusion or other persistent prothrombotic risk factors, generally supports consideration for continued anticoagulation therapy. The central message for clinicians is that LAAO is an important adjunctive therapy, not a universal replacement for anticoagulation in all patients.

Significant research gaps persist in this field. There is a pressing need for well-designed, prospective, randomized controlled trials to directly compare the long-term clinical outcomes—encompassing stroke, major bleeding, and mortality—of surgical LAAO (employing various postoperative anticoagulation strategies) against treatment with modern DOACs alone in comparable patient populations. Further research should also focus on standardizing postoperative imaging protocols, defining optimal imaging intervals for long-term surveillance, and clarifying the clinical significance

and appropriate management strategies for small residual LAA communications or stumps. Addressing these critical questions through rigorous investigation will be instrumental in refining clinical guidelines and optimizing stroke prevention strategies for the expanding global population of patients living with atrial fibrillation.

Clinical Perspectives

- AF carries high stroke risk from LAA; AtriClip offers mechanical occlusion.
- Real-world data demonstrate high procedural success and low complication rates with AtriClip.
- Individualize anticoagulation post-AtriClip by CHA₂DS₂-VASc and closure imaging.
- RCTs and standardized imaging protocols are needed to optimize post-LAAO care.

Conflict of Interest

Conflict of interest statement for all authors: We do not have any financial or non-financial conflicts of interest.

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