JCS Journal of Chest Surgery
https://doi.org/10.5090/jcs.22.081
pISSN: 2765-1606 eISSN: 2765-1614
J Chest Surg. 2023;56(2):90-98

Clinical Research

Comparison of Early Complications of Oral Anticoagulants after Totally Thoracoscopic Ablation: Warfarin versus Non-vitamin K Antagonist Oral Anticoagulants

MuHyung Heo, M.D.[1], Dong Seop Jeong, M.D., Ph.D.[1], Suryeun Chung, M.D., Ph.D.[1], Kyoung Min Park, M.D., Ph.D.[2], Seung Jung Park, M.D., Ph.D.[2], Young Keun On, M.D., Ph.D.[2]

[1]Department of Thoracic and Cardiovascular Surgery, Samsung Medical Center, Sungkyunkwan University School of Medicine; [2]Department of Internal Medicine, Cardiac and Vascular Center, Samsung Medical Center, Sungkyunkwan University School of Medicine, Seoul, Korea

ARTICLE INFO
Received August 7, 2022
Revised November 8, 2022
Accepted November 14, 2022

Corresponding author
Dong Seop Jeong
Tel 82-2-3410-1213
Fax 82-2-3410-3485
E-mail dongseop.jeong@samsung.com
ORCID
https://orcid.org/0000-0002-6947-8403

Background: Atrial fibrillation (AF) is the most common type of cardiac arrhythmia. Totally thoracoscopic ablation (TTA) is a surgical treatment showing a high success rate as a hybrid procedure with radiofrequency catheter ablation to control AF. This study compared the early complications of warfarin and non-vitamin K antagonist oral anticoagulants (NOACs) in patients who underwent TTA.

Methods: This single-center retrospective cohort study enrolled patients who underwent planned TTA for AF from February 2012 to October 2020. All patients received postoperative anticoagulation, either with warfarin or a NOAC (apixaban, rivaroxaban, dabigatran, or edoxaban). Propensity score matching was performed for both groups. Early complications were assessed at 12 weeks after TTA and were divided into efficacy and safety outcomes. Both efficacy and safety outcomes were compared in the propensity score-matched groups.

Results: Early complications involving efficacy outcomes, such as stroke and transient ischemic attack, were seen in 5 patients in the warfarin group and none in the NOAC group. Although the 2 groups differed in the incidence of efficacy outcomes, it was not statistically significant. In safety outcomes, 11 patients in the warfarin group and 24 patients in the NOAC group had complications, but likewise, the between-group difference was not statistically significant.

Conclusion: Among patients who underwent TTA, those who received NOACs had a lower incidence of thromboembolic complications than those who received warfarin; however, both groups showed a similar bleeding complication rate. Using a NOAC after TTA does not reduce efficacy and safety when compared to warfarin.

Keywords: Atrial fibrillation, Anticoagulants, Minimally invasive surgical procedures

Introduction

Atrial fibrillation (AF) is one of the most common arrhythmias, with a prevalence of 1%, and its incidence increases with age [1]. The morbidity and mortality associated with AF might increase if the condition is left untreated. Rate and rhythm control using drug therapy is recommended as the first-line treatment, and invasive treatment can be considered for refractory AF that does not respond to pharmacological treatment [2].

Catheter ablation is an invasive procedure, and the Cox maze procedure is a surgical treatment for AF. In cases of radiofrequency catheter ablation, multiple studies have reported an approximately 80% success rate, but the long-term outcome of a single procedure has a success rate of around 50%, with a high recurrence rate [3]. Although Cox maze surgery is highly successful [4], it is an open-heart procedure involving sternotomy, and the risk of complications is increased because of the need for cardiopulmonary bypass during surgery. As an alternative, totally thoraco-

scopic ablation (TTA) is a minimally invasive surgical procedure that is performed as a rhythm control strategy for AF.

There is no consensus on the anticoagulation regimen to be used after TTA; therefore, it is recommended to use the standard post-ablation anticoagulation regimen. Anticoagulation for at least 8 weeks is recommended owing to the risk of thromboembolic events even after successful AF ablation. After 8 weeks, oral anticoagulation is recommended to patients with AF according to the CHA_2DS_2-VASc score [5]. Regarding the types of oral anticoagulants used in AF, the safety of warfarin use has been confirmed, while non-vitamin K oral anticoagulants (NOACs) are increasingly being used due to their safety and convenience. However, studies confirming the safety and efficacy according to the type of anticoagulant after TTA are lacking. In this study, we aimed to confirm the efficacy and safety of NOACs compared to warfarin in patients after TTA.

Methods

Patients

In this single-center retrospective cohort study, 535 patients who underwent TTA for AF from February 2012 to October 2020 were initially selected. We excluded 5 patients who did not receive oral anticoagulation after TTA, and 8 patients who had missing values for preoperative echocardiography. We enrolled 522 patients in the study (Fig. 1), and the incidence rate of early complications after surgery was assessed according to the type of anticoagulant.

This study was approved by the Institutional Review Board of Samsung Medical Center (IRB approval no., 2022-02-028-001). The requirement for informed consent from individual patients was omitted because of the retrospective design of this study.

Anticoagulation

All patients took oral anticoagulants for at least 12 weeks. From 2012 to 2014, patients received anticoagulation during the post-ablation follow-up period according to a guideline that recommended anticoagulation after catheter ablation for 3 months before 2014 and longer than 2 months after 2014 [2,6]. Patients were divided into 2 groups: those taking warfarin and those taking NOACs after surgery. All patients underwent preoperative heparinization according to standard protocols the day before surgery. After TTA, if there was no risk of bleeding, patients received bridging anticoagulation with heparin before starting oral anticoagulation. Heparin was administered as a continuous intravenous infusion, and the target range of activated partial thromboplastin time (aPTT) was between 55 and 75 seconds. The aPTT level was checked every 6 hours, and if the target aPTT was not reached, the intravenous dose was continuously increased and adjusted. For oral anticoagulation, either warfarin or 1 of 4 NOACs approved by the US Food and Drug Administration (apixaban, rivaroxaban, edoxaban, and dabigatran) was used. In the warfarin group, the target range of the international normalized ratio (INR) was set between 2.0 to 2.5, and heparin was administered continuously until the INR reached above 1.5. In the NOAC

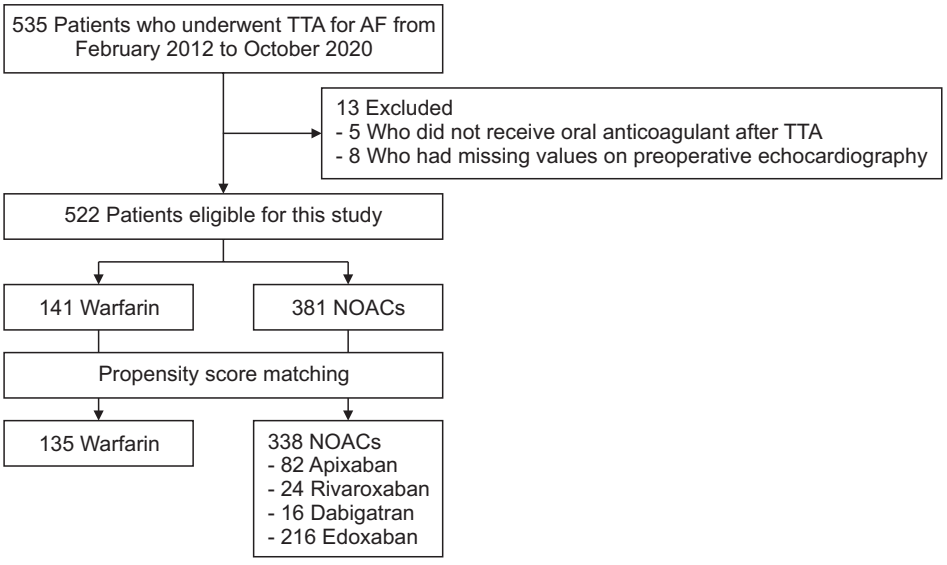

Fig. 1. Study flow of patients treated with anticoagulants. TTA, totally thoracoscopic ablation; AF, atrial fibrillation; NOAC, non-vitamin K antagonist oral anticoagulant.

group, heparinization was stopped immediately after administering a NOAC.

Operative techniques

At Samsung Medical Center, TTA was defined as a surgical ablation technique without cardiopulmonary bypass through video-assisted thoracoscopic surgery. For surgery, 3 minimal incisions were made on each side of the chest wall, followed by a port insertion. Starting from the right, a 5-mm port was placed in the chest through the incision at the fourth intercostal space and midaxillary line, and then CO_2 was injected to secure the operating field. A 5-mm port was secured in the anterior axillary third intercostal space and midaxillary sixth intercostal space, and the existing 5-mm port was extended to a 12-mm port. After opening the pericardium, right-side ablation was performed on the superior vena cava and on the box region. Pulmonary vein isolation was performed using an AtriCure isolator transpolar clamp (AtriCure Inc., Cincinnati, OH, USA). Clamping was performed 6 times using bipolar radiofrequency energy. The port was inserted in the same way on the left side, and pulmonary vein isolation was performed in the same way as on the right. After the division of the ligament of Marshall, box lesion ablation was completed. Once the ablation was completed, the left atrial auricle was resected using an endoscopic stapling device or clipped using an atrial auricle clip.

Postoperative complications

The incidence rate of early complications after surgery was assessed based on the type of anticoagulation. Early complications were defined as complications occurring within 12 weeks after the surgery and were divided into efficacy and safety outcomes. Efficacy outcomes, understood as thromboembolic events, included stroke, transient ischemic attack (TIA), and any other cardiac thromboembolic event. Safety outcomes included major bleeding, minor bleeding, and pericarditis requiring intervention and rehospitalization. Major bleeding was defined as bleeding that needed any form of invasive procedure or surgery that led to transfusion of 2 or more units of red blood cells [7]. Any bleeding other than major bleeding as defined above was considered minor.

Statistical analysis

Continuous variables were expressed as mean±standard deviation, and the Student t-test was used to compare the mean values. Categorical variables were compared in proportions using the chi-square test and the Fisher exact test. We performed propensity score matching analysis. In the NOAC group and the warfarin group, N-to-1 individual matching was performed within a caliper by a propensity score with a variable matching ratio (caliper=0.2, matching ratio=3:1). The weighted chi-square test was performed as it was judged that it would not be necessary to perform censored data analysis on the rate of event occurrence for 12 weeks. The weights used in the weighted chi-square were calculated by variable matching ratios. Since weights were used for the outcomes in Table 1, an estimated value was used for the frequency of events. The p-value could not be calculated for events with a frequency of 0. Kaplan-Mei-

Table 1. Comparison of early complications between the warfarin and NOAC groups after propensity score matching

Variable	Matched data			Weighted matched data		
	Warfarin (N=135)	NOACs (N=338)	p-value	Warfarin (N=135)	NOACs (N=338)	p-value
Efficacy outcomes						
All events	5 (3.7)	0	NA	5 (3.7)	0	NA
Stroke	4 (3.0)	0	NA	4 (3.0)	0	NA
Transient ischemia attack	1 (0.7)	0	NA	1 (0.7)	0	NA
Other cardiac thromboembolic event	0	0	NA	0	0	NA
Safety outcomes						
All events	11 (8.1)	24 (7.1)	0.843	11 (8.1)	24.6 (7.3)	0.760
Major bleeding	1 (0.7)	3 (0.9)	1.000	1 (0.7)	2.9 (0.9)	0.895
Minor bleeding	7 (5.2)	11 (3.3)	0.468	7 (5.2)	10.8 (3.2)	0.302
pericarditis	3 (2.2)	10 (3.0)	0.896	3 (2.2)	10.8 (3.2)	0.589
Death	0	1 (0.3)	1.000	0	0.8 (0.2)	0.527

Values are presented as number (%).
NOAC, non-vitamin K antagonist oral anticoagulant; NA, not available.

er survival analysis was used to plot curves for freedom from the safety and efficacy outcomes, and the 2 study groups were compared using the log-rank test. Early complications of NOACs were calculated from unmatched data, and the early complications of the 4 NOAC groups (apixaban, rivaroxaban, dabigatran, or edoxaban) were compared using the chi-square test. A p-value of less than 0.05 was considered statistically meaningful. Statistical analyses were performed with R Statistical Software ver. 4.2.0 (The R Foundation for Statistical Computing, Vienna, Austria).

Results

Baseline characteristics

Of the 522 patients, 141 (27%) received warfarin and 381 patients (73%) received a NOAC. Fig. 2 shows the frequency of anticoagulants used after TTA by operation date and the number of early complication events. The number of patients using NOACs exceeded that of patients using warfarin from 2015 onwards, and edoxaban was the most frequently used NOAC. After propensity score matching, the warfarin group contained 135 patients (28.5%), and the NOAC group comprised 338 patients (72.5%). The proportion of NOACs was as follows: apixaban, 17.3%; rivaroxaban, 5.1%; dabigatran, 3.4%; and edoxaban, 45.7% (Table 2). Table 3 shows the baseline demographic and clinical characteristics of patients. Before propensity score matching, age showed a statistically significant difference. However, there were no statistically significant differences between the 2 groups after propensity matching.

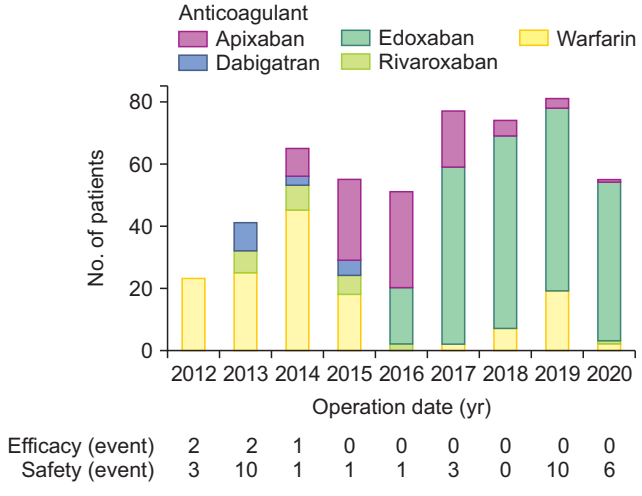

Fig. 2. Frequency of use according to anticoagulant type by operation date.

Early complications

Regarding the efficacy outcomes, 5 patients (3.7%) experienced early complications in the warfarin group, of whom 4 patients had stroke events and 1 patient had TIA. There were no patients with early complications in the NOAC group, and no other thromboembolic events were identified in either group (Table 1).

Early complications associated with safety outcomes were confirmed in 11 patients (7.6%) in the warfarin group and 24 patients (weighted frequency=24.6, weighted proportion=7.3%) in the NOAC group (p=0.760). Four patients required surgical treatment or intervention for major bleeding—1 patient (0.7%) in the warfarin group and 3 patients (weighted frequency=2.9, weighted proportion=0.9%) in the NOAC group—with no significant difference between the groups. Minor bleeding was observed in 7 patients (5.2%) in the warfarin group and in 11 patients (weighted frequency=10.8, weighted proportion=3.2%) in the NOAC group, but no statistically significant difference was found. Pericarditis that required intervention and rehospitalization after TTA was confirmed in 3 patients (2.2%) in the warfarin group and 10 patients (weighted frequency=10.8, weighted proportion=3.2%) in the NOAC group, and there was no significant difference between the 2 groups. There was 1 death (weighted frequency=0.8, weighted proportion=0.2%) in the NOAC group.

The curves for freedom from the safety and efficacy outcomes in the 2 groups are shown in Fig. 3. For the effectiveness outcomes, a statistically significant difference was found (p<0.0001), while for the safety outcomes, no significant difference between the 2 groups was identified.

We compared the difference in outcomes according to the type of NOAC (Table 4). Safety events occurred in 3.2% of the patients who received apixaban, 16.7% of those who received rivaroxaban, 23.5% of those who received dabigatran, and 5.3% of those who received edoxaban. Safety outcomes showed a statistically significant difference accord-

Table 2. Classification of anticoagulants (N=522)

Anticoagulant	Before matching	After matching
Warfarin	141 (27.0)	135 (28.5)
NOACs	381 (73.0)	338 (72.5)
Apixaban	94 (17.7)	82 (17.3)
Rivaroxaban	24 (4.5)	24 (5.1)
Dabigatran	17 (3.2)	16 (3.4)
Edoxaban	250 (47.2)	216 (45.7)

Values are presented as number (%).
NOAC, non-vitamin K antagonist oral anticoagulant.

https://doi.org/10.5090/jcs.22.081

Table 3. Baseline patient characteristics

Characteristic	Before matching				After matching		
	Warfarin (N=141)	NOACs (N=381)	p-value	SMD	Warfarin (N=135)	NOACs (N=338)	SMD
Age (yr)	55.62±9.16	57.72±8.94	0.018	0.232	55.78±8.88	56.09±8.56	0.035
Sex (male)	15 (10.6)	51 (13.4)	0.490	0.085	14.0 (10.4)	38.0 (11.2)	0.028
Body mass index (kg/m^2)	25.41±2.95	25.78±3.26	0.240	0.119	25.46±2.86	25.59±3.29	0.04
CHA2DS2-VASc score	1.18±1.20	1.35±1.33	0.179	0.136	1.16±1.18	1.13±1.22	0.022
Smoking			0.687	0.085			0.06
Never smoker	72 (51.1)	188 (49.3)			66.0 (48.9)	162.7 (48.1)	
Ex-smoker	55 (39.0)	162 (42.5)			55.0 (40.7)	145.2 (43.0)	
Current smoker	14 (9.9)	31 (8.1)			14.0 (10.4)	30.0 (8.9)	
AF type			0.746	0.075			0.046
Paroxysmal	24 (17.0)	67 (17.6)			23.0 (17.0)	54.7 (16.2)	
Persistent	34 (24.1)	80 (21.0)			31.0 (23.0)	73.0 (21.6)	
Long-standing	83 (58.9)	234 (61.4)			81.0 (60.0)	210.3 (62.2)	
AF duration (mo)	50.40±55.33	52.62±51.55	0.669	0.041	51.02±56.23	50.32±49.69	0.013
Hypertension	47 (33.3)	150 (39.4)	0.245	0.126	44.0 (32.6)	115.2 (34.1)	0.031
Diabetes mellitus	18 (12.8)	43 (11.3)	0.754	0.046	17.0 (12.6)	43.4 (12.8)	0.007
Congestive heart failure	14 (9.9)	35 (9.2)	0.929	0.025	14.0 (10.4)	33.0 (9.8)	0.021
Hypertrophic cardiomyopathy	4 (2.8)	13 (3.4)	0.959	0.033	4.0 (3.0)	9.6 (2.8)	0.007
Chronic kidney disease[a]	2 (1.4)	4 (1.0)	1.000	0.033	0	0	<0.001
Hemodialysis	2 (1.4)	0	0.126	0.170	0	0	<0.001
Peripheral artery occlusive disease	4 (2.8)	3 (0.8)	0.168	0.154	1.0 (0.7)	2.1 (0.6)	0.015
Stroke history	21 (14.9)	72 (18.9)	0.351	0.107	21.0 (15.6)	45.9 (13.6)	0.056
Percutaneous coronary intervention history	5 (3.5)	11 (2.9)	0.919	0.037	4.0 (3.0)	10.4 (3.1)	0.007
Radiofrequency catheter ablation history	0.18 (0.38)	0.16 (0.37)	0.639	0.046	0.18 (0.38)	0.16 (0.37)	0.046
Preoperative echocardiography							
Left ventricle ejection fraction	59.70±7.63	59.39±7.62	0.684	0.040	59.54±7.60	59.64±7.17	0.014
Left atrial diameter	45.84±6.93	46.66±7.32	0.25	0.115	45.84±7.00	46.25±7.00	0.058
Left atrial volume index	49.16±17.16	50.49±18.33	0.457	0.074	49.05±17.15	49.88±17.65	0.048

Values are presented as mean±standard deviation or number (%)
NOAC, non–vitamin K antagonist oral anticoagulant; SMD, standardized mean difference; AF, atrial fibrillation.
[a]Estimated glomerular filtration rate <60 mL/min/1.73 m^2.

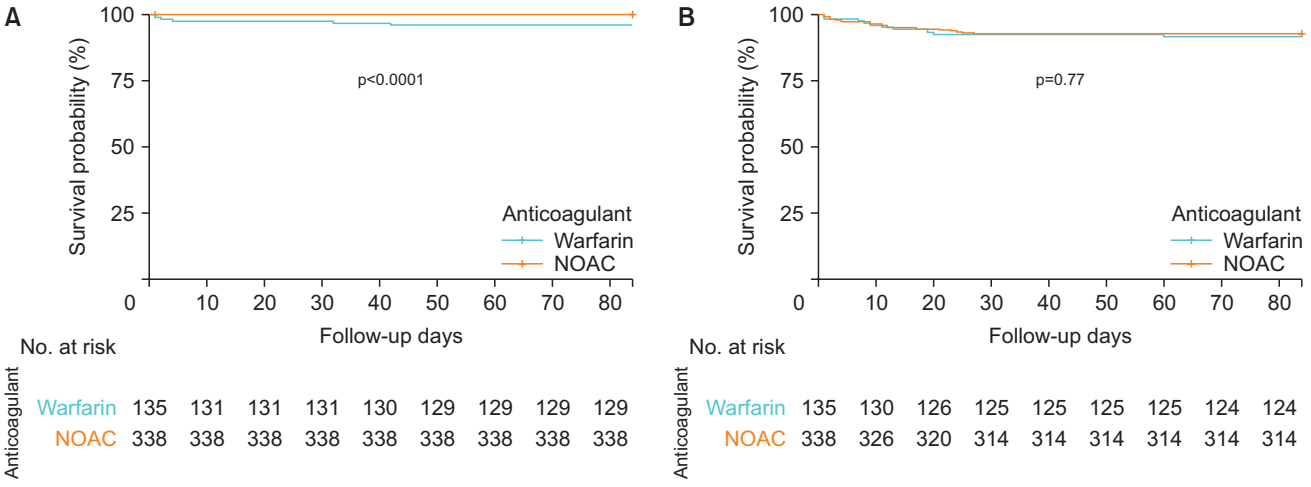

Fig. 3. Kaplan-Meier curve of matched early complications. (A) Efficacy outcomes of the matched warfarin group and non-vitamin K antagonist oral anticoagulant (NOAC) group. (B) Safety outcomes of the matched warfarin group and NOAC group.

Table 4. Comparison of early complications by type of NOAC before propensity score matching

Variable	NOACs (N=385)	Apixaban (N=94)	Rivaroxaban (N=24)	Dabigatran (N=17)	Edoxaban (N=250)	p-value
Efficacy outcomes						
All events	0	0	0	0	0	NA
Safety outcomes						
All events	24 (6.2)	3 (3.2)	4 (16.7)	4 (23.5)	13 (5.3)	0.002
Major bleeding	3 (0.8)	0	0	1 (5.9)	2 (0.8)	0.087
Minor bleeding	11 (2.9)	1 (1.1)	1 (4.2)	2 (11.8)	7 (2.8)	0.111
Pericarditis	10 (2.6)	2 (2.2)	3 (12.5)	1 (5.9)	4 (1.6)	0.012
Death	1 (0.3)	0	0	0	1 (0.4)	0.909

Values are presented as number (%).
NOAC, non-vitamin K antagonist oral anticoagulant; NA, not available.

Table 5. Characteristics of the 5 patients with early complications regarding efficacy

Patient	Event	Event day	Age (yr)	Sex	Body mass index (kg/m^2)	CHA2DS2-VASc score	Atrial fibrillation type	Stroke history	aPTT (sec)	Prothrombin time (sec)	Rhythm
Patient 1	Stroke	POD 42	44	M	22.2	2	Long-standing	Yes	NA	1.81	NS
Patient 2	Stroke	POD 4	62	F	25.7	2	Long-standing	No	35.2	1.02	NS
Patient 3	Stroke	POD 4	38	M	25.5	0	Long-standing	No	46.0	1.93	NS
Patient 4	Stroke	POD 4	65	M	24.1	3	Persistent	Yes	37.0	1.14	NS
Patient 5	TIA	POD 1	57	M	29.9	0	Persistent	No	29.3	1.05	NS

aPTT, activated partial thromboplastin time; POD, postoperative day; M, male; F, female; NA, not available; NS, normal sinus rhythm; TIA, transient ischemic attack.

ing to the type of NOAC (p=0.002). The rate of pericarditis was also found to be different among groups: apixaban, 2.2%; rivaroxaban, 12.5%; dabigatran, 5.9%; and edoxaban, 1.6% (p=0.012).

The 5 cases with efficacy outcomes are reviewed in Table 5. The patients maintained a normal sinus rhythm after surgery and were bridged with heparin until warfarin was initiated. Thromboembolic events occurred within 5 days in 4 patients, and TIA occurred 42 days after TTA in 1 patient. In the immediate postoperative period, events occurred in 4 patients even though heparin bridging was implemented at the time of the events.

Discussion

With the advent of NOACs, numerous studies have been conducted to compare their safety and efficacy to warfarin, which has been used as the main anticoagulant in AF [8-11]. However, the advantages of NOACs remain a matter of debate, and studies have shown similar results regardless of what type of anticoagulants were used after ablation. TTA is a surgical ablation therapy with no established guidelines for perioperative anticoagulation. The TTA surgical procedure differs from the maze procedure, which is representative of surgical ablation, in that open-heart surgery is not required. Therefore, it was thought that applying the maze procedure's guideline to TTA would be appropriate owing to the lack of consensus [12].

Studies comparing warfarin and NOACs directly in association with TTA are limited. A randomized clinical trial was conducted on warfarin and edoxaban, and no difference was shown in complications between the 2 drugs [13]. In our study, we found a significant difference in freedom from the efficacy outcomes in early complications between patients using warfarin and NOACs after TTA, but we could not confirm whether this result was statistically meaningful because the NOAC group had no thromboembolic events. In the past, comparative studies on anticoagulation after catheter ablation have suggested the possibility of replacing NOACs with warfarin [14-16]. According to a meta-analysis conducted by Cardoso et al. [14], the risk of major bleeding and stroke associated with NOACs was lower than that of warfarin. This corroborates our results, as we observed more events in the warfarin group regarding the efficacy outcomes. Since the correlation between thromboembolic events and the anticoagulant type could not be confirmed, there is insufficient evidence to assert the suitability of NOACs compared with warfarin after TTA.

To evaluate the difference in the complication rate seen in our study, 5 cases with stroke and TIA were reviewed (Table 5). Among the patients who experienced these events, 2 had a CHA_2DS_2-VASc score of 0, the other 2 had a score of 2, and the last 1 had a score of 3. Patients with a low probability of thromboembolic events were included. In a study by Noseworthy et al. [15], discontinuation of an oral anticoagulant in post-ablation patients, irrespective of their CHA_2DS_2-VASc score, increased the likelihood of cardiac embolism for at least 3 months. This suggests that thromboembolic events can occur in any patient post-ablation regardless of the CHA_2DS_2-VASc score, supporting the importance of anticoagulation.

For catheter ablation, periprocedural uninterrupted anticoagulation has been established as the standard therapy regardless of warfarin or NOAC [17]. However, if normal sinus rhythm is maintained after successful catheter ablation, the question of whether anticoagulation should be performed immediately is still being debated. According to a systematic review conducted by Proietti et al. [18], there is no significant difference in the frequency of cerebrovascular events regardless of the patient's CHA_2DS_2-VASc score if sinus rhythm is achieved after catheter ablation. However, the risk of bleeding was higher in the anticoagulation group. There is currently no consensus on whether to use anticoagulants in patients who maintain normal sinus rhythm after successful TTA. Among our patients who experienced stroke, all 4 patients who had an event in the immediate postoperative period maintained normal sinus rhythm after the postoperative period. However, the aPTT and prothrombin time did not reach the target levels in any of these patients. It can be speculated that in patients with sinus rhythm after TTA, clinical results similar to those achieved in patients after catheter ablation can be expected. However, additional research is needed to confirm the evidence that the same postoperative anticoagulation guidelines could be used in TTA as in catheter ablation, and additional research is also warranted to confirm the need for immediate anticoagulation and its safety.

The proportions of anticoagulants used between June 2016 and June 2017 at 10 tertiary hospitals in South Korea in patients with AF with nonvalvular heart disease were as follows: warfarin, 20.1%; apixaban, 31%; rivaroxaban, 18%; dabigatran, 20.9%; and edoxaban, 10% [19]. In comparison with our study, there appears to be a remarkable difference in the proportion of edoxaban. Edoxaban, which has been released on the market relatively recently, has been confirmed to have a lower risk of thromboembolic events than warfarin [20]. However, no results have been published comparing effectiveness among NOACs. Most available studies have compared the results between warfarin and a NOAC, but none have compared the differences according to the type of NOAC. Several studies have compared dabigatran, rivaroxaban, and warfarin [21,22], but showed no significant differences in bleeding risk or ischemic risk. In a study comparing apixaban, rivaroxaban, and dabigatran, there was no difference in complications according to the type of NOAC [23]. The comparison of the outcomes of NOAC in our study showed some differences regarding safety outcomes. For pericarditis, a multiple comparison was performed to compare outcomes among each NOAC, and there appeared to be a difference in incidence rate between rivaroxaban and edoxaban. However, the number of patients using rivaroxaban in our study was much different from that of patients using edoxaban, and the incidence of pericarditis was too low. Therefore, further research is needed to confirm whether there is a difference in pericarditis incidence according to the type of NOAC. More broadly, to clarify differences in the effects of different types of NOAC after TTA, more studies should be conducted with large cohorts.

There are some limitations of our study. First, this was a retrospective, single-center study. However, since this was a moderate-sized study, we aimed to provide relatively accurate results for the comparison between the warfarin and NOAC groups. Second, as a study conducted at a single, high-volume center, enrolled patients received the procedure by surgeons with increasing levels of experience over time; hence, it is thought that the complication occurrence might have been affected by the procedure itself. In other words, the effect of the operator factor can be reduced only if a larger study or a multicenter study is conducted. Lastly, although the study size was not small, this study did not derive clinically applicable results confirmed by statistical significance owing to the low frequency of complications after surgery. We believe it is necessary to confirm the complication rates in studies with larger cohorts.

In conclusion, in this study focusing on patient outcomes depending on the type of anticoagulation after TTA, no thromboembolic events or differences in the survival rate were observed in the NOAC group. In addition, there was no difference in outcomes related to bleeding risk between the warfarin and NOAC groups. Although no statistically significant difference could be identified regarding thromboembolic events, our results support the claim that NOAC use after TTA does not reduce efficacy and safety when compared to warfarin.

Article information

ORCID

MuHyung Heo: https://orcid.org/0000-0002-0687-9074
Dong Seop Jeong: https://orcid.org/0000-0002-6947-8403
Suryeun Chung: https://orcid.org/0000-0002-9619-0640
Kyoung Min Park: https://orcid.org/0000-0002-8406-3142
Seung Jung Park: https://orcid.org/0000-0003-3288-0594
Young Keun On: https://orcid.org/0000-0003-1025-7283

Author contributions

Conceptualization: DSJ. Data curation: MH. Formal analysis: MH. Methodology: MH, DSJ. Writing–original draft: MH, DSJ. Writing–review & editing: all authors. Final approval of the manuscript: all authors.

Conflict of interest

No potential conflict of interest relevant to this article was reported.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

References

1. Stewart S, Hart CL, Hole DJ, McMurray JJ. *Population prevalence, incidence, and predictors of atrial fibrillation in the Renfrew/Paisley study*. Heart 2001;86:516-21. https://doi.org/10.1136/heart.86.5.516
2. January CT, Wann LS, Alpert JS, et al. *2014 AHA/ACC/HRS guideline for the management of patients with atrial fibrillation: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines and the Heart Rhythm Society*. J Am Coll Cardiol 2014;64:e1-76. https://doi.org/10.1016/j.jacc.2014.03.022
3. Ganesan AN, Shipp NJ, Brooks AG, et al. *Long-term outcomes of catheter ablation of atrial fibrillation: a systematic review and meta-analysis*. J Am Heart Assoc 2013;2:e004549. https://doi.org/10.1161/JAHA.112.004549
4. Prasad SM, Maniar HS, Camillo CJ, et al. *The Cox maze III procedure for atrial fibrillation: long-term efficacy in patients undergoing lone versus concomitant procedures*. J Thorac Cardiovasc Surg 2003;126:1822-8. https://doi.org/10.1016/s0022-5223(03)01287-x
5. Hindricks G, Potpara T, Dagres N, et al. *2020 ESC guidelines for the diagnosis and management of atrial fibrillation developed in collaboration with the European Association for Cardio-Thoracic Surgery (EACTS): the Task Force for the diagnosis and management of atrial fibrillation of the European Society of Cardiology (ESC) developed with the special contribution of the European Heart Rhythm Association (EHRA) of the ESC*. Eur Heart J 2021;42:373-498. https://doi.org/10.1093/eurheartj/ehaa612
6. European Heart Rhythm Association; European Association for Cardio-Thoracic Surgery, Camm AJ, et al. *Guidelines for the management of atrial fibrillation: the Task Force for the Management of Atrial Fibrillation of the European Society of Cardiology (ESC)*. Eur Heart J 2010;31:2369-429. https://doi.org/10.1093/eurheartj/ehq278
7. Schulman S, Angeras U, Bergqvist D, et al. *Definition of major bleeding in clinical investigations of antihemostatic medicinal products in surgical patients*. J Thromb Haemost 2010;8:202-4. https://doi.org/10.1111/j.1538-7836.2009.03678.x
8. Giugliano RP, Ruff CT, Braunwald E, et al. *Edoxaban versus warfarin in patients with atrial fibrillation*. N Engl J Med 2013;369:2093-104. https://doi.org/10.1056/NEJMoa1310907
9. Granger CB, Alexander JH, McMurray JJ, et al. *Apixaban versus warfarin in patients with atrial fibrillation*. N Engl J Med 2011;365:981-92. https://doi.org/10.1056/NEJMoa1107039
10. Patel MR, Mahaffey KW, Garg J, et al. *Rivaroxaban versus warfarin in nonvalvular atrial fibrillation*. N Engl J Med 2011;365:883-91. https://doi.org/10.1056/NEJMoa1009638
11. Connolly SJ, Ezekowitz MD, Yusuf S, et al. *Dabigatran versus warfarin in patients with atrial fibrillation*. N Engl J Med 2009;361:1139-51. https://doi.org/10.1056/NEJMoa0905561
12. Page P; CCS Atrial Fibrillation Guidelines Committee. *Canadian Cardiovascular Society atrial fibrillation guidelines 2010: surgical therapy*. Can J Cardiol 2011;27:67-73. https://doi.org/10.1016/j.cjca.2010.11.008
13. Lee Y, Jeong DS, Ahn J, et al. *New oral anticoagulant versus vitamin K antagonists for thoracoscopic ablation in patients with persistent atrial fibrillation: a randomized controlled trial*. Semin Thorac Cardiovasc Surg 2021 Dec 5 [Epub]. https://doi.org/10.1053/j.semtcvs.2021.12.003
14. Cardoso R, Knijnik L, Bhonsale A, et al. *An updated meta-analysis of novel oral anticoagulants versus vitamin K antagonists for uninterrupted anticoagulation in atrial fibrillation catheter ablation*. Heart Rhythm 2018;15:107-15. https://doi.org/10.1016/j.hrthm.2017.09.011
15. Noseworthy PA, Yao X, Deshmukh AJ, et al. *Patterns of anticoagulation use and cardioembolic risk after catheter ablation for atrial fibrillation*. J Am Heart Assoc 2015;4:e002597. https://doi.org/10.1161/JAHA.115.002597
16. Sugrue A, Siontis KC, Piccini JP, Noseworthy PA. *Periprocedural anticoagulation management for atrial fibrillation ablation: current knowledge and future directions*. Curr Treat Options Cardiovasc Med 2018;20:3. https://doi.org/10.1007/s11936-018-0600-8

17. Freeman JV, Shrader P, Pieper KS, et al. *Outcomes and anticoagulation use after catheter ablation for atrial fibrillation*. Circ Arrhythm Electrophysiol 2019;12:e007612. https://doi.org/10.1161/CIRCEP.119.007612
18. Proietti R, AlTurki A, Di Biase L, et al. *Anticoagulation after catheter ablation of atrial fibrillation: an unnecessary evil?: a systematic review and meta-analysis*. J Cardiovasc Electrophysiol 2019;30:468-78. https://doi.org/10.1111/jce.13822
19. Kim H, Lee YS, Kim TH, et al. *A prospective survey of the persistence of warfarin or NOAC in nonvalvular atrial fibrillation: a comparison study of drugs for symptom control and complication prevention of atrial fibrillation (CODE-AF)*. Korean J Intern Med 2020;35:99-108. https://doi.org/10.3904/kjim.2017.415
20. Steffel J, Ruff CT, Hamershock RA, et al. *First experience with edoxaban and atrial fibrillation ablation: insights from the ENGAGE AF-TIMI 48 trial*. Int J Cardiol 2017;244:192-5. https://doi.org/10.1016/j.ijcard.2017.05.098
21. Maura G, Blotiere PO, Bouillon K, et al. *Comparison of the short-term risk of bleeding and arterial thromboembolic events in nonvalvular atrial fibrillation patients newly treated with dabigatran or rivaroxaban versus vitamin K antagonists: a French nationwide propensity-matched cohort study*. Circulation 2015;132:1252-60. https://doi.org/10.1161/CIRCULATIONAHA.115.015710
22. Aryal MR, Ukaigwe A, Pandit A, et al. *Meta-analysis of efficacy and safety of rivaroxaban compared with warfarin or dabigatran in patients undergoing catheter ablation for atrial fibrillation*. Am J Cardiol 2014;114:577-82. https://doi.org/10.1016/j.amjcard.2014.05.038
23. Rillig A, Lin T, Plesman J, et al. *Apixaban, rivaroxaban, and dabigatran in patients undergoing atrial fibrillation ablation*. J Cardiovasc Electrophysiol 2016;27:147-53. https://doi.org/10.1111/jce.12856