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DEVICE-RELATED THROMBUS AFTER LEFT ATRIAL APPENDAGE OCCLUSION IN PATIENTS WITH ATRIAL FIBRILLATION: A PROSPECTIVE FOLLOW-UP

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Aim. To study the incidence, predictors, and clinical outcome of device-related thrombus (DRT) after left atrial appendage occlusion (LAAO) in patients with atrial fibrillation (AF).

Methods. A prospective observational study included 120 patients with non-valvular AF who underwent LAAO with Watchman (n=92) and Amplatzer Amulet (n=28). The presence of device-related thrombus (DRT) was assessed at visits 45 days, 6 months, 1 year, 2 years, 3 years after implantation by transesophageal echocardiography.

Results. A total of 11 (9.2%) patients had DRT during the follow-up period. The greatest number of thrombosis was observed after 45 days (n=4) and after 6 months (n=4). There was no significant difference in the incidence of DRT between device types. Independent predictors of thrombosis were: history of myocardial infarction (hazard ratio (HR) 12.88 [95% confidence interval (CI) 3.21-51.62]; p<0.001), chronic heart failure (HR 8.83 [95% CI 1.91-40.77]; p=0.005), residual leak size >5 mm in the early postoperative period (HR 6.13 [95% CI 2.53-14.86]; p<0.001) and the degree of spontaneous echo contrast during the initial examination (HR 9.09 [95% CI 1.36-60.58], p=0.023). There were no cases of thromboembolic complications associated with DRT. One patient developed a non-fatal stroke at 35 weeks of follow-up, while DRT was detected at the visit at the end of the 3rd year of follow-up.

Conclusion. DRT after LAAO was observed in the early and long-term follow-up periods. This event was associated with the baseline patients' characteristics and post-procedural aspects with no dependence on type of antithrombotic therapy.

Key words: atrial fibrillation; left atrial appendage occlusion; Watchman; Amplatzer Amulet; thrombosis; thromboembolic complications

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Left atrial appendage occlusion (LAAO) is an effective method to decrease the risk of ischemic stroke (IS) in patients with atrial fibrillation (AF), and although currently LAAO is a class IIb recommendation with the level of evidence B in the European Society of Cardiology Guidelines for the diagnosis and management of AF [1], growing evidence confirms the benefits of such strategy [2, 3].

The idea of the method is to anatomically isolate the left atrial appendage (LAA) from the left atrium cavity, thereby preventing the formation of thrombi and their migration into systemic circulation [4]. There are completely transdermal endovascular devices for LAAO (Watchman, Watchman FLX, Amplatzer ACP/Amulet) and a combined device requiring simultaneous endovascular and transthoracic access (LARIAT) [5]. Currently in the Russian Federation only three of them are authorized and used - Watchman, Watchman FLX (Boston Scientific, Natwick, MA, USA) and Amplatzer Amulet (Abbott, St Jude Medical, Plymouth, MA, USA).

Among the different requirements, the most important expectations from an endovascular device are its ability

Table 1.

Identified cases of device-related thrombus

Follow-up duration	45 days	6 months	1 year	2 years	3 years
Number of observations	4	4	1	0	2
Cumulative percentage	3.3%	6.7%	7.5%	7.5%	9.2%

Table 2.

Comparison of clinical, anatomical, echocardiographic, periprocedural characteristics of patients in groups with and without DRT (continued)

Indicator	Total cohort (n=120)	Without DRT (n=109)	With DRT (n=11)	p
Age, years*	66.5 (59.25-72)	66.0 (59-71.5)	67.0 (67-77)	0.118
Male, n (%)	60 (50.0)	53 (48.6)	7 (63.6)	0.529
Body mass index, kg/m^2*	29.7 (26.1-33.1)	29.7 (26.3-33.1)	26.8 (25.8-38.1)	0.504
Paroxysmal atrial fibrillation, n (%)	39 (32.5)	37 (33.9)	2 (18.2)	0.500
Smoking, n (%)	18 (15.0)	16 (14.7)	2 (18.2)	0.670
Arterial hypertension, n (%)	70 (58.3)	64 (58.7)	6 (54.5)	>0.999
Diabetes mellitus, n (%)	30 (25.0)	26 (23.9)	4 (36.4)	0.464
Stroke, n (%)	44 (36.7)	40 (36.7)	4 (36.4)	>0.999
Hemorrhagic stroke	9 (7.5)	9 (8.3)	0 (0)	>0.999
Transient ischemic attack, n (%)	6 (5.0)	6 (5.5)	0 (0)	>0.999
Arterial embolism, n (%)	7 (5.8)	6 (5.5)	1 (9.1)	0.499
Coronary Artery Disease, n (%)	40 (33.3)	33 (30.3)	7 (63.6)	0.041
Myocardial infarction, n (%)	20 (25.0)	23 (21.1)	7 (63.6)	0.005
History of PCI, n (%)	26 (21.7)	21 (19.3)	5 (45.5)	0.059
History of CABG, n (%)	6 (5.0)	4 (3.7)	2 (18.2)	0.094
GI erosions/ulcers, n (%)	37 (30.8)	35 (32.1)	2 (18.2)	0.500
Liver disease, n (%)	3 (2.5)	3 (2.8)	0 (0)	>0.999
COPD / asthma, n (%)	4 (3.3)	4 (3.7)	0 (0)	>0.999
Active cancer, n (%)	2 (1.7)	2 (1.8)	0 (0)	>0.999
History of cancer, n (%)	7 (5.8)	7 (6.4)	0 (0)	>0.999
Peripheral artery disease, n (%)	19 (15.8)	15 (13.8)	4 (36.4)	0.072
Congestive heart failure, n (%)	43 (35.8)	35 (32.1)	8 (72.7)	0.016
Left ventricle ejection fraction <60%, n (%)	8 (6.7)	5 (4.6)	3 (27.3)	0.025
Pulmonary artery systemic pressure, mm Hg*	30 (28-38)	30 (27.5-35)	37.5 (27.5-38)	0.196
CKD (stage 3a and higher), n (%)	30 (25.0)	26 (23.9)	4 (36.4)	0.464
Bleeding, n (%)	60 (50.0)	59 (54.1)	1 (9.1)	0.008
Charlson Comorbidity Index, score*	5.5 (4-7)	5 (4-6)	7 (6-7)	0.035
CHA_2DS_2-VASc, score*	4 (3-5)	4 (3-5)	4 (3-7)	0.585
CHA_2DS_2-VASc ≥5, n (%)	40 (33.3)	36 (33.0)	4 (36.4)	>0.999
HAS-BLED, score*	3 (2-3)	3 (2-3)	3 (2-3)	0.407
HAS-BLED ≥3, n (%)	68 (56.7)	60 (55.0)	8 (72.7)	0.346
High risk of bleedings, n (%)	75 (62.5)	67 (61.5)	8 (72.7)	0.533
Contraindications to anticoagulants, n (%)	73 (60.8)	67 (61.5)	6 (54.5)	
Refusal to take anticoagulants, n (%)	47 (39.2)	42 (38.5)	5 (45.5)	0.750
LAA chicken wing type, n (%)	54 (45.0)	50 (45.9)	4 (36.4)	0.449
LAA windsock type, n (%)	40 (33.3)	35 (32.1)	5 (45.5)	
LAA cauliflower type, n (%	13 (10.8)	11 (10.1)	2 (18.2)	
LAA cactus type, n (%)	13 (10.8)	13 (11.9)	0 (0)	
LAA orifice diameter, mm*	22 (20-24)	22 (20-24)	24 (21-24)	0.152
Spontaneous echo contrast 0, n (%)	1 (0.8)	1 (0.9)	0 (0)	0.019
Spontaneous echo contrast I, n (%)	5 (4.2)	5 (4.6)	0 (0)	
Spontaneous echo contrast II, n (%)	85 (70.8)	80 (73.4)	5 (45.5)	
Spontaneous echo contrast III, n (%)	22 (18.3)	19 (17.4)	3 (27.3)	
Spontaneous echo contrast IV, n (%)	7 (5.8)	4 (3.7)	3 (27.3)	

to adjust to different LAA anatomic variants, low rate of procedure-related complications, the ability to completely isolate the LAA from the systemic circulation without residual flow, and low thrombogenicity of the occluder itself [4]. To prevent thrombus formation on a occluder surface before its complete endothelization, patients are administered antithrombotic therapy (ATT). Nevertheless, device-related thrombus (DRT) remains one of the potential procedure-related complications. According to different studies, thrombosis rate varies in the range of 3% to 6% [6]. The pathophysiological basis of this condition largely remains unknown. Tentative predictors have been proposed, including elderly age, history of ischemic stroke or a transient ischemic attack, LAA width, reduced left ventricle ejection fraction (LVEF). [7]. The evidence on association between DRT and complications such as thromboembolic (TE) events is limited, due to a low rate of confirmed thrombosis and clinical events. Furthermore, there is no universally accepted approach to treatment strategy or subsequent echocardiographic follow-up once a thrombus is detected.

The aim of this prospective study was to evaluate the rate, predictors and clinical outcomes of thrombosis associated with different types of occluder devices after endovascular LAAO in patients with AF during short- and long-term observation.

METHODS

This prospective observational study included 120 patients with non-valvular AF undergoing endovascular LAAO during 2011 - 2019. The study protocol was approved by the local Ethics Committee and all subjects provided written Informed Consent. Inclusion criteria were as follows: the patient's consent to undergo the implantation of a LAA-occluding device, contraindications to long-term anticoagulant use or patient's refusal to undergo such therapy. Exclusion criteria: proximal deep venous thrombosis on legs, LAA thrombosis.

The following occluders were used: Watchman (n=92) and Amplatzer Amulet (n=28). The standard ATT protocol for the Watchman arm required continuous administration of acetylsalicylic acid (ASA) with warfarin for 45 days with subsequent switch to clopidogrel, discontinued in 6 months, while in the Amplatzer Amulet arm - long-term ASA administration, in the first 6 months - in combination with clopidogrel. The ATT regimen, including after the detection of an DRT, was determined at the discretion of the treating doctor, depending on the clinical circumstances and the risk of hemorrhagic complications. The post-implantation follow-up period was 3 years. Assessments for DRT presence were performed on 5 visits (45 days, 6 months, 1 year, 2 years, 3 years) by transesophageal echocardiography (TEE) at the study site. Also, TE events were assessed, including stroke, transient ischemic attack (TIA), systemic embolism (SE).

Statistical analysis

Statistical analysis was performed with IBM SPSS Statistics software package, version 28. Baseline, peri- and postprocedural characteristics, as well as the ATT regimen, were summarized using descriptive statistics. Normal distribution of quantitative variables was done by Shapiro-Wilk test. Mann-Whitney test for quantitative variables and the $\chi 2$ test, with exact Fisher test, for categorical variables were applied to identify differences between the characteristics of patients with or without DRT. Univariate and multivariate regression analysis with Cox proportional hazards model were used to identify predictors of DRT. Significance level for all hypothesis tests was set at $p < 0.05$.

RESULTS

Patient characteristics

Among the 120 patients enrolled into the study, the proportion of those attending the Day 45 visit and completing TEE was 97.5% (117), on Month 6 - 9.3% (118), in 1 year - 95.8% (115), in 2 years - 81.7% (98) and in 3

Table 2.

Comparison of clinical, anatomical, echocardiographic, periprocedural characteristics of patients in groups with and without DRT (continuation)

Indicator	Total cohort (n=120)	Without DRT (n=109)	With DRT (n=11)	p
Watchman device, n (%)	92 (76.7)	84 (77.1)	8 (72.7)	0.717
Amplatzer device, n (%)	28 (23.3)	25 (22.9)	3 (27.3)	
Device size, мм*	27 (24-30)	27 (24-30)	27 (25-30)	0.582
Peridevice leak >5 mm, n (%)	7 (5.8)	5 (4.6)	2 (18.2)	0.125
DOACs post-implantation, n (%)	25 (29.2)	29 (26.6)	6 (54.5)	0.078
Warfarin post-implantation, n (%)	23 (19.2)	23 (21.1)	0 (0)	0.121
Clopidogrel post-implantation, n (%)	71 (59.2)	67 (61.5)	4 (36.4)	0.121
ASA post-implantation, n (%)	108 (90.0)	98 (89.9)	10 (90.9)	>0.999
Vascular complications, n (%)	7 (5.8)	6 (5.5)	1 (9.1)	0.499
Procedures success, n (%)	114 (95.0)	104 (95.4)	10 (90.9)	0.446

Notes: here and below *- median (interquartile range in brackets); ASA - acetylsalicylic acid; CABG - coronary artery bypass grafting; COPD - chronic obstructive pulmonary disease; CKD - chronic kidney disease; DOACs - direct oral anticoagulants; GI - gastrointestinal; ** - HAS-BLED ≥3, or a history of hemorrhagic stroke, or a history of BARC 3 bleeding; LAA - left atrium appendage; PCI - percutaneous coronary intervention.

years - 57.5% (69). Throughout the follow-up period DRT was found in 11 patients (9.2% see Table 1). The greatest number of thrombosis cases was found on Day 45 (n=4) and Month 6 (n=4). There were no cases of persisting or recurrent thrombosis on follow-up visits. Description and comparison of clinical characteristics, history, echocardiographic and periprocedural characteristics in patients with and without DRT are presented in Table 2.

Both patients with and without DRT had similar age (median - 67 and 66 years respectively), high risk of bleeding, based on bleeding history or HAS-BLED ≥3 (72.7% and 61.5% respectively), and contraindications to oral anticoagulants (54.5% and 61.5%). Major bleedings occurred more frequently in the group of patients without DRT (54.1% vs 9.1%, p = 0.008). In the group of patients with DRT Coronary Artery Disease (63.6% versus 30.3%, p=0.041) and history of myocardial infarction (MI) (63.6% versus 21.1%, p=0.005) were more prevalent. In addition, in patients with DRT conditions such as EF <60% and congestive heart failure (CHF) were also more prevalent (27.3% versus 4.6%, p=0.025; 72.7% versus 32.1%, p=0.016 respectively). Charlson comorbidity index was significantly higher in the group of patients with DRT (median 7 versus 5, p=0.035). Furthermore, according to the TEE done immediately before the procedure, in the group of patients with DRT the degree of spontaneous echo contrast (SEC) (p=0.019) was higher. There were no significant differences in the anatomic structure and diameter of LAA (p=0.449 and p=0.152 respectively). Also, no differences were found in the thrombosis rate between the types of devices used (p=0.717).

Antithrombotic therapy

The data on antithrombotic therapy after the procedure are presented in Table 3. Reduced doses of direct oral anticoagulant (DOAC) were used in 14.3% (5/35) patients: 3 patients with DRT and 2 without. In the group of patients with DRT treatment with DOAC + ASA was administered in 54.5%, double ATT in 36.4%, enoxaparin sodium in 9.1% patients. By the time DRT was detected 6 (54.5%) patients were on DOAC + ASA, 3 (27.2%) patients - on double ATT, and 1 each - on ASA (9%) and without ATT (9%) (see Table 4). After thrombosis detection patients were on anticoagulation in 36.3% cases.

Predictors and outcomes

Variables that demonstrated a significance level of p≤0.2 for association with the outcome in a univariate analysis were then tested in a proportional hazards model; they were as follows: age, Coronary Artery Disease, MI, percutaneous coronary intervention, coronary artery bypass grafting, peripheral artery disease, CHF, EF<60%, bleeding history, Charlson comorbidity index, SEC degree on TEE, early peridevice leak >5 mm, DOAC or clopidogrel administration at discharge. The following significant predictors of DRT risk were identified: history of MI (hazard ratio (HR) 12.88 [95% confidence interval (CI) 3.21-51.62]; p<0.001), CHF presence (HR 8.83 [95% CI 1.91-40.77]; p = 0.005), peridevice leak >5 mm in the early post-procedural period (HR 6.13 [95% CI 2.53-14.86]; p = <0.001) and the SEC degree (HR 9.09 [95% CI 1.36-60.58]; p = 0.023) (see Table 5).

In the group of patients without DRT the TE event rate was 3.7% (4/109), in patients with DRT - 9.1 % (1/11). The only TE event case in the group of patients with DRT developed before thrombosis identification: a non-fatal stroke in a patient developed on week 35 of the follow-up period, whereas thrombosis was found in the long-term, on a year 3 visit of the follow-up period. No association was found between the device-associated thrombosis and the development either TE events (IS/TIA/SE) (HR 3.52 [95% CI 0.37-33.26]; p = 0.271), or strokes of any type (HR 3.19 [95% CI 0.35-28.90]; p = 0.303).

DISCUSSION

Studying an endovascular LAAO complication such as an occluder surface thrombosis is highly relevant, considering the significant benefits offered by such procedure. Our prospective 3-year observation using two device models: (Watchman and Amplatzer Amulet) demonstrated the following: 1) DRT was found in 9.2% patients; 2) history of MI, CHF, peridevice leak >5 mm in the early post-procedural period, as well as the SEC degree were found to be predictors of thrombosis development; 3) no association to thromboembolic events was established in the studied cohort of patients.

The rate of DRT was found to be comparable to the previously published data. E.g. in an analysis of 1739 patients from the PROTECT-AF, PREVAIL studies and the CAP and CAP2 registries of Watchman device implantation, occluder surface thrombosis was found in 3.74% [8]. In a subanalysis of a registry of 1078 patients who were implanted Amplatzer Amulet, the DRT rate was 1.7% [9]. In a meta-analysis, mostly covering data from multicenter and single-center registries, as well as series of clinical cas-

Table 3.

Antithrombotic therapy in patients after endovascular LAAO

Indicator	Total cohort (n=120)	Without DRT (n=109)	With DRT (n=11)
Without ATT, n (%)	1 (0.8)	1 (0.9)	0 (0)
DAPT, n (%)	59 (49.2)	55 (50.5)	4 (36.4)
DAPT + warfarin, n (%)	7 (5.8)	7 (6.4)	0 (0)
Warfarin, n (%)	7 (5.8)	7 (6.4)	0 (0)
DOACs, n (%)	1 (0.8)	1 (0.9)	0 (0)
DOACs + ASA, n (%)	29 (24.2)	23 (21.1)	6 (54.5)
Warfarin + ASA, n (%)	9 (7.5)	9 (8.3)	0 (0)
DOACs + DAPT, n (%)	3 (2.5)	3 (2.8)	0 (0)
DOACs + clopidogrel, n (%)	2 (1.7)	2 (1.8)	0 (0)
Enoxaparin, n (%)	1 (0.8)	0 (0)	1 (9.1)
Enoxaparin + DAPT, n (%)	1 (0.8)	1 (0.9)	0 (0)

Notes: here and below p_{com}=0.054; ATT - antithrombotic therapy; DAPT - double antiplatelet therapy.

es, the overall rate of device thrombosis was 3.9%, without significant differences the Amplatzer and Watchman devices [10]. It is noteworthy that in most studies the follow-up period was limited to just 1 year. Furthermore, in many studies the number of TEE examinations per patient fell well below the intensity achieved in our study: e.g. patients in the CAP and CAP2 registries underwent TEE on Day 45 and Month 12, respectively, potentially resulting in underestimation of the true DRT rate [8]. Applying such approach, excluding Month 6 visit, to our study would result in the thrombosis rate of 4.2% for year 1.

The exact causes and delicate mechanisms explaining the development of occluder surface thrombosis have yet to be fully elucidated. Most probably, thrombi formation in the early post-procedural period is due to delayed endothelization [11], whereas in the longer term various contributing factors could have a role, both primary (high risk of TE events, CHF, history of IS or MI) and secondary (such as, a fraction remaining uncovered, significant peridevice leak). Predictors of thrombosis development in our study were related both to prior conditions and to the results of the procedures itself: history of MI, CHF, peridevice leak >5 mm in the early post-procedural period and SEC degree according to the pressure-procedural TEE. In the above-mentioned analysis of the studies and registries on the Watchman device the following predictors are described: history of TIA or IS, persistent AF, cardiovascular diseases, LAA diameter and LV EF [8]. The SEC degree as a thrombosis predictor is identified in s study by Sedaghat et al. [12]. In addition, the authors also pointed at the association between the LV EF and reduced LA peak emptying velocity and DRT. In an analysis of several studies on Amplatzer devices the LAA diameter was found to be the significant thrombosis predictor [9]. The role of the peridevice leak in the development of thrombosis on its surface remains debated [13]. According to the recently published registry (n=200) comparing the efficacy and safety of Watchman and Amplatzer Cardiac Plug devices, in two of three patients demonstrating peridevice leak a DRT was found [14]. In the largest series of systematic follow-up on patients demonstrating post-procedural peridevice leak (n=455) enrolled in the PROTECT AF trial, no reliable association was found between peridevice leak and increased TE event risk [15]. However, this data should be reviewed in greater detail: the follow-up period in the trial was short (1 year), the number of ischemic events was low (16 events), and different ATT regimens were applied.

Table 4.

Antithrombotic therapy regimen in patients with DRT

№	Visit*	ATT**	ATT***
1	Day 45	DOAC + ASA	DOAC
2	Day 45	DOAC + ASA	DAPT
3	Day 45	DOAC + ASA	DOAC
4	Day 45	DOAC + ASA	DAPT
5	Month 6	DAPT	Warfarin
6	Month 6	DOAC + ASA	DAPT
7	Month 6	DAPT	Warfarin
8	Month 6	DOAC + ASA	DAPT
9	Year 1	DAPT	ASA
10	Year 3	ASA	ASA
11	Year 3	no ATT	no ATT

Notes: * - on which the DRT was detected; ** - on which the DRT occurred; *** - initiated upon detection of a DRT, replacing the previously administered; all patients demonstrated the absence of a DRT on follow-up TEE.

As of now, the largest dataset on DRT comes from a multicenter registry including a group of 237 patients with DRT and 474 patients from the control group [16]. Multivariate analysis identified 5 risk factors of thrombosis: hypercoagulation, iatrogenic pericardial effusion, chronic kidney disease, depth of implantation >10 mm of the pulmonary vein margin, and non-paroxysmal AF. It seems interesting to discuss the contribution of pericardial effusion and chronic kidney disease in thrombi formation. Probably such conditions limited procedure completion, which may have resulted in an unsatisfactory device positioning. Other parameters, including age, sex, LV EF and the ATT regimen used after the device implantation demonstrated no prognostic value.

No cases of TE events or deaths associated with DRT were reported in our study. An analysis of studies with Watchman device implantation shows that 16/65 (25%) patients with DRT had a history of IS or SE, as compared to 114/1674 (6.8%) patients without thrombosis ($p<0.001$). Both unadjusted and adjusted rates of all types of strokes and SE were higher in patients with DRT, without an associated increase in mortality. However, in the EWOLUTION study involving 1020 patients undergoing Watchman device implantation, despite the DRT rate of 4.1%, there was no difference in the rate of IS, death, or the combined endpoint of death/IS/TIA [17]. With Amplatzer Cardiac Plug a between-group difference was also

Table 5.

Independent predictors of DRT development over 3 years of follow-up

Risk factors	Univariate analysis			Multivariate analysis		
	HR	95% CI	p	HR	95% CI	p
History of MI	5.29	1.55-18.09	0.008	12.88	3.21-51.62	<0.001
Congestive heart failure.	5.57	1.46-21.27	0.012	8.83	1.91-40.77	0.005
Peridevice leak >5 mm*	4.72	1.01-22.19	0.049	6.13	2.53-14.86	<0.001
Spontaneous echo contrast degree**	2.80	1.39-5.64	0.004	9.09	1.36-60.58	0.023

Notes: HR - hazard ratio; * - in the early post-procedural period; ** - the presented hazard ratios are given per 1 increment on the echo contrast scale.

observed: DRT was associated with a higher risk of IS or TIA, compared to patients without DRT (p=0.007) [9]. In a recent meta-analysis, the total number of ischemic events in studies comparing outcomes in patients with vs without DRT (32 studies; n=7689) was 13.2% (37 of 280) in patients with DRT and 3.8% (285 of 7399) in patients without DRT (p <0.001) [18]. According to the sensitivity analysis which included only randomized trials and prospective multicenter registries, the DRT rate was 3.7% and found to be associated with a higher rate of ischemic events (p <0.001). This study supports the concept according to which the association between DRT and TE events is insignificant; however, further studies are needed to confirm such findings. An important confounding factor affecting the study results is the lack of standardization in managing such patients in the following parameters: the frequency and method of LAA imaging, different types of devices implanted, ATT regimens, including the ones utilized after DRT detection. The ATT schemes reported in literature are highly variable [19]. The analysis of data on Amplatzer device implantation produced noteworthy findings: the reported DRT rate is about 1.7% per year, although patients in this group were on anticoagulation more frequently than patients without DRT (29% and 17.5% respectively) [9]. If a DRT was found, anticoagulation was initiated in 83% cases. A similar trend is observed in this study too: in 54.5% of DRT cases patients had been on anticoagulation. As mentioned previously, there was no specific ATT protocol to be followed upon the detection of a DRT, and such decisions were left at the doctor's treating discretion. The rate of anticoagulant therapy use after DRT detection was 36% and, regardless of the treatment chosen, thrombosis resolved by the follow-up visit. There are no specific guidelines determining ATT decisions in case of a DRT. However, available evidence suggests that resuming/initiation of anticoagulation effectively results in DRT resolution in >90% patients [20], with same bleeding-related concerns, as device implantation generally implies a high risk of hemorrhagic events. All the considerations mentioned above emphasize the need to further investigate ATT regimens in patients undergoing the LAAO procedure.

Study limitations. The limitations of this study include a small sample size, lower visit attendance by patients by Year 3, potentially resulting in the underestimation of DRT cases. Patients were not randomized depending on the implanted device model and ATT regimen. In addition, patients received different ATT regiments upon DRT detection, preventing any conclusions regarding the efficacy of any specific treatment scheme. A higher statistical power is required to make a reliable judgement on the possible link between DRT and TE events.

CONCLUSION

Device-related thrombus is not an uncommon complication following endovascular isolation of the left atrium appendage on long-term observation. Patients prone to thrombi formation on the device surface, are more likely to have a history of MI, congestive heart failure, peridevice leak >5 mm the early post-procedural period, and a high degree of spontaneous echo contrast. Although no thromboembolic events associated with DRT occurred in the studied cohort of patients, the presence and significance of such association still requires further investigation. Randomized trials are necessary to identify an effective and safe antithrombotic regimen to be administered upon detection of a device-related thrombus.

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