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Prevalence and Predictors of Non-adherence to Oral Anticoagulation Therapy Up To 24 Months After Acute Pulmonary Embolism: Results from a Prospective Observational Study

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Abstract

Background: Oral anticoagulation (OAC) therapy is essential to avoid venous thromboembolism recurrence, but drug-adherence sometimes might be poor.

Aim: To describe OAC adherence in patients after acute pulmonary embolism (PE) and to identify risk factors for non-adherence.

Methods: We prospectively evaluated 324 PE patients (mean age 62.9 ± 14.3, 51.5% male) after 3, 6, 12 and 24 months, resulting in 1620 study visits. Data were analyzed using multivariable logistic models.

Results: Out of the study population, 19 patients (5.9%) were identified to be non-adherent to OAC therapy. Significant predictors of non-adherence were a history of stroke and diabetes mellitus (DM) (OR = 6.07, 95% CI 1.58-23.36, $P = .027$ and OR = 3.46, 95% CI 1.15-10.40, $P = .009$, respectively).

Conclusion: The adherence rate to OAC is quite high in patients after acute PE, but patients with DM and a history of stroke should be focused on in order to further improve OAC adherence.

Keywords

acute pulmonary embolism, thromboembolism, oral anticoagulation therapy, adherence, compliance

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Introduction

Acute pulmonary embolism (PE) is a common and potentially fatal cardiovascular disorder, which is characterized by an embolic occlusion of one or more pulmonary arteries. The incidence of PE is estimated to be about 0.5-1 cases per 1000 subjects per year, and increases with age.[1] It is the third most common cause of mortality among the cardiovascular diseases, after coronary artery disease and stroke.[2]

If possible, all PE patients should be treated with an oral anticoagulation (OAC) therapy. In exceptional cases, long-term treatment with low molecular weight heparin (LMWH) is necessary. The duration of OAC is depending on the underlying cause of PE, individual risk factors and the risk of recurrence after ending OAC. PE patients related with a strong, transient provoking risk factor (eg immobilization due to surgery) may end OAC after 3 months

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of treatment. Prolonged treatment is recommended in cases with ongoing strong risk factors (eg active cancer) and patients with unprovoked PE.[1,3,4]

OAC therapy is a safe, effective and convenient treatment for most patients.[5] Vitamin K antagonists (VKAs) have been used for more than 70 years and have been mainly replaced by the new direct OAC agents (DOACs). DOACs show a lower risk of bleeding, show a much shorter half life and have an equal or even higher efficiency and less inter-individual variability than VKAs. In addition, no International Normalized Ration (INR) -controls and dosage adjustments need to be carried out and there are less interactions with food or other medications.[6] Continuous intake of OAC is very important, as gaps in treatment can lead to venous thromboembolism (VTE) recurrence.[7] Studies have already shown that mortality and recurrence of VTE increase significantly when OAC are not taken strictly.[8]

Despite the convenient, usually well-tolerated and effective OAC treatment, non-adherence to therapy remains a major problem.[9] This may be either due to unwanted side effects of the therapy, carelessness or not being convinced of the need of treatment. After an acute PE, the therapeutic effect of OAC on the patients' symptoms may be very small; sometimes there will be no improvement of symptoms or effect on wellbeing at all. Furthermore, PE may be diagnosed incidentally and may be completely asymptomatic, so that the need for therapy may be difficult to understand for patients.

Adherence is defined by the World Health Organization (WHO) as the extent to which the persons' behavior corresponds with agreed recommendations from a healthcare provider.[10] This includes the beginning of therapy, implementation of the therapy regime and continuation or discontinuation of treatment.[11] Reduced medication adherence may have multifactorial reasons, which have been classified by the WHO into 5 groups: socio-economic factors, therapy-related factors, patients-related factors, condition-related factors and health system/health care team-related factors.[10] Recent literature points out that drug adherence in general is affected by certain factors, such as comorbidity, age, type of medication in use, number of drugs and complexity of treatment, treatment time, frequency of intake, health literacy, employment status and income, socio-economic status as well as beliefs and satisfaction with therapy.[12-14] In addition, it has been proven that adherence to OAC therapy is an issue especially in the first 12 months.[15] It is therefore crucial to develop strategies that promote patient engagement during this critical period to maximize treatment efficacy and minimize the risk of thromboembolic events. On the other hand, adherence to oral anticoagulation after acute PE especially beyond a follow-up period of 12 months is sparsely investigated but might be an especially important issue.

The aim of this study is to describe OAC adherence in patients after acute PE over a period of 2 years and to characterize factors that may predict poor drug adherence. This shall help better understanding whom to focus on in order to improve the adherence to OAC and the effectiveness of therapy.

Methods

This single-center, prospective, observational study was performed at the University Hospital of Augsburg. The study protocol was approved by the ethics committee of the Ludwig-Maximilians-Universität München on 1. August 2017 (Reference number: 17-378) and was published in 2019.[16]

Study Population

The study included all consecutive patients >18 years admitted to the University Hospital of Augsburg with incident or recurrent confirmed acute PE, diagnosed either by computed tomography (CT) pulmonary angiography or ventilation–perfusion lung scanning. Asymptomatic patients with unexpected PE on a regular CT were also included.

Data Collection

After the patients have given informed consent, the study nurses interviewed the participants during their hospital stay using a standardized questionnaire. These interviews covered basic demographic information, symptoms on presentation, predisposing and PE-provoking factors and comorbidities. In addition, clinical data were collected from the patients' medical chart after discharge from hospital.

Follow-up of the PE Patients

All patients received postal questionnaires after hospital discharge on a regular basis (in the first year after 3, 6 and 12 months; thereafter every 12 months; we used data until month 24). The postal questionnaire contained questions on disease symptoms, comorbidities, health-related quality of life, dyspnea, major bleeding complications, recurrent events and healthcare utilization as well as current medication. Questions about OAC included whether it was discontinued and, if so, whether this was done independently or in consultation with health care providers.

Outcome Parameters

The primary outcome was the adherence to OAC in patients with acute PE and whether the therapy was discontinued independently or in consultation with medical personnel. Patients who unauthorized ended OAC therapy during the 24 months follow-up were defined as non-

adherent. Patients, who followed their physician's recommendations and continued or discontinued treatment, were defined as adherent. This information was obtained by self-reported questionnaires.

Statistical Analysis and Assessment Criteria

The demographic and clinical characteristics of the study population by adherence were shown as either frequencies and percentages of total or means with standard deviations (SD). All statistical analyses were conducted using IBM Statistical Package of Social Science SPSS (Version 29.0.1.0). The chi-square test or Fisher's exact test were used to compare adherent and non-adherent patients with regard to a nominal characteristic. To compare the two patient groups with regard to a metric characteristic, the t-test for independent samples was used. If no statistical significance could be demonstrated for higher-level groups (eg recurrent PE during follow-ups, smoking status, employment status, type of DOAC last taken, start of OAC therapy) no further testing for subgroups was performed. In case of a significant result, column-wise comparisons were performed using z-tests adjusting the significance level by the Bonferroni method. $P < .05$ was considered statistically significant.

If information on the intake of the OAC was missing once or inconsistently, but was subsequently continued, it was assumed that questions on medication intake were misunderstood and OAC was taken continuously. Patients who already discontinued OAC before the first follow-up after 3 months were considered as non-adherent. If the information about the time of discontinuation was unrealistic, the data were compared with the source data and corrected accordingly.

Those variables reaching a P-value $< .10$ in any of the bivariate analyses (DM and stroke) were selected as predictors for the multivariable logistic regression models. Furthermore, we selected the variables age, sex, employment and education. A multivariable logistic regression model was calculated for determining the association between predictors (independent variables) and non-adherence (yes/no; dependent variable). We summarized the categories for educational qualification and occupation: high school diploma or technical college entrance qualification = higher education, medium maturity = intermediate education, secondary school leaving certificate or no degree = lower education. For the employment status we used the categories retirement, unemployed and others.

Results

Between July 2017 and June 2023, a total of 1862 consecutive PE patients were screened. Out of these patients, 436 died in hospital or could not be included due to severe language barrier, or deteriorated mental status. Consequently, a total of 1426 eligible patients were identified. Out of these patients, 475 refused to participate in the study or were lost before inclusion. We identified 324 patients who completed all 5 follow-up questionnaires during the 24 months follow-up period, resulting in 1620 study visits suitable for analysis.

Socio-demographic and clinical data are shown in Table 1. Mean age was 62.9 years (±14.3 years) with 156 (51.1%) male patients. All patients received anticoagulation therapy during the hospital stay either with heparin (low molecular or unfractionated) or with OAC. Regarding the type of OAC, Apixaban (n = 144, 46.2%) was taken most frequently followed by Rivaroxaban (n = 102, 32.7%), Edoxaban (n = 42, 13.5%), Phenprocoumon (n = 18, 5.8%), and Dabigatran (n = 4, 1.3%). In 7.9% of the patients, the type of OAC has been changed during the 24 months follow-up and in 52 patients (16.5%) the dosage has been reduced. Regarding the time of discontinuation for all 324 patients, 12 patients (3.7%) canceled OAC at 3 months, 21 (6.5%) at 9 months, 54 (16.7%) at 12 months and 23 (7.1%) at 24 months.

Non-adherence

Nineteen patients (5.9%) were considered as non-adherent, 305 patients (94.1%) were defined as adherent. In the adherent group, 91 patients (29.8%) discontinued treatment in consultation with medical staff and 214 patients (70.2%) took OAC continuously over the 2 years follow-up. Regarding the time of discontinuation for the non-adherent patients, 7 patients (36.8%) canceled OAC at 3 months, 3 (15.8) at 9 months, 4 (21.1%) at 12 months and 5 (26.3%) at 24 months.

For the 19 non-adherent patients, information regarding the type of anticoagulation taken is only available for 12 patients. Regarding the type of OAC which was taken by the non-adherent patients, treatment with Rivaroxaban (n = 6, 50.0%) was discontinued most frequently followed by Apixaban (n = 4, 33.3%), Edoxaban (n = 1, 8.3%) and Phenprocoumon (n = 1, 8.3%).

Predictors of Non-adherence

Patients with diabetes mellitus (DM) or a history of stroke unauthorized discontinued OAC therapy significantly more often compared with PE patients without these comorbidities ($P = .027$ and $P = .009$, respectively). The risk of discontinuation was 6 times higher for patients with stroke (OR = 6.07, 1.58-23.36 95% CI) compared to patients without stroke. Furthermore, patients with DM had a 3.5 times higher risk of non-adherence compared to patients without diabetes (OR = 3.46, 1.15-10.40 95% CI). Neither age nor occupational situation nor educational status showed a significant effect on the risk of treatment discontinuation (Table 2).

Table 1. Socio-demographic and Clinical Characteristics in PE Patients Overall and Stratified by OAC Adherence.

Characteristics	Overall n = 324	Adherent n = 305	Non adherent n = 19	*P*-value
Age (years)	62.9 (±14.3)	62.9 (±14.5)	62.5 (±12.4)	.898
Body weight (in kg) n = 309 (adherent: n = 290, non-adherent: n = 19)	88.3 (±22.6)	88.6 (±22.9)	84.1 (±16.7)	.407
BMI (kg/m^2) n = 309 (adherent: n = 290, non-adherent: n = 19)	29.6 (±7.0)	29.7 (±7.2)	28.5 (±4.5)	.481
Male, n (%)	167 (51.5%)	156 (51.1%)	11 (57.9%)	.568
DVT at the time of diagnosis of PE, n (%)	77 (23.8%)	73 (23.9%)	4 (21.1%)	1.00
History of surgery during follow-ups, n (%) n = 323 (adherent: n = 304, non-adherent: n = 19)	104 (32.2%)	99 (32.6%)	5 (26.3%)	.572
History of PE				
Recurrent PE during follow-ups, n (%) n = 323(adherent: n = 304, non-adherent: n = 19)				1.00
No PE	308 (95.4%)	289 (95.1%)	19 (100.0%)	
With OAC	11 (3.4%)	11 (3.6%)	0 (0.0%)	
Without OAC	4 (1.2%)	4 (1.3%)	0 (0.0%)	
Major bleeding during follow-ups, n (%) n = 323 (adherent: n = 304, non-adherent: n = 19)	5 (1.5%)	4 (1.3%)	1 (5.3%)	.263
Comorbidities, n (%)				
Cancer	46 (14.2%)	45 (14.8%)	1 (5.3%)	.493
MI n = 320 (adherent: n = 301, non-adherent: n = 19)	5 (1.6%)	4 (1.3%)	1 (5.3%)	.265
Stroke n = 320 (adherent: n = 301, non-adherent: n = 19)	19 (5.9%)	15 (5.0%)	4 (21.1%)	.020
Diabetes mellitus n = 322 (adherent: n = 303, non-adherent: n = 19)	45 (14.0%)	39 (12.9%)	6 (31.6%)	.035
COPD n = 319 (adherent: n = 300, non-adherent: n = 19)	34 (10.7%)	32 (10.7%)	2 (10.5%)	1.00
Depression n = 319 (adherent: n = 300, non-adherent: n = 19)	45 (14.1%)	43 (14.3%)	2 (10.5%)	1.00
Chronic heart failure n = 314 (adherent: n = 295, non-adherent: n = 19)	16 (5.1%)	16 (5.4%)	0 (0.0%)	.610
Peripheral artery disease n = 319 (adherent: n = 300, non-adherent: n = 19)	10 (3.1%)	9 (3.0%)	1 (5.3%)	.464
Smoking status, n (%)				.374
Never smoker	184 (56.8%)	176 (57.7%)	8 (42.1%)	
Former smoker	120 (37.0%)	111 (36.4%)	9 (47.4%)	
Current smoker	20 (6.2%)	18 (5.9%)	2 (10.5%)	
Employment status, n (%) n = 323 (adherent: n = 304, non-adherent: n = 19)				.238
Working full time	88 (27.2%)	81 (26.6%)	7 (36.8%)	
Working part time	33 (10.2%)	33 (10.9%)	0 (0.0%)	
Retirement	166 (51.4%)	158 (52.0%)	8 (42.1%)	
Parental, maternity leave	2 (0.6%)	2 (0.7%)	0 (0.0%)	
In education	4 (1.2%)	4 (1.3%)	0 (0.0%)	
Housewife, Houseman	22 (6.8%)	19 (6.2%)	3 (15.8%)	
Unemployed	8 (2.5%)	7 (2.3%)	1 (5.3%)	
Education, n (%) n = 321 (adherent: n = 302, non-adherent: n = 19)				.860
High school diploma	78 (24.3%)	72 (23.8%)	6 (31.6%)	
Technical college entrance qualification	23 (7.2%)	21 (7.0%)	2 (10.5%)	
Medium maturity	92 (28.7%)	87 (28.8%)	5 (26.3%)	
Secondary school leaving certificate	120 (37.4%)	114 (37.7%)	6 (31.6%)	
No degree	2 (0.6%)	2 (0.7%)	0 (0.0%)	
Others	6 (1.9%)	6 (2.0%)	0 (0.0%)	
Type of DOAC last taken, n (%) n = 312 (adherent: n = 300, non-adherent: n = 12)				.638

(continued)

Table 1. Continued.

Characteristics	Overall n = 324	Adherent n = 305	Non adherent n = 19	*P*-value
Apixaban	144 (46.2%)	140 (46.7%)	4 (33.3%)	
Dabigatran	4 (1.3%)	4 (1.3%)	0 (0.0%)	
Edoxaban	42 (13.5%)	41 (13.7%)	1 (8.3%)	
Enoxaparin	1 (0.3%)	1 (0.3%)	0 (0.0%)	
Rivaroxaban	102 (32.7%)	96 (32.0%)	6 (50.0%)	
Phenprocoumon	18 (5.8%)	17 (5.7%)	1 (8.3%)	
Tinzaparin	1 (0.3%)	1 (0.3%)	0 (0.0%)	
Change of OAC, n (%) n = 315 (adherent: n = 300, non-adherent: n = 15)	25 (7.9%)	25 (8.3%)	0 (0.0%)	.618
Reduction of OAC dosage, n (%) n = 315 (adherent: n = 300, non-adherent: n = 15)	52 (16.5%)	52 (17.3%)	0 (0.0%)	.144

Data are presented as means ± SD for continuous variables and as counts with percentage of total for categorical variables.
Abbreviations: BMI, Body mass index; DVT, deep vein thrombosis, PE, pulmonary embolism; DOAC, direct oral anticoagulant; OAC, oral anticoagulation; MI, myocardial infarction.

Discussion

The aim of this study was to describe the prevalence of OAC non-adherence and to identify factors that may predict non-adherence to OAC in survivors of acute PE.

Medication adherence is a complex process influenced by several factors. Adherence to long-term therapy for chronic diseases has been shown to be only around 50% in developed countries.[9] Even today, medication adherence remains a problem. Systematic reviews and meta-analyses of adherence studies from 2010 to 2020, including 27 million patients with hypertension, showed that the global prevalence of non-adherence to antihypertensive medications ranged from 27% to 40%.[17]

Table 2. Association Between Characteristics (Independent Variables) and non-Adherence (Dependent variable). Multivariable Logistic Regression Model.

Characteristics	OR	95% CI	*P*-value
Age	1.01	[0.97; 1.06]	.576
Sex = male	1.64	[0.55; 4.89]	.375
Stroke	6.07	[1.58; 23.36]	.009
Diabetes Mellitus	3.46	[1.15; 10.40]	.027
Employment status			.341
Retirement	0.65	[0.16; 2.75]	.562
Unemployed	2.86	[0.28; 29.36]	.377
Others	2.54	[0.45; 14.18]	.289
Education			.270
Mid Level	1.27	[0.35; 4.66]	.720
High Level	2.67	[0.76; 9.34]	.124

n = 315, adherent: n = 296, non-adherent: n = 19.
OR, odds ratio, 95%CI, 95%-confidence interval for odds ratio. sex reference category = female, stroke reference category = no stroke, diabetes mellitus reference category = no diabetes mellitus, employment status reference category = full time/part time, education reference category = low level education.

When treating acute health problems, adherence to therapy is usually higher, but in chronic diseases, drug-adherence is described to decrease dramatically after the first 3 months of treatment.[18] Especially in OAC therapy, non-adherence is reported to be a major problem, as the lack of direct and apparent benefits from VTE-prophylaxis may lead to a lack of motivation to continue therapy.[19] In addition, long-term treatment may impede drug-adherence.

In our study, 5.9% of PE patients were identified to be non-adherent to OAC therapy over a 24-months follow-up period. This shows a quite high adherence rate and proves a strong level of compliance with regard to OAC therapy 2 years after PE. On the other hand, we found significant predictors of non-adherence, such as DM and a history of stroke. This is in so far remarkable, as patients with these comorbidities are normally used to monitor their diseases and to take medication, and they should be aware of the long-term consequences of not taking their medication consistently. Although the number of patients might be small, these are the patients to focus on and monitor much closer.

Among stroke patients, non-adherence has shown to be associated with factors such as advanced age, male sex, smoking status, amount of prescribed drugs per day, beliefs about medication and overuse, possible side effects and health literacy scores.[20-22] About 25% of all ischemic strokes are cardio-embolic in nature and here, atrial fibrillation (AF) is the most common cause.[23] AF is a clinical condition that also requires OAC therapy. In a meta-analysis of 30 studies, up to 30% of AF patients were non-adherent and thus, were more likely to suffer from stroke.[24] This might, at least in part, explain the higher rate of non-adherence among stroke patients. Risk factors for non-adherence to OAC in AF were shown to be minority race, male sex, alcohol use, low physical

activity or poor mental health, unmarried status, poor sleep quality, presence of arterial hypertension, older age, forgetfulness and medication concerns, OAC intake twice daily and DM.[7,19,25,26]

Patients with DM sometimes show very poor adherence to therapy. A recent meta-analysis of 156 studies revealed that only 54% of patients with type 2 DM were adherent to prescribed therapies.[27] The most frequent reasons for non-adherence are forgetfulness and fear of side effects.[27] In DM, non-adherence was associated with younger age, possibly due to the fact that older patients might be more aware about long term consequences of chronic diseases. Some studies indicated that women might be less adherent than men to DM therapies.[28]

Possibly due to the small number of non-adherent PE patients in our study, we were not able to find any significant predictors of non-adherence in terms of age, gender or other socio-economic factors.

Our study is one of very few observational cohort studies in PE patients with a long-term follow-up and benefits from the prospective assessment of outcomes. However, we admit that our study has also some limitations. First, adherence was determined using self-reported questionnaires and, therefore, might be confounded by a recall bias. While this method is practical, it is susceptible to bias, particularly among patients with stroke or diabetes, who may experience cognitive, visual, or comprehension difficulties. This is especially relevant given that these comorbidities emerged as significant predictors of non-adherence. It remains unclear whether the observed associations reflect true differences in behavior or misreporting due to these challenges. Future studies should consider incorporating other objective measures of adherence, such as pharmacy refill records, electronic prescription data, or direct support and monitoring by trained personnel. These approaches could help ensure more accurate assessments and strengthen the validity of findings related to medication adherence. Second, we identified only very few non-adherent PE patients in our study. Due to this small sample size, it might be difficult to reach statistical significance, and we might have underestimated predictors of non-adherence, so that our results should be seen as exploratory and hypothesis generating In addition, and for the same reason, the point estimates resulting from the regression models showed limited accuracy, which is reflected in wide 95% CI. A larger sample size could remedy this. Another limitation is the single center design of the study; however, the University Hospital Augsburg provides healthcare for a population of more than 546 500 inhabitants, whose sociodemographic characteristics have been shown to be highly representative for the German population.[29]

In summary, our study reports a quite high adherence rate to OAC and proves a strong level of compliance with regard to DOAC therapy over a 24-months follow-up period after acute PE. Our observations are in agreement with other studies, identifying DM and a history of stroke as significant predictors of low adherence to OAC.

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Ethical Considerations

All procedures performed in this study involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. All patients gave written informed consent. The study protocol was approved by the ethics committee of the Ludwig-Maximilians-Universität München on the first of August 2017 (Reference number: 17-378).

Consent to Participate

Informed consent for participation was obtained from all subjects involved in the study.

Author Contributions

Conceptualization: W.M, I.K., C.M., J.L., T.M.B.; Formal analysis: W.M.; Investigation: C.M., I.K., T.M.B.; Methodology: W.M., I.K., C.M.; Funding acquisition: J.L., C.M., T.M.B.; Resources: T.M.B., W.M., J.L., C.M., I.K; Supervision: T.M.B.; Writing – original draft: W.M.; Writing – review & editing: T.M.B., J.L., C.M., I.K. All authors read and approved the final version of the paper.

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Declaration of Conflicting Interests

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Data Availability

The datasets generated during and/or analyzed during the current study are not publicly available due to data protection aspects but are available in an anonymized form from the corresponding author on reasonable request.

References

1. Kruger PC, Eikelboom JW, Douketis JD, Hankey GJ. Pulmonary embolism: update on diagnosis and management. *Med J Aust*. 2019;211(2):82-87. doi: 10.5694/mja2.50233
2. Turetz M, Sideris AT, Friedman OA, Triphathi N, Horowitz JM. Epidemiology, pathophysiology, and natural history of pulmonary embolism. *Semin Intervent Radiol*. 2018;35(2):92-98. doi: 10.1055/s-0038-1642036. Epub 2018 Jun 4. PMID: 29872243; PMCID: PMC5986574.
3. Duffett L, Castellucci LA, Forgie MA. Pulmonary embolism: update on management and controversies. *Br Med J*. 2020;370. doi: 10.1136/bmj.m2177
4. Konstantinides SV, Meyer G, Becattini C, Bueno H, Geersing GJ, Harjola VP, a.o. 2019 ESC guidelines for the diagnosis and management of acute pulmonary embolism developed in collaboration with the European respiratory society (ERS): the task force for the diagnosis and management of acute pulmonary embolism of the European Society of Cardiology (ESC). *Eur Heart J*. 2019;41(4):543-603. doi: 10.1183/13993003.01647-2019
5. Grove EL, Skjøth F, Nielsen PB, Christensen TD, Larsen TB. Effectiveness and safety of self-managed oral anticoagulant therapy compared with direct oral anticoagulants in patients with atrial fibrillation. *Sci Rep*. 2018;8(1):15805. doi: 10.1038/s41598-018-33531-7. PMID: 30361687; PMCID: PMC6202319.
6. Barrionuevo B, Scatularo C, Antoniolli M, et al. Predictors of use of direct oral anticoagulants in acute pulmonary embolism. *Archivos de cardiologa de Mexico*. 2023;92(4):454-460. doi: 10.24875/ACM.22000038
7. Merchant K, Desai PV, Morris S, Sirkar SD, Masic D, Shah P, u. a. Predictors of anticoagulation adherence in patients with acute pulmonary embolism. *Thrombosis Update*. 2022;6:100100. doi :10.1016/j.tru.2022.100100
8. Cart L, Serzian G, Humbert S, et al. Clinical patterns and significance of non-compliance with guideline-recommended treatment of acute pulmonary embolism. *Arch Cardiovasc Dis*. 2020;113(1):31-39. doi: 10.1016/j.acvd.2019.09.009
9. Kisa A, Sabaté E, Nuño-Solinís R, Karkashian C. *Adherence to Long-term Therapies. Evidence for Action*. World Health Organization; 2003.
10. Geest SD, Sabaté E. Adherence to long-term therapies: evidence for action. *Eur J Cardiovasc Nurs*. 2003;2(4):323-323. doi: 10.1016/S1474-5151(03)00091-4
11. Vrijens B, De Geest S, Hughes D, Przemyslaw K, Demonceau J, Ruppar T, a.o. A new taxonomy for describing and defining adherence to medications. *Br J Clin Pharmacol*. 2012;73(5):691-705. doi: 10.1111/j.1365-2125.2012.04167.x.
12. Cheen MHH, Tan YZ, Oh LF, Wee HL, Thumboo J. Prevalence of and factors associated with primary medication non-adherence in chronic disease: a systematic review and meta-analysis. *Int J Clin Pract*. 2019;73(6):e13350. doi: 10.1111/ijcp.13350
13. Lima PRG, Gonçalves GMS, Rodrigues RCM, de Souza Oliveira-Kumakura AR. Factors related to patient adherence to the use of new oral anticoagulants. *Rev Esc Enferm USP*. 2021;56:e20210191. doi: 10.1590/1980-220X-REEUSP-2021-0191
14. Al AlShaikh S, Quinn T, Dunn W, Walters M, Dawson J. Predictive factors of non-adherence to secondary preventative medication after stroke or transient ischaemic attack: a systematic review and meta-analyses. *Eur Stroke J*. 2016;1(2):65-75. doi: 10.1177/2396987316647187
15. Deshpande CG, Kogut S, Laforge R, Willey C. Impact of medication adherence on risk of ischemic stroke, major bleeding and deep vein thrombosis in atrial fibrillation patients using novel oral anticoagulants. *Curr Med Res Opin*. 2018;34(7):1285-1292. doi: 10.1080/03007995.2018.1428543. Epub 2018 Feb 15. PMID: 29334815.
16. Meisinger C, Linseisen J, Kirchberger I, von Scheidt W, Berghaus TM. Long-term outcomes in patients with acute pulmonary embolism after in-hospital treatment: study protocol of the prospective Lungenembolie Augsburg Studie (LEA study). *BMJ Open*. 2019;9(10). doi: 10.1136/bmjopen-2019-031411
17. Lee EKP, Poon P, Yip BHK, et al. Global burden, regional differences, trends, and health consequences of medication nonadherence for hypertension during 2010 to 2020: a meta-analysis involving 27 million patients. *J Am Heart Assoc*. 2022;11(17):e026582. doi: 10.1161/JAHA.122.026582
18. Osterberg L, Blaschke T. Adherence to medication. *N Engl J Med*. 2005;353:487-497. doi: 10.1056/NEJMra050100
19. Horst S, de Vries T, Chu G, et al. Prevalence and predictors of non-adherence to direct oral anticoagulant treatment in patients with atrial fibrillation. *TH Open*. 2023. doi: 10.1055/a-2161-0928
20. Arkan G, Sarıgöl Ordin Y, Ozturk V, Ala R. Investigation of medication adherence and factors affecting it in patients with stroke. *J Neurosci Nurs*. 2021;54(1):35-41. doi: 10.1097/JNN.0000000000000621
21. Cao W, Kadir AA, Wang J, et al. Medication non-adherence and associated factors among older adult stroke survivors in China. *Front Pharmacol*. 2022;13:1054603. doi: 10.3389/fphar.2022.1054603
22. Tiili P, Leventis I, Kinnunen J, et al. Adherence to oral anticoagulation in ischemic stroke patients with atrial fibrillation. *Ann Med*. 2021;53(1):1613-1620. doi: 10.1080/07853890.2021.1968031
23. Elsheikh S, Hill A, Irving G, Lip GYH, Abdul-Rahim AH. Atrial fibrillation and stroke: state-of-the-art and future directions. *Curr Probl Cardiol*. 2024;49(1, Part C):102181. doi: 10.1016/j.cpcardiol.2023.102181
24. Salmasi S, Loewen P, Tandun R, Andrade J, Vera M. Adherence to oral anticoagulants among patients with atrial fibrillation: a systematic review and meta-analysis of observational studies. *BMJ Open*. 2020;10:e034778. doi: 10.1136/bmjopen-2019-034778

25. Reading SR, Black MH, Singer DE, Go AS, Fang MC, Udaltsova N, a.o. Risk factors for medication nonadherence among atrial fibrillation patients. *BMC Cardiovasc Disord*. 2019;19(1):38. doi:10.1186/s12872-019-1019-1
26. Pacleb A, Lowres N, Randall S, Neubeck L, Gallagher R. Adherence to cardiac medications in patients with atrial fibrillation: a pilot study. *Heart, Lung Circ*. 2019;29. doi: 10.1016/j.hlc.2019.11.012
27. Piragine E, Petri D, Martelli A, Calderone V, Lucenteforte E. Adherence to oral antidiabetic drugs in patients with type 2 diabetes: systematic review and meta-analysis. *J Clin Med*. 2023;12:1981. doi: 10.3390/jcm12051981
28. Billimek J, Malik S, Sorkin DH, et al. Understanding disparities in lipid management among patients with type 2 diabetes: gender differences in medication nonadherence after treatment intensification. *Women's Health Issues*. 2015; 25(1):6-12. doi: 10.1016/j.whi.2014.09.004
29. Meisinger C, Peters A, Linseisen J. From the MONICA-project via KORA to the NAKO-study: practical utility of epidemiological studies in the augsburg region. *Gesundheitswesen*. 2016;78(2):84-90. doi: 10.1055/s-0041-110916