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ORIGINAL RESEARCH ARTICLE

Burden of Inappropriate Prescription of Direct Oral Anticoagulants at Hospital Admission and Discharge in the Elderly: A Prospective Observational Multicenter Study

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Abstract

Introduction Direct oral anticoagulants (DOACs) were developed to overcome some of the limitations associated with vitamin K antagonists (VKAs), such as interindividual variability or the need for therapeutic drug monitoring. However, the complexity of DOAC dose regimens can still lead to dosing errors and potential bleeding-related or thromboembolic adverse events, especially in the elderly.

Objective Our objective was to evaluate the rate of inappropriate preadmission DOAC prescriptions at hospital and to evaluate the ability of hospitals to correct them.

Methods An observational prospective study was conducted in elderly patients (aged ≥ 65 years) hospitalized in six acute units of three Parisian university hospitals between February and July 2018. DOAC prescriptions prior to admission and at discharge were analyzed according to the guidelines in the summaries of product characteristics.

Results A total of 157 patients were included in the study, with a median age of 84 years (interquartile range [IQR] 77–89). The median glomerular filtration rate, determined with the Cockcroft–Gault equation, was 48 mL/min (IQR 35–61). Apixaban was the most frequently prescribed drug, mainly for atrial fibrillation. Overall, 48 (30.6%) and 34 (22.4%) prescriptions were inappropriate prior to admission and at discharge, respectively, showing a significant decrease ($p < 0.001$). Hospitals significantly corrected more inappropriate prescriptions (37.5%) than they generated (4.6%) ($p < 0.05$). The nature of the inappropriate prescribing was underdosing (68.8% and 76.5% prior to admission and at discharge, respectively), followed by overdosing (stable rate at almost 20%) and indication errors. No risk factors for inappropriate use were identified by our analysis.

Conclusion One-third of DOAC preadmission prescriptions for elderly patients were inappropriate, indicating that a need remains to strengthen DOAC prescribing guidelines in ambulatory clinical practice. However, the rate of inappropriate prescriptions decreased at patient discharge. Future studies are needed to test actions to promote the proper use of DOACs.

1 Introduction

The direct oral anticoagulants (DOACs) available in France—dabigatran, rivaroxaban and apixaban—were first approved in 2008 to prevent venous thromboembolism in surgery in adults following a hip or knee replacement [1–3]. In 2009 and 2011, three pivotal studies showed the noninferiority of dabigatran [4] and rivaroxaban [5] versus warfarin and the superiority of apixaban [6] versus warfarin in the prevention of stroke or systemic embolism in patients with atrial fibrillation (AF). Finally, in 2012, DOACs were approved for the treatment of deep vein thrombosis and pulmonary embolism, and in the prevention of their reoccurrence [1–3]. Edoxaban is still not available in France.

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Key Points

Errors in direct oral anticoagulant prescriptions were present in 30.6% of patients prior to admission to hospital. However, the rate of errors decreased to 22.4% at discharge.

Prescription errors at admission and discharge mainly involve underdosing of apixaban.

Recent trends in the prescription of anticoagulants has shown a switch from vitamin K antagonists (VKAs) to DOACs. In France, between 2014 and 2016, VKA consumption decreased by 10% and DOAC consumption increased by 360% [7]. At the end of 2013, DOAC prescriptions accounted for 30% of oral anticoagulant prescriptions [8]. Only 75% of patients receiving DOACs were aged ≥ 65 years in 2013. DOACs are now recommended as the first-choice treatment for the prevention of stroke or systemic embolism in patients with AF [8, 9].

Compared with VKAs, which have narrow therapeutic ranges, DOACs have multiple benefits, e.g., predetermined fixed doses or no need for therapeutic drug monitoring. DOACs are considered at least as effective and safe as VKAs, with a comparable risk of major bleeding [10]. As for VKAs, the thromboembolic risk is also significant with DOACs, especially in underdosed patients. In this regard, the French National Authority for Health recently reported an increase of underdosed prescriptions, possibly motivated by a fear of hemorrhagic events [7]. Moreover, the absence of therapeutic drug monitoring and of specific antidotes, except for dabigatran, increases the risk of underdosing on account of physicians' fear of hemorrhaging. This reinforces the need for close monitoring of DOAC prescriptions. DOACs may carry a greater risk of inappropriate prescription (drug misuse) because of the multitude of doses and schedules according to indication, age, weight and renal function, which are the first criteria for dose adjustment and a significant source of dose errors [11]. Drug interactions (e.g., verapamil and dabigatran) also increase the risk of misuse.

Older patients are the main population exposed to DOACs and are considered at high risk of drug-related adverse events. Malnutrition, renal impairment and age-related pharmacokinetic modifications can lead to DOAC accumulation and, ultimately, to hemorrhagic events. Older people are often polymedicated [12], which increases the risk of drug interactions and the potential of under- or overdosing.

To date, only a few studies have investigated the proportions of DOAC misuse, reporting misuse rates of 10–45% in primary care, depending on the population and the drug considered [13–16]. Since hospitalization in the elderly should be an opportunity for treatment optimization [17], these misuses should decrease at discharge.

1.1 Aim

The main objective of our study was to compare the rates of inappropriate DOAC prescriptions for elderly inpatients prior to admission and at hospital discharge to measure the influence of hospitalization on the generation or correction of prescription errors. The secondary objective was to categorize inappropriate uses and to identify patients at risk for inappropriate use.

1.2 Ethics Approval

All data were collected anonymously, as this study was only observational; therefore, no approval from an ethics committee was necessary under French legislation. However, agreement to use the data was obtained from the patients. The study was declared to the French National Agency for Medicines and Healthcare Product Safety (#2017-A02964-49) and approved by the French National Data Protection Commission (#2116046 v 0).

2 Methods

2.1 Design

An observational, prospective, multicenter study was conducted in six clinical units of the Hospital Group HUEP (Hôpitaux Universitaires Est Parisien—Assistance Publique-Hôpitaux de Paris), Paris, France, including internal medicine, cardiology, acute geriatric and post-emergency departments at Saint-Antoine hospital, the internal medicine department at Tenon hospital and the acute geriatric department at Rothschild hospital. Patients were included between February and July 2018.

2.2 Participants

Patients aged ≥ 65 years who were admitted to one of the units from home or the emergency department with a DOAC prescribed prior to admission were eligible. We excluded patients who were included in a medical interventional research program, who objected to study participation or who were under legal tutelage. Rehospitalized patients who were already included could not be included twice.

In each unit, patients were included by a trained junior pharmacist (AB) at admission, after checking inclusion and exclusion criteria and seeking their agreement. During the hospital stay, physicians wrote prescriptions that were reviewed daily by local pharmacists, who checked

that patients received the correct dose, based on indication, renal function, age, body weight and concomitant medications. Any inappropriate prescription was reported to the physicians.

2.3 Data Sources

Data were collected at patient inclusion and completed at discharge by the investigator, using patient medical records: computerized files (ORBIS®, PHEDRA®, ACTIPIDOS® software), paper files, laboratory results, prescriptions brought by the patient at admission and patient discharge prescription.

2.4 Variables

The following data were collected: sex, age, weight at admission, residence (home, nursing home), serum creatinine levels at admission and discharge, DOAC prescribed (dose and indication) prior to admission and at discharge, number of medications on ambulatory prescription at admission and prescription at discharge, length of hospital stay and destination after hospital discharge.

Glomerular filtration rate (GFR) was estimated using the Cockcroft–Gault (CG) and Chronic Kidney Disease-Epidemiology Collaboration (CKD-EPI) equations. Kidney function was categorized using the *International Statistical Classification of Diseases and Related Health Problems*: no renal impairment (GFR ≥ 90 mL/min), mild renal impairment (60 ≤ GFR ≤ 89 mL/min), moderate renal impairment (30 ≤ GFR ≤ 59 mL/min), severe renal impairment (15 ≤ GFR ≤ 29 mL/min) and terminal renal impairment (GFR < 15 mL/min).

If patients had acute renal failure at admission, serum creatinine was measured after renal function recovery.

DOAC prescriptions were considered inappropriate as soon as one of the following criteria was not in accordance with the summary of product characteristics (SPC): indication, dose, renal function, concomitant medications contraindicated and pathophysiological contraindication (for details, see Tables 1 and 2 in the Electronic Supplementary Material).

2.5 Statistical Analysis

Results are presented as means ± standard deviations or medians (interquartile range [IQR]) for continuous variables and as absolute numbers and percentages for categorical variables. Mann–Whitney tests were used to compare medians, and Fisher's exact test or the Chi squared test were used to compare percentages. A McNemar test was performed to compare pair-matched percentages. To determinate risk factors associated with inappropriateness, univariate analyses were performed; covariates with a $p \leq 0.20$ were then entered in a multivariate regression model. Covariates considered potentially associated with inappropriate use of DOAC (age, sex) could be included in the model. In additional analyses, patients were categorized according to their age (± 80 years), weight (± 60 kg) or serum creatinine (± 133 µmol/L), as apixaban calls for dose adjustment according to these values, or according to GFR (± 50 mL/min) as rivaroxaban calls for dose adjustment according to this value.

At admission, the analyzed population included all patients, whereas at discharge, dead patients were removed from the analysis. If data were missing, including weight, which renders the GFR calculation impossible, no imputation was performed and the patient was excluded from the analysis. $p < 0.05$ was predetermined to represent statistical significance. Analyses were performed with R studio (version 0.98.1091, 2009–2014 RStudio Inc).

3 Results

3.1 Patients

From February to July 2018, a total of 165 patients were identified for inclusion in the study (Table 1). However, eight patients were excluded because data were missing (weight in six patients, DOAC indication in two patients), leaving 157 patients for analysis (Fig. 1). The median age was 84 years (IQR 77–89), most patients were women (61%) and median weight was 65 kg (IQR 55–80). The median GFR was 48 mL/min (IQR 35–61) using the CG equation and 57 mL/min (IQR 46–74) using the CKD-EPI equation at admission and increased slightly to 50 mL/min (IQR 35–60.25) and 61 mL/min (IQR 47.75–73), respectively, at hospital discharge.

3.2 Descriptive Data

The most commonly prescribed DOAC prior to admission was apixaban (60.5%), followed by rivaroxaban (33.1%) and dabigatran (6.4%) (Table 1). At discharge, 29 (19.1%) DOAC prescriptions were modified: seven (4.6%) were switched to heparin, four (2.6%) were switched to a VKA and 18 (11.9%) were stopped. During hospitalization, three (1.7%) DOACs were switched to another DOAC. In total, 130 patients (82.8%) received a DOAC for AF and 21 patients (13.4%) for venous thromboembolism, whereas six prescriptions (3.8%) had another indication. The median number of medications in a prescription was seven (IQR 5–9) prior to admission and eight (IQR 6–10) at discharge. The median length of hospital stay was 9 days (IQR 5–14). After discharge, 108 patients (68.8%) went home or to a nursing home, 27 patients (17.2%) were transferred to

Table 1 Characteristics of included patients

Characteristics	*N* (%)[a]			
Patient characteristics (*N* = 157)				
Median age (IQR), years	84 (77–89)			
Sex (F/M)	96/61 (61)			
Median weight (IQR), kg	65 (55–80)			
	At admission (*N* = 157)		At discharge (*N* = 152)	
Median serum creatinine (IQR), µmol/L	92 (72–112)		88 (70.75–108.25)	
Creatinine clearance, mL/min				
Formula used	CG	CKD-EPI	CG	CKD-EPI
Median (IQR)	48 (35–61)	57 (46–74)	50 (35–60.25)	61 (47.75–73)
Distribution				
< 15	1 (0.6)	0 (0)	1 (0.7)	0 (0)
15–29	23 (14.7)	11 (7.0)	20 (13.1)	11 (7.2)
30–59	89 (56.7)	76 (48.4)	88 (57.9)	62 (40.8)
60–89	38 (24.2)	66 (42.0)	36 (23.7)	72 (47.4)
≥ 90	6 (3.8)	4 (2.6)	7 (4.6)	7 (4.6)
Anticoagulant prescribed	Prior to admission (*N* = 157)			
Apixaban	95 (60.5)		79 (52.0)	
Rivaroxaban	52 (33.1)		40 (26.3)	
Dabigatran	10 (6.4)		4 (2.6)	
No DOAC	0 (0)		29 (19.1)	
Heparin	0 (0)		7 (4.6)	
VKA	0 (0)		4 (2.6)	
No anticoagulant	0 (0)		18 (11.9)	
Indication				
Atrial fibrillation	130 (82.8)			
VTE treatment or prophylaxis	21 (13.4)			
Other	6 (3.8)			
Number of drugs	Prior to admission (*N* = 157)			
Median (IQR)	7 (5–9)		8 (6–10)	
Distribution				
≤ 5	41 (26.1)		27 (17.8)	
6–10	87 (55.4)		90 (59.2)	
≥ 11	29 (18.5)		35 (23.0)	
Hospital characteristics (N pts included)				
Saint-Antoine cardiology department	50			
Saint-Antoine internal medicine department	19			
Saint-Antoine acute geriatric department	23			
Saint-Antoine post emergency department	262			
Rothschild acute geriatric department	13			
Tenon internal medicine department	26			
Length of stay, days				
Median (IQR)	9 (5–14)			
Distribution				
≤ 5	48 (30.6)			
6–10	43 (27.4)			
≥ 11	66 (42.0)			
Destination after hospital discharge				
Home or nursing home	108 (68.8)			
Transfer to another acute medical facility	27 (17.2)			
Transfer to a rehabilitation facility	17 (10.8)			
Death	5 (3.2)			

CG Cockcroft–Gault equation, *CKD-EPI* Chronic Kidney Disease-Epidemiology Collaboration equation, *DOAC* direct oral anticoagulant, *F* female, *IQR* interquartile range, *M* male, *pts* patients, *VKA* vitamin K antagonist, *VTE* venous thromboembolism

[a]Data are presented as N (%) unless otherwise indicated

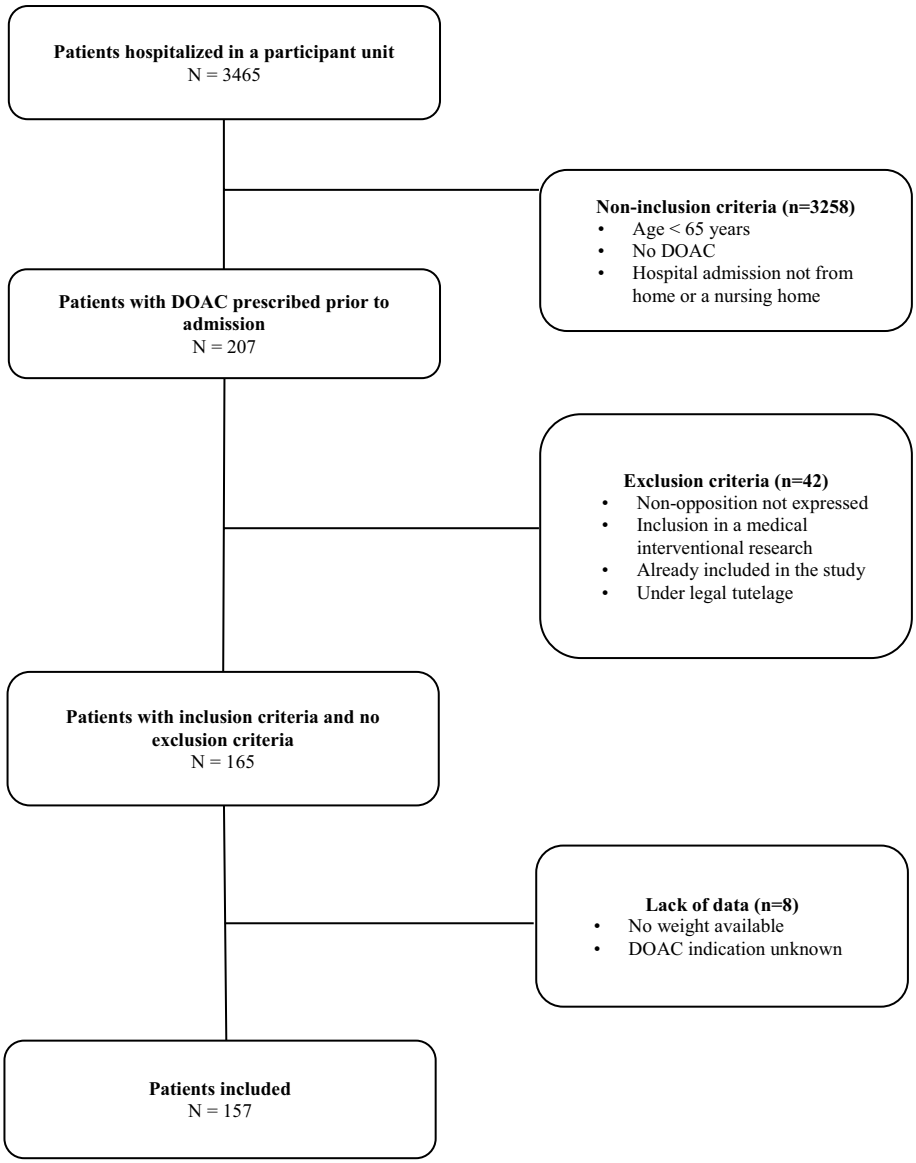

Fig. 1 Inclusion flowchart

another acute medical facility and 17 (10.8%) were transferred to rehabilitation facilities. Five patients (3.2%) died during their hospital stay.

3.3 Primary Objective

Prior to admission, 48 patients (30.6%) had an inappropriate prescription (Table 2). At discharge, 34 patients (22.4%) had an inappropriate prescription; in 33 patients (21.7%), the nature of the inappropriateness was under- or overdosing.

The decrease in rate of inappropriate DOAC prescriptions was significant between admission and discharge ($p < 0.001$) (Table 2).

Among the 48 inappropriate prescriptions prior to admission, 29 (60.4%) remained inappropriate at discharge, 18 (37.5%) were modified and became appropriate and one (2.1%) patient died, leading to an error correction rate of 37.5%. Among the 109 appropriate prescriptions prior to admission, 100 (91.7%) remained appropriate at discharge, five (4.6%) became inappropriate and four (3.7%) patients died, leading to an error generation rate of 4.6%.

Thus, the rate of correction of inappropriate prescriptions during hospitalization was significantly higher than that of generation of inappropriate prescriptions ($p < 0.05$).

We observed the same inappropriate prescription rate for each DOAC between preadmission and discharge: apixaban prescriptions were inappropriate in 26 of 95 patients (27.4%) prior to admission and 21 of 79 (26.6%) at discharge ($p > 0.05$), rivaroxaban prescriptions were inappropriate in 19 of 52 patients (36.5%) prior to admission and 12 of 40 (30.0%) at discharge ($p > 0.05$), and dabigatran prescriptions

Table 2 Appropriateness of direct oral anticoagulant prescriptions before admission and at discharge

Outcomes			*p* value
DOAC withdrawal during hospitalization	29		
Deaths during hospitalization	5		
	Before admission (*N* = 157)	At discharge (*N* = 152)	
Appropriateness			< 0.001
Appropriate prescription	109 (69.4)	118 (77.6)	
Inappropriate prescription	48 (30.6)	34 (22.4)	
Cause of inappropriateness			> 0.05
Indication	4 (2.6)	1 (0.7)	
Dosing	44 (28.0)	33 (21.7)	
Underdosing	33 (21.0)	26 (17.1)	
Overdosing	10 (6.4)	7 (4.6)	
Inappropriate dosing schedule	1 (0.6)	0 (0)	
Drug–drug contraindication	0 (0)	0 (0)	
Pathophysiological contraindication	0 (0)	0 (0)	

Data are presented as N (%)

DOAC direct oral anticoagulant

were inappropriate in three of ten (30.0%) patients prior to admission and one of four (25.0%) at discharge ($p > 0.05$).

3.4 Secondary Objectives

Categories of inappropriate prescriptions evolved as follows: underdosing increased from 68.8% (33/48) prior to admission to 76.5% (26/34) at discharge, overdosing was stable (20.8% [10/48] prior to admission to 20.6% [7/34] at discharge) and inappropriate indications decreased from 8.3% (4/48) to 2.9% (1/34) between admission and discharge. At admission, inappropriate indications included one central retinal artery occlusion, one chronic post-embolic pulmonary hypertension, one aortic heart valve replacement and one deep vein thrombosis that had been resolved for 6 years; at discharge, DOACs were inappropriately prescribed for one aortic heart valve replacement. One prescription with an inappropriate dosing schedule prior to admission was corrected during hospitalization ($p > 0.05$ for all comparisons). Underdosing mainly affected apixaban (70.0% prior to admission and 69.2% at discharge), whereas the most overdosed DOAC prescribed was rivaroxaban (70.0% prior to admission and 57.1% at discharge).

Univariate analyses were performed at admission (Table 3) and discharge (Table 4). Significant differences between appropriateness and inappropriateness were only observed with serum creatinine and GFR estimated with the CKD-EPI formula at admission, whereas no significant difference was observed at discharge. Thus, multivariate analyses were not possible as covariates that could be included in the regression model were not independent. Nor were we able to identify any risk factor for inappropriate prescribing.

3.5 Sensitivity Analysis

When the CKD-EPI equation was used instead of the CG equation, 58 of 157 (36.9%) prescriptions would have been inappropriate prior to admission and 39 of 152 (25.7%) at discharge ($p < 0.001$). Differences with the CG equation were not significant.

With an authorized gap of 10% for creatinine clearance, 10% for serum creatinine and 5% for weight, 42 (26.8%) prescriptions would have been inappropriate prior to admission and 24 (15.8%) at discharge ($p < 0.001$). Differences with results without gap were not significant.

4 Discussion

This study showed that the rate of inappropriate DOAC prescriptions decreased significantly at discharge, although the magnitude of such a decrease remains insufficient. However, hospitals generated significantly more appropriate than inappropriate prescriptions. Prescriptions were reviewed by clinical pharmacists, which may have contributed to therapy optimization, as noted by Lee et al. [18].

This study also evidenced a high burden of inappropriate DOAC prescriptions prior to hospital admission, thus challenging the management of medication in hospital. This result is comparable with those from previous studies, emphasizing that the prescription of DOACs should

Table 3 Outcomes at admission

Variable	Appropriate prescription ($N=109$)	Inappropriate prescription ($N=48$)	p value
Mean age, years	82.66 ± 8.24	83.79 ± 8.50	0.434
Sex			
Female	65 (41.4)	31 (19.7)	0.558
Male	44 (28)	17 (10.8)	
Weight, kg	68.73 ± 18.54	67.00 ± 15.45	0.572
Serum creatinine, µM	99.47 ± 34.45	85.90 ± 28.35	0.017
GFR (CG), mL/min	49.17 ± 22.10	52.14 ± 16.25	0.404
GFR (CKD-EPI), mL/min	56.51 ± 18.61	63.38 ± 16.62	0.030
DOAC			0.535
Apixaban	69 (43.9)	26 (16.6)	
Dabigatran	7 (4.5)	3 (1.9)	
Rivaroxaban	33 (21)	19 (12.1)	
Number of drugs	7.87 ± 3.43	7.56 ± 3.12	0.594
Age, years			0.259
< 80	42 (26.8)	14 (8.9)	
> 80	67 (42.7)	34 (21.7)	
Renal failure			0.241
GFR (CG) > 50 mL/min	61 (38.9)	22 (14)	
GFR (CG) < 50 mL/min	48 (30.6)	26 (16.6)	
Weight, kg			0.607
> 60	68 (43.3)	32 (20.4)	
< 60	41 (26.1)	16 (10.2)	
Serum creatinine, µM			0.174
> 133	94 (59.9)	45 (28.7)	
< 133	15 (9.6)	3 (1.9)	

CG Cockcroft–Gault equation, *CKD-EPI* Chronic Kidney Disease-Epidemiology Collaboration equation, *DOAC* direct oral anticoagulant, *GFR* glomerular filtration rate

be carefully monitored in community-dwelling patients [13–17]. Moudallel et al. [19] reported a prevalence of inappropriate dosing at discharge similar to that in our study (25.0 vs. 21.7%). Franchi et al. [20] found inappropriate DOAC doses at a rate of 19.5%; but this study focused on patients with AF.

Underdosing represented two-thirds of total inappropriate prescriptions. This is particularly concerning as underdosing is associated with a higher risk of stroke, especially with apixaban, for which the risk is increased by a factor of five [21]. Some physicians may intentionally decrease doses in patients at high risk of hemorrhage despite SPC guidelines. Further studies should be conducted in these specific populations.

Overdosing and nonintentional underdosing can be partially explained by the equation used to estimate GFR. Using SPC guidelines as a reference, we recommend using the CG equation to estimate GFR and adapt DOAC doses. However, the CG equation is inappropriate in elderly patients as it underestimates GFR [22]. In clinical practice, physicians may thus use the CKD-EPI equation rather than the CG equation to calculate GFR. Studies comparing the CKD-EPI and CG equations reported a higher estimation of GFR using the CKD-EPI, leading to increased DOAC doses [23]. In our study, sensitivity analysis indicated that the rate of inappropriate prescribing was not influenced by the equation used to determine creatinine clearance.

We wanted to investigate whether a small variation in clearance creatinine, serum creatinine or weight could decrease the rate of inappropriate prescriptions. Sensitivity analysis showed a nonsignificant decrease in rates, mainly at discharge. Therefore, inappropriate prescribing cannot be related to serum creatinine or weight measurement errors.

Unfortunately, we were unable to identify risk factors for inappropriate prescriptions. In addition, no DOAC was involved in more inappropriate prescriptions than another. Therefore, we cannot describe a population at risk of inappropriate prescribing, so future interventions to improve the use of DOACs should be applied to all patients prescribed DOACs.

In 2016, published data reported that rivaroxaban accounted for half of DOAC prescriptions. In our study, the most commonly prescribed DOAC was apixaban, which is associated in the literature with less major bleeding-related adverse drug events than the other DOACs [7, 24]. In our study, prescription of dabigatran was low, and switches from dabigatran to another DOAC were made during hospitalization. This may be because dabigatran has a lower benefit/risk balance than the other DOACs because of coronary syndrome and bleeding risks. Furthermore, dabigatran is contraindicated in severe renal impairment.

4.1 Limitations

Our study has some limitations. First, the size of the population was modest. However, as this was a multicenter study (six departments in three hospitals), the risk of selection bias was decreased.

Second, although the study was prospective, files were analyzed after patient discharge and were sometimes incomplete. A comprehensive medication history performed prospectively by pharmacists would have allowed for the identification of medication errors, such as duration of treatment or modalities of administration. Eight DOAC prescriptions were not analyzed because patient weight or DOAC indication data were missing.

Moreover, the DOAC prescriptions were interpreted and classified as appropriate or inappropriate by a single researcher, which carries a risk of misclassification.

Table 4 Outcomes at discharge

Variable	Appropriate prescription ($N=118$)	Inappropriate prescription ($N=34$)	p value
Mean age, years	82.52 ± 8.52	84.24 ± 7.41	0.289
Sex			0.867
Women	71 (46.7%)	21 (13.8%)	
Men	47 (30.9%)	13 (8.6%)	
Weight, kg	68.26 ± 18.43	68.15 ± 15.78	0.974
Serum creatinine at admission, µM	97.01 ± 32.13	85.94 ± 35.25	0.085
GFR at admission (CG), mL/min	50.12 ± 22.31	52.15 ± 12.55	0.613
GFR at admission (CKD-EPI), mL/min	57.62 ± 18.26	64.53 ± 16.74	0.0507
Serum creatinine at discharge, µM	96.69 ± 32.68	85.00 ± 30.77	0.0646
GFR at discharge (CG), mL/min	50.21 ± 22.29	52.76 ± 15.06	0.532
GFR at discharge (CKD-EPI), mL/min	58.08 ± 18.19	64.82 ± 16.77	0.0548
GFR variation A–D	0.31 ± 14.54	0.94 ± 12.38	0.819
Number of drugs before admission	7.65 ± 3.39	8.06 ± 3.17	0.534
Number of drugs at discharge	8.09 ± 3.16	8.68 ± 3.05	0.341
Number difference A–D			0.792
No difference	32 (21.1)	10 (6.6)	
Differences	86 (56.6)	24 (15.8)	
Age, years			0.0814
< 80	47 (30.9)	8 (5.3)	
> 80	71 (46.7)	26 (17.1)	
Renal failure			0.298
GFR (CG) > 50 mL/min	54 (35.5)	19 (12.5)	
GFR (CG) < 50 mL/min	64 (42.1)	15 (9.9)	
Weight, kg			0.351
> 60	73 (48.0)	24 (15.8)	
< 60	45 (29.6)	10 (66)	
Serum creatinine at discharge, µM			0.526
> 133	14 (9.2)	2 (1.3)	
< 133	104 (68.4)	32 (21.1)	
Length of stay, days			0.996
< 5	37 (24.3)	10 (6.6)	
> 5	81 (53.3)	24 (15.8)	
Destination at discharge			0.883
Home	83 (54.6)	25 (16.4)	
Transfer	35 (23.0)	9 (5.9)	

Data are presented as mean ± standard deviation or N (%) unless otherwise indicated

A–D admission–discharge, *CG* Cockcroft–Gault equation, *CKD-EPI* Chronic Kidney Disease-Epidemiology Collaboration equation, *GFR* glomerular filtration rate

Finally, the data collected did not indicate when DOAC treatment was initiated. The DOAC prescription could have been appropriate at the time of initiation but inappropriate at hospital admission because of GFR degradation or changes in age and weight. Monitoring of patients receiving DOACs should be close and constant.

4.2 Generalizability

Our results are generalizable to polymedicated elderly patients and to similar medical departments (i.e., medical wards with pharmaceutical review of prescriptions) in terms of inappropriate DOAC prescription at admission and discharge.

5 Conclusion

Our study showed that one-third of DOAC prescriptions in elderly patients prior to admission to hospital are inappropriate. The rate of inappropriate prescribing decreases at patient discharge. Therefore, future intervention studies should be launched to improve DOAC prescriptions and promote proper use of DOACs.

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Compliance with Ethical Standards

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Conflict of interest A. Bruneau, C. Schwab, M. Anfosso, C. Fernandez and P. Hindlet have no potential conflicts of interest that might be relevant to the contents of this manuscript.

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