

Putting DOAC Doubts to Bed(side): Point-of-Care ClotPro® Testing Confirms Comparable Functional Outcomes in Anticoagulated and Non-Anticoagulated Stroke Patients

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Research Article

Keywords: ischemic stroke, direct oral anticoagulants, point-of-care testing, ClotPro, functional outcome

Posted Date: May 7th, 2025

DOI: <https://doi.org/10.21203/rs.3.rs-6288029/v1>

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Additional Declarations: No competing interests reported.

Abstract

Background

Direct oral anticoagulants (DOACs) are now the guideline-recommended alternative to vitamin K antagonists (VKAs) for long-term anticoagulation. However, accurately assessing their impact on ischemic stroke outcomes remains challenging, primarily due to uncertainty regarding anticoagulation status at the time of hospital admission. This study addresses that gap by using point-of-care testing (POCT) to confirm DOAC activity at the bedside, allowing for a more accurate comparison of 90-day functional outcomes between anticoagulated and non-anticoagulated stroke patients.

Methods

We conducted a retrospective cohort study of 786 ischemic stroke patients admitted to the University of Pécs between February 2023 and February 2025. Active DOAC therapy was confirmed using the ClotPro® viscoelastic testing platform, with Ecarin Clotting Time (ECT) employed for thrombin inhibitors and Russell's Viper Venom (RVV) assays for factor Xa inhibitors. Patients were categorized as non-anticoagulated ($n = 767$) or DOAC-treated with confirmed activity ($n = 19$). Mahalanobis distance-based matching was applied to account for confounding variables including age, sex, pre-stroke modified Rankin Scale (mRS), and National Institutes of Health Stroke Scale (NIHSS) scores at admission and 72 hours post-stroke. The primary outcome was the change in mRS from baseline to 90 days. Statistical analysis included ordinary least squares (OLS) regression and principal component analysis (PCA).

Results

After matching, 90-day functional outcomes were comparable between groups (mean mRS-shift: 2.00 in DOAC-treated vs. 1.78 in non-anticoagulated; $p = 0.745$). OLS regression showed no independent association between DOAC status and recovery ($p = 0.599$). In contrast, NIHSS score at 72 hours ($p = 0.004$) and age ($p = 0.015$) were significant predictors of outcome. PCA supported these findings, identifying stroke severity as the primary driver of outcome.

Conclusion

Ischemic stroke patients with confirmed active DOAC therapy at admission achieve 90-day functional outcomes comparable to non-anticoagulated patients. The integration of bedside POCT improves the reliability of outcome assessments and highlights the clinical value of real-time anticoagulation verification in acute stroke management.

1 Introduction

1.1 The Challenge of Assessing DOAC Activity in Acute Stroke

Ischemic stroke remains a leading cause of morbidity worldwide [1], underscoring the importance of accurately identifying factors that influence patient recovery. Direct oral anticoagulants (DOACs), such as dabigatran, rivaroxaban, apixaban, and edoxaban, have fundamentally changed anticoagulation management [2, 3] and are frequently recommended over traditional vitamin K antagonists (VKAs) in clinical guidelines [4], owing to their predictable pharmacokinetics, favorable safety profiles, and reduced need for routine laboratory monitoring [5–8].

Despite their widespread use, assessing the true impact of DOAC therapy on ischemic stroke outcomes remains methodologically challenging. The primary difficulty lies in accurately determining whether patients are actively anticoagulated upon hospital presentation [9]. Most studies classify patients as “on DOACs” based on self-reported medication use or prescription history; however, this approach does not reliably capture actual anticoagulant activity at the time of admission.

While international normalized ratio (INR) testing is well-established for monitoring VKAs, it is not a reliable marker of DOAC activity. Accurate assessment of DOAC levels requires specific assays. For dabigatran, dilute thrombin time (TT) [10] or ecarin-based assays [11] are considered the most reliable, while calibrated anti-Xa assays are the preferred method for measuring factor Xa inhibitors [12–14].

In the absence of these specialized tests, standard laboratory parameters may offer limited surrogate insight: For dabigatran, TT or activated partial thromboplastin time (APTT) are generally more informative than prothrombin time (PT)/INR [15, 16], whereas PT/INR is typically more reliable than APTT for detecting factor Xa inhibitors [17, 18]. However, traditional laboratory-based assays are frequently subject to delays due to centralized processing and limited availability outside regular working hours [19], while standard coagulation assays lack sufficient sensitivity [20].

Consequently, the inability to rapidly and reliably confirm anticoagulation status has introduced misclassification bias in prior studies, resulting in inconsistent interpretations of the true efficacy and safety of DOAC therapy in acute ischemic stroke.

1.2 The Role of Point-of-Care Testing

To address these challenges, rapid point-of-care testing (POCT) methods have gained increasing attention as a means of verifying anticoagulation status in acute clinical settings. Urine-based DOAC detection assays represent one such POCT approach and offer a quick and non-invasive alternative [21–23]. However, their diagnostic utility is limited by an inability to detect low drug concentrations and their susceptibility to dilution effects, as well as interference from cellular components (e.g., erythrocytes, leukocytes, microorganisms), or co-excreted substances and medications [24].

In recent years, viscoelastic point-of-care testing (POCT) platforms such as rotational thromboelastometry (ROTEM®) [25] and thromboelastography (TEG®) [26], have been increasingly adopted for real-time coagulation assessment in acute care settings. ClotPro® builds on these technologies with innovations that make it particularly suitable for evaluating anticoagulation status. While other systems such as ROTEM® and TEG® can be adapted to detect DOAC effects, ClotPro® offers standardized, drug-specific assays as part of its core test panel: Ecarin Clotting Time (ECT) for direct thrombin inhibitors and Russell's Viper Venom (RVV) for factor Xa inhibitors. These assays enable bedside confirmation of active anticoagulation within minutes, providing a practical tool for acute stroke management.

In this study, we evaluated 90-day functional outcomes in ischemic stroke patients by comparing those with objectively confirmed DOAC activity at admission - verified in real time using the ClotPro® POCT system - to non-anticoagulated counterparts.

2 Methods

2.1 Study Design and Setting

This retrospective cohort study was conducted at the Department of Neurology, University of Pécs. Data from ischemic stroke patients admitted between February 2023 and February 2025 were obtained from the Transzláció Ideggyógyászati Nemzeti Laboratórium (TINL) STROKE-registry.

Inclusion criteria were (1) imaging-confirmed diagnosis of ischemic stroke via computed tomography or magnetic resonance imaging, (2) documented pre-stroke functional status using the modified Rankin Scale (mRS), (3) availability of National Institutes of Health Stroke Scale (NIHSS) scores at admission and 72 hours post-stroke, and (4) complete 90-day mRS follow-up data.

Patients were categorized into two groups based on their anticoagulation status at admission: non-anticoagulated (n = 767) and DOAC-treated with confirmed active anticoagulation (n = 19).

2.2 Point-of-Care Testing for Anticoagulation Verification

For patients reporting DOAC use, anticoagulation status was assessed immediately upon admission using the ClotPro® viscoelastic testing platform (Haemonetics Corporation, Boston, MA, USA; formerly enicor GmbH, Munich, Germany). Two DOAC-specific assays were used: the ECT assay for detecting direct thrombin inhibitors and the RVV assay for identifying factor Xa inhibitors (rivaroxaban, apixaban, edoxaban). In accordance with the manufacturer's recommendations, patients were classified as actively anticoagulated if clotting time (CT) was ≥ 180 seconds on the ECT assay or ≥ 100 seconds on the RVV assay.

2.3 Outcome Measures

The primary outcome was the shift in mRS score from baseline (pre-stroke) to 90 days post-stroke, representing functional recovery or decline.

2.4 Statistical Analysis

Continuous variables were reported as mean $\pm$ standard deviation (SD) or median with interquartile range (IQR), depending on distribution. Categorical variables were summarized as frequencies and percentages. The Shapiro-Wilk test was used to assess normality. Between-group comparisons were made using Fisher's exact test for categorical variables and either Student's t-test or Mann-Whitney U test for continuous variables, as appropriate.

To ensure comparability between groups, Mahalanobis distance-based matching was performed, balancing the groups according to age, sex, pre-stroke mRS, admission NIHSS scores, and NIHSS scores at 72 hours post-stroke. Post-matching balance was assessed using standardized mean differences (SMDs), with an SMD of < 0.20 indicating acceptable balance.

Ordinary least squares (OLS) regression was used to assess the association between anticoagulation status and mRS-shift, adjusting for matched covariates. Principal component analysis (PCA) was performed to address multicollinearity and identify the most influential predictors of functional recovery. For both standard and PCA-derived regression models, 95% confidence intervals (CIs) were calculated to quantify the precision of predictor estimates. All analyses were conducted using Python version 3.14, with statistical significance set at $p < 0.05$.

2.5 Ethics approval

The study protocol was reviewed and approved by the Scientific and Research Ethics Committee of the Medical Research Council of the University of Pécs (RRF-2.3.1-21-2022-00011, 01/09/22) and the Scientific and Research Ethics Committee of the Medical Research Council of Hungary (BM/22444-1/2024, 01/09/24). Informed consent was waived for this study as the data were collected as part of routine clinical documentation, in accordance with the institutional ethics approval.

3 Results

3.1 Demographic and Clinical Characteristics

Prior to matching, significant baseline differences existed between DOAC-treated and non-anticoagulated patients (Table 1). Patients in the DOAC-treated group were significantly older (mean age 79.74 ± 9.40 years) compared to the non-anticoagulated group (69.40 ± 12.51 , $p < 0.001$) and had slightly higher pre-stroke mRS scores (1.21 ± 1.27 vs. 0.61 ± 1.15 , $p = 0.057$).

Additionally, cardioembolic stroke was significantly more prevalent in the DOAC group (63.2% vs. 26.9%, $p < 0.001$), and onset-to-door time was markedly shorter (105 [68-232] vs. 310 [102-832] minutes, $p < 0.001$).

Comorbidities such as hypertension and diabetes mellitus were also more frequent among DOAC-treated patients (hypertension: 100% vs. 79.8%, p=0.020; diabetes: 57.9% vs. 33.6%, p=0.047), whereas current smoking was more common in the non-anticoagulated group (31.9% vs. 0.0%; p=0.002).

Regarding acute stroke treatment, DOAC-treated patients were significantly less likely to receive TL (0.0% vs. 27.9%, p=0.007), reflecting expected anticoagulation-related treatment limitations, while rates of MT were similar between groups (15.8% vs. 17.2%, p=0.870).

After applying Mahalanobis distance-based matching, these baseline differences were effectively minimized, achieving balance across most covariates (Table 2, SMDs for all matched variables <0.20). The resulting groups were well-balanced in terms of age (79.72 ± 9.67 vs. 78.00 ± 8.17 years, p=0.568) and pre-stroke mRS scores (1.28 ± 1.27 vs. 1.11 ± 1.23, p=1.00).

However, some variables remained significantly different post-matching, including cardioembolic stroke prevalence (66.7% vs. 22.2%, p=0.007), onset-to-door times (110 [72-221] vs. 408 [130-584] minutes, p<0.001), and diabetes mellitus (55.6% vs. 16.7%, p=0.035).

Additionally, as expected, DOAC-treated patients continued to be significantly less likely to receive TL (0.0% vs. 33.3%, p=0.007).

Despite these remaining differences, none of these factors were found to significantly predict 90-day functional outcomes in adjusted analyses (see Section 3.3). This reinforces that while DOAC-treated patients exhibited distinct baseline characteristics, these differences did not translate into worse functional outcomes.

Table 1. Demographic and Clinical Characteristics Before and After Matching

	Non-anticoagulated (n=767)	DOAC (n=19)	p-Value	Matched non-anticoagulated (n=18)	Matched DOAC (n=18)	p-Value
Demographics						
Age (years), mean $\pm$ SD	69.40 $\pm$ 12.51	79.74 $\pm$ 9.40	<0.001*	78.00 $\pm$ 8.17	79.72 $\pm$ 9.67	0.568
Sex, male, n (%)	378.0 (49.3%)	11.0 (57.9%)	0.494	10 (55.6%)	11 (61.1%)	1.000
Clinical Characteristics						
Pre-stroke mRS score, mean $\pm$ SD	0.61 $\pm$ 1.15	1.21 $\pm$ 1.27	0.057	1.11 $\pm$ 1.23	1.28 $\pm$ 1.27	0.692
NIHSS score at admission, mean $\pm$ SD	6.83 $\pm$ 6.17	7.11 $\pm$ 6.24	0.851	7.06 $\pm$ 6.31	7.28 $\pm$ 6.37	0.917
NIHSS score at 72 hours, mean $\pm$ SD	5.44 $\pm$ 8.17	5.37 $\pm$ 9.77	0.975	5.06 $\pm$ 9.67	5.61 $\pm$ 9.99	0.866
ICH, n (%)	37 (4.8%)	0 (0.0%)	0.326	1 (5.6%)	0 (0.0%)	0.310
Etiology, cardioembolic, n (%)	206 (26.9%)	12 (63.2%)	<0.001*	4 (22.2%)	12 (66.7%)	0.007*
Onset-to-door time (min), median [IQR]	310 (102-832)	105 (68-232)	<0.001*	408 (130-584)	110 (72-221)	<0.001*
Plasma glucose (mmol/l), mean $\pm$ SD	7,74 $\pm$ 2.99	7,14 $\pm$ 2.21	0.381	7,41 $\pm$ 162	7,23 $\pm$ 2.23	0.993
Medical history, n (%)						
Hypertension	612 (79.8%)	19 (100%)	0.020*	14 (77.8%)	18 (100.0%)	0.104
Diabetes mellitus	258 (33.6%)	11 (57.9%)	0.047*	3 (16.7%)	10 (55.6%)	0.035*
Current smoking	245 (31.9%)	0 (0.0%)	0.002*	3 (16.7%)	0 (0.0%)	0.229
Alcohol use	332 (43.3%)	9 (47.4%)	0.816	13 (72.2%)	9 (50.0%)	0.305
Recanalization therapy, n (%)						

TL	214 (27.9%)	0 (0.0%)	0.007*	6 (33.3%)	0 (0.0%)	0.007*
MT	132 (17.2%)	3 (15.8%)	0.870	3 (16.7%)	3 (16.7%)	1.000
TL + MT	65 (8.5%)	0 (0.0%)	0.186	0 (0.0%)	0 (0.0%)	1.000

Abbreviations: DOAC = direct oral anticoagulant, SD = standard deviation, mRS = modified Rankin Scale, NIHSS = National Institutes of Health Stroke Scale, ICH = intracranial hemorrhage, IQR = interquartile range, TL = thrombolysis, MT = mechanical thrombectomy

Table 2. Standardized Mean Differences (SMDs) Before and After Matching

	SMD before matching	SMD after matching
Age	0.935	0.192
Sex	0.171	0.110
Pre-stroke mRS score	0.493	0.133
NIHSS score at admission	0.044	0.035
NIHSS score at 72 hours	0.008	0.056

Abbreviations: SMD = standardized mean difference, mRS = modified Rankin Scale, NIHSS = National Institutes of Health Stroke Scale

3.2 Functional Outcomes

At 90 days post-stroke, functional outcomes were comparable between DOAC-treated and non-anticoagulated patients. Before matching, there was no significant difference in mean mRS-shift between the two groups (DOAC-treated: 1.89 vs. non-anticoagulated: 1.75; $p=0.771$). Following matching, this similarity persisted, with the DOAC group showing a mean mRS-shift of 2.00 compared to 1.78 in the non-anticoagulated group ($p=0.745$; Figure 1).

3.3 Ordinary Least Squares Regression Analysis and Functional Outcome Prediction

Regression analysis showed no significant association between confirmed active DOAC anticoagulation status and 90-day functional recovery, as measured by mRS-shift ($p=0.599$). In contrast, NIHSS at 72 hours ($p=0.004$) and age ($p=0.015$) emerged as significant independent predictors of functional outcome

(Table 3). The model yielded an adjusted R^2 of 0.541, indicating that a substantial proportion of the variability in recovery was explained, despite the inherent clinical complexity of the dataset.

Table 3. Regression Coefficients for Predictors of mRS-shift

Predictor	Coefficient	p-Value	95% CI
Anticoagulation status	0.4905	0.599	-1.433 to 2.414
Age	0.1188	0.015*	0.026 to 0.211
Sex	-0.4080	0.629	-2.154 to 1.338
Pre-stroke mRS score	-0.1236	0.707	-0.804 to 0.557
NIHSS score at admission	-0.0083	0.942	-0.245 to 0.229
NIHSS score at 72 hours	0.1930	0.004*	0.070 to 0.316
ICH	-1.7137	0.439	-6.267 to 2.839
Etiology, cardioembolic	-1.1696	0.289	-3.419 to 1.080
Onset-to-door time	0.0004	0.583	-0.001 to 0.002
Plasma glucose	0.0944	0.682	-0.381 to 0.570
Hypertension	0.6411	0.624	-2.059 to 3.341
Diabetes mellitus	-0.7698	0.423	-2.740 to 1.201
Current smoking	-0.6960	0.599	-3.427 to 2.035
Alcohol use	-0.0914	0.915	-1.872 to 1.689
TL	0.3097	0.826	-2.601 to 3.220
MT	0.6762	0.449	-1.161 to 2.513

Abbreviations: mRS = modified Rankin Scale, CI = confidence interval, NIHSS = National Institutes of Health Stroke Scale, ICH = intracranial hemorrhage, TL = thrombolysis, MT = mechanical thrombectomy

3.4 Principal Component Analysis and Functional Outcome Prediction

To address multicollinearity among baseline variables and identify the most influential predictors of mRS-shift, PCA was conducted. This dimensionality reduction technique transformed the original set of correlated variables into orthogonal principal components (PCs), each capturing a distinct portion of variance within the dataset. The first eight PCs collectively explained 89.9% of the total variance, indicating that the majority of the original data structure was preserved (Table 4). Among these, PC1 and

PC2 accounted for the greatest proportion of variance, 18.27% and 16.64%, respectively, suggesting they reflect the most prominent underlying dimensions associated with functional recovery.

Table 4. Explained Variance and Cumulative Variance for Principal Components

Principal Component	Explained Variance (%)	Cumulative Variance (%)
PC1	18.27	18.27
PC2	16.64	34.90
PC3	14.35	49.26
PC4	11.52	60.78
PC5	9.89	70.67
PC6	8.25	78.93
PC7	5.98	84.90
PC8	5.02	89.92

Abbreviations: PC = principal component

3.5 Regression Analysis Using Principal Component Analysis-Derived Components

Regression analysis incorporating the PCA-derived components further confirmed that DOAC anticoagulation status was not significantly associated with 90-day functional recovery ($p=0.703$). In contrast, PC2 emerged as the strongest independent predictor of mRS shift ($p<0.001$), suggesting that this component captured the most relevant variance associated with post-stroke functional outcomes (Table 5).

Table 5. Regression Coefficients for Predictors of mRS-shift

Predictor	Coefficient	p-Value	95% CI
Anticoagulation status	-0.3264	0.703	-2.076 to 1.423
PC1	-0.0392	0.841	-0.439 to 0.360
PC2	0.9276	<0.001*	0.495 to 1.360
PC3	0.1233	0.561	-0.309 to 0.556
PC4	0.2432	0.269	-0.201 to 0.688
PC5	0.0934	0.708	-0.415 to 0.602
PC6	0.1789	0.517	-0.384 to 0.742
PC7	-0.5224	0.106	-1.166 to 0.121
PC8	0.5545	0.100	-0.114 to 1.223
TL	-1.1450	0.306	-3.407 to 1.117
MT	-0.4734	0.540	-2.046 to 1.099

Abbreviations: mRS = modified Rankin Scale, CI = confidence interval, PC = principal component, TL = thrombolysis, MT = mechanical thrombectomy

Analysis of the PCA loadings (Figure 2) revealed that PC2 was primarily influenced by NIHSS at admission (loading: 0.62), NIHSS at 72 hours (0.53), and cardioembolic stroke etiology (0.32). This loading pattern underscores the central role of stroke severity and early neurological status in determining functional recovery. The contribution of cardioembolic stroke to PC2 likely reflects its association with more severe clinical presentations, which are well-documented predictors of worse outcomes.

4 Discussion

4.1 Interpretation of Findings

Accurately determining anticoagulation status in acute stroke patients remains a clinical challenge. Although traditional laboratory assays offer high analytical precision, their utility in emergency settings is often limited by processing delays and restricted availability outside routine hours, making them less practical for acute stroke management. To address this limitation, our study implemented POCT for bedside verification of DOAC activity, enabling immediate and objective classification of anticoagulation status at admission.

Despite initial baseline differences, such as older age, higher prevalence of cardioembolic stroke, and shorter onset-to-door times in the DOAC group, 90-day functional outcomes were comparable between DOAC-treated and non-anticoagulated patients. These findings indicate that, when baseline

characteristics are appropriately controlled for, concerns regarding poorer recovery in anticoagulated patients may be unfounded.

4.2 Mechanisms Underlying Observed Differences

Our findings suggest that post-stroke functional outcomes are primarily driven by stroke severity, rather than anticoagulation status. This conclusion is supported by both OLS regression and PCA, which consistently identified NIHSS score as the strongest predictor of recovery at 90 days.

The significant contribution of cardioembolic stroke to PC2 further supports this association, indicating that this stroke subtype is inherently linked to poorer outcomes. This relationship likely reflects its tendency to present with higher initial NIHSS scores and greater infarct burden. These observations are consistent with prior studies demonstrating that cardioembolic strokes are associated with more severe neurological deficits [27] and larger infarct volumes [28, 29], both of which negatively impact recovery, despite appropriate treatment. Together, these findings underscore that stroke severity, rather than DOAC anticoagulation status, remains the primary determinant of functional prognosis in ischemic stroke patients.

4.3 Comparisons with Previous Research

Our findings align with and build upon prior research investigating the impact of DOAC therapy in acute ischemic stroke. Seiffge et al. reported no significant difference in functional independence (mRS ≤ 2) between DOAC-treated and non-anticoagulated patients, even after adjusting for baseline characteristics [30]. Similarly, Küpper et al. observed comparable outcomes between these groups [31]. However, both studies primarily relied on self-reported medication use or electronic medical records to classify anticoagulation status. While some laboratory assays were employed, testing was neither systematic nor performed at the time of admission, and was often subject to considerable delays, limiting the reliability of DOAC classification. Our study addresses this limitation by adopting POCT to confirm active anticoagulation at the bedside.

The validity of the ClotPro® platform used in our study has been supported by strong concordance with conventional laboratory-based DOAC assays, as demonstrated by Groene et al [32]. In addition to its agreement with central lab standards, ClotPro® has shown comparable performance to other POCT systems; studies by Yoshii et al. and Infanger et al. confirmed its alignment with established ROTEM® thresholds, underscoring its reliability across viscoelastic testing platforms [33, 34].

Beyond analytical validity, ClotPro® has demonstrated clinical reliability across a variety of acute care settings. Its effectiveness in trauma settings has been validated by Oberladstätter et al. [35], while its applicability in stroke care is currently being assessed in an ongoing clinical trial by Sedghi et al. [36].

Collectively, these studies highlight the value of ClotPro® in acute care, supporting its integration into acute stroke workflows for rapid and reliable assessment of anticoagulation status.

4.4 Limitations and Future Directions

Despite the strengths of our study, several limitations must be acknowledged. First, we did not measure DOAC plasma concentrations using liquid chromatography-tandem mass spectrometry, which remains the gold standard for precise anticoagulant quantification. Instead, we relied on ClotPro® POCT, which, while validated, provides a functional rather than pharmacokinetic assessment.

Second, the relatively small number of patients with confirmed DOAC activity ($n = 19$) reflects the real-world prevalence of this subpopulation but limits the statistical power and generalizability of our findings. While we applied Mahalanobis distance-based matching to minimize confounding, the retrospective design of our study carries an inherent risk of residual bias from unmeasured variables.

Third, our outcome analysis focused exclusively on the mRS-shift, a widely used but relatively coarse measure of post-stroke functional recovery. We did not include broader assessments of cognitive function, quality of life, or long-term mortality, which could provide a more comprehensive understanding of recovery trajectories.

Future prospective, multicenter studies with larger cohorts of DOAC-treated patients are needed to validate our findings and allow for more detailed subgroup analyses based on stroke etiology and comorbidities. Further research should also consider expanding outcome measures beyond the mRS-shift to include patient-centered metrics such as quality-of-life assessments, cognitive function, and long-term survival. Finally, comparative studies of different POCT platforms will be essential for standardizing anticoagulation assessment and informing best practices for integration into acute stroke care pathways.

5 Conclusion

Our study demonstrates that ischemic stroke patients with confirmed active DOAC anticoagulation at admission achieve 90-day functional outcomes comparable to those of non-anticoagulated patients. Recovery was primarily influenced by stroke severity, rather than anti-coagulation status. These findings underscore the clinical value of POCT in acute stroke care and highlight the need for further research to refine management strategies for anticoagulated patients.

Abbreviations

DOAC	direct oral anticoagulant
VKA	vitamin K antagonist
POCT	point-of-care testing
ECT	Ecarin clotting time
RVV	Russell's viper venom
mRS	modified Rankin Scale
NIHSS	National Institutes of Health Stroke Scale
OLS	ordinary least squares
PCA	principal component analysis
INR	international normalized ratio
TT	thrombin time
APTT	activated partial thromboplastin time
PT	prothrombin time
TINL	Transzláció Ideggyógyászati Nemzeti Laboratórium
CT	clotting time
SD	standard deviation
IQR	interquartile range
SMD	standardized mean difference
CI	confidence interval
PC	principal component

Declarations

Ethics approval and consent to participate

The study protocol was reviewed and approved by the Scientific and Research Ethics Committee of the Medical Research Council of the University of Pécs (RRF-2.3.1-21-2022-00011, 01/09/22) and the Scientific and Research Ethics Committee of the Medical Research Council of Hungary (BM/22444-1/2024, 01/09/24). Informed consent was waived for this study as the data were collected as part of routine clinical documentation, in accordance with the institutional ethics approval.

Consent for publication

Not applicable.

Availability of data and materials

The data supporting the findings of this study are provided within the manuscript and its supplementary information files. For any additional requests regarding raw data, please contact the corresponding authors.

Competing interests

The authors declare that they have no competing interests.

Funding

Not applicable.

Author's contributions

J.S. led all major aspects of the study, including conceptualization, methodology, formal analysis, data curation, visualization, and original draft preparation. B.C. contributed significantly to the study design, data interpretation, and manuscript writing. Z.K. and E.B. assisted with validation, literature review, and critical revisions. E.J. supported data collection and helped with administrative and technical tasks during the study. L.S. supervised the project, provided methodological guidance, and oversaw overall administration. All authors made substantial intellectual contributions, reviewed the manuscript, and approved the final version for publication.

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Figures

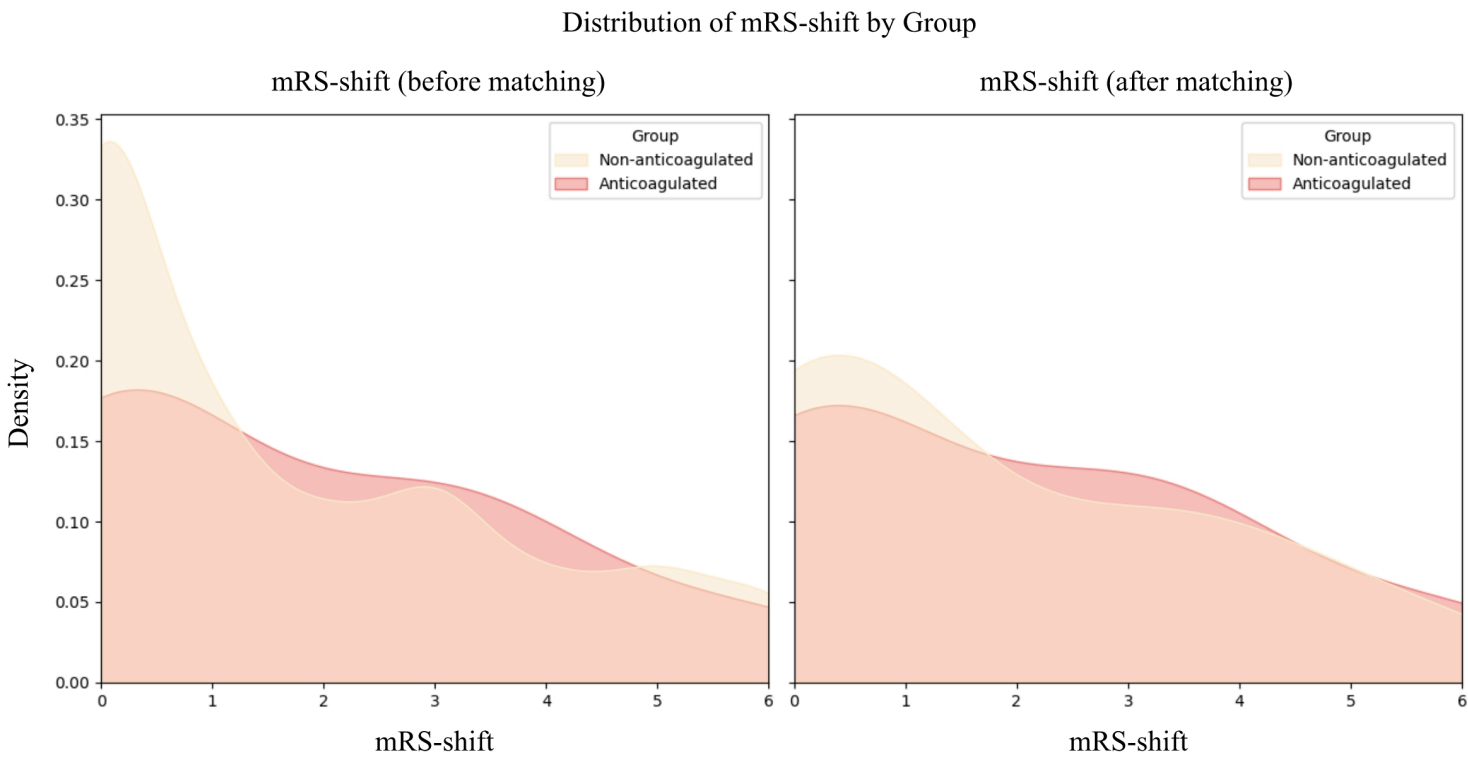


Figure 1

Distribution of mRS-shift by Group (Before and After Matching)

Abbreviations: mRS = modified Rankin Scale

PCA Loadings for Principal Components 1-8

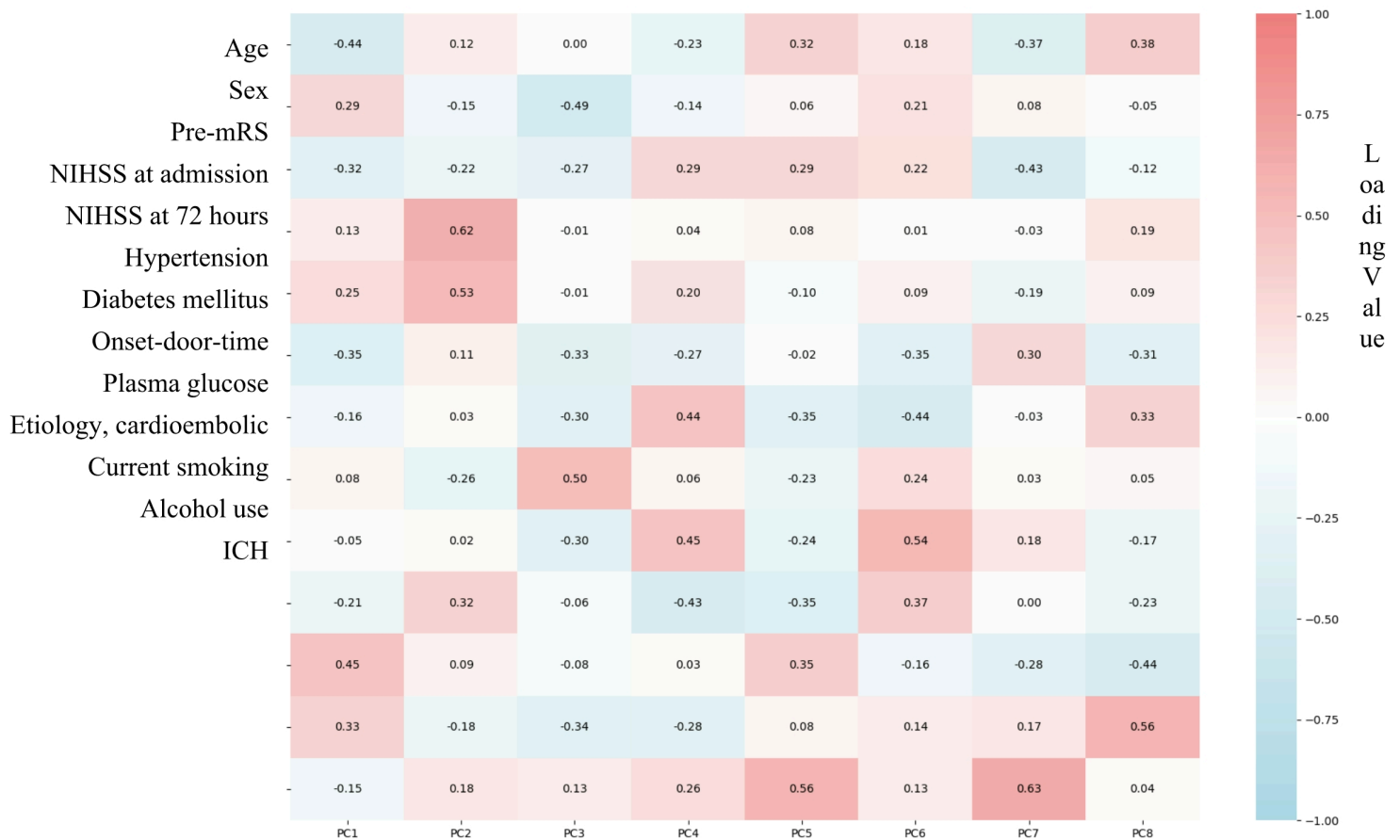


Figure 2

Heatmap of PCA Loadings for the Top Eight Components

Abbreviations: PCA = principal component analysis, PC = principal component, mRS = modified Rankin Scale, NIHSS = National Institutes of Health Stroke Scale, ICH = intracranial hemorrhage. Note: Each cell in the heatmap represents the strength and direction of correlation between a baseline variable and a principal component. Darker shades indicate stronger contributions, with positive and negative associations revealing how different variables group together within each component.