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Delayed door to puncture time during off-duty hours is associated with unfavorable outcomes after mechanical thrombectomy in the early window of acute ischemic stroke

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Abstract

Backgrounds The impact of off-duty hours mechanical thrombectomy on outcomes remains a subject of controversy. The impacts of off-duty hours on procedures are influenced by various factors, but the most critical one is the time delay in initiating the procedure after the patient's arrival at the emergency room. Recently, a report suggested that the impact of time delay on post-procedural outcomes is evident in patients who arrive at the emergency room within 6 h of symptom onset, referred to as the "early window." We hypothesized that the impact of procedure delays on outcomes during off duty-hours would be most significant within this early window. This study aimed to investigate the impact of door-to-puncture time (DTPT) delays in patients who underwent mechanical thrombectomy for acute ischemic stroke (AIS) during off-duty hours in both the early and late time windows.

Methods We investigated patients who presented to the emergency center between 2014 and 2022. Among a total of 6,496 AIS patients, we selected those who underwent mechanical thrombectomy within 24 h of the onset of acute anterior circulation occlusion. The eligible patients were divided into two groups: those who arrived within 6 h of symptom onset and received the procedure within 8 h (early window), and those who received the procedure between 8 h and 24 h after symptom onset (late window). The study assessed the association between the onset to puncture time in each group and poor outcomes, measured by the modified Rankin scores(mRs) at 90 days. Furthermore, the study analyzed the impact of receiving the procedure during off-hours in both the early and late windows on outcomes. Specifically, the analysis focused on the impact of delayed DTPT in patients during off-duty hours on outcomes measured by the 90-days mRS.

Results Among the eligible patients, a total of 501 AIS patients underwent mechanical thrombectomy for acute anterior circulation occlusion within 24 h. Of these, 395 patients (78.8%) fell into the early window category, and 320 patients (63.9%) underwent the procedure during off-duty hours. In the early window, for every 60-minute increase in OTPT, the probability of occurrence a poor outcome at 90 days significantly increased in the fully adjusted model (OR = 1.21; 95% CI, 1.02 to 1.43; $p = 0.03$). In the early window, delayed procedures during off-duty hours (exceeding 103 min of DTPT) were identified as an independent predictor of poor outcomes (OR = 1.85; 95% CI, 1.05 to 3.24;

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$p = 0.03$). However, in the late window, there was no association between DTPT and outcomes at 90 days, and the impact of DTPT delays during off-hours was not observed.

Conclusions Through this study, it became evident that the impacts of off-duty hours in mechanical thrombectomy were most pronounced in the early window, where the impact of time delay was clear. Therefore, it is believed that improvements in the treatment system are necessary to address this issue.

Keywords Mechanical thrombectomy, Stroke, Weekend effect, Outcome

Backgrounds

In recent times, the importance of mechanical thrombectomy in acute ischemic stroke (AIS) has been increasingly emphasized [1]. In the case of mechanical thrombectomy, when its effectiveness was initially proven in 2015, it was primarily targeted at AIS patients within 6 h of stroke onset [2]. However, starting in 2018, the treatment window was expanded to 24 h based on the presence of a treatable target mismatch using imaging analysis techniques like RAPID system [3–5].

It is known that acute stroke patients who arrive at the hospital during off-duty hours, such as nights or holidays, often experience poorer treatment outcomes [6]. These phenomena can be explained by various factors [7–9], but the most significant factor is believed to be the delayed initiation of treatment due to the absence of specialized medical staff during weekends or off-duty hours [10, 11].

Meanwhile, a recent study has shown a significant impact of time delay on patient outcomes following mechanical thrombectomy in the early time window, whereas such an effect was not observed in the late time window [12]. Therefore, the impact of off-hours on AIS patients who undergo mechanical thrombectomy is likely to vary differently in the early window and late window patients, depending on the time metrics.

Accordingly we aimed to investigated whether the impact of workflow time and procedural delays on the functional outcome of AIS patients undergoing mechanical thrombectomy varies according to the hospital's operational hours. Furthermore we examined the impact of workflow time on prognosis in the early and late window groups respectively to identify the risk group for a bad prognosis due to prolonged workflow time.

Methods

Patient selection

This study recruited AIS patients who were registered prospectively in the Clinical Research Center for Stroke in Korea (CRCS-K) registry [13] at Dong-A University Hospital from 2014 to 2022. Dong-A University Hospital is located in Busan Metropolitan CitySouth Korea. It is designated as the Busan Regional Cardiocerebrovascular Centerwhich treats more than 800 AIS patients annually. Patients are mostly transferred from Busan or neighboring cities and one study of stroke patients attending the institution between 2015 and 2022 found that the average distance patients traveled was 38.2 km with an average travel time of 65 min [14].

We selected patients who underwent mechanical thrombectomy due to acute large vessel occlusion in anterior circulation, excluding those who underwent the procedure due to worsening symptoms during hospitalization or patients with an onset-to-puncture time exceeding 24 h.

Patients eligible for mechanical thrombectomy underwent testing and procedures under the "CODE RED" stroke code [15] upon their arrival at the emergency center. Mechanical thrombectomy was performed in accordance with the treatment guidelines provided by the American Heart Association [1]. Eligible patients underwent an initial assessment, including a routine brain CT scan to check for the presence of brain hemorrhage, followed by MRI imaging. MR imaging including diffusion-weighted images (DWIs) and MR angiography is the recommended imaging choice for patients with AIS of early window. In the late window, perfusion images were added to the MRI.

In the late window, patient selection was determined from 2014 to 2018 by individual interventionists and vascular neurologists. This selection process typically relied on the core-penumbra mismatch observed through visual inspection of machine-generated images and clinical factors. Starting from 2019, patient selection in the late window was conducted based on DEFUSE III using the RAPID system [3].

Data collection

CRCS-K is multi center prospective and hospital-based stroke registry with the support of Ministry of Health and Welfare in South Korea and 81 hospitals are joining in the core database [16]. The stroke core database was established to allow the input of common data in each medical institution. When patients were admitted to a stroke center participating in the registry, the following data were collected from the registry: age, sex, National Institute of Health Stroke Scale (NIHSS) at admission, whether the patient received intravenous alteplase (IV t-PA) at presentation or not, the location of large vessel occlusion (LVO) on cerebral vessel imaging, onset to door time (OTDT), door-to-puncture time (DTPT), onset to puncture time (OTPT), and modified Rankin Scale (mRS) at 90 days.

We collected baseline Alberta Stroke Program Early CT Score (ASPECTS) before performing the mechanical thrombectomy procedure [17]. The location of vessel occlusion was confirmed using pre-procedural Angio CT or MRA, categorizing them into M1, M2, distal ICA, proximal ICA, or tandem occlusion based on the location. Stroke types were classified according to the Trial of Org 10,172 in Acute Stroke Treatment (TOAST) classification with specific modifications. The TOAST classification was implemented using a magnetic resonance imaging (MRI)-based algorithm for the subtype classification of acute ischemic stroke, known as MAGIC [18].

Definition of group division

In this study, patients were categorized into "early window" and "late window" based on the onset to puncture time (OTPT). In this study, patients who arrived within 6 h of symptom onset and underwent mechanical thrombectomy within 8 h were defined as the early window group [19], while those who underwent the procedure between 8 and 24 h were defined as the late window group. Additionally, based on the working hours of our hospital, we categorized patients into "on-duty hours" and "off-duty hours" groups. "Off-duty hours" were defined as official holidays, weekends, and the time between 5 pm and 8 am on weekdays. During on-duty hours, the on-site interventionist, nurses, and imaging technicians are present and ready for prompt procedural intervention. However, during off-duty hours, the system involves relevant personnel being on call for the procedure and preparing to perform the intervention upon receiving the call to come to the hospital.

Clinical outcomes

The definition of successful reperfusion after mechanical thrombectomy was based on the modified Thrombolysis In Cerebral Infarction (mTICI) Scale, categorized as 2b-3 [20]. The primary end point was a poor outcome at 90 day (modified Rankin scale, mRS > 2). Trained study nurses assessed the mRS at 90 day by telephone interview, with the patients or his or her next of kin, or by hospital chart review. Outcome mRS values after 90-day were dichotomized into good outcome and poor outcome for independence (mRS 0–2 vs. 3–6). Symptomatic intracerebral haemorrhage (sICH) was defined according to the European cooperative acute stroke study (ECASS) III criteria as ICH with deterioration of the NIHSS score by 4 points that was not attributed to other causes [21].

The main outcomes of this study are as follows: First, to investigate whether patients falling into the early window and late window groups during mechanical thrombectomy are influenced by the time it takes from onset to puncture on their 90-day functional outcomes. Second, if there is an impact, we aimed to determine whether delays in procedural time during off-duty hours can affect the prognosis.

Statistical analysis

The clinical characteristics of the patients were summarized, and the specific subgroups were described using descriptive statistics. Categorical variables were presented as numbers (percentages). Continuous variables were expressed as means (SD). The categorical variables of the groups were compared Pearson's chi-square test, while Student'st was used to compare the continuous variables of the groups. The relationships between the continuous variable OTPT and the binary functional outcomes at 90-day (good or poor) were assessed using logistic regression models using generalized estimating equations in the adjusted models. Age was dichotomized at 70 years of age and the NIHSS was arbitrarily stratified into three categories of 1–7 8–15 and 16–42 defined as mild moderate and severe neurological impairment respectively.

After assessing the continuous time-drawback predicted probability curves, we defined DTPT values exceeding 50 percentiles in both the early window and late window as "delayed procedure". Subsequently, we treated "off-duty hours" and "delayed procedure" as a composite variable and proceeded to conduct logistic regression to understand the impact of delayed procedure initiation during off-hours on the prognosis for both the early and late windows. During this process, adjustments were made for age, NIHSS (National Institutes of Health Stroke Scale) score, presence of diabetes, ASPECT score on initial brain CT, t-PA usage, successful reperfusion, and occurrence of symptomatic Intracerebral Hemorrhage (SICH). After logistic regression, we verified the appropriateness of the model using the Hosmer-Lemeshow test.

All statistical analyses were performed using the STATA for MAC, version 18, software. The level of statistical significance was set at $P < 0.05$.

Results

During the study period, a total of 6,496 AIS (Acute Ischemic Stroke) patients presented to our stroke center, out of which 595 underwent mechanical thrombectomy. Based on the research objectives, we selected 520 patients with lesions located in the anterior circulation. Among them, 19 patients with an OTPT exceeding 24 h were excluded. Ultimately, a total of 501 patients who underwent mechanical thrombectomy were included in the study.

The mean admission NIHSS and ASPECTS were 13.2±5.0 and 7.9±1.1, respectively. Out of the 501 target patients, 395 (78.8%) underwent the procedure in the early window (0–8 h.), and 153 (21.2%) underwent it in the late window (8–24 h.). Additionally, 320 patients (63.9%) received the procedure during off-duty hours (Table 1).

Early window vs. late window

*Compared to the late window, patients in the early window showed shorter workflow times.*Regarding clinical outcomes after procedures, there was no significant difference in the frequency of successful reperfusion *and the poor outcomes on 90-day mRS scores* between the early window and late window ($p=0.27$, Table 1).

In the early window, for every 60-minute increase in OTPT, the probability of occurrence a poor outcome at 90 days significantly increased in the fully adjusted model (OR=1.21; 95% CI, 1.02 to 1.43; $p=0.02$, Fig. 1A). However, in the late window, there was no statistically significant increase in the probability of experiencing a poor outcome at 90 days for every 60-minute increase in OTPT (OR=1.14; 95% CI, 0.99 to 1.30; $p=0.07$, figure B).

The impacts of delayed procedure in off-hours

Among the 395 early window patients, 248 (62.8%) underwent the procedure during off-duty hours, and when compared to patients who had the procedure during on-duty hours, *the door-to-puncture time (DTPT) was significantly longer (82.7±30.8 vs.*

Table 1 Comparisons of baseline characteristics between early and late window

	Early window	Late window	Total	*P*
Number	395 (78.8%)	106 (21.2%)	501 (100%)	
Age	69.4 (11.9)	69.8 (11.0)	69.5 (11.7)	*0.71*
Age > 70	200 (50.6)	55 (51.9)	255 (50.9)	*0.82*
Female	162 (41.0%)	41 (38.7%)	203 (40.5%)	*0.66*
NIHSS	13.4 (4.8)	12.5 (5.3)	13.2 (5.0)	*0.10*
Mild	52 (13.2%)	23 (21.7%)	75 (15.0%)	*0.06*
Moderate	196 (49.6%)	52 (49.1%)	248 (49.5%)	
Severe	147 (37.2%)	31 (29.2%)	178 (35.5%)	
Hypertension	222 (56.2%)	56 (52.8%)	278 (55.5)	*0.54*
Diabetes	103 (26.1%)	36 (34.0%)	139 (27.7)	*0.11*
Atrial fibrillation	208 (52.7%)	47 (44.3%)	255 (50.9)	*0.13*
Current smoking	65 (16.5%)	10 (9.4%)	75 (15.0)	*0.01*
Old stroke	67 (17.0%)	26 (24.5%)	93 (18.6)	*0.08*
TOAST classification				*0.07*
Large artery atherosclerosis	87 (22.0%)	35 (33.0%)	122 (24.4)	
Cardioembolism	208 (52.7%)	48 (45.3%)	256 (51.1)	
Others	11 (2.8%)	5 (4.7%)	16 (3.2)	
Undetermined	89 (22.5%)	18 (17.0%)	107 (21.4)	
Occlusion site				*0.16*
MCA	233 (59.0%)	67 (63.2%)	300 (59.9)	
dICA	79 (20.0%)	18 (17.0%)	97 (19.4)	
pICA	38 (9.6%)	15 (14.2%)	53 (10.6)	
M2	22 (5.6%)	15 (4.7%)	27 (5.4)	
Tandem	23 (5.8%)	1 (0.9%)	24 (4.8)	
ASPECTS	7.9 (1.1)	7.9 (1.2)	7.9 (1.1)	*0.71*
Transferred cases	104 (26.3%)	36 (34.0%)	140 (27.9)	*0.12*
Off-hours	248 (62.8%)	68 (64.2%)	316 (63.1)	*0.80*
IV t-PA	311 (78.7%)	12 (11.3%)	323 (64.5)	*< 0.01*
OTDT	129.5 (87.7)	683.4 (239.5)	246.7 (263.4)	*< 0.001*
DTPT	103.3 (34.9)	115.9 (55.8)	106.0 (40.5)	*< 0.01*
OTPT	232.8 (95.6)	799.3 (237.9)	352.6 (269.7)	*< 0.001*
Successful reperfusion	292 (73.9%)	79 (74.5%)	371 (74.1)	*0.90*
SICH	22 (5.6%)	6 (5.7%)	28 (5.6)	*0.97*
Poor outcomes	215 (54.4%)	64 (60.4%)	279 (55.7)	*0.27*

Abbreviation NIHSS National institute of health stroke scale, TOAST (Trial of ORG 10172 in Acute Stroke Treatment), MCA Middle cerebral artery dICA distal internal carotid artery, pICA proximal internal carotid artery, ASPECTS Alberta stroke program early CT score, OTDT Onset to door time, DTPT Door to puncture time, OTPT Onset to puncture time, SICH Symptomatic intracerebral hemorrhage

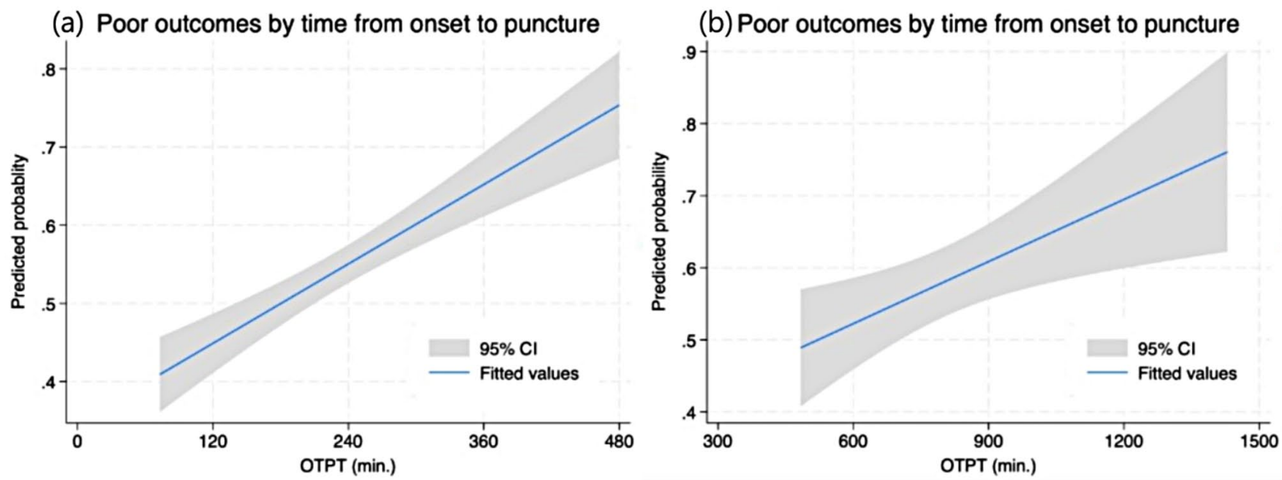

Fig. 1 Relationship between onset to puncture time and poor outcome at 90 days after mechanical thrombectomy. Relationships between OTPT and poor outcome at 90 days after mechanical thrombectomy in early window (**a**) and late window (**b**) were analyzed by using multivariate analysis. In the early window (**a**), for every 60-minute increase in OTPT, the probability of occurrence a poor outcome at 90 days significantly increased in the fully adjusted model (OR = 1.21; 95% CI, 1.02 to 1.43; $p = 0.03$). However, in the late window (**b**), there was no statistically significant increase in the probability of experiencing a poor outcome at 90 days for every 60-minute increase in OTPT (OR = 1.14; 95% CI, 0.99 to 1.30; $p = 0.07$, Fig. 1b)

115.5±31.3 min.,p<0.001). Furthermore, the outcomes of patients who underwent procedures during off-duty hours in the early window were poorer compared to those during on-hours ($p=0.04$, Table 2), and even after adjusting for confounding factors, the association between procedures during off-duty hours and poor outcomes at 90 days remained statistically significant (Table 3). To investigate the impact of delayed procedures during off-duty hours, a composite variable was created based on the 50th percentile of DTPT, which was 103 min in the early window. When examining its influence on outcomes at 90 days after the procedure, it was found that delayed procedures during off-hours (exceeding 103 min of DTPT) were an independent predictor for poor outcomes (Table 3).

Among the 106 late window patients, 68 (64.2%) underwent procedures during off-hours, OTDT and DTPT were prolonged but there were no differences in outcomes at 90 days after the procedure between on-duty hours and off-duty hours ($p=0.46$, suppl Table 1).

Discussion

This study demonstrates two key points. Firstly, in AIS patients undergoing mechanical thrombectomy, the impact of time, specifically the onset to puncture time, on post-procedure outcomes is significant in the early window, but its effect becomes less clear in the late window.

Secondly, the impact of off-duty hours on mechanical thrombectomy is evident in patients undergoing delayed procedures, especially in cases where the door-to-puncture time exceeds 103 min during the early window.

In AIS patients undergoing mechanical thrombectomy, there are two distinct time frames for the procedure. In the "early window", the procedure is strictly time-based, and it is typically performed within a specific time frame after the stroke onset [13, 22]. For "late window" patients, the procedure relies on an image-based frame, which utilizes imaging techniques such as RAPID system to confirm salvageable tissues and guide the intervention [5, 23]. The feasibility of these two procedural frames is influenced by variations in collateral grade and the speed of infarct progression, which can differ from one patient to another. Particularly in the "late window," patients tend to have relatively higher collateral grades, and there is a higher frequency of "slow progressors" whose infarct progression is delayed [24, 25].

In this study, although patients in the late window group had a prolonged OTDT compared to patients in the early window group, there was no statistical difference in their neurological severity at admission. This finding suggests that late window patients had better collateral flow and slower disease progression. This observation is consistent with previous clinical trials and registry analyses, which also showed similar trends [12, 23, 24].

This contradicts the "late window paradox," observed in some clinical studies [12], where a larger beneficial effect of EVT over the standard of care was seen in the late treatment time window relative to the early window. In this study, such a paradoxical effect was not evident. In a previous registry study [12], similar to our data, the phenomenon of the late window paradox was not observed, in contrast to the findings in several clinical trials [23]. The reason for this phenomenon may be attributed to the timeline of the study, which began in 2014, and the establishment of clinical guidelines for patient selection in the late window in 2018 [12]. Additionally, the acquisition

Table 2 Comparisons of baseline characteristics between on- and off-duty hours in early window

	On-duty hours	Off-duty hours	*P*
Number	147 (37.2%)	248 (62.8%)	
Age	70.5 (11.4)	68.7 (12.1)	*0.14*
Age > 70	81 (55.1%)	119 (48.0%)	*0.17*
Female	61 (41.5%)	101 (40.7%)	*0.88*
NIHSS	14.2 (4.6)	13.0 (4.9)	*0.02*
Mild	14 (9.5%)	38 (15.3%)	*0.14*
Moderate	71 (48.3%)	125 (50.4%)	
Severe	62 (42.2%)	85 (34.3%)	
Hypertension	84 (57.1%)	138 (55.6%)	*0.77*
Diabetes	35 (23.8%)	68 (27.4%)	*0.43*
Atrial fibrillation	87 (59.2%)	121 (48.8%)	*0.05*
Current smoking	88 (22.3%)	37 (34.9%)	*0.01*
Old stroke	26 (17.7%)	41 (16.5%)	*0.07*
TOAST			*0.15*
LAA	34 (23.1%)	53 (21.4%)	
Caedioembolism	85 (57.8%)	123 (49.6%)	
Others	4 (2.7%)	7 (2.8%)	
Undetermined	24 (16.3%)	65 (26.2%)	
Occlusion site			*0.50*
MCA	95 (64.0%)	138 (55.6%)	
dICA	26 (17.7%)	53 (21.4%)	
pICA	11 (7.5%)	27 (10.9%)	
M2	7 (4.8%)	15 (6.0%)	
Tandem	8 (5.4%)	15 (6.0%)	
ASPECTS	8.0 (1.1)	7.9 (1.0)	*0.36*
Transferred cases	49 (33.3%)	55 (22.2%)	*0.02*
IV t-PA	122 (83.0%)	189 (76.2%)	*0.11*
OTDT	122.1 (80.7)	133.8 (91.5)	*0.20*
DTPT	82.7 (30.8)	115.5 (31.3)	*< 0.001*
OTPT	204.8 (86.2)	249.3 (97.2)	*< 0.001*
Successful reperfusion	114 (77,6%)	178 (71.8%)	*0.21*
SICH	6 (4.1%)	6 (6.5%)	*0.32*
Poor outcomes	70 (47.6%)	145 (58.5%)	*0.04*

Abbreviation NIHSS National institute of health stroke scale, TOAST (Trial of ORG 10172 in Acute Stroke Treatment), MCA Middle cerebral artery dICA distal internal carotid artery, pICA proximal internal carotid artery, ASPECTS Alberta stroke program early CT score, OTDT Onset to door time, DTPT Door to puncture time, OTPT Onset to puncture time, SICH Symptomatic intracerebral hemorrhage

of the RAPID system for accurate identification of late window-eligible patients at our institution began in 2019. As a result, it is possible that the mechanical thrombectomy patient selection process for late window cases conducted before 2018 at our institution was not as precise, leading to these differences in outcomes.

In the continuous models, the effect of mechanical thrombectomy on functional outcome decreased as OTPT was prolonged, consistent with previous literature [22, 26]. *However, in the late window, prolonged OTPT did not have a statistically significant impact on outcomes. Therefore, it is reasonable to conclude that the influence of time on functional outcome in the late window was smaller than that in the early window. This may be due to the image-based selection for mechanical thrombectomy in the late window, and this finding aligns with the previous registry-based studies* [12].

Research has been examined the differences in outcomes between mechanical thrombectomy performed during off-duty hours versus on-duty hours in AIS patients. *Several studies have identified delays in workflow time, differences in hospital staffing, patient transfer system, and variations in healthcare system between countries as contributing factors to poor functional outcomes during off-duty hours* [27].

A previous study [28] reported that patients who underwent mechanical thrombectomy during off-duty hours had a higher initial severity compared to those treated during on-duty hours, suggesting that patients treated during off-hours had worse outcomes.

Table 3 Univariate and multivariate analysis for poor outcomes at 90 days after mechanical thrombectomy in early window

	Univariate analysis		Multivariate analysis	
	OR	***p***	**OR**	***P***
Age > 70	2.21 (1.47–3.40)	*< 0.01*	2.36 (1.44–3.88)	*< 0.01*
DM	1.92 (1.20–3.06)	*< 0.01*	1.89 (1.10–3.24)	*0.02*
AF	1.49 (1.00-2.23)	*0.05*	2.47 (1.14–5.38)	*0.02*
TOAST classification				
Cardioemblism	0.79 (0.47–1.31)	*0.36*	0.26 (0.10–0.64)	*< 0.01*
Others	0.35 (0.09–1.28)	*0.11*	1.12 (0.26–4.78)	*0.87*
Undetermined	0.50 (0.27–0.91)	*0.02*	0.43 (0.21–0.88)	*0.02*
NIHSS				
Moderate	1.88 (1.00-3.54)	*0.05*	3.11 (1.44–6.73)	*< 0.01*
Severe	3.08 (1.60–5.94)	*< 0.01*	5.63 (2.48–12.76)	*< 0.001*
Successful Reperfusion	0.19 (0.11–0.35)	*< 0.01*	0.18 (0.10–0.33)	*< 0.001*
SICH	23.4 (2.87–190.7)	*< 0.01*	23.6 (2.86-194.78)	*< 0.01*
Off-hours	1.55 (1.03–2.33)	*0.04*		
Delayed procedure	1.51 (1.02–2.26)	*0.04*		
Off hours x delayed procedure			1.85 (1.05–3.24)	*0.03*
OTDT	1.00 (1.00–1.00)	*< 0.01*	1.00 (1.00–1.00)	*< 0.01*

Abbreviation TOAST (Trial of ORG 10172 in Acute Stroke Treatment), NIHSS National institute of health stroke scale, SICH Symptomatic intracerebral hemorrhage, OTDT onset to door time

However, in this study, there were no significant differences between the two groups in terms of NIHSS and ASPECTS scores.

Workflow time delay due to on-call teams' participation in the procedure was suggested to be one of the most significant factors [11]. In this study, there was a delay of 31 min in DTPT during off-duty hours compared to on-duty hours. In the real-world practice, neurointervention teams are typically not present on-site during off-duty hours, leading to delayed procedure start times. This has raised concerns about potentially poorer outcomes following interventions during off-hours compared to those during regular working hours. However, in a Chinese multi-center registry study [29], there was no significant difference in the outcomes between on- and off-duty hours mechanical thrombectomy procedures. This can be attributed to the fact that all participating centers are expected to be fully resourced and staffed independent of working hours. Therefore, the presence or absence of impacts due to off-hours during mechanical thrombectomy ultimately depends on whether there is a delay in procedure time based on the availability of the procedural team.

Considering the significant impact of time delays on outcomes during mechanical thrombectomy in the early window, and especially the notable DTPT delays during off-duty hours, it was assumed that the impact of off-duty hours at our hospital would be observed primarily in patients with delayed DTPT in the early window. In line with the authors' hypothesis, it was observed that in the early window group, patients with an DTPT exceeding 103 min, which represents the 50th percentile, had worse outcomes when undergoing mechanical thrombectomy during off-hours. The authors' research findings align with a Japanese registry study [11], which indicated that in cases where the DTPT exceeded 60 min during off-duty hours, the prognosis of mechanical thrombectomy was unfavorable. Of course, there is a study [30] that reported no significant impact on outcomes between the two treatment timeframes, despite the difference in DTPT. However, it's worth noting that the DTPT difference in this study was only 13 min.

In this study, we drew a meaningful conclusion that among patients undergoing mechanical thrombectomy within the time-sensitive early window, those who experienced procedural delays during off-duty hours had a significantly poorer prognosis at 90 days post-procedure. However, it is important to note several limitations in our findings.

First the effect of OTDT on functional prognosis of AIS patients was relatively small. Although the effect of OTDT was not statistically significant in the multiple regression analysis the result should be interpreted with caution because patients in this study were categorized according to OTDT and the effect of workflow time on functional outcomes was analyzed separately. Previous studies have shown that OTDT was proved to be one of the major prognostic factors for the functional prognosis of AIS [31]. Second SICH appears to be associated with poorer functional outcomes after mechanical thrombectomy, but the small sample size limits the generalizability of the results of this study. Third, the study conducted at a single stroke center lacked a sufficient number of target patients based on the registry data. Second, because this study was an observational study, it was not easy to accurately divide between the early window and late window as seen in clinical trials. Additionally, because this study was an observational study, it was not easy to accurately divide between the early window and late window as seen in clinical trials.

In conclusion, we believe that procedural delays during mechanical thrombectomy performed during off-duty hours can impact outcomes. Therefore, there is a need for an effective response within the stroke care system to address this issue.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12883-024-03874-y.

Supplementary Material 1

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None.

Author contributions
J. K. C conceived the research project, performed the statistical analysis and wrote the manuscript. S. L performed the statistical analysis. H. I. C wrote the manuscript. Y. L, B. A. Y, and D. H. K gathered the data for the analysis. All the authors have read and approved the final version of the manuscript.

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Data availability
No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate
This single center retrospective analysis was conducted in accordance with the Declaration of Helsinki and approved by the Institutional Review Board of Dong-A University Hospital (IRB No. D20230807).

Consent for publication
This work complies with all the instructions of the authors. The authorship requirements have been met and the final manuscript was approved for publication by all the authors. No identifiable information on the study participants is published in this manuscript or any related data; therefore, consent to the publication of their identifiable data is not needed.

Competing interests
The authors declare no competing interests.

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