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Time is Brain: Evaluating Prehospital Delay and Door-to-Needle Time in Acute Ischemic Stroke Patients in Aden, Yemen. Analytical Cross-Sectional Study

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Time is Brain: Evaluating Prehospital Delay and Door-to-Needle Time in Acute Ischemic Stroke Patients in Aden, Yemen. Analytical Cross-Sectional Study

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Abstract

Background: Acute ischemic stroke (AIS) is a time-critical emergency, in which prehospital and in-hospital delays may limit access to reperfusion therapy. There is limited evidence regarding the stroke-care pathway in Yemen. The current study evaluated prehospital delay, door-to-needle (DTN) time, factors related to late presentation to hospital and thrombolysis eligibility among patients with AIS in Aden, Yemen.

Methods: This was a hospital based observational cross-sectional study with retrospective review of medical records of 127 patients with AIS that were admitted to selected tertiary hospitals in Aden. Prehospital delay was defined as the time from symptom onset to hospital arrival and analyzed as a continuous variable and a categorical variable (early arrival, ≤270 minutes; delayed arrival, >270 minutes). Continuous variables were reported as median and interquartile range (IQR) and categorical variables as frequency and percentage. Tests used included the Mann–Whitney U test, Pearson's chi-square test and Spearman's rank correlation.

Results: Median prehospital delay was 240 minutes (IQR, 300; range, 15-3600). Of the 127 patients, 67 (52.8%) presented within 4.5 hours and 60 (47.2%) presented after this time point. The most frequent reasons for delayed presentation were lack of knowledge of stroke symptoms (32.28%), unspecified reasons (24.41%) and long distance to hospital (22.05%). Living in a rural area was significantly associated with longer prehospital delay ($U = 1451.5$, $Z = -2.721$, $p = 0.007$). The median time to first medical assessment, brain imaging, and imaging results were 5, 15, and 25 minutes, respectively. The overall proportion of patients eligible for intravenous thrombolysis was 44.09%, and 22.05% received alteplase. For patients receiving thrombolysis, median DTN time was 26 minutes (IQR, 6). Prehospital delay was not significantly associated with either initial assessment or imaging time intervals.

Conclusion: Prehospital delay is an important barrier for timely reperfusion therapy in Aden, Yemen, with almost half of the patients presenting beyond the conventional 4.5-hour window. Better stroke awareness, emergency medical services, transportation and referral pathways, particularly for rural populations, could improve the timeliness of access to stroke care.

Keywords: Acute ischemic stroke; Prehospital delay; Time of hospital arrival; Door-to-needle time; Intravenous thrombolysis; Yemen.

Introduction

The principle that time is of the essence in the case of acute ischemic stroke (AIS) can be understood as fundamental, since brain tissue is lost quickly as soon as blood flow is interrupted(1). AIS is a major cause of death, long-term disability, and high healthcare costs all over the world. It places a serious strain on patients, their families, healthcare systems, and economies(2). The total burden of stroke is rising because of population aging and the increasing prevalence of vascular risk factors, including hypertension, diabetes mellitus, obesity, smoking, and cardiovascular disease(3). Ischemic stroke accounts for about 85% of all strokes globally and is therefore a major area of focus for initiatives aimed at reducing stroke-related disability and death.(3-6)

AIS is time-sensitive since the effectiveness of reperfusion therapy relies on the time that elapses between the onset of symptoms and the start of treatment(7). For certain patients, intravenous thrombolytic therapy with recombinant tissue plasminogen activator, especially alteplase, remains a valuable option and should be administered as quickly as possible within the treatment window(8). In appropriate cases, mechanical thrombectomy can also benefit patients with a large-vessel occlusion. All steps—quick identification, transportation, diagnostic evaluation, and initiation of treatment—are essential in managing acute stroke.(9-13)

Acute ischemic stroke timely reperfusion therapy mainly depends on two-time intervals: prehospital delay and Door-to-Needle Time (DTN)(8). Prehospital delay is defined as the time from symptom onset to arrival at a hospital that can provide acute stroke care. Besides measuring continuous time interval for prehospital delay, classifying patients according to hospital arrival time may be helpful in determining the proportion who arrive within or beyond the standard 4.5-hour window for intravenous thrombolysis(9). This difference is particularly relevant in resource-constrained settings where delays in symptom recognition, transportation problems, and limited access to emergency medical care may reduce opportunities for timely reperfusion therapy(14). Thus, characterization of hospital arrival patterns may help to identify delays in acute stroke care and opportunities to improve access to treatment(15). It consists of symptom recognition, decision-making, Emergency Medical Services (EMS) activation, transportation and referral(16). Poor symptom recognition, delayed help seeking, self-medication or alternative treatments, long distances, transportation and financial barriers, limited ambulance availability and inefficient referral pathways may lead to delays. These challenges are even more pronounced in low-resource settings with

limited emergency and specialized stroke services. (10–16)

DTN is the time from hospital arrival to intravenous thrombolytic therapy administration, and is an important marker of efficiency in acute stroke care(17). Eligible patients should be considered for treatment within 60 minutes(17). In the hospital, delays may occur in triage, neurologic assessment, imaging, laboratory testing, treatment decisions, medication preparation, consent, and communication with the team. Standardized stroke protocols and coordinated multidisciplinary care can reduce such delays and facilitate timely reperfusion therapy. (12, 17–19)

Delays often occur at different stages of stroke treatment. Evidence suggests room for improvement in both pre-hospital and in-hospital care(18). Research has found that the main factor delaying thrombolysis is the time it takes patients to reach the hospital(18). Additional delays may occur during hospital assessment, neuroimaging, treatment decisions, and thrombolytic administration(17). Well-organized stroke systems, specialized teams, rapid neuroimaging, emergency bypasses, and better coordination among healthcare professionals are all associated with shorter DTN times and higher rates of thrombolytic use.(19-21)

This is particularly the case in Yemen, where stroke is a major health problem and structural and logistical problems hamper the health care system. According to the thesis, stroke is responsible for 8.7% of all deaths in Yemen, and ischemic stroke accounts for 70 to 77% of hospital admissions(22, 23). A lack of a well-developed health care infrastructure, specialized stroke services, adequate emergency transport, socioeconomic difficulties, and limited access to advanced diagnostic and therapeutic services may delay acute stroke management. Earlier research in Yemen has shown that delayed presentation at hospital is due to low awareness, difficulties in accessing transportation, living in remote areas, and limited access to thrombolytic services. (24, 25)

While the length of treatment is important, there is a lack of evidence on the whole process from the onset of stroke to thrombolysis in Yemen. The available evidence focuses primarily on prehospital delay, and limited data are available on the association between prehospital delay and the effectiveness of hospital-based stroke care. This study identifies a local knowledge gap: no published study has carefully examined both prehospital delay and DTN among AIS patients eligible for thrombolysis in Aden, Yemen. (19, 25-27)

The research examined time to reach the hospital and DTN time for patients with AIS

in selected hospitals in Aden, Yemen. It examined what causes delays in reaching the hospital and the links between various prehospital and in-hospital time intervals in stroke care. The study examined the entire process from symptom onset to thrombolytic treatment to identify modifiable barriers to timely reperfusion and generate locally relevant evidence to support improvements in emergency stroke services and in-hospital stroke care pathways.

2. Methods

2.1 Study Design and Setting

This was a hospital-based observational cross-sectional study with retrospective medical-record review conducted among patients diagnosed with acute ischemic stroke (AIS) in selected tertiary hospitals in Aden, Yemen. This study utilized a review of medical records of eligible patients managed between [June 2025] and [June 2026]. The hospitals involved provide emergency stroke care, neuroimaging and intravenous thrombolytic therapy and serve as referral centers for patients from primary and secondary healthcare facilities.

2.2 Study Participants: All patients with confirmed diagnosis of AIS, managed in the participating hospitals during the study period, and with sufficiently complete medical records were included in the study. A census approach was adopted, where all eligible records were included rather than a sample. Patients were included if they had a documented diagnosis of AIS, were treated in a participating hospital during the study period and had sufficient information to determine the relevant treatment time intervals. Patients with hemorrhagic or non-ischemic stroke, patients managed outside of the study hospitals, and patients without adequate documentation of the primary outcome or key time variables were excluded.

2.3. Definitions and Variables: Primary outcome was treatment delay measured by door-to-needle (DTN) time in patients receiving intravenous thrombolysis. The main variables were defined as follows; Prehospital delay was defined as the difference in time from symptom onset to hospital arrival. Prehospital delay was also analyzed as a continuous variable and categorized as early hospital arrival (≤270 minutes) and delayed hospital arrival (>270 minutes) with 4.5 hours as the operational cutoff. This cut-off was chosen to differentiate patients presenting within the usual time window for intravenous thrombolysis from those presenting after. The distribution of hospital arrival times in the study population was described using the categorical variable. Physician time: time from

arrival at the hospital to first physician assessment. Door-to-imaging time: Time from patient arrival at hospital to completion of initial brain imaging. Imaging-to-interpretation time: time from imaging completion until documented interpretation of findings. Door-to-decision-to-thrombolysis time: time from arrival at hospital to documentation of decision to thrombolysis. Door-to-needle time: Time from hospital arrival to the start of intravenous thrombolytic therapy. Potential explanatory variables were age, sex, residence, transportation, referral status, symptom recognition, and documented patient-, transportation- and health-system-related factors.

2.4 Data Sources and Measurement: We used a structured data collection form to retrospectively extract data from emergency department logs, physician and nursing notes, radiology reports, laboratory logs, referral notes and medication administration records. The form was designed based on the aims of the study and relevant literature and was reviewed and validated by experts to establish clarity, relevance and completeness. It was pilot-tested and a small number of eligible records were excluded from the final analysis. In preliminary data collection, necessary modifications were made.

2.5 Combating Biases: Several measures were taken to minimize potential bias. All eligible records were included in an effort to reduce selection bias. Standardized operational definitions were created for all time periods before data extraction. A standardized data collection form was pilot tested prior to the main study to ensure consistency. Data checking identified records with missing or inconsistent time stamps, which were not used for the estimation of undocumented time intervals.

2.6 Sample size: The study adopted a census approach. Therefore, all the available medical records eligible for the study period were included. Therefore, no formal calculation of sample size was done. A total of 127 eligible AIS patient records with sufficient information were included in the final analysis.

2.7 Outcome Measures: The primary outcomes were prehospital delay and DTN. Additional outcomes included the proportion of patients eligible for intravenous thrombolysis, the proportion receiving thrombolytic therapy, reported causes of delayed hospital presentation, and relationships between sequential stroke-care time intervals. The observed DTN was compared with the internationally recommended 60-minute or less benchmark for eligible patients.

2.8 Statistical Analysis: Data were coded and entered into Microsoft Excel and analyzed using Statistical Package for Social Sciences, version 22 (Armonk, NY: IBM

Corp). Continuous variables were summarized with medians and interquartile ranges (IQRs), while categorical variables were presented as frequencies and percentages. The Mann–Whitney U test, Pearson's chi-square test, and Spearman's rank correlation were used as appropriate to assess differences and associations among study variables. Statistical significance was set at $p < 0.05$.

2.9. Ethical Considerations: Ethical approval was obtained from the Medical Research Ethics Committee, Faculty of Medicine and Health Sciences, University of Science and Technology, Aden, Yemen (MEC/AD0154) and administrative permission was obtained from the participating hospitals. Written informed consent was obtained from participants or legally authorized representatives when appropriate. To ensure confidentiality, personal identifiers were removed, and each participant was assigned a unique study identification number. The study was conducted in compliance with the principles of the Declaration of Helsinki.

3. Results

3.1. Social Demographic Characteristics

The demographic features of the 127 patients reflected a predominantly older and male population. Most participants were older than 50 years (86.61%). Males represented 66.14% of the participants. Residence was fairly evenly distributed among the participants; slightly more participants were from rural areas (51.18%) than urban areas (48.82%). Overall, education levels were low: 47.24% had no formal education, 21.26% had primary education, 15.75% had secondary education, and 15.75% had university education, while most participants were married (81.10) —Table 1.

Table 1. Demographic characteristics of the study population (n= 127)

Demographic characteristic	Category	Frequency (n)	Percentage (%)
Age (years)	<30	1	0.79
	30–50	16	12.60
	>50	110	86.61
Gender	Male	84	66.14
	Female	43	33.86
Residence	Urban	62	48.82
	Rural	65	51.18
Educational level	No formal education	60	47.24
	Primary education	27	21.26
	Secondary education	20	15.75

	University or higher	20	15.75
Marital status	Single	11	8.66
	Married	103	81.10
	Widowed	11	8.66
	Divorced	2	1.57

3.2. Baseline Clinical Characteristics of Study Participants

Among the 127 patients with AIS, hypertension was the most common comorbidity (63.8%), followed by diabetes mellitus (47.2%). Previous stroke or TIS was reported in 33.9%, and 26.8% had a history of heart disease. Regarding smoking, 60.6% had never smoked, 23.6% were current smokers, and 15.7% were former smokers. All participants had ischemic stroke as defined by the study inclusion criteria, as described in Table 2.

Table 2. Baseline Clinical Characteristics of Study Participants (n= 127)

Variable	Category	Frequency (n)	Percentage (%)
History of HTN	Yes	81	63.8
	No	46	36.2
History of DM	Yes	60	47.2
	No	67	52.8
History of Previous Stroke or TIA	Yes	43	33.9
	No	84	66.1
History of heart disease	Yes	34	26.8
	No	93	73.2
Smoking status	Current	30	23.6
	Former	20	15.7
	Never	77	60.6

3.3. Prehospital Delay and Contributing Factors

In the study population of 127 patients with acute ischemic stroke, 67 (52.8%) presented to hospital within the predefined early-arrival interval, and 60 (47.2%) patients presented beyond the selected cutoff and were classified as delayed hospital arrival. So almost half of the patients presented after the predefined threshold, indicating a significant burden of prehospital delay in this population, as shown in Table 3.

Table 3. Distribution of Patients According to Prehospital Arrival Category (n = 127)

Hospital arrival category	Frequency (n)	Percentage (%)
Early hospital arrival (≤270 minutes)	67	52.8
Delayed hospital arrival (>270 minutes)	60	47.2
Total	127	100

Several important factors contributing to delayed presentation to hospital were demonstrated in the prehospital characteristics of patients with acute ischemic stroke. Most cases (88.19%) had witnessed onset of stroke and the most common initial presentation was multiple neurological symptoms (70.08%). Although 50.39% of patients sought hospital care immediately after recognition of symptoms, 40.16% waited at home. The prevailing transport mode was by private cars (85.83%) and use of ambulance was minimal (10.24%). The most frequent reason for delay in prehospital was lack of knowledge of stroke symptoms (32.28%), followed by other causes (not specified) (24.41%) and long distance to hospital (22.05%). , as shown in Table 4.

Table 4. Factors Contributing to Prehospital Delay (n=127)

Factor	Category	n	%
Witnessed stroke symptom onset	Yes	112	88.19
	No	15	11.81
First recognized stroke symptom	Multiple symptoms	89	70.08
	Weakness	24	18.90
	Loss of consciousness	8	6.30
	Speech difficulty	3	2.36
	Other symptoms	2	1.58
	Severe headache	1	0.79
Initial action after symptom recognition	Immediately went to hospital	64	50.39
	Waited at home	51	40.16
	Consulted private clinic/pharmacy	11	8.66
	Used traditional remedies	1	0.79
Transportation to hospital	Private car	109	85.83
	Ambulance	13	10.24
	Taxi	5	3.94
Reported reason for prehospital delay	Lack of awareness of stroke symptoms	41	32.28
	Other unspecified causes	31	24.41
	Long distance to hospital	28	22.05
	Transportation problems	13	10.24
	Multiple contributing factors	12	9.45
	Financial constraints	2	1.57

3.4. Prehospital and In-Hospital Time Intervals

The distributions of the four-time variables were summarized using the median, interquartile range (IQR), minimum, and maximum since they were not normally distributed. The median prehospital delay from stroke symptom onset to hospital arrival was 240 minutes (IQR 300 minutes). Values ranged from 15 to 3600 minutes.

The median time to first medical contact was 5 minutes (IQR: 10 minutes), ranging from 2 to 210 minutes. The median time to brain imaging was 15 minutes (IQR: 20 minutes), with a range of 5 to 540 minutes, and the median time to brain imaging result was 25 minutes (IQR: 22 minutes), with a range of 5 to 555 minutes, as described in Table 5.

Table 5. Descriptive Statistics of Prehospital and In-Hospital Time Intervals Among Patients with Acute Ischemic Stroke (n=127)

Time Variable	Median (min)	IQR (min)	Minimum (min)	Maximum (min)
Prehospital delay (symptom onset to hospital arrival)	240	300	15	3600
Time to first medical contact	5	10	2	210
Time for brain imaging	15	20	5	540
Time to the brain imaging result	25	22	5	555

3.5. Comparison of Prehospital and In-Hospital Time Intervals

A Friedman test compared the four-time intervals during the stroke care pathway: prehospital delay, time to first medical assessment, time to brain imaging, and time to brain imaging result.

The analysis revealed a statistically significant difference among the four-time intervals (χ^2 (3) = 348.667, $p < 0.001$), showing that the median duration differed across stages of patient management, as shown in Table 6.

Table 6. Comparison of Prehospital and In-Hospital Time Intervals

Statistic	Value
Number of participants (N)	127
Chi-square (χ^2)	348.667
Degrees of freedom (df)	3
p-value	< 0.001

3.6. Thrombolysis-Related Time Intervals

Descriptive analysis of thrombolysis-related time intervals used the median, interquartile range (IQR), minimum, and maximum because the variables were not normally distributed. The median time to decision for thrombolysis was 20 minutes (IQR: 6 minutes), ranging from 13 to 40 minutes. The median time to thrombolysis was 26 minutes (IQR: 6 minutes), ranging from 20 to 55 minutes, as shown in Table 7.

Table 7. Descriptive Statistics of Thrombolysis-Related Time Intervals Among Patients Receiving Thrombolytic Therapy (n=26)

Time Variable	Median (min)	IQR (min)	Minimum (min)	Maximum (min)
Time to decision for thrombolysis	20	6	13	40
Time to thrombolysis	26	6	20	55

3.7. Thrombolysis-Related Time Intervals Comparison

Fig. 1. Distribution of time intervals related to thrombolysis in 26 patients who received intravenous thrombolytic therapy. The median time to decision for thrombolysis was 20 minutes (IQR, 6 min). The median time to thrombolysis was 26 minutes (interquartile range [IQR]: 6 minutes). Most of the patients passed through these stages within brief time intervals. However, several experienced longer delays, especially in thrombolysis administration time, leading to significant variability between the two measures.

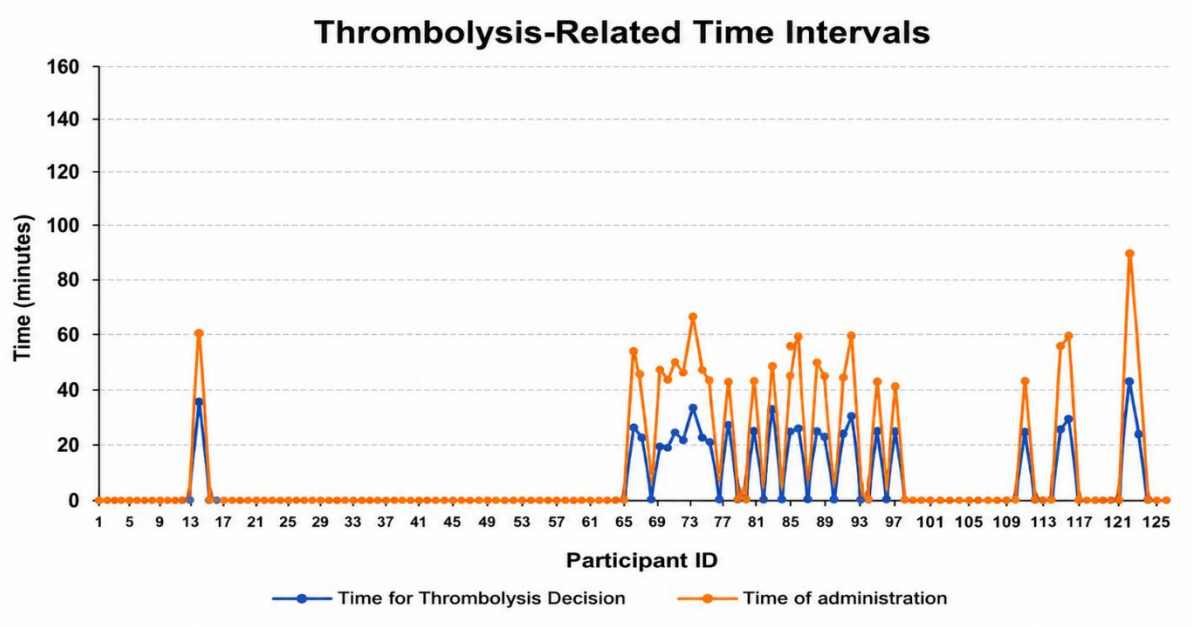


Fig. 1. Thrombolysis-related Time Intervals

3.8. Consolidated Thrombolysis Findings Among Patients with Acute Ischemic Stroke

The findings of thrombolytic management underscore significant gaps in the acute stroke management pathway. Among 127 patients with acute ischemic stroke, 44.09% were thrombolytic candidates and 55.91% were not candidates for thrombolytic therapy.

Of these patients, 20.47% met the recommended door-to-needle target and 79.53% did not. Regarding pharmacological treatment, 22.05% of patients were treated with alteplase, whereas the majority (77.95%) received other treatment modalities. These findings taken together suggest limited use of thrombolytic therapy and less than optimal achievement, as described in Table 8.

Table 8. Consolidated Thrombolysis Findings Among Patients with Acute Ischemic Stroke (n=127)

Domain	Category	n	%
Eligibility for thrombolytic therapy	Eligible	56	44.09
	Not eligible	71	55.91
Recommended door-to-needle time	Achieved	26	20.47
	Not achieved	101	79.53
Thrombolytic agent administered	Alteplase	28	22.05
	Other treatment modalities	99	77.95

3.10. Association, Correlation, and Inferential Statistics

3.10.1. Association Between Place of Residence and Prehospital Delay

A Mann-Whitney U test was used to compare prehospital delay between urban and rural residents. The difference in delay by place of residence was statistically significant ($U = 1451.5$, $Z = -2.721$, $p = 0.007$). Table 3.10.1 shows that the mean rank for rural patients (72.67) was higher than that of urban patients (54.91) implying that the prehospital delays were longer in the rural areas., as shown in Table 9.

Table 9. Comparison of Prehospital Delay Between Urban and Rural Residents Using the Mann–Whitney U Test (n = 127).

Variable	Group	n	Mean Rank	Mann–Whitney U	Z	*p*-value
Prehospital delay (minutes)	Urban	62	54.91	1451.50	-2.721	**0.007**
	Rural	65	72.67			

3.10.2. Association Between Clinical Characteristics and Eligibility for Thrombolytic Therapy

There were no statistically significant associations between thrombolytic eligibility and hypertension, diabetes, previous stroke/TIA, heart disease or smoking status (all $p > 0.05$), suggesting that these clinical characteristics were not significantly associated with thrombolytic eligibility in the study population., as shown in Table 10.

Table 10. Association Between Clinical Characteristics and Eligibility for Thrombolytic Therapy Among Patients with Acute Ischemic Stroke (n = 127).

Clinical Characteristic	Eligible for Thrombolysis n (%)	Not Eligible for Thrombolysis n (%)	χ^2	*p*-value
Hypertension			0.407	0.523
Yes (n = 81)	34 (42.0)	47 (58.0)		
No (n = 46)	22 (47.8)	24 (52.2)		
Diabetes mellitus			1.531	0.216
Yes (n = 60)	23 (38.3)	37 (61.7)		
No (n = 67)	33 (49.3)	34 (50.7)		
Previous stroke/TIA			0.000	0.988
Yes (n = 43)	19 (44.2)	24 (55.8)		
No (n = 84)	37 (44.0)	47 (56.0)		
Heart disease			1.474	0.225
Yes (n = 34)	18 (52.9)	16 (47.1)		
No (n = 93)	38 (40.9)	55 (59.1)		
Smoking status			0.014	0.993
Current smoker (n = 30)	13 (43.3)	17 (56.7)		
Former smoker (n = 20)	9 (45.0)	11 (55.0)		
Never smoker (n = 77)	34 (44.2)	43 (55.8)		

3.10.3. Correlation Between Prehospital and In-Hospital Stroke Care Time Intervals

There was no significant correlation between the initial in-hospital assessment, imaging, availability of imaging results and thrombolysis decision and the prehospital delay. However, it had significant moderate negative correlation with time of thrombolysis administration and door-to-needle time. Conversely, the in-hospital time intervals were strongly and significantly interrelated, particularly the relationships between assessment, imaging, imaging results and thrombolysis-related times,

suggesting that delays at one stage of in-hospital care tended to carry over into subsequent stages, as described in Table 11

Table 11. Spearman's Rank Correlation Between Prehospital and In-Hospital Stroke Care Time Intervals Among Patients with Acute Ischemic Stroke (n = 127).

Variables	**Spearman's rho (ρ)**	***p*-value**	**Interpretation**
Prehospital delay vs first medical assessment	0.145	0.103	Weak positive, not significant
Prehospital delay vs brain imaging time	0.092	0.304	Very weak positive, not significant
Prehospital delay vs. brain imaging result time	0.018	0.842	Negligible, not significant
Prehospital delay vs time to thrombolysis decision	−0.161	0.433	Weak negative, not significant
Prehospital delay vs time to thrombolysis administration	−0.395	0.046	Moderate negative, significant
Prehospital delay vs Door-to-Needle time	−0.476	0.014	Moderate negative, significant
First medical assessment vs Brain imaging time	0.784	<0.001	Strong positive
First medical assessment vs Brain imaging result time	0.672	<0.001	Strong positive
Brain imaging time vs Brain imaging result time	0.868	<0.001	Very strong positive
Brain imaging result time vs Thrombolysis decision	0.849	<0.001	Very strong positive
Thrombolysis decision vs Thrombolysis administration	0.734	<0.001	Strong positive
Thrombolysis administration vs Door-to-Needle time	0.858	<0.001	Very strong positive

4. Discussion, conclusion, and recommendations

Discussion

The present study provides an overview of the demographic and clinical characteristics of patients with acute ischemic stroke (AIS) and the major barriers to timely thrombolytic therapy in Aden, Yemen. The findings show that the main challenge in the stroke-care pathway occurred before hospital arrival, not during the initial in-hospital evaluation. The median prehospital delay was 240 minutes, while most in-hospital

assessment and diagnostic intervals were short(28). These findings suggest that improving community recognition of stroke, EMS use, transportation, and referral pathways may have a greater impact on timely reperfusion than further reducing already short hospital-based intervals.(11, 15, 16, 19, 28)

Most of the study population were older adults; 86.61% were above 50 years. Males accounted for 66.14% of participants. More than 50% lived in rural areas, and 47.24% had no formal education(29). This demographic profile is important for stroke prevention and access to care because older age is associated with more vascular risk factors, and rural residence and limited education may decrease awareness of stroke and access to specialized services(30). The high proportion of rural patients is particularly relevant in Aden and surrounding areas, where distance, transportation constraints, and the centralization of specialized stroke services may affect timely hospital presentation. (6, 24, 31-33)

The most frequent clinical risk factor was hypertension (63.8%), and the second was diabetes mellitus (47.2%). Previous stroke or TIA was reported in 33.9%, heart disease in 26.8%, and current or past smoking in 2/5 of participants(5). These findings underscore the major contribution of modifiable vascular risk factors to the stroke burden. Hypertension, diabetes, cardiac disease, and smoking highlight the need to improve primary and secondary prevention through blood pressure and glycemic control, management of cardiac disease, smoking cessation, and follow-up of patients with previous cerebrovascular events. (4, 32, 34, 35)

A key finding was that 88.19% of strokes were witnessed onsets, but there was still a significant prehospital delay. This means that having a witness is not enough to ensure rapid presentation; stroke symptom recognition must be paired with awareness of urgency and immediate activation of emergency care(19, 36). Meanwhile, 70.08% of patients had multiple neurological symptoms, but many of them did not immediately go to the hospital. About 40.16% stayed home after symptom recognition, 8.66% first visited a private clinic or pharmacy, and 0.79% used traditional remedies. These behaviors show that recognizing symptoms does not equate to taking appropriate emergency action (14, 19, 37-39).

Community education should emphasize the importance of stroke recognition and the need to present immediately to a hospital, avoiding delays at home or in facilities lacking stroke-treatment capacity(14, 19).

Another important barrier was transportation. Most patients (85.83%) reached the hospital in a private vehicle, and only 10.24% in an ambulance(16, 19). Limited use of EMS may be due to shortage of ambulances, poor transportation infrastructure, delayed response, or low public awareness of the role of EMS in stroke. Private transport may also restrict opportunities for prehospital assessment and hospital prenotification(14, 37, 40, 41). Strengthening EMS capacity and developing coordinated prehospital stroke pathways could facilitate early recognition, transport, and activation of hospital stroke teams(14, 42).

The most commonly reported reason for prehospital delay is connected to awareness and healthcare access, not direct financial barriers(16, 38). Geographic and transportation challenges are also reflected in the association between rural residence and a longer prehospital delay(19). Time to hospital arrival varied widely, suggesting that community-based stroke-awareness campaigns should be supplemented with increased ambulance availability, regional referral networks, and improved access to stroke-capable hospitals, especially in rural areas(18, 43). The delay is near the conventional therapeutic window of intravenous thrombolysis and thus poses a critical threat to treatment eligibility(8). By contrast, once patients arrived at the hospital, the median time to the first medical assessment was 5 minutes, to brain imaging was 15 minutes, and to imaging results was 25 minutes. The large differences in the measured time intervals and the relatively short in-hospital time intervals suggest that the main bottleneck in this setting was prehospital rather than hospital-based care(42, 44-47).

44.09% of patients were eligible for intravenous thrombolysis, and 55.91% were not. The low eligibility rate may be due in part to delayed presentation, although unknown time of onset and contraindications to treatment may also contribute(48, 49). In 26 patients who received thrombolytic therapy, the median time from decision to thrombolysis was 20 minutes, time to administration was 26 minutes, and median DTN was 25 minutes. These findings imply that for patients presenting within the treatable window and eligible, decision and treatment were generally swift(10, 11, 20).

The study also found that only 22.05% of patients received intravenous alteplase, whereas 77.95% received other treatments. This low use of alteplase reflects the broader problem of limited thrombolysis in many low-resource settings. Importantly, the findings highlight that the entire stroke-care pathway needs intervention to increase thrombolysis rates, and not just the hospital workflow(28, 50). Increased EMS utilization, direct transport to stroke-capable hospitals, earlier presentation, and

streamlined referral pathways will likely increase the number of patients presenting within the therapeutic window(5, 14, 42).

The inferential findings support this interpretation. Only rural residence was significantly associated. Hypertension, diabetes, prior stroke/TIA, heart disease, and smoking were not significantly associated with eligibility for thrombolysis. This is clinically plausible because eligibility is largely based on treatment timing, neuroimaging, stroke characteristics, and contraindications, not chronic vascular risk factors(44, 51, 52).

Finally, correlation analysis revealed significant positive correlations among the consecutive in-hospital time intervals, suggesting that delays in one step might be transmitted to subsequent steps of stroke management. By contrast, no significant association was observed between prehospital delay and initial in-hospital assessment and imaging times. This pattern suggests that hospital processes after arrival are fairly standardized and that the main opportunity for improvement lies in delays before hospital presentation(21, 44).

Overall, the results suggest that the main barrier to timely reperfusion is delayed presentation rather than slow hospital processing. A thorough approach should include community stroke-awareness programs, rapid recognition and activation of emergency services, increased EMS availability, fewer transportation barriers in rural areas, improved referral networks, and continued efficient hospital stroke pathways. These interventions may increase the number of patients reaching hospital within the therapeutic window and improve access to reperfusion therapy in Yemen.

This study has several limitations. Its single-center design may limit its generalizability to other hospitals and regions. Information on symptom onset, health care-seeking behavior, and reasons for delay was partly obtained from the patients or relatives and may be subject to recall bias. The observational cross-sectional design does not allow for causal relationships to be established between individual factors and delays in treatment. In addition, key determinants such as ambulance response time, emergency department workload, socioeconomic factors, and factors related to the health care provider were not assessed. These limitations should be considered when interpreting the findings.

In this study, a census approach was used to evaluate the entire stroke-care pathway, from symptom onset and hospital arrival to imaging, treatment decision, and

thrombolytic administration. Data were collected using standardized definitions and a pilot-tested data-collection form from multiple clinical records to improve data consistency and reduce measurement bias. The study also provides locally relevant evidence from Aden, Yemen, since there is a lack of evidence on delays in prehospital and in-hospital stroke care in this region. Checked 4.4 Suggestions

The findings support strengthening of community stroke awareness, emergency medical services and regional referral pathways to facilitate earlier presentation to hospital, especially for patients in rural areas. Hospitals should establish effective stroke pathways and review key indicators (e.g., neuroimaging, DTN time) regularly, with multidisciplinary training and quality improvement initiatives. Finally, larger multicenter prospective studies are needed to validate these findings and explore other patient-, provider-, and health-system factors that affect treatment delays. Got it.

Conclusion

In this study, prehospital delay was identified as the main barrier to timely reperfusion therapy for patients with acute ischemic stroke. Median prehospital delay was 4 hours. The most frequent reasons for delayed presentation were lack of stroke awareness, long distance to the hospital, and transportation difficulties. Rural residence was significantly associated with longer prehospital delay. However, in-hospital evaluation, neuroimaging, and thrombolysis procedures were generally effective despite these difficulties. Therefore, improving timely access to thrombolysis may require better community awareness, emergency medical services, transportation, and regional referral systems. Vascular risk factors were common, but no significant association was found with thrombolysis eligibility. Overall, only 44.09% of patients were eligible for intravenous thrombolysis, and 22.05% received alteplase, reflecting the significant impact of delayed hospital presentation on reperfusion access.

Declarations

Ethical considerations and consent to participate

Ethical approval was obtained from the Research Ethics Committee (MEC/AD0154) and administrative permission was obtained from the participating hospitals. Written informed consent was obtained from participants or legally authorized representatives when appropriate. To ensure confidentiality, personal identifiers were removed, and

each participant was assigned a unique study identification number. The study was conducted in compliance with the principles of the Declaration of Helsinki.

Consent for publication

This manuscript does not present any individual participant identifying information or identifiable personal data.

Data and material availability

The datasets generated and/or analyzed during the current study are available from the corresponding author on reasonable request.

Disclosure statement

The authors declare that there is no potential conflict of interest concerning the research, authorship, and/or publication of this article.

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Author Contributions

Mohammed Ali Khalifa: Conceptualization, Study design, Methodology, Investigation, Data curation, Formal analysis, Interpretation of results, Writing – original draft, Writing – review and editing, Supervision. Dina Mohammed: Data curation, data collection, investigation, writing-review editing. Abdulhakim Maher: Investigation, Data Collection, Data Curation, Writing- Review & Editing. Abeer Fadhel: Investigation, data collection, data curation, writing – review & editing. Hamzah Abdulrazaq: Data curation, Writing - review & editing, Investigation. Mohammed Suliman: Investigation, data collection, writing – review & editing. Rana Mohammed: Investigation, Data curation, Writing - review & editing. Shohob Mukhtar: Investigation, data curation, writing-review & editing. Zainab Magdi: Data collection, investigation and writing – review & editing. Aussan Al-Athwari: Investigation, data collection, writing – review & editing. Yasameen Mahdi: Conceptualization, writing – review and editing. Bashir A. Yousef: Interpretation of results, Writing - review & editing. All authors contributed to the study, have critically reviewed and revised the

manuscript, have approved the final version and have agreed to be accountable for all aspects of the work.

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Ethical Permission Letter

University of Science and Technology
Faculty of Medicine & Health Sciences
MEDICAL RESEARCH ETHICS COMMITTEE

جامعة العلوم والتكنولوجيا
كلية الطب والعلوم الصحية
لجنة أخلاقيات البحث العلمي

For Committee Use Only
MEC No. (MEC /AD0154)

Date: 08 /04/ 2026

MEDICAL ETHICS COMMITTEE APPROVAL

This letter is to affirm that the Faculty's **Medical Research Ethics Committee (MREC),** has reviewed the proposal titled:

Assessment of Door-to-Needle Time and Factors Contributing to Prehospital Delay Among Acute Ischemic Stroke Patients Eligible for Thrombolysis in Selected Hospitals in Aden, Yemen

A proposal presented by **Dr. Mohammed Ali Khalifa;** a teaching-staff member of the Faculty of Medicine & Health Sciences, University of Science & Technology, Aden, Yemen

Herewith, the **MREC** declares that the reviewed proposal has fulfilled the guarantees and safeguards for the Faculty's Medical Research Ethics Committee; and that the proposal is in compliance with the MREC's Policy.

Dr. Fahmi Shaher.
Chair, Ethics Committee.
Email: f.shaher@aden.ust.edu

Data Collection Sheet

نُجري هذا البحث العلمي بهدف تحسين جودة الرعاية الصحية المقدمة لمرضى السكتة الدماغية الحادة في مدينة عدن. تسهم مشاركتكم في فهم أسباب التأخر في العلاج والمساعدة على تطوير الخدمات الطبية وإنقاذ الأرواح. مشاركتكم طوعية ومقدّرة.

ملخص نموذج الموافقة المستنيرة:

عنوان البحث :تقييم زمن الباب إلى الإبرة والعوامل المساهمة في التأخر قبل الوصول للمستشفى لدى مرضى السكتة الدماغية الحادة المؤهلين للعلاج المذيب للجلطات في مستشفيات مختارة بعدن – اليمن.

يهدف هذا البحث إلى دراسة الوقت المستغرق لبدء العلاج والعوامل المؤثرة في التأخر قبل الوصول للمستشفى. ستتم جمع البيانات من السجلات الطبية أو من خلال أسئلة مختصرة دون أي تدخل علاجي إضافي. المشاركة طوعية بالكامل، ويحق لكم الانسحاب في أي وقت دون أي تأثير على الرعاية الصحية المقدمة لكم. ستُحفظ جميع المعلومات بسرية تامة وتُستخدم لأغراض البحث العلمي فقط، دون ذكر الأسماء أو أي بيانات تعريفية. بموافقتكم، فإنكم تقرّون بفهمكم لطبيعة الدراسة وأهدافها وموافقتكم على المشاركة فيها.

التوقيع: _____ **التاريخ:** _____

SECTION A: Socio-Demographic Information

1. **Patient Code:** _____
2. **Age (years):** _____
3. **Sex:** ☐ Male ☐ Female
4. **Residence:** ☐ Urban ☐ Rural
5. **Education Level:**
   ☐ No formal education ☐ Primary
   ☐ Secondary ☐ University or higher
6. **Occupation:** _____
7. **Marital Status:**
   ☐ Single ☐ Married ☐ Widowed ☐ Divorced

==========

SECTION B: Clinical And Medical History (From Patient Record)

8. **History of hypertension:** ☐ Yes ☐ No
9. **History of diabetes mellitus:** ☐ Yes ☐ No
10. **History of previous stroke or TIA:** ☐ Yes ☐ No
11. **History of heart disease:** ☐ Yes ☐ No
12. **Smoking status:** ☐ Current smoker ☐ Former smoker ☐ Never smoker
13. **Stroke type confirmed by imaging:**

☐ Ischemic stroke ☐ Non-Ischemic Stroke

SECTION C: Prehospital Delay Information

14. **Date of symptom onset:** ____ / ____ / _____

15. **Time of symptom onset:** ____: ____ ☐ AM ☐ PM

16. **Was the onset witnessed?** ☐ Yes ☐ No

17. **First symptom noticed (tick all that apply):**
    ☐ Weakness of face/arm/leg ☐ Speech difficulty
    ☐ Loss of consciousness ☐ Visual disturbance
    ☐ Severe headache ☐ Other: _____

18. **Action taken after symptom onset:**
    ☐ Immediately went to hospital ☐ Waited at home
    ☐ Consulted private clinic/pharmacy ☐ Used traditional remedies

19. **Mode of transportation to hospital:**
    ☐ Ambulance ☐ Private car
    ☐ Taxi ☐ Other: _____

20. **Reason for delay in reaching hospital (if any):**
    ☐ Lack of awareness of stroke symptoms
    ☐ Transportation problem ☐ Financial reasons
    ☐ Distance to hospital ☐ Fear or denial
    ☐ Other: _____

==========

SECTION D: Hospital Time Documentation Checklist

22. **Time of arrival at emergency department (Door time):**
    ____: ____ ☐ AM ☐ PM

23. **Time of first medical assessment:**
    ____: ____ ☐ AM ☐ PM

24. **Time of brain imaging (CT/MRI):**
    ____: ____ ☐ AM ☐ PM

25. **Time imaging result available:**
    ____: ____ ☐ AM ☐ PM

26. **Time decision for thrombolysis made:**
    ____: ____ ☐ AM ☐ PM

27. **Time of thrombolysis administration (Needle time):**
    ____: ____ ☐ AM ☐ PM

SECTION E: Door-To-Needle Time Calculation

28. Door-to-Needle Time (minutes): _____
29. Door-to-Needle Time ≤ 60 minutes?
    ☐ Yes ☐ No

==========

SECTION F: Eligibility And Treatment Information

30. Patient eligible for thrombolysis: ☐ Yes ☐ No
31. Thrombolytic agent used:
    ☐ Alteplase ☐ Other: _____
32. If thrombolysis delayed (>60 minutes), main reason:
    ☐ Delay in imaging
    ☐ Delay in decision making
    ☐ Lack of drug availability
    ☐ Consent delay
    ☐ Other: _____

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SECTION G: Comments / Observations

_____

_____

_____