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ORIGINAL RESEARCH

Prehospital emergency response times for stroke patients in Iran: a cross-sectional study

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Abstract: **Background:** Stroke is considered as one of the most important causes of emergency medical services (EMS) dispatch worldwide. Stroke is a time-sensitive condition and rapid transport of the patients improves the prognosis. In this study, we described prehospital emergency response times for stroke patients in Isfahan, Iran. **Methods:** In the current cross-sectional descriptive study, suspected stroke patients who were transported by EMS in Isfahan, Iran, from June 2022 to June 2023 were included. The data was extracted from patients' files. The time interval between the receipt of a call and the EMS arrival at the scene (arrival time), the time interval between on-scene EMS arrival and the ambulance departure to the medical center (stroke scene time), and the time it takes to reach the medical center (transport time) were collected. **Results:** Overall, 79 patients with a mean age of 71.56 ± 12.03 were included. EMS diagnosed 63 (79.75%) of the patients with a definite diagnosis and 14 (17.72%) with probable stroke. Two false negative results were found. The average arrival time, was 11.56 ± 6.60 minutes, on-scene stroke time was 13.85 ± 7.23 minutes and the average transport time was 11.90 ± 6.08 minutes. The mean total EMS response time was 37.90 ±11.29 minutes. **Conclusion:** Overall, our study showed that while the EMS transport time is longer than ideal, the total time to transport to the hospital is short enough not to affect the outcome. EMS was also found to be adept at spotting the signs of stroke and rapidly starting the process of treatment.

Keywords: Stroke; Emergency Medical Services; Emergency Medical Dispatch; Pre-hospital care

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1. Introduction

Pre-hospital care is the cornerstone of emergency medical services (EMS) and management. Traumatic injuries and time-sensitive illnesses such as cardiac arrest, stroke, sepsis, and obstetric emergencies are significant contributors to premature mortality and disability in low- and middle-income countries (1). In these countries, the majority of early deaths from such time-sensitive conditions are the result of inadequate pre-hospital care, unavailability of transport, or both (2). Pre-hospital care quality can be examined in two main avenues: the time to deliver the patient to the hospital and the treatments undertaken before reaching the hospital.

In 2019 stroke accounted for 6.55 million deaths globally, making it the second leading cause of death (3). In the United States alone, a stroke occurs every 40 seconds, and every 4 minutes a patient dies due to a stroke (4). Strokes can be categorized into two major groups,

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ischemic, compromising about 85% of all strokes, and hemorrhagic, which consists of about 15% of all cases (5). The difference in the etiology of stroke makes a different diagnostic approach and treatment course necessary; notably, the steps taken to address an ischemic stroke can be fatal for hemorrhagic kinds, necessitating a robust rapid diagnostic work-up in the prehospital settings. Treatment for ischemic strokes can, and should be, started as soon as the emergency medical team (EMT) is present at the site, as an ischemic stroke can progress to rapid and irreversible brain damage (6). Treatment is focused on alleviating the ischemia and reperfusion injury and emphasized the superiority of endovascular thrombectomy over medical management for large vessel occlusion strokes (7, 8). In the case of a lack of time or a robust diagnostic tool, starting the treatment with reasonable doubt could be life-saving.

When the ambulance services arrive on-scene and suspect a stroke, the standard procedure includes recording a 12-lead electrocardiograph (ECG), establishing two intravenous accesses, measuring vital signs, and evaluating the patient for pre-defined symptoms of stroke. While much effort has been made in recent years to understand and implement strategies to improve the treatment selection criteria of acute stroke patients, researchers have identified that among multiple factors, the single most important issue in determining the eligibility for treatment is the time from stroke onset to arrival at the hospital (9). This time of arrival (TOA) is determined by many different smaller factors, from whether to transport first to a primary stroke center (PSC) and then to a comprehensive stroke center (CSC) or directly to a CSC (10) as well as the distance of the centers to the patient and other personal factors. A review including several studies from different countries and periods showed that only 21% to 40% of all ischemic stroke patients arrive at hospitals within the first 3 hours from the stroke onset and another 5–13% within 3–6 hours (11). Despite this constant finding that delayed hospital arrival is a major factor contributing to low intravenous thrombolysis (IVT) rate, the analysis of stroke onset to hospital arrival time intervals reported in the studies performed between 2008 and 2016 revealed that the percentage of stroke patients arriving at the hospital in due time for IVT had shown only little improvement over the years (12).

Different studies have been conducted about differences in the pre-hospital management of stroke patients in Iran. A cross-sectional study in Kashan among acute ischemic stroke patients showed that most cases trust and use EMS ambulances to transfer to the hospital. Besides the time from the onset of symptoms to the alteplase administration being around 129 minutes, the longest delay in these patients was related to the time between the arrival of the EMS ambulance to the hospital (13). Another cross-sectional investigation in Rasht showed that the time between the symptoms' appearance to the alteplase injection was 152 min, and although most of the patients were transferred to the hospital in time, the rate of EMS usage was low (14). The differences in pre-hospital stroke management necessitate this evaluation in different regions. Therefore, in this study, we described prehospital emergency response times for stroke patients in Isfahan, Iran.

2. Methods

2.1. Study design and ethics approval

In the current cross-sectional descriptive study, suspected stroke patients who were transported by EMS to six different stroke centers in Isfahan, Iran from June 2022 to June 2023 were included. Isfahan is a province in the center of Iran with more than 5 million residuals. Isfahan is a referral city for many different diseases and a considerable number of patients are sent in from neighboring provinces and cities for medical care and intervention. Stroke patients are also usually referred to hospitals and medical centers in Isfahan for further care. There are six different hospitals in Isfahan that manage an emergency stroke diagnosis comfortably (Gharazi, Alzahra, Kashani, Khorshid, Farabi, and Amin), and the patients are usually taken to the closest one.

The protocol of this study was approved by the ethical committee of Isfahan University of Medical Sciences (IR.MUI.MED.REC.1401.383). The researchers adhered to the principles of the Helsinki declarations and due to the retrospective design of data collection, the informed consent was waived by the Ethics Committee.

2.2. Eligibility criteria

Our inclusion criteria for this study were every patient primarily diagnosed with stroke using the Cincinnati Prehospital Stroke Scale by trained EMS staff in the prehospital setting, who was brought to the emergency room (ER) by ambulance or other EMS. Patients with unavailable data or incomplete data were excluded.

2.3. Data collection

The data were extracted from the hospital and EMS archives: the time interval between the receipt of a call and the EMS arrival at the scene (arrival time), the time interval between the on-scene EMS arrival and the ambulance departure to the medical center (stroke scene time), and the time it took to reach the medical center (transport time), as well as patient baseline information, initial diagnosis made by the EMS, the final diagnosis, and the patient's past medical history. These data exist for every patient brought in by the EMS. Afterward, informal interviews were conducted with EMS staff and disaster experts to better identify the challenges they face during response time.

2.4. Measurements

The stroke diagnosis by EMS staff was made using the Cincinnati Prehospital Stroke Scale (15). The Cincinnati Prehospital Stroke Scale (CPSS) is scored from 0 to 3, with one point given for each of the following physical exam findings: facial droop, arm drift, and slurred speech. A prior study in South Korea found that a prehospital score of 2 predicts thrombolysis in patients after ER arrival (16). Here we defined the definite stroke diagnosis by EMS in a case of CPSS score 3. The probable stroke was diagnosed by EMS with CPSS scores 1 and 2. The Cincinnati Prehospital Stroke Scale was validated for the Iranian population by Zohrevandi et al (17). The final diagnosis of stroke was made by the neurologist through a physical examination which has been confirmed by imaging modalities.

2.5. Statistical analysis

Sample size calculation was made according to Sirousinejad et al, study (13). By considering a time range of 2 to 24 minutes for the arrival time (mean ± standard deviation: 10.45± 4.73 minutes), a confidence interval of 95% and a margin of error of 1 minute, the required sample size was estimated as 52 patients. Qualitative data is reported as frequency with percentage, and quantitative data as average with a standard deviation. Statistical analysis was done using SPSS version 25 (SPSS Inc., Chicago, IL, USA).

3. Results

3.1. Patients' characteristics

Overall, 79 patients were included in our study, 56 (70.9%) of them being male. The average age was 71.56 ±12.03 years and the majority of patients had a higher-than-normal systolic blood pressure with an average of 143.22 ± 24.92 mmHg and a diastolic pressure of 83.97 ± 14.15 mmHg. Tachycardia was seen in 26 (32.91%) patients with an average pulse rate of 80.9 ± 19.65 beats/minute. Considering hypoglycemia as one of the first differential diagnoses for the loss of consciousness, blood sugar was checked by the EMS and the average was 144.29 ± 45.05 mg/dL. Only 1 (1.27%) patient was unconscious due to hypoglycemia. Hypoxia was also a rare finding, with 3 (3.79%) patients suffering from SPO2 < 94% (Table 1). EMS diagnosed 63 (79.75%) of the patients with a definite diagnosis and 14 (17.72%) with probable stroke. However, two patients were diagnosed with MI or hypoglycemia which later turned out to be a stroke. The primary and final diagnoses are presented in Table 1.

Table 1: Characteristics of the patients at the time of EMS arrival

Variable	Value (n = 79)
Age (years, mean ± SD)	71.56 ±12.03
Gender (n, %)	
Male	56 (70.9)
Female	23 (29.1)
Chief complaint (n, %)	
Loss of consciousness	14 (17.72)
Chest pain	6 (7.59)
Weakness	11 (13.92)
Comorbidities (n, %)	
Cardiovascular	9 (11.39)
Diabetes	4 (5.06)
Previous stroke history	15 (18.99)
Vital sign (mean ± SD)	
Systolic blood pressure (mmHg)	143.22 ± 24.92
Diastolic blood pressure (mmHg)	83.97 ± 14.15
Blood sugar (mg/dL)	144.29 ± 45.05
Pulse rate (beat/minute)	80.9 ± 19.65
Respiratory rate, (n/minute)	19.9 ±12.86
SpO2 (%)	94.81 ± 2.54
Primary diagnosis by the EMS (n, %)	
Probable stroke	14 (17.72)
Definite stroke	63 (79.75)
Probable myocardial infarction	1 (1.27)
Hypoglycemia	1 (1.27)
Final diagnosis in the hospital (n, %)	
Ischemic stroke	67 (84.81)
Hemorrhagic stroke	12 (15.19)

SD: standard deviation; SpO2: blood oxygen saturation.

3.2. EMS Response Times for Stroke Patients

The average arrival time was 11.56 ± 6.60 minutes, the on-scene stroke time was 13.85 ± 7.23 minutes, and the average transport time was 11.9 ± 6.08 minutes. The

Table 2: Response times and treatment options of included patients

Variable	Value (n=79)
Response times (min, mean ± SD)	
Arrival time	11.56 ± 6.60
On-scene stroke time	13.85 ±7.23
Transport time	11.90 ± 6.08
Total response time	37.9 ± 11.29
Total time quartiles (n, %)	
<25% (<20.7)	14 (17.72)
25% to 50% (20.7 to 36.5)	25 (31.64)
50% to 75% (36.5 to 44.2)	28 (35.44)
>75% (>44.2)	12 (15.19)
In-hospital treatment option (n, %)	
Thrombolytic therapy	37 (46.83)
Invasive surgery	13 (16.46)
Conservative	29 (36.70)

SD: standard deviation

mean total EMS response time was 37.90 ±11.29 minutes. Overall, 39 (49.37%) of the responses were in the faster 50% and 40 (51.63%) were in the slower 50%, with 12 (15.19%) being slower than 44.2 minutes. In the hospital, Alteplase was started for 37 (46.83%) of the patients while 13 (16.46%) required more invasive surgeries such as a thrombectomy (Table 2).

The interviews highlighted that the driveways and motorways in the city stopped the Isfahan EMS from responding quickly enough. They also stated that usually, the EMS center is too far from the incident to reach it in time.

4. Discussion

We analyzed EMS stroke responses in Isfahan, Iran, for over a year. We found the EMS total response time to be on average 37.9 (±11.29) minutes. Alteplase was started for 37 (46.8%) of the patients with a definite diagnosis of ischemic stroke. After the patients were brought in, 67 (84.8%) of them were diagnosed with ischemic stroke.

Response time is, unsurprisingly, a major factor in the outcome of patients with any kind of emergency. It has been shown that each hour an ischemic stroke goes untreated, there is a higher chance of a less favorable outcome with a degree of disability and less functional independence, while the mortality is increased (18, 19). Per WHO guidelines, the ideal response time for EMS - from call to home - is 8 minutes (20). Large-scale studies in other countries show that European and North American countries routinely hit the designated target of an 8-minute response time (20-23). In other cities in Asia, Latin America, and Africa however, it is not unexpected to fall short (24-26). Studies put Athens and São Paulo as the worst in EMS response time, with 29 and 27 minutes respectively (27, 28). Interestingly, with an average response time of 11.56 (±6.6) minutes, we score better in this goal. While this time is not up to par based on the WHO standards, it is comparable to some European cities, such as Amsterdam with a response time of 15 minutes, or Berna in Switzerland with an average of around 11.5 minutes (28). After the initial response time, on-scene time and total time are important and should be taken into consideration. A large-scale study in the USA (a country with robust EMS and response units) on stroke patients and EMS response time, reported a median time of 15.00 (11.00–19.35) minutes. While they report the median on-scene time to be about 5.83 (3.73–9.00) minutes - being substantially lower than what we found - their median total time [36.40 (28.65-48.00)] and on-scene timing is similar to ours. This shows that while EMS in Isfahan takes longer than ideal to reach the patient, they are efficient and fast in preparing the patient and transporting them to the medical centers (29). What we can conclude from the above results is that the EMS is usually late to the scene, compared to the ideal set by the WHO, but they manage to make up the lost time. This means that the EMS is capable and fast in their response, and their accuracy of diagnosis shows expertise as well. However, the delay in response time is due to a deeper problem in Isfahan. The roads are old, and the city has not been made with modern infrastructure in mind, with an old part that is crowded and hard to navigate. Furthermore, the EMS in Iran suffers from a lack of both personnel and hardware. Rapid response centers are not as many as they should be and they are not situated in high-demand areas, coupled with a low number of ambulances and teams, leading to an initial longer response time.

The response time, however, is not the sole indicator of EMS efficacy in dealing with patients suffering from an acute stroke, either ischemic or hemorrhagic. It's an attractive thought to measure EMS performance using response time as the sole predictor; it's simple to use, report, and understand. A low response time indicates a high coverage by the EMS and its ability to respond to a variety of emergency calls (30). The standard 8-minute response time mentioned above was developed in 1979 based on non-traumatic cardiac arrest patients, and since then has been enforced globally (31, 32). However, such cases are only 1-2% of all EMS missions (33). Shortening the response time is achieved by hastening the

care of the patient, a potentially fatal decision, driving the ambulance faster, not without its risks, or by deployment of ambulances to high-demand areas in anticipation of an event or increasing the number of EMS teams, not applicable without significant costs. Needless to say, none of the solutions is ideal. However, one factor that shows that EMS in Isfahan for stroke patients is functioning well, is their relative accuracy in diagnosing patients early. In our study, we found that the EMS usually correctly diagnose, or at least establish the differential diagnosis of the stroke. They managed to correctly start alteplase in a significant number of cases and transported the patients to the center in a timely manner, even considering the slower-than-ideal time to door. One other thing that has drastically improved the efficacy of prehospital care in Isfahan is the introduction of the national registry system. With it, the EMS team can document the condition of the patient, his/her vital signs, diagnosis, and other vital factors to help them prepare beforehand. This registry can also be used in research and studies in the future to help with better planning and management.

4.1. Limitations

To the best of our knowledge, this is the first investigation at 6 healthcare centers in Isfahan surrounding the pre-hospital management of stroke patients. Our results would be helpful to policy makers in reducing the burden of strokes in Isfahan. On the other hand, this study has some limitations. First, this is a cross-sectional study and further longitudinal studies are needed to better clarify the outcome of the patients. Second, all included centers are academic healthcare centers. It is suggested that further investigations be done among other health centers.

5. Conclusion

Overall, our study showed that while the EMS transport time takes longer than ideal, the total time to transport the patient to the hospital was short enough not to affect the outcome. EMS was also found to be adept at spotting the signs of a stroke and rapidly starting the process of treatment.

6. Declarations

6.1. Acknowledgments

None.

6.2. Conflict of interests

The authors declare that they have no competing interests.

6.3. Funding and supports

This study was supported by the Isfahan University of Medical Sciences.

6.4. Authors' contributions

Study concept and design (KTA, OA, FH), data gathering and analysis (KTA, AA), and manuscript preparation (KTA, OA, FH, MAM). All authors have read and approved the final version of the manuscript.

6.5. Ethical statement

The ethics committee of Isfahan University of Medical Sciences (IR.MUI.MED.REC.1401.383) approved this study and the authors complied with the principles of the Declaration of Helsinki.

6.6. Informed consent

Informed consent was taken from patients on admission papers that explained to them that the hospitalization record may be used for research purposes with confidentiality, without their names and surnames. In addition, informed consent was obtained from the participants based on the Helsinki Declaration.

6.7. Availability of supporting data

The datasets used and analyzed in this study are available from the corresponding author upon reasonable request.

6.8. Using artificial intelligence chatbots statement

The authors declare that no artificial intelligence chatbots were used in the conduct of the research or in the writing of this research article.

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