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Abstract

Background Thrombolysis improves stroke outcome, but efficacy of the treatment is limited by time. Therefore, recognition of stroke symptoms by dispatch centres and by emergency medical services (EMS) is crucial, as is minimization of pre-hospital delays. We investigated the pre-hospital delays in patients with stroke treated with thrombolysis and compared the delays between rural and urban patients.

Methods Patients that had received thrombolysis at Oulu University Hospital (OUH) between 1 January 2013 and 31 December 2015 were identified. Patients were divided into urban and rural based on the site of the EMS mission. Pre-hospital charts and medical records were reviewed. Onset-to-dispatch, dispatch-to-arrival of EMS, on-scene, transport and door-to-needle times were studied.

Results Three hundred one stroke patients were treated with thrombolysis at OUH, and 232 of them were included in the study. Positive Face Arm Speech Test (FAST) findings, priority dispatch code and transport code were associated with shorter transport delays. The priority dispatch was not used in 12.5% of stroke patients treated with thrombolysis. The rural patients had a four minutes longer dispatch-to-arrival delay and 50 (34, 74) minutes longer transport time. The door-to-needle time was 8 (5, 14) minutes shorter in rural patients than in urban patients.

Conclusions Positive FAST findings and the use of priority dispatch code and priority transport code were associated with shorter transport delays. There is room for improvement in door-to-needle time and in stroke recognition by the dispatch centre and EMS providers. For the rural population, helicopter transportation could reduce the long pre-hospital time.

Keywords

stroke, dispatch, pre-hospital, pre-hospital time, onset-to-treatment time, emergency medical services

Background

Several studies have shown that early thrombolysis is essential for improving clinical outcomes of stroke, and a time frame of 4.5 hours is recommended in the guidelines [1, 2, 3]. Most strokes occur outside of a hospital or other treatment facility, which emphasizes the significance of pre-hospital phase in pursuit of proper stroke treatment and outcome. Treatment within one hour of stroke onset has been reported as promising excellent outcome in all stroke patients, irrespective of age and pre-existing comorbidity [4]. Currently, the goal of emergency medical services (EMS) is to transport the stroke patient directly to the primary point of care, where definitive treatment can be administered, in order to reduce the onset-to-treatment time (OTT) [5, 6, 7, 8]. A multicentre study suggested that a pre-hospital notification of stroke can shorten the door-to-needle delay [9]. A study from Finland concluded that pre-hospital delays were predominantly patient-dependent delays and that the only pre-hospital delay that could be easily reduced was the on-scene time [10]. In the pre-hospital setting, especially early recognition of stroke symptoms by the dispatch centre has been associated with activation of EMS and shorter OTT [11, 12, 13, 14].

In Finland, only half of the population lives in an area where it is possible to receive thrombolysis [15]. In Northern Finland, 48% of the population lives farther than 50 km from the primary point of care. Previous results on pre-hospital delays in stroke have been conducted in the Helsinki metropolitan area and may not be generalizable to Northern Finland. The acute care of stroke in rural areas has been reported to be suboptimal in North America [16]. More data are needed in order to improve pre-hospital treatment of this time-sensitive patient group in mixed rural-urban area in Nordic context. Reducing pre-hospital delays requires knowledge of the specific delays, e.g. onset-to-dispatch or transport delays. The purpose of this study was to investigate dispatch and transport urgency and delays in stroke patients treated with thrombolysis. In addition, we aimed to compare the patients from rural and urban areas in order to determine if the level of care was similar in these different settings.

Methods

Study area

Oulu University Hospital (OUH) is the only hospital that offers thrombolysis for stroke in the province of Northern Ostrobothnia. The province consists of large rural areas (population 194 463) and the urban area surrounding the city of Oulu (population 215 591) on 31 December 2016 [Statistics Finland]. Patients were assigned into two groups, 'rural' or 'urban', on the basis of the scene of their stroke. We divided the study area to urban and rural locations according to the classification of Statistics Finland (Table 1) [17]. It divides the municipalities in rural, semi-urban and urban municipalities depending on the proportion of inhabitants living in urban settlements and the population of the largest settlement. In the present study, the classification was modified, and the municipalities were divided into two categories, urban and rural, with the latter including semi-urban municipalities. We also defined the only urban municipality located outside of the Oulu region, Raahe, as rural. This was done because Raahe can be considered similar to the rural areas in regard to stroke care, e.g. distance to OUH. In 2015 Raahe had a population of 25 359, and it is located 75 km from the OUH.

Patients

The eligibility of the patients with stroke treated with thrombolysis between 1 January 2013 and 31 December 2015 at the OUH was ascertained retrospectively. A total of 301 stroke patients treated with thrombolysis were identified from hospital discharge registry. To meet the requirements of the study, with the aim to investigate dispatch and transport urgency and time delays, only the patients that were transported to OUH primarily by EMS were included for the final analysis. The patients identified from the hospital discharge registry had an ischemic stroke verified by a neurologist and a radiologist. Transportation time, pre-hospital delays, and findings of the neurological screening based on the Face Arm Speech Test (FAST) [18] were retrieved from the ambulance charts. Pre-hospital delays included the time from the onset of symptoms to EMS dispatch, the time from dispatch to on-scene arrival, the on-scene time and the transportation time to the hospital. In addition, the door-to-needle time was retrieved from the medical records in OUH.

Exclusion criteria consisted of incomplete pre-hospital or hospital medical records and stroke occurrence during hospital stay. In addition, we excluded secondary transports from other hospitals, patients that used private transportation and patients that were first encountered by general practitioners (GP) instead of EMS.

Definitions

The onset time was defined as the time when the symptoms were observed by the patient or by the person that called the dispatch centre, and as documented in the ambulance chart. Dispatch-to-arrival time was defined as the time between EMS dispatch and the arrival of the first EMS unit. The time of arrival was defined as the handing over of the patient from EMS to emergency room (ER). On-scene time was the interval between the arrival of the first EMS unit on scene and the time the transportation was started. The transport time was defined as the time between the start of transportation and the patient hand-over from EMS to ER. Door-to-needle time was defined as the time between the arrival at the hospital and the time thrombolysis was initiated. These time intervals were used to calculate the OTT. The distance between the scene address and OUH was measured using a utility in Google maps. In addition, the number of dispatches with the priority code 'stroke' was obtained from the Centre for Pre-hospital Emergency Care at OUH that records all the EMS missions.

Dispatch centre and EMS

The Emergency Response Centre Administration (ERCA) is responsible for all the six dispatch centres in Finland. [19]. Emergency calls are assessed by criteria-based national protocols, and the appropriate EMS unit is dispatched to the scene with a symptom-specific dispatch code. Each mission receives also a dispatch urgency code, where A indicates a suspected life-threatening situation, B indicates another high-

risk situation, and C stands for urgent, and D for non-urgent situation. *Lights and sirens are used in all A and B missions. In C and D missions, normal speed limits are used. EMS respond to all stroke missions with lights and sirens if the patient has had symptoms less than six hours and still has signs of stroke. Lights and sirens are also used if there is a suspicion of a wake-up stroke or if the onset of the symptoms is unknown.*

Once the EMS unit has encountered a patient with suspected stroke, the clinical situation is evaluated using the FAST. The test used in this study is similar to the one developed in 1998 for the UK EMS training package as a simplified version of the existing North American stroke identification instruments [18]. It consists of three short and simple tests focusing on abnormal speech impairments, facial palsies and arm movements. If a stroke is suspected, the patient is transported to the place of definite care, which in our study was OUH. The patient is transported with a symptom-appropriate and urgency code defined by the responding EMS unit. The codes are identical to those used by ERCA.

The EMS in Finland consists of first responders (e.g. fire engines) and basic and advanced-level ambulances. **Five physician-staffed helicopters and one with a paramedic** are provided by the nation-wide Finnish helicopter emergency medical services (FinnHEMS), and the doctors by hospital districts [20]. During the study period, the physician-staffed helicopter that was located in the vicinity of OUH was dispatched only at a specific request of the ground ambulance crew in cases of stroke. Helicopter transportation was used in four (1.7%) cases.

Depending on the transport time, the EMS personnel will prepare a large-bore intravenous route and notify OUH of the patient. If necessary, a pre-hospital anaesthesiologist is available for a telephone consultation. Vital signs are monitored throughout the mission. When the patient arrives at OUH, the neurological team will receive the patient and initiate treatment and imaging as necessary.

In the present study ERCA and EMS codes were grouped categorically. Priority code ‘stroke’ was defined as a stroke-specific dispatch code. Priority code ‘other’ was defined as any type of urgency dispatch code (A and B categories) other than the stroke code. A non-priority code was defined as code C or D. Codes ‘other

than stroke' included all codes other than stroke. This variable includes both priority and non-priority codes. The priority transportation in the present study was defined as the use of urgency code A or B by EMS unit.

Ethics

According to Finnish statutes, no approval by the ethics committee is needed if the patients are not examined or contacted in the study. The study protocol was approved by the Oulu University Hospital administration (304/2015). Since hospital and division acceptance was acquired, no informed consent was required.

Statistics

Statistical analysis was performed with IBM Statistics 22 Software (IBM SPSS Statistics for Windows, Version 24.0, Armonk, NY, USA). Categorical data are presented as numbers and percentages. Medians with 25th and 75th percentiles were used as summary statistics when applicable. Comparisons between groups were performed with the Mann-Whitney non-parametric test for independent samples, and categorical data was tested using Pearson's chi-square. A *P* value of less than 0.05 was considered significant.

Results

Patient selection

We identified 301 patients that had received thrombolysis for stroke at OUH. A total of 232 patients were included in the analysis (Figure 1). A stroke was identified by the dispatch centre in 160 out of 232 patients.

The median age was similar in the urban and rural patients, but the proportion of men was higher among urban patients (Table 1). The onset-to-dispatch and the on-scene times were similar in the two groups; **p**re-

hospital response and transport times were longer in the rural patients. The frequency of EMS consulting emergency physician was higher among rural patients.

Factors associated with the length of delays

Patients with a positive FAST results had shorter on-scene and door-to-needle times. Patients assigned to transport with a priority transport code had 18 (7, 4) minutes shorter door-to-needle delays compared with patients transported with a non-priority code. If the EMS used priority transport codes, the transport time was not significantly shorter compared with the missions where the priority transport code was not used. In missions where ERCA used a priority code, the dispatch-to-arrival and door-to-needle times were shorter (Table 3).

Dispatch-to-arrival and transport times were longer in rural areas leading to longer onset-to-treatment delays. The response and transport times were shorter in urban patients, while rural patients had shorter door-to-needle times (Tables 1 and 3).

Discussion

We found that the dispatch priority code was not used in 12.5% of stroke patients treated with thrombolysis, and that the priority code 'stroke' was not used in 31.0% of the patients. Positive finding in FAST and the use of priority dispatch and transport codes were associated with shorter door-to-needle times. Rural patients with stroke had shorter door-to-needle times but significantly longer pre-hospital response and transport times than urban patients. The findings of the present study are in line with those of previous studies conducted in southern Finland and Denmark [10, 21]. Similar findings of the pre-hospital

phase, excluding logistical delays, in both rural and urban areas suggest that the dispatch system has equal performance in Northern and Southern Finland. **It is notable that in this series the door-to-the-needle time, which was approximately 45 minutes, was a significant factor with an impact on the delays.**

The two longest pre-hospital delays in Northern Finland were observed in transportation and onset-to-dispatch times. Urban and rural patients differed in response and transport times. Positive FAST findings were associated with shorter delays suggesting that patients with FAST-indicated symptoms are better identified by EMS dispatch and EMS.

In 41.2% (n=89) of the cases the delay before dialling EMS was longer than 30 minutes indicating that there is still need for public education. Our observation is in line with a Swedish study, which reported that two-thirds of the population knows at least one stroke symptom, but only one-tenth knows three stroke symptoms [22]. Less than two-thirds intended to call emergency services, and the intent decreased with age. In Norway, a mass media intervention campaign advertising symptoms included in the FAST test increased stroke awareness; it resulted in elevated stroke symptom awareness and almost doubled ER admission rate for stroke for several months [23].

Thirty-two patients out of 301 patients were transported to the local GP instead of OUH or used private transportation; this suggests that education of EMS providers still needs to be improved, and better pre-hospital tools need to be developed for more accurate and timely recognition of the stroke symptoms.

We found that 75% of the patients had an OTT longer than 2 hours. The thrombolysis was started in 75% of urban patients but only in 50% of rural patients within three hours after symptom onset. This raises a question of whether helicopter EMS (HEMS) could be used to transport patients from the rural areas. A Danish study showed that if HEMS was secondarily dispatched after a request from a ground ambulance in cases of stroke, the HEMS transportation was not faster than the ground transport [24]. No significant improvements have been found in the outcomes of stroke patients transported by HEMS, even when the results have been adjusted for transport distance [25]. These findings do not necessarily hold true in the rural areas of Finland. Other studies have suggested that the benefit of HEMS transport correlates with the distance between the incident site and the primary point of care [15, 26, 27]. We found that door-to-needle

time in OUH was long compared to what has been reported in previous studies [10]. After our study OUH has begun to improve stroke patient protocols, but no data of the results are yet available.

Retrospective design is the main limitation of our study. Onset-to-dispatch time was based on retrospective review of the ambulance charts, where the information is given in an open-format fashion. We did not include patients who reached the hospital beyond the time window for thrombolysis. Therefore, we cannot estimate how many patients could have benefitted from a reduction in the pre-hospital delays. Because the emphasis was on pre-hospital delays, no follow-up data were gathered in order to study the effect of the delays on outcomes.

Conclusion

We analysed pre-hospital and hospital delays in stroke patients in a sparsely populated area. Priority dispatch was not used in 12.5% of patients treated with thrombolysis. Positive FAST findings and the use of priority dispatch codes and priority transport codes were associated with shorter treatment delays. We conclude that efforts to reduce pre-hospital delays in patients with stroke should include public education and education of dispatch centres and EMS. **In the in-hospital processes the aim should be to minimize the door-to-needle time.**

Abbreviations

EMS	Emergency Medical Services
ER	emergency room
ERCA	Emergency Response Centre Administration (EMS dispatch)
HEMS	Helicopter Emergency Medical Services
FAST	Face Arm Speech Test
GP	**general practitioner**
OUH	Oulu University Hospital
OTT	onset-to-treatment time

Declarations

None

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Availability of data and materials

The data are available from the authors upon reasonable request and with permission from OUH.

Author's contributions

TV, LR, KM and MM conceived and designed the study. TV collected and analysed the data under the supervision of JL and LR. The manuscript was prepared by all of the authors after interpreting the results.

Competing interests

The authors declare that they have no competing interests.

Consent for publication

Not applicable.

Ethics approval and consent to participate

The study protocol was approved by the Oulu University Hospital administration.

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