The association between pre-hospital care and in-hospital treatment decisions in acute stroke: A cohort study

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Abstract

Background: Hospital pre-alerting in acute stroke improves the timeliness of subsequent treatment, but little is known about the impact of pre-hospital assessments on in-hospital care.

Objective: Examine the association between pre-hospital assessments and notification by emergency medical service staff on the subsequent acute stroke care pathway.

Methods: This was a cohort study of linked patient medical records. Consenting patients with a diagnosis of stroke were recruited from two urban hospitals. Data from patient medical records were extracted and entered into a Cox regression analysis to investigate the association between time to CT request and recording of onset time, stroke recognition (using the Face Arm Speech Test [FAST]) and sending of a pre-alert message.

Results: 151 patients (aged 71±15 years) travelled to hospital via ambulance and were eligible for this analysis. Time of symptom onset was recorded in 61 (40%), the FAST test was positive in 114 (75%) and a pre-alert message was sent in 65 (44%). Following adjustment for confounding, patients who had time of onset recorded (HR 0.73, 95% CI 0.52-1.03), were FAST positive (HR 0.54, 95% CI 0.37-0.80) or were pre-alerted (HR 0.26, 95% CI 0.18-0.38) were more likely to receive a timely CT request in hospital.

Conclusions: This study highlights the importance of hospital pre-alerting, accurate stroke recognition and recording of onset time. Those not recognised with stroke in a pre-hospital setting appear to be excluded from the possibility of rapid treatment in hospital, even before they have been seen by a specialist.

Word Count: 247 (250 limit)
Introduction

Stroke causes an estimated 5.7 million deaths worldwide and the loss of approximately 50 million disability-adjusted life years (DALYs) every year.[1] The burden of stroke can be reduced with thrombolytic treatment using alteplase, but the time window for safe and effective treatment is short: thrombolysis is effective at improving functional outcome if administered up to six hours following symptom onset[2] but only around 4-5% of stroke patients in developed countries receive this therapy.[3,4] Access to thrombolysis requires timely arrival at hospital followed by urgent assessment including brain imaging to exclude intracranial haemorrhage.

The introduction of the Face Arm Speech Test (FAST)[5] and Cincinnati Prehospital Stroke Scale[6] for use by emergency medical service (EMS) staff has improved pre-hospital recognition of stroke patients and completion of the test in suspected stroke patients is a key feature of clinical guidelines and quality standards.[7,8] Where a patient is suspected as having stroke, guidelines suggest that a message or ‘pre-alert’ is sent to warn hospital staff that a suspected stroke patient is in transit.[9] This message is relayed to the hospital stroke team who meet the patient in the emergency department and provide specialist care from the moment the patient arrives in hospital.

Hospital pre-alerting has been shown to improve the timeliness of subsequent treatment in North America and Asia[10,11] but little is known about its impact in the UK or that of pre-hospital assessments such as the use of a stroke recognition tool or recording of onset time. The latter is recommended by guidelines in the US,[8] but receives little attention in the UK.[7,9] Such recording is known to vary widely[3,12] and is important because patients with an unknown time of onset are not eligible for pre-alert or subsequent thrombolysis due to uncertainty about whether they fall within the treatment time window.[13]

The aim of this study was to examine the association between pre-hospital assessments and pre-notification (specifically, recording of symptom onset time, stroke recognition using the FAST test and sending of a hospital pre-alert) by EMS staff and subsequent time to CT request and scan and therefore eligibility for thrombolysis using routinely collected data from linked hospital and EMS clinical records.

Methods

An extended description of the methods used in this study can be found in the online supplemental material.
**Study design and setting**

This study used a cohort design. It was conducted as part of a larger project for which the process of recruitment and data collection have been detailed elsewhere.[14] Briefly, consent to the larger project was sought from patients with a suspected diagnosis of stroke who had been admitted to the acute stroke ward in two urban hospitals (West Midlands, UK) via one ambulance service. A localised EMS protocol for the rapid transfer of suspected stroke patients was in place (figure s1; online supplemental material). A summary of the patient pathway for acute stroke in the UK is detailed in the online supplemental material (figure s2).

**Selection of participants**

Patients under the care of participating consultant stroke physicians were approached for consent by a member of the research team during their stay on the acute stroke ward during a nine month period between 01/11/2010 and 31/07/2011. Informed consent was obtained from all patients to permit identifiable patient data to be collected (to allow for data linkage) and only those with capacity (or an available consultee) were approached. Those with a final diagnosis of stroke (defined in their hospital discharge letter) who followed the acute stroke care pathway were included in this analysis.

**Data collection**

The records of all consenting patients were interrogated. Identifiable patient data were used to locate and link hospital and EMS records. Data relating to patient demographics, times to hospital and CT brain scan, pre-hospital care and route to hospital were extracted from both EMS and hospital records. Additional data variables, such as time of nurse triage in the emergency department, time to first assessment by the emergency department consultant or time to first contact with the stroke team were also sought; however, these data were not routinely recorded in all patient records. Thus, time of CT request and time of CT scan (which were reliably documented by the electronic CT scan booking system) were extracted and used as a ‘proxy marker’ for timely and effective care.

Missing data were reviewed with source data verification. It was not possible to account for scenarios where assessments were conducted but not documented or where information about the patients was communicated verbally between healthcare professionals.

**Statistical analysis**
All statistical analyses were performed in SPSS version 18.0 (SPSS Inc., Chicago, USA).

Descriptive statistics were used to describe the study population, the proportion of patients accessing acute stroke services via ambulance and the proportion of patients with known onset time and recognised stroke who were pre-alerted.

For patients arriving at hospital via the EMS, the association between pre-hospital assessments and time to CT request and scan were examined. Specifically, we used proportional hazards modelling (Cox Regression) to investigate the association between three factors (recording of onset time by the EMS, FAST status [positive or negative/not recorded] or whether a pre-alert message was sent) and two outcome variables: time from arrival in hospital to CT request (primary outcome) and time from CT request to scan (secondary outcome). These outcome variables were chosen because they are accurately and routinely documented (automatically for every patient) and allow delineation of which part of the in-hospital service is being delayed; the initial decision making of the first attending hospital clinician or the CT scanning department. FAST negative patients were grouped with those where FAST was not documented for statistical purposes as it was assumed that these patients were similar in not presenting with typical stroke symptoms upon initial assessment.

Hazard ratios were adjusted for confounding variables which may have influenced the time to CT request and scan (or the decision to thrombolysed) upon arrival in hospital. In the absence of any established mathematical model describing the scenario examined here, factors were entered into the proportional hazards model as categorical variables using the backwards stepwise method. Full details of included variables and how they were coded can be found in tables s1 and s2 (online supplemental material).

The time from ambulance dispatch to key milestones on the stroke pathway was investigated specifically in patients who arrived within four hours of symptom onset (and therefore could be considered for thrombolysis if recognised and not contra-indicated). These times were compared in patients where onset time was/was not recorded by EMS staff, the FAST test was completed and positive/negative or a pre-alert message was/was not sent to the hospital.

Data are presented as means or medians (standard deviation [SD], inter-quartile range [IQR] or 95% confidence intervals [CI]), percentage of the recruited population (unless otherwise stated) and hazard ratios (95% CI), unadjusted and adjusted.
Results

Characteristics of the study participants

A total of 500 patients with stroke were admitted to the acute stroke wards during the recruitment period. Of these, 335 (67% of those eligible) were approached and 247 (74% of those approached) were recruited (figure 1). In all, 210 stroke events (in 208 patients (84% of those recruited)) were included in our analysis (39 (16%) were excluded due to not following the acute stroke care pathway, having a stroke whilst in hospital, withdrawal or loss to follow up). All relevant secondary care records were identified and data extracted (figure 1). A total of 160 patients travelled to hospital via ambulance, of which 151 (94%) ambulance records were available for data extraction (figure 1). Timings data were available in >93% of records for each time point, FAST status in 100% of records and hospital pre-alert data in 98% of located records.

Patients included in the analysis were similar to those not recruited during the study period for all recorded demographics, except they had lower hospital mortality (table 1). Included patients were elderly (mean age 71 ± 15 years) and the majority were male (54%) and of white ethnic origin (82%) (table 1). A total of 21 recruited patients (10%) received thrombolysis and the median time spent in hospital was 7 days (IQR, 4 to 16 days).

Main results

Of the 151 patients included in this analysis who travelled to hospital via the EMS, the FAST test was performed in 141 (93%) and positive in 114 (75%). Onset time was recorded by EMS staff in 61 patients, 67% of those for whom it was known (90 patients in total). In 14 patients (9% of total), onset time was recorded by EMS staff but not by hospital staff. EMS staff sent a hospital pre-alert message in 65 cases (44%).

Patients were transported to hospital by ambulance within a median of 42 minutes (IQR, 33 to 53 minutes) from ambulance dispatch, regardless of EMS recording of onset time, FAST status or the sending of a hospital pre-alert message (figure 2). Where patients were FAST positive, onset time was recorded or a pre-alert message was sent, a CT scan was requested and completed within 1 hour of arrival in hospital (median time to request and scan was 39 and 57 minutes respectively [FAST positive patients]; 37 and 50 minutes [in patients where onset time was documented]; 26 and 39 minutes [pre-alerted patients]) (figure 2). However, where patients were FAST negative or FAST had not been recorded, onset time was not documented or where the hospital was not pre-alerted, CT requests and scans were delayed (median delay to request and scan was 120 and 155 minutes respectively [in patients who were FAST negative or FAST was not documented]; 97 and 121
minutes [in patients where onset time was not documented]; 125 and 185 minutes [patients not pre-
alerted]) (figure 2). EMS recording of symptom onset time was not associated with delayed CT scan
requests in patients who arrived in hospital within four hours of symptom onset (n=73 [48%]).
However, these patients did experience delays if they were not FAST positive (median delay 74
minutes [to request]; 82 minutes [to scan]) or not pre-alerted (median delay 88 minutes [to request];
104 minutes [to scan]), despite being within the time window for thrombolysis treatment upon
arrival in hospital.

Kaplan Meier plots show that patients who had onset time recorded, were FAST positive, or where
the hospital had been pre-alerted, received consistently faster CT requests within the first four hours
in hospital (figure 3). Unadjusted hazard ratios suggest the likelihood of receiving a quick CT scan
request upon arrival in hospital was increased by 33% in those with onset time recorded (HR 0.67,
95% CI 0.48-0.94, p = 0.020), 46% in FAST positive patients (HR 0.54, 95% CI 0.37-0.80, p =
0.002), and 77% in patients where the hospital was pre-alerted prior to arrival (HR 0.23, 95% CI
0.16-0.34, p <0.001) (table 2). Adjusted analyses gave similar results other than with regard to
recording of onset time on time to CT request which was no longer significant (HR 0.73, 95% CI
0.52-1.03, p = 0.070) (table 2).

Discussion
Main findings
This study has demonstrated that, in an urban UK setting, stroke patients who are pre-alerted are
more likely to receive faster assessment upon arrival in hospital. These pre-alert messages are sent
where stroke is recognised and most frequently where onset time is known. This study highlights
the importance of accurate recording of onset time by EMS staff and stroke recognition using an
appropriate tool. Our data suggest that some stroke patients are not recognised by current stroke
recognition tools and this has the unintended consequence of delaying stroke patients who might
benefit from rapid assessment by a specialist upon arrival in hospital. The use of less specific tools
with greater sensitivity should therefore be considered to ensure the responsibility of timely stroke
recognition falls upon a specialist in hospital rather than EMS staff in a pre-hospital setting.

Study strengths and limitations
This was an observational study where patients were recruited prospectively but data were extracted
from medical records after treatment and so care must be taken when interpreting the results.
Consenting patients with stroke were included which resulted in a population representative of
those in the local stroke population other than in terms of early mortality, reflecting the difficulty in
gaining consent or assent from very sick patients.[15] Because only half of potentially eligible
patients were recruited, it is possible our results may have been skewed towards shorter time to CT
scan and a higher proportion of thrombolysed patients compared to the total population. Although
an attempt was made to sample all patients with stroke, our recruitment was limited by the
practicalities of engaging with people presenting 24 hours a day, 7 days a week.

The main rationale for gaining individual consent was to allow data linkage of patient records from
different sources which is not otherwise possible in the UK. This meant that data could be collected
from 100% of secondary care records and 94% of relevant EMS records of consenting participants.
Comparatively, only 64% of ambulance records were identified in a recent national audit of stroke
care which does not use such methods.[3]

Only patients with a final diagnosis of stroke were included in this analysis because of difficulties
systematically capturing all patients who present with stroke-like symptoms in a pre-hospital
setting. Thus, caution should be taken before drawing conclusions about the relative accuracy of the
FAST test or any other stroke recognition tool. The results suggest that up to one quarter of stroke
patients were not recognised using the FAST test but do not show what proportion of stroke mimic
patients were correctly triaged as non-strokes on the basis of this test. It was also not possible to
determine whether FAST negative patients were suspected as having stroke but ineligible for rapid
treatment due to other factors. However, if patients with stroke can be consistently and rapidly
transferred to hospital, subsequent management should commence as soon as possible, whether or
not thrombolysis is indicated.

Study findings in the context of existing literature
As with the ESCORTT study[16] and that of Ramanujam et al., in the US,[17] little difference has
been found in the time from ambulance dispatch to arrival in hospital regardless of presumed
diagnosis (by ambulance dispatcher and emergency medical staff) with median transit times in both
studies of the order of 40 minutes. However, in keeping with previous work, assessment and
communication of that presumed diagnosis does seem to affect subsequent management. Studies
from Australia,[18,19] the US,[20,21,10] Korea[22] and Singapore[11] have all found that pre-
alerting reduces both door-to-imaging and door-to-needle times although this is the first study to
identify these associations in a UK setting. One striking feature of these previous studies is the wide
variation in proportion of stroke cases which were pre-alerted varying from 22% to 67%[11,18]
with the current study falling between at 44%. It is not clear from these studies what the “correct”
proportion of pre-alerting might be and this merits further study.
The decision to pre-alert depends on recognition of stroke and identification of potential suitability for thrombolysis. Accurate recording of onset time is required to identify whether patients fall within the appropriate time window for thrombolysis. Previous research suggests that onset time is unknown in between 9-33% of stroke patients, and a proportion of patients will have wake-up stroke precluding accurate assessment of timing. In the present study, EMS staff recorded onset time in 67% of cases where it was known (i.e. recorded in either EMS or hospital records). This is lower than audit estimates in the UK which suggest that onset time is recorded in 90% of cases where it is known in patients with suspected stroke. These discrepancies may reflect the different populations used to determine these proportions (diagnosis of stroke vs. suspected stroke) but suggest that better elucidation of onset time in the pre-hospital period might improve subsequent management.

In the present study, FAST positive patients were significantly more likely to receive timely assessment upon arrival in hospital which demonstrates the importance of accurate and timely stroke recognition using an appropriate validated tool. A number of these tools exist and are utilised in pre-hospital settings across the world. The majority focus on face, arm/hand and speech symptoms of stroke (with the exception of the Ontario Pre-hospital Stroke Screen which also includes leg weakness). It is possible that FAST negative stroke patients in the present study were not detected because they had a more confusing presentation, thus delaying diagnosis and subsequent request for CT scan. For example, patients with posterior circulation stroke often present with dizziness, nausea and vomiting and nystagmus and thus less likely to be detected by the FAST test. Since these symptoms are common to other conditions, it is possible that a diagnosis of stroke may have been delayed in these patients. Whilst this warrants further investigation, data were not available to investigate this further in the present study as these more specific diagnoses are not routinely documented in medical records in the UK.

Currently, the Improving Stroke Recognition by Ambulance Services (ISRAS) study is evaluating the feasibility of EMS staff using the ROSIER assessment tool (which includes assessment of visual field defects, a common symptom of posterior stroke) and whether this improves the accuracy of stroke recognition. Regardless of the outcomes of this study, the burden of timely stroke recognition cannot rest solely on the EMS: up to one quarter of acute stroke patients travelling to hospital via ambulance are not recognised as FAST positive hence triage at the point of hospital arrival is also important. This is particularly important in areas where patients recognised with suspected stroke are transported directly to regional specialist stroke centres. Elsewhere,
specialist stroke services may not be available and thus timely diagnosis of stroke will rely on the performance of the emergency department physician. It is important that all healthcare professionals working in emergency medicine are aware of the different presentations of stroke and the limitations of stroke recognition tools such as the FAST test. One solution might be that stroke recognition tools with greater sensitivity (perhaps at the expense of specificity) are considered for use in a pre-hospital setting to ensure that all potential stroke patients arrive at the correct hospital and receive timely assessment by a specialist. Such a change in service provision would be likely to increase the number of stroke mimics being admitted to hospital, thus any new recommendations must first consider the impact on existing stroke services and resources.

Conclusions

The study suggests that providing a hospital pre-alert message is the most influential ‘pre-hospital’ factor in facilitating timely assessment for acute stroke patients upon arrival in hospital and confirms in a UK setting the findings of previous work elsewhere.[18,19,20,21,10,22,11] However, patients are only pre-alerted where stroke is recognised and symptom onset time is recorded. Given that less than half of the stroke patients in this study were pre-alerted, perhaps the criteria for this should be relaxed. The use of less specific stroke recognition tools with greater sensitivity could be considered in a pre-hospital setting to avoid certain stroke patients missing out on timely assessment by a specialist in hospital.
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Author contributions: RJMcM and JPS had the original idea. JPS undertook the analyses and wrote the first draft with RJMcM, TQ and JM. All authors contributed to protocol development, refined the manuscript and approved the final version. RJMcM is the guarantor.

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Competing interests: None declared.

Ethical approval: Approval for this project has been obtained from the National Research Ethics Service (NRES) Committee, London – Queen Square (reference; 09/H0716/71).
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Table 1. Characteristics of non-recruited and recruited stroke patients and those included in analyses

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Non-recruited population</th>
<th>Recruited population</th>
<th>Included population*</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Population (n)</strong></td>
<td>253</td>
<td>247</td>
<td>208</td>
</tr>
<tr>
<td><strong>Age (mean ± SD)</strong></td>
<td>74 ± 15 years</td>
<td>71 ± 15 years</td>
<td>71 ± 15 years</td>
</tr>
<tr>
<td><strong>Gender (% female)</strong></td>
<td>126 (50%)</td>
<td>111 (45%)</td>
<td>95 (46%)</td>
</tr>
<tr>
<td><strong>Ethnicity</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- White</td>
<td>200 (79%)</td>
<td>202 (82%)</td>
<td>170 (82%)</td>
</tr>
<tr>
<td>- South Asian</td>
<td>32 (13%)</td>
<td>22 (9%)</td>
<td>16 (8%)</td>
</tr>
<tr>
<td>- Black</td>
<td>7 (3%)</td>
<td>7 (3%)</td>
<td>7 (3%)</td>
</tr>
<tr>
<td>- Other</td>
<td>4 (1%)</td>
<td>3 (1%)</td>
<td>3 (1%)</td>
</tr>
<tr>
<td>- Not stated</td>
<td>10 (4%)</td>
<td>13 (5%)</td>
<td>12 (6%)</td>
</tr>
<tr>
<td><strong>Median time in hospital</strong></td>
<td>9 (5,20) days</td>
<td>8 (4,17) days</td>
<td>7 (4,16) days</td>
</tr>
<tr>
<td>(inter quartile range)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Died in hospital</strong></td>
<td>51 (20%)</td>
<td>17 (7%)</td>
<td>12 (6%)</td>
</tr>
<tr>
<td>(% of sample population)</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

SD = standard deviation

* Recruited population who were included in analysis (39 recruited patients were excluded because they did not follow acute care pathway, had a stroke whilst in hospital, withdrew or were lost to follow-up).
## Table 2. Cox Regression analysis estimating association of pre hospital care on times to CT request and scan.

<table>
<thead>
<tr>
<th>Predictor</th>
<th>Unadjusted</th>
<th></th>
<th></th>
<th>Adjusted*</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Hazard Ratio</td>
<td>95% CI</td>
<td>P value</td>
<td>Hazard Ratio</td>
<td>95% CI</td>
<td>P value</td>
</tr>
<tr>
<td>Onset time recorded vs. not recorded by EMS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time to scan request</td>
<td>0.67</td>
<td>0.48</td>
<td>0.94</td>
<td>0.020</td>
<td>0.73</td>
<td>0.52</td>
</tr>
<tr>
<td>Time to scan</td>
<td>0.60</td>
<td>0.42</td>
<td>0.84</td>
<td>0.003</td>
<td>0.61</td>
<td>0.42</td>
</tr>
<tr>
<td><strong>FAST+ vs. FAST- /Not done</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time to scan request</td>
<td>0.54</td>
<td>0.37</td>
<td>0.80</td>
<td>0.002</td>
<td>0.54</td>
<td>0.37</td>
</tr>
<tr>
<td>Time to scan</td>
<td>0.74</td>
<td>0.50</td>
<td>1.09</td>
<td>0.123</td>
<td>0.72</td>
<td>0.48</td>
</tr>
<tr>
<td>Hospital pre-alerted vs. not pre-alerted by EMS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time to scan request</td>
<td>0.23</td>
<td>0.16</td>
<td>0.34</td>
<td>&lt;0.001</td>
<td>0.26</td>
<td>0.18</td>
</tr>
<tr>
<td>Time to scan</td>
<td>0.46</td>
<td>0.32</td>
<td>0.65</td>
<td>&lt;0.001</td>
<td>0.63</td>
<td>0.43</td>
</tr>
</tbody>
</table>

CI = confidence intervals; EMS = emergency medication service; FAST = face, arm, speech test

Hazard ratio represents the likelihood of the CT request/scan being delayed in those who have a known onset time, are FAST+ or where a hospital pre-alert message was sent.

*Hazard ratios were adjusted for EMS recording of onset time, FAST status, patient age, route to hospital, arrival in hospital within 4 hours of symptom onset, Glasgow Coma Score and whether the hospital was pre-alerted by EMS staff prior to arrival in the ED provided they were independent of the explanatory and outcome variables. Full details of each proportional hazards model can be found in table s2 in the online supplemental material.
Figure legends

Figure 1. Proportion of patients admitted to hospital with a final diagnosis of stroke included in the final analysis (white boxes indicate excluded patients).

Figure 2. Time to CT scan in patients who travelled to hospital via ambulance by (a) whether or not EMS staff recorded onset time; (b) FAST status; (c) whether or not EMS staff pre-alerted the hospital.

*Pre-alert data unavailable on three ambulance proformas.

EMS = emergency medical service; ED = emergency department; FAST = face, arm, speech test; CT = computed tomography

Figure 3. Kaplan-Meier plots showing the proportion of patients with a CT request within the first four hours of arrival in hospital for whom; (a) onset time was/was not recorded; (b) the FAST test was positive vs. negative/not done; or (c) the hospital was/was not pre-alerted.

*Pre-alert data unavailable on three ambulance proformas.

FAST = face, arm, speech test; CT = computed tomography