# The Impact of Ambulance Practice on Acute Stroke Care

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# The Impact of Ambulance Practice on Acute Stroke Care

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***Background and Purpose***—Few patients with acute stroke are treated with alteplase, often due to significant prehospital delays after symptom onset. The aims of this study were to: (1) identify factors associated with rapid first medical assessment in the emergency department after a call for ambulance assistance, and (2) determine the impact of ambulance practice on times from the ambulance call to first medical assessment in the emergency department.

***Methods***—During a 6-month period in 2004, all ambulance-transported patients with stroke or transient ischemic attack arriving from a geographically defined region in Melbourne, Australia (population 383 000) to one of 3 hospital emergency departments were assessed prospectively. Ambulance records including the tape recording of the call for ambulance assistance and hospital medical records, were analyzed.

***Results***—One hundred ninety-eight patients were included in the study. One hundred eighty-seven ambulance patient care records were complete and available for analysis. Factors associated with first medical assessment in the emergency department $<60$ minutes from the ambulance call and $<10$ minutes from hospital arrival were: Glasgow Coma Scale $<13$ ($P<0.001$ and $P=0.021$) and hospital prenotification ($P=0.04$ and $P<0.001$). Paramedic stroke recognition and hospital prenotification were associated with shorter times from the ambulance call to first medical assessment ($P=0.001$ and $P<0.001$).

***Conclusions***—Paramedic stroke recognition and hospital prenotification are associated with shorter prehospital times from the ambulance call to hospital arrival and in-hospital times from hospital arrival to first medical assessment. This highlights the importance of including ambulance practice in comprehensive care pathways that span the whole process of stroke care. **(*Stroke*. 2007;38:2765-2770.)**

**Key Words:** acute stroke ■ awareness ■ emergency care ■ paramedics

With the advent of alteplase, stroke care as a medical emergency has been emphasized.[1] Rapid care not only increases eligibility for treatment with alteplase, but also increases the odds of better recovery after treatment.[2] In response to the narrow therapeutic time window available for acute stroke treatment,[1] stroke centers and communities have developed strategies to reduce time delays to treatment. These include hospital and ambulance based rapid care protocols,[1,3] community education,[4] and ambulance staff education programs.[5] In Australia, the administration rate for alteplase remains low due to patient delays seeking care after the onset of symptoms[6] and the limited number of hospitals with acute stroke resources and expertise.[7] Only 20% of Australians who experience a stroke are admitted to a stroke unit[6] and few of these units provide alteplase. There is no national or state coordination of acute stroke care. Rather, the processes of care for patients with stroke are determined at a local hospital or regional level. In addition, community knowledge of stroke, risk factors, warning signs, and what to do in the event of a stroke also remains poor.[8,9]

Ambulance calltakers and paramedics are ideally positioned to identify and respond rapidly to stroke events. Paramedics have the potential to not only reduce delays, but also to ensure patients are assessed in the field appropriately and transported to a hospital with suitable acute stroke care facilities.[10] Paramedics are now being included in acute care guidelines to rapidly assess stroke in the field, triage the patient to an appropriate acute stroke care facility, and prenotify the hospital of their arrival.[11] This practice may reduce time to treatment and enhance the stroke patient's care in comprehensive stroke centers with acute care protocols.[3,12] Previous studies have identified that transport by ambulance reduces prehospital times and in-hospital times to treatment.[13–15]

There have been few studies designed to assess the effectiveness of interventions to reduce "time to treatment" after the onset of acute stroke symptoms.[16] Evidence from previous community comparison and before and after intervention studies has indicated that multilayered interventions may reduce delays and increase eligibility for acute stroke

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treatment.[17,18] Investigators have assessed the implementation of a number of prehospital interventions, including paramedic education programs and changes in paramedic practice, the use of a stroke assessment tool, triage of patients with stroke directly to one hospital, and hospital prenotification by paramedics. The results reported across these studies show an increase in the accuracy of paramedic diagnosis, reduced prehospital delays, reduced in-hospital times to treatment, and an increase in the thrombolysis rate.[5,17–22]

Little is known about the relationship between prehospital and emergency care and the impact of prehospital practice on emergency department (ED) care of patients with acute stroke. The aims of this study were to identify current patterns of care for stroke patients from the call for ambulance assistance to first medical assessment in the ED.

We hypothesized that (1) factors associated with rapid medical assessment in the ED (within one hour from the call for ambulance assistance) can be identified, and (2) that the ambulance paramedic practices of (a) allocating a priority code 1 "lights and sirens," (b) recognition of stroke in the field, and (c) hospital prenotification are associated with shorter times from the call for ambulance assistance to first medical assessment in the ED and shorter ED times from hospital arrival to first medical assessment.

## Methods

### Study Description

This was a prospective, open observational study of patients from a geographically defined region (population 383 000) in metropolitan Melbourne, Australia, who presented by ambulance to one of 3 public hospital emergency departments and were given a final emergency department diagnosis of "stroke" or "transient ischemic attack." This study region was selected for several reasons. First, Melbourne Metropolitan Ambulance Service (MAS) records for the previous 12 months indicated that more than 90% of patients with stroke transported by ambulance from this region were delivered to one of 3 hospitals, namely Austin Hospital, The Northern Hospital, and Royal Melbourne Hospital. Second, recruitment of patients from this area through surveillance of these 3 hospitals was expected to yield a sample of approximately 250 patients over a 6-month period spread across the 3 hospitals. Third, the included hospitals provided different stroke services. Austin Hospital and Royal Melbourne Hospital both have large comprehensive stroke services offering intravenous thrombolysis to eligible patients. The Northern Hospital offers stroke unit care with a multidisciplinary team but, at the time of the study, did not provide thrombolysis and there was no onsite access to specialist neurological or neurosurgical expertise. At the time of this study, Austin Hospital and Royal Melbourne Hospital had rapid care stroke protocols in place to respond to patients with acute stroke and paramedic prenotification of a patient with stroke. Both these hospitals deliver alteplase and enroll patients in clinical trials of acute stroke therapies.

### Ambulance Service Protocols

In Melbourne, Australia, the MAS provides the sole emergency ambulance service in the city. At the time of this study, stroke was recognized as a time critical event by the MAS. However, there was no specific stroke clinical practice guideline for the assessment and care of patients with acute stroke[23] in place during the study period. In the absence of a specific clinical guideline for stroke, the MAS clinical guidelines require that the patient be transported to the nearest appropriate facility.[23] Thus, decisions to transport a patient to a particular hospital or to prenotify a hospital were made by individual paramedics based on each patient's clinical condition. Paramedics currently employed by MAS undertake extensive training, including advanced life support and ongoing professional development that includes clinical practice updates. MAS is staffed by paramedics and mobile intensive care ambulance paramedics. Emergency medical technicians are not part of the ambulance workforce in Melbourne.

### Emergency Response Protocols

Emergency contact with the ambulance service is through a single "000" phone number. Calltakers use the Medical Priority Dispatch System[24] approved by the MAS Medical Standards Committee, and all calls are recorded. Calltakers allocate a priority code to each case. Ambulance priority codes, similar to hospital triage codes, allocate a level of priority and responsiveness to patients. Priority code 1 (lights and sirens) is the most urgent level of response. Triage nurses in the ED use The Australasian Triage Scale[25] to rate patients with different levels of clinical urgency. Triage code 1 requires immediate attention (eg, cardiac arrest) and triage code 2 specifies medical assessment within 10 minutes from arrival. During the research period, patients identified with acute stroke presenting to the Austin Hospital and Royal Melbourne Hospital were allocated a triage code no greater than 2. No specific triage protocol for patients with stroke was in place at The Northern Hospital.

### Participant Recruitment and Inclusion Criteria

Emergency department computer records at the 3 participating hospitals were used to identify potential patients for inclusion in the study. Patients were eligible for inclusion in the study if they were 18 years of age or older, were residents within the study region, were transported to the hospital by ambulance, and were diagnosed by ED staff as having had a stroke or transient ischemic attack. The person who called for ambulance assistance ("the caller") was identified for each case. Patients were excluded if they had been transferred from another hospital by ambulance.

### Data Collection

Tapes of all calls for ambulance assistance were reviewed by one of the investigators (I.M.), a registered nurse, using a uniform screening tool to evaluate the reported symptoms, any diagnosis offered by the caller (stroke or other), medical history reported, and symptom onset time provided with and without prompting by the calltaker. The symptoms were transcribed and then coded. Each patient's clinical details, history, and event description were obtained from hospital medical records and the ambulance records. Timelines of the care provided from the call for assistance to first medical assessment in the hospital were identified from a number of sources, including ambulance central computer event chronology records. Timelines included a number of phases: the "ambulance response time" (call to ambulance arrival), "at scene time" (ambulance scene arrival to departure), "hospital transport time" (scene departure to hospital arrival), "triage time" (hospital arrival to triage), and "door to doctor time" (hospital arrival to first medical assessment). The total ambulance time from call to hospital arrival is the "ambulance service time." The total of all time segments is the "call to doctor time."

### Definitions

Stroke recognition in the field was defined as documentation that the problem was stroke in the ambulance patient care record by the paramedics. Hospital prenotification was defined as documentation in the ambulance patient care record that a hospital was notified by the paramedics in the field, recording the hospital, time of the notification, and location of the ambulance.

### Ethics Approval

Research ethics committee approval for the study was obtained from Austin Hospital, Royal Melbourne Hospital, and The Northern Hospital. The study was also approved by the MAS. Informed consent was sought from the patient or next of kin as appropriate and from the caller before any data were collected and interviews conducted.

**Table 1. Demographic Characteristics of Included Patients With Complete Ambulance Patient Care Records (n=187)**

| Variable | n | Percent |
|---|---|---|
| Age, mean | 79 | |
| Male sex | 85 | 45 |
| Semiskilled and unskilled occupations | 104 | 55 |
| Educated to high school or above | 30 | 16 |
| Living status (at time of stroke event) | | |
| Patient lives alone | 42 | 22 |
| Patient lives in assisted care facility | 23 | 12 |
| Presenting hospital | | |
| Austin | 136 | 72 |
| Northern | 51 | 28 |
| Stroke type | | |
| Ischemic stroke | 121 | 65 |
| Transient ischemic attack | 42 | 22 |
| Intracerebral hemorrhage | 24 | 13 |

## Data Analysis

Univariate logistic regression was undertaken to explore the associations between a range of demographic, clinical, and other variables and the outcome of ED first medical assessment within 60 minutes from the call for ambulance assistance (call to doctor time <60 minutes). Variables with a univariate probability value of <0.10 were then entered into a multivariable backward stepwise linear regression model for each outcome of interest. The least significant variable was removed and the model rerun. This process was repeated until all variables had a probability value of <0.05. A probability value of <0.05 was considered significant. The same process of analysis was used for factors associated with first medical assessment in the ED within 10 minutes after hospital arrival (door to doctor time <10 minutes). Mann-Whitney 2-sample rank sum test was used to analyze and compare data groups.

## Results

From a population of 383 000 people, 357 patients from the region presented to the 3 study hospitals with an ED diagnosis of stroke or transient ischemic attack during the study period. Fifty-eight percent of these patients presented by ambulance.

Two hundred seven patients were identified as eligible for inclusion in the study. Eight patients refused to participate and one patient could not be located. The remaining 198 patients (96% of all eligible patients) were recruited over a 6-month period from July 9, 2004, to January 9, 2005.

Due to industrial action taken during the study period, MAS was unable to supply the tape recordings of the ambulance call for 15 cases and 11 patient care records were incomplete or missing. One hundred eighty-seven ambulance patient care records were complete and available for review. Demographic information for included patients with complete ambulance records is shown in Table 1. No eligible patients presented to Royal Melbourne Hospital during the study period. Ten potentially eligible patients were identified at Royal Melbourne Hospital but were excluded because they had been transferred by ambulance from The Northern Hospital where they first presented.

Times from the onset of symptoms to first medical assessment in the ED are shown in Table 2. The median time from call to arrival at the hospital by ambulance was 44 minutes. The interquartile ranges for paramedic prehospital care, including ambulance response time, at scene time, and transport time to the hospital, were narrow with little variance (Table 2). Cases dispatched "lights and sirens" had a median response time of 11 minutes (interquartile range, 9 to 14) and were significantly faster ($P<0.001$) than ambulances dispatched to nonurgent cases (median, 24 minutes; interquartile range, 16 to 33). Medical practitioners who called for an ambulance seeking nonurgent transport of a patient to the hospital represented approximately one third of all nonemergency ambulance responses (15 patients). In these cases, the patient was often living in a residential care facility (45%) and older with preexisting medical conditions. Of these nonurgent patients, 60% had already experienced delays greater than 3 hours before the call and 24% had experienced a stroke more than 24 hours previously.

**Table 2. Prehospital Timelines**

| Time | Median | Interquartile Range |
|---|---|---|
| Symptom onset to ambulance call | 70 | 15–288 |
| Response time | 12 | 9–18 |
| At scene time | 16 | 12–20 |
| Transport time | 15 | 10–20 |
| Total ambulance service time | 44 | 37–54 |
| Door to doctor | 20 | 11–44 |
| Call to doctor | 69 | 55–95 |

Response time indicates ambulance call to arrival; at scene time, ambulance arrival to departure; transport time, ambulance departure to ED arrival; total ambulance service time, ambulance call to ED arrival; door to doctor, ED arrival to first medical assessment; call to doctor, ambulance call to first medical assessment in the ED.

Ambulance calltakers identified stroke as the problem in 53% of all cases and allocated a "lights and sirens" response in 76% of calls. All cases identified as stroke were allocated a "lights and sirens" response unless the caller was a doctor who specified that the case was nonurgent. Paramedics in the field identified stroke as the problem in 78% of all patients and prenotified the hospital in 23% of all cases. Almost all prenotifications (93%) were directed toward Austin Hospital.

In cases in which paramedics did not identify stroke, these patients had the longest time from ambulance call to first medical assessment in the ED (Table 3). When stroke was identified by paramedics and their assessments were first communicated at the triage desk, "ambulance times" and "door to doctor" times were shorter (Table 3). The shortest total time from "call to doctor" occurred when stroke was identified by paramedics and the hospital was prenotified of their assessment. Median in-hospital "door to doctor" times were the fastest when the hospital was prenotified by the paramedics (Table 3).

Paramedic stroke recognition and hospital prenotification were both found to be associated with shorter "call to doctor" times when compared with patients not identified as having a stroke and patients in whom no notification was made ($P=0.001$ and $P<0.001$). "Call to doctor" time was significantly less for patients identified by paramedics as having a stroke and the hospital prenotified as compared with those

**Table 3. Timelines of Prehospital Care According to Paramedic Practice (n=187)**

| | Stroke Not Identified by Paramedics | Stroke Identified by Paramedics—No Notification | Stroke Identified and Hospital Prenotified |
|---|---|---|---|
| Patients | 44 (23%) | 102 (55%) | 41 (22%) |
| Onset call | 97 (28–331) | 53 (14–280) | 66 (12–243)* |
| Call arrival | 15 (10–24) | 12 (9–16) | 13 (10–15)* |
| At scene | 17 (11–22) | 16 (12–19) | 16 (12–20)* |
| Transport | 15 (10–20) | 15 (10–20) | 13 (9–18)* |
| Call to hospital | 49 (41–57) | 43 (37–54) | 44 (37–49)* |
| Door to doctor | 33 (17–76) | 21 (13–43) | 10 (5–20)* |
| Call to doctor | 87 (68–147) | 70 (58–95) | 52 (45–73)* |
| Patients residing in care facilities | 20% | 17% | 5% |
| Age, mean | 75 | 81 | 75 |
| Male | 19 (43%) | 46 (45%) | 20 (49%) |
| Austin Hospital | 30 (68%) | 68 (67%) | 38 (93%) |
| Priority code 1 (lights and sirens) response | 25 (56%) | 80 (78%) | 37 (90%) |
| Median triage code | 3 | 3 | 2 |
| Paramedic assessment | | | |
| Stroke or transient ischemic attack history | 8 (18%) | 40 (39%) | 16 (39%) |
| Dementia history | 3 (7%) | 11 (11%) | 1 (2%) |
| Dysphasia | 10 (23%) | 72 (72%) | 36 (88%) |
| Facial droop | 4 (9%) | 45 (44%) | 17 (41%) |
| Grip or arm weakness | 14 (32%) | 65 (64%) | 36 (88%) |
| Median Glasgow Coma Scale | 15 | 15 | 11 |

*Median (interquartile range) minutes.

patients not recognized as having a stroke (median, 52 versus 87 minutes, $P=0.001$).

No significant difference was identified in prehospital times between patient groups when stroke was not identified and stroke identified but no notification (median, 49 versus 44 minutes, $P=0.08$). There were, however, significant differences in the time from call to first medical assessment (median, 87 versus 70 minutes, $P=0.005$) due to in-hospital delays. Triage nurses identified stroke in only 7% of cases in which stroke was not identified by paramedics.

When paramedics prenotified the hospital, the median advance notice time was 10 minutes (interquartile range, 8 to 16) before arrival. In the majority of cases (87%), paramedics prenotified the hospital when the ambulance was en route to the hospital.

After multivariate analysis was performed, factors associated with the total response time (ambulance call to first medical assessment in the ED) <60 minutes were ambulance dispatched "lights and sirens" ($P=0.01$) and triage code 1 or 2 ($P<0.001$) (Table 4). Ambulance priority codes and hospital triage codes are both complex assessments based on a number of clinical features, including stroke recognition. To investigate further the range of variables that are associated with speed of care for patients with stroke, both variables (priority code and triage code) were excluded from the multivariate analysis and the model was rerun.

Factors associated with rapid medical assessment in the ED (within 1 hour from the call for ambulance assistance) were identified. Univariate analysis of these factors is shown in Table 4. Findings from the multivariate analysis were: stroke identification by ambulance calltakers ($P=0.01$), paramedic-assessed Glasgow Coma Scale <13 ($P<0.001$), and hospital prenotification ($P=0.04$) were factors independently associated with times <60 minutes from the ambulance call to first medical assessment in the ED.

Similar analysis was undertaken for factors associated with first medical assessment within 10 minutes after hospital arrival. Glasgow Coma Scale <13 ($P=0.021$) and hospital prenotification ($P<0.001$) were independently associated with times <10 minutes from hospital arrival to first medical assessment in the ED.

## Discussion

This prospective open observational study has shown that, in an urban Australian setting, the time from call to hospital arrival (ambulance service time) is relatively fixed with narrow interquartile ranges across all patients, locations, and hospitals. However, faster times were associated with ambulances dispatched "lights and sirens." Total ambulance times were similar to those reported from other emergency medical services around the world.[26,27] Although there was no formal policy at the time of this study, paramedics triaged patients toward one of the hospitals with an acute stroke service (93% of all stroke prenotifications). Transport times were shortest for patients across the study region who were transported to Austin Hospital after identification of stroke in the field and hospital prenotification (Table 3). The paramedics' decision

**Table 4. Univariate and Multivariate Associations Between Variables and "Time From Ambulance Call to ED First Medical Assessment in<60 Minutes"**

| Variables | n (187) | Percent | OR (95% CI) | Univariate *P* Value | Multivariate *p* Value |
|---|---|---|---|---|---|
| Patient demographics | | | | | |
| Male sex | 85 | 45 | 1.07 (0.57–1.99) | 0.84 | |
| Age, mean | 79 | | | | |
| age >75 | 119 | 63 | 0.73 (0.39–1.38) | 0.34 | |
| Lives in an assisted care facility | 23 | 12 | 1.22 (0.48–3.05) | 0.68 | |
| Austin Hospital | 136 | 73 | 1.11 (0.55–2.24) | 0.77 | |
| Ambulance calltaker assessment | | | | | |
| Stroke identified | 89 | 45 | 1.72 (0.92–3.21) | 0.09 | 0.01 |
| Priority code 1* | 142 | 76 | 4.76 (1.77–12.82) | 0.002 | |
| Paramedic clinical assessment | | | | | |
| Stroke or transient ischemic attack history identified | 63 | 34 | 0.75 (0.38–1.46) | 0.40 | |
| Dysphasia | 119 | 63 | 1.77 (0.90–3.48) | 0.10 | |
| Facial droop | 66 | 35 | 1.62 (0.86–3.07) | 0.14 | |
| Grip or arm weakness | 114 | 35 | 2.34 (1.18–4.63) | 0.02 | |
| Glasgow Coma Scale <13 | 47 | 25 | 4.74 (2.35–9.58) | <0.01 | <0.001 |
| Stroke identified | 143 | 76 | 2.28 (0.25–20.99) | 0.47 | |
| Hospital prenotification | 44 | 24 | 3.38 (1.67–6.83) | 0.001 | 0.04 |
| Triage assessment | | | | | |
| Triage diagnosis of stroke | 76 | 41 | 1.93 (1.03–3.62) | 0.04 | |
| Triage code 1 or 2* | 73 | 39 | 7.31 (3.65–14.61) | <0.01 | |

*Not included in multivariate analysis (see "Results").
Multivariate analysis results, including priority code 1 and triage code 1 or 2 variables were priority code 1 ($P=0.01$).
Triage code 1 or 2 ($P<0.001$).

to triage and transport the patient to a specific hospital within the study region did not adversely affect time to ED medical assessment.

In the multivariate analysis, factors associated with the ambulance call to first medical assessment in the ED within 1 hour were: patients with moderate to severe Glasgow Coma Scale score assessed by the paramedic and cases in which paramedics prenotified the hospital that they had identified a patient with acute stroke in the field and their arrival was imminent. Both these factors were also associated at a multivariate level with hospital arrival to first medical assessment <10 minutes. Interestingly, no patient demographic factors nor stroke recognition by paramedics was associated with rapidity of care, unlike altered conscious state, which was so. Paramedic prenotification of the hospital was associated with rapid times from the call for ambulance assistance to first medical assessment in the ED. Prenotification may preempt the activation of hospital-based resources before the patient's arrival, reducing delays and increasing the eligibility of patients for acute stroke treatment. This approach is dependent on the receiving hospital having rapid care protocols in place to respond to the ambulance prenotification.

The timeframe of 60 minutes used in the analysis of "call to first medical assessment" time is less than the median time of 69 minutes and provides a practical clinical goal. Based on our data, a goal of 45 minutes from call to first medical assessment in the ED is potentially achievable. However, in a large city environment, it seems impractical to reduce "call to medical assessment times" to less than 45 minutes because of transport and logistical issues that result in relatively fixed ambulance service times. The time from hospital arrival to first medical assessment <10 minutes was used because it aligned with the time specified in the Australian triage scale for category 2 patients.[25]

Previous research has also shown that arrival by ambulance reduces prehospital and in-hospital delays.[14,15] However, in this study, ambulance service times remained relatively constant. This study provides evidence that the time from ambulance call to first medical assessment in the ED and the time from hospital arrival to first medical assessment may both be directly influenced by paramedic practice when the receiving hospital has rapid response protocols for patients with acute stroke in place. Both stroke recognition and hospital prenotification by paramedics were shown to be associated with shorter "call to doctor" times. Median "door to doctor" time was only 10 minutes when paramedics identified acute stroke and prenotified the hospital. On average, this was 23 minutes (70%) faster than patients who present by ambulance without stroke being identified in the field (median, 33 minutes).

In determining priority areas for future interventions to reduce delays, it appears efforts to reduce ambulance response times may have little impact on prehospital delay times. However, the organization of a "systemwide response" across prehospital and in-hospital care may provide much shorter times to medical assessment and increase eligibility of patients for acute stroke treatments.

## Conclusions

It is likely that total "call to doctor" times and specifically "door to doctor" times could be reduced if patients with acute stroke were more effectively identified in the field and hospitals more frequently notified of their arrival. This of course would be dependent on effective implementation of healthcare systems geared to respond to ambulance initiatives.[11,28]

The findings from this study highlight the importance of including ambulance practice in comprehensive care pathways that span the whole process of stroke care.

Further research is needed to evaluate the effects of developments in paramedic practice on the process of delivering acute stroke care and patient outcomes.

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## Disclosures

None.

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