Helicopter Transport of Stroke Patients and Its Influence on Thrombolysis Rates
Data From the Austrian Stroke Unit Registry

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Background and Purpose—Acute stroke management requires minimization of prehospital time. This study addresses the value of helicopter transport compared with other means of transportation to a stroke unit and compares their rates of thrombolysis on a nationwide basis.

Methods—Prospective data collection and prespecified evaluation of data from 32 stroke units between 2003 and 2009 were used. We distinguished between patients transported either directly to a stroke unit or transferred indirectly via a peripheral hospital. Thus, there were 6 transport groups: helicopter emergency service (HEMS) direct and indirect, ambulance accompanied by an emergency physician direct and indirect, and ambulance without physician direct and indirect. Demographic and clinical factors, time delays, and rates of thrombolysis of patients transported by helicopter were compared with factors of patients transported otherwise.

Results—Of 21,712 ischemic stroke patients, 905 patients (4.1%) were transported by helicopter. Of these, 752 patients (3.4%) were transported by direct HEMS, and 153 patients (0.7%) were transported by indirect HEMS. Thrombolysis rates were highest for HEMS (24% direct, 29% indirect) transport, followed by ambulance accompanied by an emergency physician (18% direct, 15% indirect). The probability of receiving thrombolysis was highest for indirect HEMS transport (OR 3.6, 2.2–6.0), followed by indirect ambulance accompanied by an emergency physician transport (OR 1.5, 1.1–1.9). The shortest times, 90 minutes or less from stroke onset to hospital arrival, were achieved with direct AMBP and direct HEMS transport.

Conclusions—The shortest hospital arrival times and highest thrombolysis rates were seen in ischemic stroke patients transported by helicopter. (Stroke. 2011;42:00-00.)

Key Words: air ambulance ■ emergency medical service ■ acute care ■ acute stroke ■ stroke unit ■ prehospital time ■ thrombolysis

Thrombolytic therapy in patients with ischemic stroke has been recommended for use within 4 and a half hours. Therefore, minimization of prehospital time delays is a most critical issue in acute stroke management. In some instances, when ground transport is considered too time-consuming, patients are transported by helicopter to minimize prehospital delays. Helicopter transport is thus used either in rural areas, or in very large cities with chronic traffic congestion in order to provide rapid transfer to a tertiary care center (stroke unit). A helicopter-based transport system can link a rural region to a stroke center and promote access to thrombolytic therapy. The increased costs of using helicopter transfer are small relative to the significant potential savings in rehabilitation and nursing home costs associated with stroke treatment.

Until now, experience has been very limited regarding helicopter transport in association with acute stroke management. Most studies are based on small numbers of helicopter transports only to single centers. A systematic search in MEDLINE with the key words helicopter, acute stroke, time delays, and thrombolysis identified 11 studies on this subject (Table 1). All studies were performed in the United States. The number of helicopter transports ranged from 24 to 123. Several studies dealt with the reduction of time delays in prehospital management. However, rates of thrombolysis in association with helicopter transport have been documented in only 3 of the 11 studies. Larger trials are needed to test the superiority of helicopter transport for stroke patients.

This study was aimed at including a large number of helicopter-transported ischemic stroke patients (n=905) treated within a national network of stroke units. The specific questions of this study were to find out whether helicopter...
<table>
<thead>
<tr>
<th>Study</th>
<th>Year</th>
<th>Country</th>
<th>Description and Findings</th>
<th>Design</th>
<th>Helicopter Transports (N)</th>
<th>Mention of Stroke Patient Characteristics</th>
<th>Tissue Plasminogen Activator Administered</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alberts&lt;sup&gt;8&lt;/sup&gt;</td>
<td>1992</td>
<td>USA</td>
<td>Educational program to reduce time delays in referral of stroke patients; recommendation of using helicopter transport being one educational effort</td>
<td>Analysis of data from Duke University stroke registry before and after educational program</td>
<td>Not mentioned</td>
<td>...</td>
<td></td>
</tr>
<tr>
<td>Conroy&lt;sup&gt;5&lt;/sup&gt;</td>
<td>1999</td>
<td>USA</td>
<td>Case records of stroke patients transferred within 24 hours between 1996 and 1997 were reviewed. Questionnaires about perceived reasons for helicopter transfer were sent out</td>
<td>Retrospective case series</td>
<td>73</td>
<td>Yes</td>
<td>0 of 73 (0%)</td>
</tr>
<tr>
<td>Chalela&lt;sup&gt;9&lt;/sup&gt;</td>
<td>1999</td>
<td>USA</td>
<td>Safety of air medical transport after or during administration of tissue plasminogen activator</td>
<td>Retrospective chart review</td>
<td>24</td>
<td>Yes</td>
<td>24 of 24 (100%)</td>
</tr>
<tr>
<td>Thomas&lt;sup&gt;6&lt;/sup&gt;</td>
<td>2002</td>
<td>USA</td>
<td>Comparison of characteristics of stroke patients transported by helicopter during the pre-thrombolysis era (1985–1995) and during the thrombolysis era (1996–1999). Helicopter plays increasing role</td>
<td>Retrospective before-and-after study</td>
<td>192; 76 during the pre-thrombolysis era, 116 during the thrombolysis era</td>
<td>Yes</td>
<td>...</td>
</tr>
<tr>
<td>Silliman&lt;sup&gt;2&lt;/sup&gt;</td>
<td>2003</td>
<td>USA</td>
<td>Examination of a field-to-stroke center helicopter transport program in rural areas</td>
<td>Prospectively collected consecutive helicopter transports, observational study</td>
<td>111</td>
<td>Yes</td>
<td>18 of 47 (38%)</td>
</tr>
<tr>
<td>Silbergleit&lt;sup&gt;3&lt;/sup&gt;</td>
<td>2003</td>
<td>USA</td>
<td>Evaluation of cost-effectiveness of helicopter transport of stroke patients</td>
<td>Costs per additional good outcome and per quality-adjusted life-year were calculated</td>
<td>—</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>Kwan&lt;sup&gt;4&lt;/sup&gt;</td>
<td>2004</td>
<td>USA</td>
<td>Evaluated the effect of an intervention (one of them being helicopter transport) to reduce delays to administration of tissue plasminogen activator</td>
<td>Systematic review of previous clinical studies (2 of 10 studies dealing with helicopter transport)</td>
<td>—</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>Svenson&lt;sup&gt;10&lt;/sup&gt;</td>
<td>2006</td>
<td>USA</td>
<td>Comparison of transport times for helicopter with ground ambulance for interfacility transfer of cardiac or stroke patients; helicopter transport was faster</td>
<td>Observational study</td>
<td>70</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>Leira&lt;sup&gt;11&lt;/sup&gt;</td>
<td>2006</td>
<td>USA</td>
<td>To prove feasibility of clinical trials during aerial interhospital transport of patients; trials are feasible</td>
<td>Prospective data collection of all consecutive aerial transfers to the University of Iowa Hospitals</td>
<td>215 (12 ischemic stroke patients)</td>
<td>Yes</td>
<td>...</td>
</tr>
<tr>
<td>Konstantopoulos&lt;sup&gt;7&lt;/sup&gt;</td>
<td>2007</td>
<td>USA</td>
<td>Analysis of 123 ischemic stroke patients transported by helicopter. To assess for system improvements over time, data were analyzed between 2 consecutive 30-month periods</td>
<td>Retrospectively reviewed consecutive case series</td>
<td>123</td>
<td>Yes</td>
<td>...</td>
</tr>
<tr>
<td>Leira&lt;sup&gt;12&lt;/sup&gt;</td>
<td>2009</td>
<td>USA</td>
<td>Evaluation of safety and acceptability of initiating acute stroke trials during early helicopter evacuation and testing an intervention to facilitate informed consent; enrollment onto stroke intervention trials is feasible during helicopter transport</td>
<td>Randomized controlled trial University of Iowa</td>
<td>100</td>
<td>Yes</td>
<td>...</td>
</tr>
</tbody>
</table>
transport effectively reduced prehospital time delays in all settings and whether it significantly increased rates of thrombolysis.

**Methods**

Since 2003, the Austrian Stroke Unit Registry has prospectively collected data on baseline characteristics, management, and outcome of all stroke patients admitted to 32 of the 34 Austrian stroke units; the details of these have been published previously. Data entry, administration, and scientific analysis are approved and coordinated by an expert committee from the Austrian Stroke Society. Formal approval for each data analysis by a local ethics committee is not needed. Data collection, ratings, and data entry were performed only by experienced stroke neurologists at the times of admission to and discharge from the stroke unit. In Austria, an emergency call is answered by a trained dispatcher at the rescue coordination center who decides, based on telephone triage and availability, which type of transportation is sent out. If necessary, an ambulance with a physician or helicopter emergency service can be requested. In Austria, as in many other European countries, the accompanying physician is a certified emergency physician with a high level of expertise. Other persons, such as paramedics, have a lower level of expertise and only little formal training. Thus, patients come either by ambulance (AMB) accompanied by emergency paramedical staff only, by ambulance accompanied by an emergency physician (AMBP), or by helicopter emergency service (HEMS); HEMS is always accompanied by emergency physicians. Within these 3 means of transportation, we distinguished between patients coming either directly from home to a hospital with a stroke unit and those transferred indirectly from a peripheral hospital without a stroke unit. Thus, we distinguished between the following 6 groups: HEMS direct, HEMS indirect, AMBP direct, AMBP indirect, AMB direct, AMB indirect.

Only data of patients older than 18 years with diagnosis of acute ischemic stroke were included in this analysis. Demographic and clinical factors of ischemic stroke patients transported by direct and indirect HEMS were compared with factors of patients transported by ambulance accompanied by AMBP and AMB. Our analysis included demographic and clinical data such as age, sex, and severity of stroke measured by National Institutes of Health Stroke Scale, Barthel Index, modified Rankin Scale, prehospital and intrahospital times, risk factors for stroke, and rates of thrombolysis.

**Statistics**

As a statistical environment, we used R version 2.7.1 (R Foundation for Statistical Computing, Vienna, Austria). Comparisons between categorical variables were made with the $\chi^2$ test for independence. Multiple-group comparisons of continuous variables were performed with the Kruskal-Wallis test. A stepwise logistic regression model with thrombolysis as the dependent variable was performed optimizing the Bayesian Information Criterion. The following variables were included as predictors in the model: age, gender, mode of transport, time from stroke onset to stroke unit admission, stroke severity as measured by National Institutes of Health Stroke Scale, modified Rankin Scale before stroke, previous stroke, hypertension, hypercholesterolemia, atrial fibrillation, cardiac diseases, previous myocardial infarction, peripheral arterial disease, diabetes mellitus, smoking, and alcohol abuse.

**Results**

Between January 2003 and May 2009, 33 081 patients were admitted to 32 stroke units in Austria. After filtering data by age older than 18 years, transport with 1 of the defined transport groups, and diagnosis of ischemic stroke, 21 712 ischemic stroke patients were eligible for this study. Of these ischemic stroke patients, 905 patients (4.1%) were transported by helicopter, 752 patients (3.4%) were transported by direct air, and 153 patients (0.7%) were transported by interfacility air. Approximately half of the patients came directly by ambulance not accompanied by an emergency physician. Another quarter of the patients were transported directly by ambulance accompanied by a physician (Table 2). The rest of the patients came with the other transport groups.

Demographic and clinical characteristics of patients transported by helicopter are shown in Table 2; in all groups, patients transferred from another hospital were younger than were patients who came directly. Patients transported by helicopter were 3 to 4 years younger than were patients in the other transport groups. In all groups, more male patients were transported, but notably more so in the helicopter groups. Patients in the helicopter groups suffered more severe stroke symptoms, as measured by National Institutes of Health Stroke Scale, on admission. Helicopter-transported patients more often had Rankin Scale 0 before stroke compared with other transport groups (direct HEMS transport, 72.9% versus direct AMBP, 65.8% and direct AMB, 64.6%; indirect HEMS transport, 85.6% versus indirect AMBP, 76.5% and indirect AMB, 72.6%).

The shortest transport times (Table 3) from stroke onset to hospital arrival were achieved with direct AMBP and direct

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**Table 2. Demographic and Clinical Characteristics of Patients With Ischemic Stroke According to Transport Mode**

<table>
<thead>
<tr>
<th>Transport Group</th>
<th>N</th>
<th>%</th>
<th>Median</th>
<th>Interquartile Range</th>
<th>Sex (% Male)</th>
<th>NIHSS on Admission</th>
<th>N</th>
<th>Median</th>
<th>Interquartile Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>HEMS direct</td>
<td>752</td>
<td>3.40</td>
<td>72</td>
<td>62–80</td>
<td>54.7</td>
<td>8</td>
<td>21712</td>
<td>3–17</td>
<td></td>
</tr>
<tr>
<td>HEMS indirect</td>
<td>153</td>
<td>0.70</td>
<td>66</td>
<td>52–73</td>
<td>68.0</td>
<td>7</td>
<td>21712</td>
<td>3–16</td>
<td></td>
</tr>
<tr>
<td>AMBP direct</td>
<td>5891</td>
<td>27.20</td>
<td>75</td>
<td>65–82</td>
<td>50.5</td>
<td>7</td>
<td>21712</td>
<td>3–16</td>
<td></td>
</tr>
<tr>
<td>AMBP indirect</td>
<td>1109</td>
<td>5.10</td>
<td>69</td>
<td>60–78</td>
<td>57.5</td>
<td>6</td>
<td>21712</td>
<td>3–13</td>
<td></td>
</tr>
<tr>
<td>AMB direct</td>
<td>11357</td>
<td>52.30</td>
<td>76</td>
<td>66–82</td>
<td>50.9</td>
<td>4</td>
<td>21680</td>
<td>2–8</td>
<td></td>
</tr>
<tr>
<td>AMB indirect</td>
<td>2450</td>
<td>11.30</td>
<td>71</td>
<td>60–79</td>
<td>54.9</td>
<td>3</td>
<td>20890</td>
<td>1–7</td>
<td></td>
</tr>
</tbody>
</table>

HEMS indicates helicopter emergency service; AMBP, ambulance with accompanying physician; AMB, ambulance without accompanying physician; NIHSS, National Institutes of Health Stroke Scale.

*Due to missing values, data are reduced from a total of 21 712 ischemic stroke patients to 21 680 and 20 890.

†“Direct” refers to patients transported directly to a center with a stroke unit.

‡“Indirect” refers to patients transferred from another hospital to a center with a stroke unit.
HEMS transport. Only in these 2 transport groups did more than 70% of patients (Table 3) arrive within 2 hours of stroke onset; in the other groups, far fewer patients came within 2 hours. Direct transports were always faster than were indirect transports. The shortest door-to-needle times (Table 3; 40 minutes or less) were recorded for patients transported by indirect HEMS and indirect AMBP transport.

The most striking result of this analysis was the high rates of thrombolysis in patients transported by helicopter (Figure). Of 21,712 ischemic stroke patients, 2,501 patients received thrombolysis. In the direct HEMS group, 180 of 745 patients (24%) were treated with thrombolytic therapy; in the indirect HEMS group, the rate of thrombolysis was even higher at 29% (44 of 153 patients were treated with thrombolytic agents). In the AMBP group, rates of thrombolysis were 18% and 15% (direct and indirect transport, respectively). In the other groups, rates were far lower.

Accordingly, the probability of receiving thrombolysis calculated in a multivariate regression model (Table 4) was highest for indirect HEMS (OR 3.6, 2.2–6.0), followed by indirect AMBP transport (OR 1.5, 1.1–1.9) and direct HEMS (OR 1.3, 1.0–1.6), compared with direct AMB transport. The strongest predictor for likelihood of receiving thrombolysis was stroke severity. Time intervals (if known) longer than 120 minutes from stroke onset to admittance as well as age older than 70 years were negative predictors for thrombolysis. Additional significant negative predictors were previous stroke and more than 1 point on the modified Rankin scale before stroke. Sex did not turn out to be a significant predictor.

Discussion

Our prospective observational cohort study is the first study based on large numbers of helicopter transports to investigate the effectiveness of helicopter transport regarding prehospital management of ischemic stroke patients and subsequent time-dependent therapy with thrombolysis. Although only 4% of ischemic stroke patients (905 helicopter transports of 21,712 total transports) were transported by helicopter, this transport mode has been shown to be the most efficacious regarding rates of thrombolysis, especially when patients were transported by helicopter from a peripheral hospital without a stroke unit.

In our study, transport times were similar for direct helicopter transport and direct ambulance transport, provided the ambulance was equipped with an emergency physician. Similarly, Svenson et al showed that transport time was shorter for helicopter transport, but average helicopter transport was as fast as the best ground transport. Díaz et al compared helicopter transport times with ground transport times and showed that only at distances greater than 10 miles was air transport faster than simultaneously dispatched ground transport. Individual time savings for helicopter transport...
transport compared with ground transport cannot be estimated in this study because data on the locations of stroke events and the primary admitting hospitals (for indirect transports) are not recorded in this registry.

In regions lacking specialized stroke care, telemedicine can facilitate the administration of intravenous recombinant tissue plasminogen activator and could be an alternative to expensive air transport.\(^1\)\(^6\) While the decision for or against thrombolysis can be facilitated, the periprocedural management, especially the multidisciplinary care, cannot easily be substituted with a telemedical one. Therefore, in Austria, a network of stroke units has been established in a predefined way so that a stroke unit (with few exceptions in remote mountain regions) can be reached from any community within 90 minutes. In Austria, almost all patients receive thrombolytic treatment on stroke units served by neurologists. In such a setting, fast transport to the next stroke unit is considered the best option for acute stroke patients.

As expected, because of the costliness and limited availability of helicopters, patients arriving by helicopter were younger, suffered more severe stroke symptoms, and seemed to be less impaired before stroke onset compared with patients in the ground transport groups. Patients are selected by emergency physicians or the local physicians of primary admitting hospitals. Especially in the case of indirect helicopter transfer, neurologists of the admitting stroke unit are consulted by telephone prior to transfer to decide on a patient’s eligibility for thrombolysis; also, if available, computed tomography images of the brain are sent per e-mail. Indeed, 89% of all direct and 95% of all indirect helicopter transports to stroke units had a confirmed diagnosis of acute stroke. This and the high rates of thrombolysis in the helicopter groups indicate that preselection of ischemic stroke patients and assignment to a certain mode of transportation during prehospital management is a successful process offering fast access to therapy with thrombolysis. The costliness of helicopter transport may increase the pressure to treat these patients with recombinant tissue plasminogen activator. Nevertheless, as reported for this and other databases, shorter prehospital times correlated with longer door-to-needle times, probably reflecting a feeling of “having more time.”\(^1\)\(^3\)\(^,\)\(^1\)\(^3\)

The limitation of our study is that being a nonrandomized, observational study, we cannot test directly the effectiveness of the decision-making process involved in the choice of transport mode (eg, protocols used by dispatchers). It therefore could not have been the purpose to compare outcome parameters, because there are too many subsequent factors influencing outcome, such as recanalization as a result of thrombolysis, rehabilitation, and occurrence of complications. We focused on the rates of thrombolysis as end points of a performance process and not of an outcome study. Furthermore, financial costs for the different transport groups and subsequent costs for rehabilitation were not calculated, because such data are not in the Registry. However, previous studies have shown the cost-effectiveness of helicopter transport.\(^3\)\(^,\)\(^4\)

In conclusion, this study is the first with high numbers of helicopter transports in association with ischemic stroke patients and thrombolysis in a nationwide setting. It shows that helicopter transport is most efficacious for short prehospital time management enabling time-dependent therapy with thrombolysis for a large number of patients.

### Disclosures

None.
References

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