Safety of Air Medical Transportation After Tissue Plasminogen Activator Administration in Acute Ischemic Stroke

Julio A. Chalela, MD; Scott E. Kasner, MD; Edward C. Jauch, MD, MS; Arthur M. Pancioli, MD

Background and Purpose—We sought to determine the safety of air medical transport (AMT) of patients with acute ischemic stroke (AIS) immediately after or during administration of tissue plasminogen activator (tPA). Patients with AIS treated with tPA in nonuniversity hospitals frequently need transfer to tertiary care centers that can provide specialized care. AMT is a widely available mode of transport that is crucial in providing expedient and quality health care to critically ill patients while assuring high level of care during transportation. The safety of AMT of patients with AIS after or during administration of tPA has not been examined.

Methods—We performed retrospective chart review of 24 patients with AIS who were treated with intravenous tPA and transferred by helicopter to the Hospital of the University of Pennsylvania or the University of Cincinnati Hospital. The charts were reviewed for neurological complications, systemic complications, and adherence to the National Institutes of Neurological Disorders and Stroke (NINDS) protocol for AIS management.

Results—No major neurological or systemic complications occurred. Four patients had hypertension warranting treatment, 3 patients experienced motion sickness, 1 patient developed a transient confusional state, and 1 patient experienced minor systemic bleeding. Four NINDS protocol violations occurred, all related to blood pressure management.

Conclusions—In this small series, AMT of AIS patients after thrombolysis was not associated with any major neurological or systemic complications. Flight crew education on the NINDS AIS protocol is essential in limiting the number of protocol violations. AMT of patients with AIS provides fast and safe access to tertiary centers that can provide state of the art stroke therapy. (Stroke. 1999;30:2366-2368.)

Key Words: emergency medical services ■ stroke treatment ■ tissue plasminogen activator

Air medical transportation (AMT) of the critically ill patient is a widely used practice. It was first introduced during the Korean War for the transportation of injured soldiers. Air transfer decreases time to specialized medical intervention and in many instances allows for timely treatment of certain diseases and complications in flight and for continuation of therapies initiated in the originating hospital. Its use has been extensively evaluated in patients with myocardial infarction, trauma, cardiac arrest, and burns.1-3 The safety of this practice is not clear; although most authors consider it safe, some have reported an increased incidence of untoward events such as cardiac arrhythmias, hypotension, and respiratory arrest.2 Patients with acute ischemic stroke (AIS) treated with thrombolytics often benefit from air transfer to tertiary care centers that can provide neurointensive care, endovascular therapies, and consultation with stroke specialists. The possible impact of the transport mechanism itself is not clear. Schneider et al2 have reported an increased incidence of complications in patients with myocardial infarction transferred by helicopter. It is conceivable that some of the complications suggested in the cardiac literature could apply to patients with AIS.

This study examines the experience from 2 university hospitals that transfer patients with AIS via helicopter during or immediately after thrombolytic administration. The purpose of the study was to examine the safety of this practice and to determine whether therapeutic interventions performed during AMT adhered to accepted standards of thrombolytic treatment for AIS.

Subjects and Methods

A structured retrospective review was conducted of the medical records and flight logs of all patients with AIS treated with tissue plasminogen activator (tPA) who were transferred by helicopter to the Hospital of the University of Pennsylvania or the University of Cincinnati Hospital between March 1997 and March 1999. Twenty-five patients were transferred by air, but complete records were obtainable only in 24 patients. The following patient data were obtained: age, sex, and baseline National Institutes of Health Stroke Scale (NIHSS) score. tPA dose and administration time with relation

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Complications During Air Medical Transport

<table>
<thead>
<tr>
<th>Complication</th>
<th>Patients, n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intracerebral hemorrhage</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Hypertension</td>
<td>4 (16)</td>
</tr>
<tr>
<td>Arrhythmias</td>
<td>1 (4)</td>
</tr>
<tr>
<td>Systemic bleeding</td>
<td>1 (4)</td>
</tr>
<tr>
<td>Motion sickness</td>
<td>3 (12)</td>
</tr>
<tr>
<td>Acute confusion</td>
<td>1 (4)</td>
</tr>
</tbody>
</table>

At time of air transfer were determined. Flight log sheets were reviewed for flight times and ground distances. Evidence of neurological deterioration and cardiovascular, pulmonary, and hemorrhagic complications was determined. Neurological complications were defined as any deterioration in the neurological examination, change in the NIHSS on arrival when compared with pretransfer NIHSS score, or change in the Glasgow Coma Scale (GCS) score. When the NIHSS was not available, it was abstracted from the patients records.4 Cardiovascular complications included life-threatening arrhythmias, such as ventricular tachycardia or ventricular fibrillation, hypotension (defined as mean arterial pressures of <100 mm Hg), hypertension (defined as systolic >180 mm Hg or diastolic >105 mm Hg), angina, or myocardial infarction. The maximum systolic blood pressure and maximum diastolic blood pressure during air transfer were recorded. Pulmonary complications included oxygen desaturation as determined by continuous pulse oximetry, or clinical signs of dyspnea or apnea. Hemorrhagic complications included systemic bleeding and intracerebral bleeding. Intracerebral hemorrhage was determined by follow-up head CT scan performed in all patients 24 hours after treatment. Adherence to the National Institute of Neurological Disorders and Stroke (NINDS) protocol for thrombolysis of AIS was determined.5 Any other therapies instituted in-flight were recorded. Failure of monitoring equipment and need to reinsert intravenous lines, nasogastric tubes, or Foley catheters were also recorded.

Results

Sixteen patients were transferred via helicopter to the Hospital of the University of Pennsylvania and 8 patients to the University of Cincinnati Hospital. Twenty-three patients were transferred in a BK117 American Eurocopter, and 1 was transferred in a B105 American Eurocopter. All flights were performed under fair weather following visual field reference protocols. Both helicopters were equipped with advanced cardiac life support equipment. Flight teams consisted of either nurse and paramedic or nurse and physician. Eight patients were transferred with a physician on board. A land-based emergency physician acted as medical commander for all flights. The medical commander was contacted in 2 situations to discuss in-air patient management. The in-air transfer time ranged from 5 to 25 minutes, with a median of 11 minutes.

Twelve men and 12 women composed the group. The ages ranged from 27 to 87 years, with a median age of 70 years. The NIHSS scores before transfer ranged from 7 to 32 points, with a median of 14.5. The median NIHSS after transfer was also 14.5 points. The stroke team at the receiving hospital guided patient selection and treatment with tPA instituted at the referring hospital in all 24 patients. The referring hospital performed a neurological evaluation, baseline laboratory examinations, and CT examination in all 24 patients. All patients received the tPA bolus at the originating hospital. Seven patients (29%) completed the tPA infusion a median of 30 minutes before transfer. Seventeen patients (71%) received the bolus dose on ground but continued to receive the infusion during air transfer. Five patients (21%) completed the infusion during transfer. Continuous cardiac monitoring and continuous pulse oximetry were performed in all patients. All patients received supplemental oxygen.

No patient experienced life-threatening complications or major neurological deterioration (Table). Three patients had a 2-point decline in NIHSS score. In 16 patients for whom the GCS was available, it remained unchanged during transfer. Follow-up CTs were performed at 24 hours in all patients. No intracranial hemorrhages were detected. Three patients developed motion sickness. One patient developed a transient confusional state that resolved on landing. One patient had frequent monomorphic ventricular extrasystoles that were self-limited and resolved up landing. No pulmonary complications were identified. One patient with an angiogram-related stroke developed minor bleeding from the groin puncture site. One patient developed angioedema manifested by tongue and lip swelling that required intubation on landing.

When NINDS protocol adherence was examined, 4 protocol violations, all related to blood pressure management, were detected. Two NINDS protocol violations occurred in patients transferred with physicians and 2 in patients transferred without physicians. One patient with elevated blood pressure was not monitored at 15-minute intervals as recommended by the NINDS. In 3 remaining patients, blood pressure elevations >180/105 mm Hg were not treated in accordance with the NINDS protocol. Other possible NINDS protocol violations, such as use of aspirin, heparin, or other antithrombotic medications or insertion of intravenous lines in noncompressible sites, did not occur.

Two patients received >500 mL of glucose-containing solutions during air transfer. In-flight therapies were instituted in 2 patients, both for blood pressure control. In 14 patients, patient comfort, rather than the traditionally recommended supine position, determined head positioning. Information about head positioning was not available in 8 patients. Medical equipment failure did not occur, and reinsertion of intravenous lines or other devices was not necessary.

Discussion

The development of acute interventions applicable to AIS patients has led to widespread use of AMT of critically ill patients to centers that can provide sophisticated neurointensive care and offer endovascular therapies. In addition, enrollment of AIS patients in clinical trials involving neuroprotective agents often requires emergency transfer to tertiary centers that may best be accomplished with AMT. Helicopters are particularly advantageous, because they reduce transfer time to about one half that of a ground ambulance.6 In addition, flight crew staff members are often more skilled than the staff that travels on ground ambulances. Remarkably little is known about the safety of this practice. Studies examining the safety of transferring patients with acute neurological disorders within the hospital have found a 10% incidence of adverse events related to the transfer itself.7

Among the most frequent complications reported are obtu-
tion, hypertension, hypotension, oxygen desaturation, electrocardiographic changes, and respiratory distress.\textsuperscript{7} Serious untoward events, including chest pain, arrhythmias, hypotension, cardiac arrest, and seizures, have been reported in 49\% of cardiac patients transferred by air compared with 15\% transferred by ground.\textsuperscript{2} It has been hypothesized that noise, vibration, gravitational and rotational forces, and psychological stress may account for the high complication rate.\textsuperscript{6} Vibrations with frequencies of <10 Hz can induce muscle fatigue, headache, nausea and vomiting.\textsuperscript{6} Limited access to the lower half of the patient’s body and difficulty in assessment of speech during transfer may interfere with neurological assessment in some helicopters.\textsuperscript{6} With the type of helicopters used and the navigation protocols used in this study, the above-mentioned problems are not a concern.

Despite putative risks, we did not find a clinically significant complication rate in our small series of patients. The low complication rate may have been related to the overall short period of air transfer involved, the careful selection of patients eligible for thrombolytic therapy, or the careful monitoring provided by the flight crew. It is noteworthy that 5 of the 24 patients (21\%) had severe strokes (NIHSS >20 points), making stroke severity an unlikely confounder. It is possible that the high complication rate encountered in some cardiac series was related to the underlying cardiac pathology and not to the transfer mechanism itself. High catecholamine levels reported in cardiac patients transferred by air may explain the high incidence of cardiac arrhythmias.\textsuperscript{8} Elevated catecholamine levels could be deleterious in patients with AIS, particularly after thrombolysis. Although 4 patients (17\%) had elevated blood pressures that required treatment, hypertension is present in up to 70\% of patients with AIS, and thus it is unlikely that a hypersympathetic state associated with air transfer accounts for the elevated blood pressure.\textsuperscript{9} Only 1 patient had frequent ventricular extrasystoles that resolved on landing, possibly due to a transient increase in sympathetic tone.

No major hemorrhagic complications were observed. Even though suboptimal blood pressure control may correlate with intracranial bleeding,\textsuperscript{3} this complication did not occur. The only case of systemic bleeding in our series was related to a femoral artery puncture performed before flight, which was easily controlled with local pressure performed by the flight crew.

All other complications were minor and did not pose significant risks to the patients. Motion sickness is a well-known complication of AMT and ground ambulance transfer.\textsuperscript{1,6} Motion sickness affected 3 patients but had no impact on their neurological status. A transient confusional state observed in 1 patient has been described in patients transferred by helicopter and is thought to be promoted by impaired visuospatial orientation during flight.\textsuperscript{1,6} This is a benign phenomenon that usually responds to gentle reassurance and orientation, and in our patient resolved completely on landing.

Of major concern are the 4 NINDS protocol violations encountered in our series, all related to blood pressure control. Three violations were due to inadequate blood pressure treatment, and 1 was related to inadequate blood pressure monitoring. Although the patients did not experience any complications, strict adherence to the NINDS protocol is necessary to ensure patient safety.\textsuperscript{5} It is possible that the patients were suffering from transient hypertension related to the transfer process, but leaving hypertension untreated even during brief air transfer poses a potential risk.

AMT of patients in nonmilitary settings is considered fairly safe in terms of aviation accidents. In 1982, the worst year in aeromedical navigation, 25 accidents occurred per 100 000 patients transferred.\textsuperscript{6} There were no casualties or flight abnormalities in our series of patients transferred by helicopter. All patients were transferred during fair weather and airlifted at helipads, whereas landing at casualty sites may be associated with higher number of accidents. No medical equipment failure or need to replace any medical devices occurred, suggesting that safety in this setting is not inferior to that in other intensive care settings.

In this small retrospective series, AMT of AIS patients after thrombolysis was not associated with any major neurological or systemic complications. Instruction to the flight crew on strict adherence to the NINDS protocol, in particular to blood pressure control, is necessary for optimal care of AIS patients. AMT provides a safe and expeditious way to ensure that patients with AIS receive state of the art therapy at tertiary care centers. To better determine the safety of this practice, a prospective study comparing AMT in AIS against ground transportation should be performed.

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References

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