Use of a Field-to-Stroke Center Helicopter Transport Program to Extend Thrombolytic Therapy to Rural Residents

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Background and Purpose—Giving stroke victims who reside outside communities with hospitals that can administer tissue plasminogen activator (rtPA) access to thrombolytic therapy is a challenge. Helicopter transport to a stroke center is a potential way to make rtPA available to these communities. We examined the experience of the Shands-Jacksonville Acute Stroke Transport Program, a field-to-stroke center helicopter transport program that serves rural counties in the northeastern Florida/southeastern Georgia region.

Methods—Prospectively collected data of 111 consecutive helicopter transports to Shands-Jacksonville, from an 11-county region, over a 3-year period were reviewed.

Results—Eighty-five patients (76%) had a cerebrovascular event. Forty-seven patients (42%) had an ischemic stroke, 19 (17%) had a transient ischemic attack, and 19 (17%) had a hemorrhagic stroke. Thrombolytic therapy was administered to 18 ischemic stroke patients (38%), with 15 being treated intravenously. Three patients who arrived beyond the 3-hour window were treated intra-arterially. Average field-to-hospital distance for all patients was 29.4 miles (range, 11 to 90 miles). Most patients (n=65) arrived within 135 minutes from symptom onset.

Conclusions—A helicopter-based transport system can link a rural region to a stroke center and promote access to thrombolytic therapy. (Stroke. 2003;34:729-733.)

Key Words: emergency medical services ■ stroke management ■ stroke, acute ■ tissue plasminogen activator

When initiated within 3 hours of symptom onset in patients with ischemic stroke, recombinant tissue plasminogen activator (rtPA) is associated with a 30% greater likelihood of minimal or no disability at 3 months and 1 year compared with placebo.1,2 Only a minority of ischemic stroke patients (<5%) are treated with rtPA.3–6 Several factors interact to explain the underutilization of rtPA, including patients’ lack of knowledge regarding stroke symptoms,7 some neurologists’ reluctance to use rtPA,8 and lack of access to hospitals that administer rtPA. Lack of access is complicated by the fact that many hospitals in the United States, particularly those in rural areas, lack facilities or expertise to provide this treatment. For example, a survey of all hospitals in North Carolina demonstrated that stroke rtPA protocols existed in only 31 of 125 inpatient facilities, and nearly one quarter of the state’s population did not reside in a county with a hospital that offers rtPA.9 A similar survey conducted in Illinois showed that 28% of acute receiving hospitals lack a rtPA protocol.10

Jacksonville is the largest city in northeastern Florida. It is surrounded by mostly rural counties, some with limited access to healthcare facilities. In 1997 the use of rtPA within the greater Jacksonville region was limited to a few downtown hospitals. In an effort to provide residents of rural counties in northeastern Florida and southeastern Georgia with access to thrombolytic therapy, the Shands-Jacksonville Acute Stroke Transport Program (SJASTP) was launched that year. This helicopter-based program links local emergency medical services (EMS) within rural counties to the stroke team at Shands-Jacksonville (SJ). Our experience with the first 40 transported patients has been reported.11 We now report our experience during the program’s first 3 years.

Subjects and Methods

Community

Jacksonville, with 735,617 residents,12 is the most populous city in northeastern Florida. The city is spread over 900 square miles of area,13 making Jacksonville the largest city in the continental United States. Jacksonville is located near the Florida-Georgia border, and it is surrounded by counties that are chiefly rural. A few suburban communities are located in those counties that abut Jacksonville. Most hospitals in these surrounding counties lack 24-hour CT capabilities and neurologists on their medical staff. SJ is a 750-bed tertiary medical center located in downtown Jacksonville. The hospital is a major teaching hospital affiliate of the University of Florida College of Medicine, provides care to a large indigent population, and is a referral center for most of northeastern Florida and southeastern Georgia. SJ has been the level I trauma center for the greater Jacksonville region since 1985. Since that time, helicopter
ambulance has been used to transport trauma victims from outlying counties to SJ.

Program History
A coordinated strategy was developed in October 1997 between the stroke team at SJ and several county EMS systems to make thrombolytic therapy of stroke available to acute stroke victims residing in those counties. This strategy was founded on preexisting transport protocols that had been established to transport trauma victims. Approval of the each county’s medical director and chief of EMS was required before a county could join the transport network. Before the flight program was initiated in a county, 3 of the authors (S.L.S., B.Q., V.H.) conducted a seminar with the local EMS personnel, who were educated about signs of stroke and the effectiveness of rtPA as an acute treatment. At these seminars, the field triage checklist and transport protocol were also reviewed. Approximately once per year thereafter, 1 of the authors (S.L.S.) traveled to each county to reeducate the paramedics and dispatchers about the protocol, provide feedback regarding patients who had been flown from the county, and review inappropriate transports from the county. Five counties participated in the SJASTP at its initiation in 1997. This program expanded into other counties during its first 3 years of existence (Figure 1). Two of the original counties withdrew from the program after local hospitals began using intravenous rtPA for stroke. Nine counties in northeastern Florida and southeastern Georgia were participating in the flight program on December 31, 2000.

Transport Protocol
After a 911 call is made to a county dispatcher, a local paramedic/ground ambulance is sent to the scene. If, according to the paramedic’s clinical impression, the patient had a stroke, a triage checklist (Figure 2) is completed. If all “yes” and all “no” parameters are met, the local unit calls the TraumaOne helicopter dispatcher at SJ, and the helicopter is launched. The SJ dispatcher also notifies the emergency department attending physician and the on-call neurologist. During communications between the ground ambulance crew and the helicopter dispatcher, an appropriate pick-up point is determined. Designated landing zones are present within each county. The helicopter, however, is not limited to using the designated pick-up sites. Any location that is least 60×60 ft (100×100 ft at night), flat, and free of obstructions can be used as a patient pick-up site. While the helicopter is in flight, the patient is transported to the pick-up site via ground ambulance. The patient is transferred from ground to air ambulance, then flown to the emergency department at SJ. Baseline blood work, brain CT scanning, neurological consultation, and, when appropriate, rtPA administration are done in the emergency department.

TraumaOne is a BK-117 helicopter ambulance stationed at SJ. A flight crew consisting of a pilot, a nurse, and a paramedic are on site 24 h/d. Cruising speed is approximately 130 mph. If the TraumaOne helicopter is involved in another run, making it unavailable to transport a stroke patient, the SJ dispatcher can request that another helicopter stationed at a nearby hospital pick up the patient and transport him or her to SJ. The helicopter charges are $3300 for liftoff plus $45 for every mile traveled with the patient on board.

Data Collection
Data were collected prospectively on all patients transported to SJ as part of the SJASTP. Some charts were retrospectively reviewed to gather missing data points. Information collected included mileage, time from symptom onset until emergency department arrival, discharge diagnosis from the hospital, and whether or not rtPA was administered. Mileage information was collected from the run sheets that the helicopter crew generates during each flight. The mileage is calculated by the onboard flight odometer. Time from symptom onset was defined as the last time that a patient was neurologically normal. If the patient awoke with symptoms, the time last seen neurologically normal was defined as the onset time. Time of arrival in the emergency department was abstracted from the nursing notes.

Results
At the outset, 5 counties with a total population of 283 812 residents participated in the SJASTP. By December 2000, 9 counties with a total population of 234 520 were transporting stroke patients to SJ. The surface area covered by the transport program was 3692 square miles at program inception. The program covered a surface area of 5762 square...
miles at the end of the study period, an area that is 744 square miles larger than the state of Connecticut.

Between October 1, 1997, and December 31, 2000, 111 patients with a diagnosis of possible acute ischemic stroke were transported via helicopter to SJ. All but 6 patients (5%) were flown by the primary helicopter service, TraumaOne. The 105 patients with possible stroke flown by TraumaOne between October 1997 and December 2000 represent 4% of their field-to-hospital transports to SJ over that time frame. Potential stroke patients were received from all participating counties. The average loaded 1-way flight distance from field to hospital was 29.4 miles (range, 11 to 90 miles). The average helicopter charge was $4623. Sixty-three (57%) of transported patients were male, and the mean age of all the patients was 64.5 years (range, 32 to 92 years).

Approximately three quarters of the transported patients had a final diagnosis of a cerebrovascular event (Table 1), most frequently ischemic stroke. Most of the patients without a cerebrovascular event had a neurological illness, and nonneurological illness was rare (Table 2). Of the 47 patients with a final diagnosis of ischemic stroke, 15 (32%) were treated with intravenous thrombolytic therapy. For rtPA-treated patients, mean pretreatment National Institutes of Health Stroke Scale score was 13 (range, 4 to 22). Ten (67%) were male, and mean age was 65 years (range, 49 to 91 years). This therapy was started at a mean of 152 minutes (range, 100 to 180 minutes) after symptom onset. The average 1-way flight distance for these patients was 29.7 miles (range, 14 to 59 miles). This represented 23% (15/66) of all patients treated with rtPA at our institution over the study time period. Reasons for not giving rtPA intravenously were listed in Table 3. Four of these patients awoke with symptoms, 3 hours after symptom onset, despite documented symptom onset be-59% of all transported patients. Seventeen of the 32 patients represent 81% of all transports arriving within 3 hours and 59% of all transported patients. Seventeen of the 32 patients who arrived beyond the 3-hour mark should not have been flown to SJ because their symptom onset time violated the transport guidelines. Four of these patients awoke with symptoms, onset time was unclear in another 5 patients, and 7 were transported despite documented symptom onset beginning >3 hours before initial EMS contact.

Discussion

Helicopters were first used to transport seriously injured patients to trauma centers in 1969. Since then, regional transport programs have been developed throughout the United States. In 2000, there were 342 air medical service providers in the United States. Trauma is the single largest diagnosis that accounts for scene transports. Although the impact of helicopter emergency services on clinical outcome from trauma is controversial, the perceived advantages of helicopter transport versus ground transport are believed to be derived from the rapid transport that a helicopter provides.

The Brain Attack Coalition has called for the establishment of a 2-tiered system (primary and comprehensive) of designated stroke centers for the management of these patients and recommends that patients with stroke are taken to these centers. Our experience suggests that a field-to-helicopter transport program for acute ischemic stroke is a feasible way to extend stroke expertise to communities that lack local access to rtPA. By establishing a coordinated program that links local EMS teams and the stroke team at SJ and by bypassing local hospitals that could not administer rtPA, we were able to transport patients from moderate distances within a reasonable time frame for rtPA administration. The majority of transports arrived at our facility within 135 minutes of symptom onset, despite the delay inherent in the

### TABLE 1. Final Diagnoses of Transported Patients (n=111)

<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>No. (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ischemic stroke</td>
<td>47 (42)</td>
</tr>
<tr>
<td>Transient ischemic attack</td>
<td>19 (17)</td>
</tr>
<tr>
<td>Hemorrhagic stroke</td>
<td>19 (17)</td>
</tr>
<tr>
<td>Nonstroke</td>
<td>26 (23)</td>
</tr>
</tbody>
</table>

### TABLE 2. Nonstroke Transports (n=26)

<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Delirium</td>
<td>8</td>
</tr>
<tr>
<td>Seizure</td>
<td>7</td>
</tr>
<tr>
<td>Conversion disorder</td>
<td>2</td>
</tr>
<tr>
<td>Syncope</td>
<td>2</td>
</tr>
<tr>
<td>Multiple sclerosis</td>
<td>1</td>
</tr>
<tr>
<td>Meningitis</td>
<td>1</td>
</tr>
<tr>
<td>Brain neoplasm</td>
<td>1</td>
</tr>
<tr>
<td>Migrainous event</td>
<td>1</td>
</tr>
<tr>
<td>Hypoglycemia</td>
<td>1</td>
</tr>
<tr>
<td>Radiculopathy</td>
<td>1</td>
</tr>
<tr>
<td>Abdominal aortic aneurysm</td>
<td>1</td>
</tr>
</tbody>
</table>

### TABLE 3. rtPA Exclusions for Patients With Ischemic Stroke (n=32)

<table>
<thead>
<tr>
<th>Exclusion</th>
<th>No. (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NIHSS &lt;4 and/or improving deficits</td>
<td>12 (38)</td>
</tr>
<tr>
<td>Arrived &gt;3 h after onset</td>
<td>5 (16)</td>
</tr>
<tr>
<td>Time of onset unclear</td>
<td>5 (16)</td>
</tr>
<tr>
<td>Medical contraindication</td>
<td>4 (13)</td>
</tr>
<tr>
<td>Awoke with symptoms</td>
<td>4 (13)</td>
</tr>
<tr>
<td>MCA hypodensity on CT</td>
<td>1 (3)</td>
</tr>
<tr>
<td>Patient refused</td>
<td>1 (3)</td>
</tr>
</tbody>
</table>
need to transport the patient, by local EMS to the designated pick-up point and with an average round trip flight distance of 59 miles. A significant percentage (38%) of patients with ischemic stroke were treated with thrombolytic therapy. In addition, paramedics were correctly able to identify patients with stroke. Only 24% of transported patients had a noncerebrovascular cause for their symptoms. In an effort to limit the number of nonstroke transports, paramedic education regarding common manifestations of stroke was provided before county participation in the SJASTP. In addition, this topic was covered at the annual review session within each county. Common signs of stroke were also contained on the field checklist.

This rate of EMS accuracy in diagnosing stroke was comparable to previously published figures. Ambulance crew members involved in a ground ambulance hospital bypass protocol in Newcastle, England, were 80% accurate when diagnosing a cerebrovascular event.21 A review of stroke patients brought to 2 university hospitals showed that urban paramedics had 61% accuracy in diagnosing stroke.22 In the future we may be able to reduce the number of nonstroke transports by incorporating a validated EMS stroke recognition tool, such as the Los Angeles Prehospital Stroke Screen23 or the Cincinnati Prehospital Stroke Scale,24 into our field checklist. We do not know how many strokes were misdiagnosed by the local paramedics involved in the SJASTP because no surveillance system was in place in the community hospital network to capture these data.

This is, to our knowledge, the first report examining the feasibility of an organized field-to-stroke center helicopter transport program for stroke patients. A previous report on helicopter transport of stroke patients focused on the experience of an interhospital transfer system.25 Eight of 73 patients received rtPA before transport; none were treated with thrombolytic therapy on arrival at the stroke center. Two centers in Ontario, Canada, have demonstrated that organized ground ambulance transport programs are a feasible way to make rtPA available to nonurban residents. Twenty-three patients transported made up 28% of all patients treated with rtPA over 2 years at the London Health Sciences Center. These patients were transported a mean distance of 41 miles from nonurban emergency departments. The Regional Acute Stroke Protocol at Kingston General Hospital incorporates both hospital-to-stroke center transfer and community hospital bypass using ground ambulances.27 During the first year of this protocol, 40% of patients receiving rtPA at Kingston General Hospital were transported from outside Kingston.

Sixty-one million Americans reside in a rural area.28 Several strategies to make thrombolytic therapy accessible to acute stroke patients who reside in nonurban areas have been reported. These include centrally directed protocols that transport patients to comprehensive stroke centers where rtPA is administered. Interhospital emergency department transfers and local hospital bypass protocols, such as the SJASTP and other aforementioned protocols,26,27 are examples of this strategy. Developing rtPA capabilities in local community hospitals is an alternative strategy. Rural community hospitals in Minnesota have described positive experiences with the use of rtPA for stroke,29,30 and in Texas an aggressive multilevel stroke educational program increased the rate of use of acute stroke therapy in nonurban hospitals.6

Treating with rtPA at local hospitals, then transporting the patient to a comprehensive stroke center for postinfusion care and diagnostic evaluation, is a third strategy that is used by the Sisters of the Third Order of St Francis Stroke Network.31 Economic studies of the use of rtPA for the treatment of acute ischemic stroke have found this intervention to be cost-effective.32,33 The use of our helicopter program to extend the area served by a comprehensive stroke program led to higher costs associated with the use of thrombolytics because the average cost of flying a patient to SJ was $4623. With the available data we cannot perform a cost-effectiveness analysis; however, the increased costs are small relative to the significant potential savings in rehabilitation and nursing home costs associated with this treatment modality.32 Further cost-effectiveness studies will need to incorporate this variable into the analysis.

The SJASTP has some drawbacks. First, our program does not capture all acute strokes in participating counties. Transport activation is dependent on EMS notification. Only a minority of nonurban stroke patients may use 911 to initially seek medical attention.34 Second, patients who delay their 911 call by >90 minutes after symptom onset may not arrive at our hospital within the time frame required for intravenous thrombolytic therapy. If thrombolytic therapy was available at their local hospital, they could have been treated there. These late-arriving patients are considered for intra-arterial thrombolysis at our institution if it can be initiated within 6 hours of symptom onset.35 Four of the 5 ischemic stroke patients who arrived beyond 3 hours after symptom onset underwent emergent angiography for possible intra-arterial thrombolytic therapy.

In summary, we have described the experience of a helicopter-based transport system for people with acute ischemic stroke. We have demonstrated that a helicopter-based transport system for acute stroke victims can link a region to a stroke center and promote access to rtPA therapy. It remains to be proven if protocols based on ground or air ambulance are associated with quicker and more reliable access to rtPA. It also remains to be proven if centrally directed versus noncentrally directed transport paradigms are associated with more consistent use of rtPA and better outcomes. For now, decisions regarding whether a region should encourage development of transport strategies to urban centers or encourage delivery of rtPA in rural hospitals should be made locally with knowledge of each region’s particular geographic, demographic, and fiscal circumstances. The SJASTP was devised as a mechanism to circumvent a regional lack of ability for rural areas surrounding Jacksonville, Fla, to administer rtPA. Our experience also suggests that a helicopter-based transport network requires support personnel and a director who are committed to EMS education and feedback, as well as program oversight.

References


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