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# Telemedicine for Acute Stroke Triumphs and Pitfalls

Marian P. LaMonte, MD, MSN; Mona N. Bahouth, MSN, CS, CRNP; Peter Hu, MSE;  
Mohammed Y. Pathan, MD; Karen L. Yarbrough, MS, CS, CRNP; Ruwani Gunawardane, MD;  
Patrick Craey, MD; Wesley Page, MD

**Background and Purpose**—Telemedicine is emerging as a potential timesaving, efficient means for evaluating patients experiencing acute stroke. In areas where local stroke care specialists are not available, telemedicine can link an emergency department physician with a specialist in a stroke treatment center. This consultation provides an opportunity for administration of thrombolytic drugs within the short therapeutic time window associated with ischemic stroke. Here, we describe our stroke treatment center experiences and report safe administration of recombinant tissue plasminogen activator (rtPA) during telemedicine consultation.

**Methods**—The University of Maryland Medical Center uses a triplexed integrated services digital network line providing a 30-frames-per-second video link to St Mary's Hospital >100 miles away. The system uses a pan, tilt, and zoom camera with remote site control, allowing 2-way, real-time, audiovisual communication and CT image transfer. We retrospectively reviewed all acute stroke consultations provided to St Mary's Hospital between 1999 and 2001.

**Results**—We reviewed 50 consultations. Of the 50, 23 were attempted through telemedicine linkage, and 27 were by traditional telephone conversation, followed by transfer. Of the 23 telemedicine consultations, 2 were aborted because of technical difficulties. Of the patients evaluated by traditional means, 1 of 27 (3.8%) received intravenous rtPA; 5 of 21 (23.8%) received rtPA after telemedicine consultation. No patients experienced complications.

**Conclusions**—Telemedicine consultation provided treatment options not previously available at the remote hospital. Administration of rtPA during telemedicine consultation was feasible and safe, and the system was well received. Lack of reimbursement for telemedicine services will hinder widespread adaptation of this promising technology for remote acute stroke treatment. (*Stroke*. 2003;34:725-728.)

**Key Words:** stroke consultation ■ stroke, acute ■ telemedicine ■ thrombolytic therapy

Despite extensive community and professional education addressing the need for emergency response to symptoms of acute stroke, recombinant tissue plasminogen activator (rtPA) remains an underused modality for treatment. Many institutions lack the resource of a specialized team providing full-time response to acute stroke patients, including evaluation and administration of appropriate acute stroke therapies. These institutions depend on the availability of rapid transfer of patients to the closest regional stroke center for provision of therapies. The primary reason that patients do not receive intravenous thrombolytic therapy is arrival at a stroke treatment center (STC) outside the 3-hour window.<sup>1</sup> Telemedicine is emerging as a timesaving, efficient means for emergency patient evaluation.<sup>2</sup> In areas without a local consulting stroke specialist, telemedicine can be an ideal means of providing optimal stroke care within the short therapeutic time window.

At our STC, our interhospital telemedicine system combines the technical application of a real-time video system with the clinical expertise of an acute stroke provider available on a full-time basis. To the best of our knowledge, this application of telemedicine consultation has not been described previously in the literature. This article documents our experience with telemedicine for acute stroke consultation from 1999 to 2001.

## Methods

Our regional stroke center, the Maryland Brain Attack Center at the University of Maryland Medical Center (UMMC), is staffed by Brain Attack Team (BAT) members 24 hours per day 7 days per week for specialty acute stroke consultation. The team consists of 2 attending neurologists (M.P.L., R.G.), 2 acute care nurse practitioners specially trained in acute stroke (M.N.B., K.L.Y.), and 1 cerebrovascular fellow (M.Y.P.). All members respond as primary providers for acute stroke consultation. Since 1996, our BAT has provided acute stroke consultation to community hospital emergency

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From the Departments of Neurology (M.P.L., M.N.B., M.Y.P., K.L.Y., R.G.) and Anesthesiology (P.H.), University of Maryland School of Medicine, Baltimore, and Department of Emergency Medicine (P.C., W.P.), St Mary's Hospital, Leonardtown, Md.

Correspondence to Marian P. LaMonte, MD, MSN, Department of Neurology, University of Maryland Medicine, 22 S Greene St, Room N4W46, Baltimore MD 21201. E-mail mlamonte@som.umaryland.edu

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departments throughout the state of Maryland via traditional telephone consultation. Neurology consultation can be initiated by any healthcare provider in the state or surrounding region when acute stroke is clinically suspected by accessing Maryland ExpressCare, the coordinating center of our University system.

In 1997, the BAT began proof-of-concept testing of telemedicine systems with other researchers at the medical center.<sup>3-5</sup> By mid 1997, the stroke care specialists had focused on St Mary's Hospital in Leonardtown, Maryland, 100 miles from UMMC, as an emergency department (ED) appropriate for a real-time audiovisual link with the BAT. Before telemedicine, patients were transported from St Mary's Hospital to our stroke center for evaluation and treatment. Thus, the research team postulated that a telemedicine link would decrease door-to-needle time and consequently increase the number of patients receiving intravenous rtPA because transport time would be eliminated. In addition, a "live" link might also advance immediate specialty care to further benefit the stroke patient. Administrative and clinical meetings were held to determine needs, establish common goals, develop the system concept, test equipment, secure the communication link, and secure funding.

A site survey was completed to identify all existing technologies and establish a formal plan for the implementation of telemedicine technologies within the ED setting. Several systems were reviewed by members of the Maryland Brain Attack Center, technologists, and engineers within the department of anesthesiology for clarity of picture transmission, reliability, and ease of use. Training was completed with professionals at St Mary's Hospital regarding concepts of acute stroke treatment and use of the National Institutes of Health Stroke Scale (NIHSS). Official certification was obtained by all staff anticipating involvement in the care of acute stroke patients within their institution. Our toll-free 24-hour referral number connecting outside hospitals to the UMMC was provided. All BAT members were formally appointed to the medical staff at St Mary's Hospital. Technical support personnel were identified at the outlying hospital and trained in the use of the telemedicine technology. Support staff members were identified at both sites to provide 24-hour technical support during acute stroke consultation. The telemedicine equipment was installed, and trial runs were completed.

The UMMC uses VTEL TC2000 U with a triplexed integrated services digital network (ISDN) line providing a 30-frames-per-second video link to St Mary's Hospital. The system uses a pan, tilt, and zoom camera with remote site control, allowing 2-way, real-time, audiovisual communication and transfer of CT scans. The telecommunication link between the St Mary's Hospital ED in Leonardtown and our medical center in Baltimore is equipped with remote-controllable video cameras, dual television monitors, and specific computer software. Audio and video data are transmitted through 3 high-speed digital telephone lines via an ISDN. The superior image quality allows the stroke care expert to see images as detailed as dilation of the patient's pupils. Likewise, the patient and family see the real-time image of the stroke specialist throughout the entire consultation. Through the same communication network, physicians can relay laboratory data and vital signs, as well as transmit CT scans.

The telemedicine consultation with the BAT member begins when a physician in the ED at St Mary's Hospital identifies a patient's symptoms as consistent with those of acute stroke. The referring physician calls the toll-free telephone number for the Maryland ExpressCare coordinator, who immediately pages the on-call BAT member. A brief 3-way telephone consultation among the referring physician, the BAT member, and the Maryland ExpressCare coordinator establishes the request for consultation. Verbal consent for telemedicine evaluation is obtained from the patient or family member by the ED attending personnel before initiation of the specialty consultation. The stroke care specialist then proceeds to the telemedicine area where equipment is located. The system is kept in constant running mode so that there is no delay in patient visualization. Because the equipment is not located in each provider's home, a call during "off hours" requires that the provider return to the hospital to use the telemedicine system for a consultation. Therefore,

we expected that the telemedicine system would be used predominantly during daytime and weekday hours during our pilot study.

Through the interactive, 2-way, audio-video link, a detailed history is obtained from the patient and family. A full neurological examination is then performed by the stroke specialist. The camera is controlled by the consultant to visualize focused areas of interest during the assessment. Stroke severity scores are calculated using a restructured version of the NIHSS developed specifically for telemedicine use. This reconstruction of the scale reformats the traditional components of the tool to avoid excess maneuvering of the camera for view adjustment during evaluation. CT scans are digitized by the referring hospital for review by the specialist using the telemedicine system. Clinical diagnosis and recommendations regarding appropriate acute interventions are discussed with the patient, referring physician, and family members. If a patient is deemed suitable for thrombolytic therapy, rapid instruction is provided to staff members to ensure proper administration and monitoring of the patient during infusion of the medication. Continuous patient monitoring and staff guidance are provided during treatment with intravenous thrombolytic therapy. Currently, there is no charge to the patient for this specialty consultation.

We retrospectively reviewed all acute stroke consultations provided to St Mary's Hospital between January 1999 and December 2001. Consultation records and patient discharge summaries were reviewed for any adverse events during telemedicine consultation or treatment with thrombolytic therapy. Nondescriptive patient data were also accrued for patients treated through traditional consultation methods and those evaluated through telemedicine consultation.

After transfer to our medical center, all patients or their family members were given a brief questionnaire about their experience with telemedicine consultation.

## Results

During the study period, 50 acute stroke consultations were provided to St Mary's Hospital ED physicians. Twenty-three telemedicine links were attempted; 2 were aborted because of technical difficulties. Twenty-seven consultations were managed by traditional telephone conversation to discuss the initial suspected diagnosis and the patient's stability for transport. One of the 27 patients (3.8%) initially managed via telephone and directly transferred to the UMMC received intravenous thrombolytic therapy. Telephone consultation rather than telemedicine was used in 27 cases for the following reasons: (1) calls came at times when the on-call BAT attending was away from the hospital in which the telemedicine system was located; (2) patients were beyond the 3-hour treatment window at the time of the initial call; and (3) the clinical condition of the patient excluded him or her from currently available acute stroke treatments.

Of the 21 patients, 5 (23.8%) evaluated via telemedicine received rtPA during consultation with the BAT attending personnel. No complications were identified during the treatment phase of telemedicine consultation. All 5 rtPA recipients were transferred to our STC after completion of lytic therapy.

Diagnoses rendered via telemedicine consultation included acute ischemic stroke (both anterior and posterior circulation), subarachnoid hemorrhage, intracerebral hemorrhage, seizure, hypoglycemia, and transient ischemic attack. Any patients transferred after either telephone or telemedicine consultation were returned to the community for follow-up care.

The sample size was too small to detect variability among care providers in our primary end points. Stroke nurse

practitioners at our medical center are rigorously trained by stroke neurologists. No barriers to treatment or safety issues have been identified specific to the specialty of the care provider.

On 2 occasions, temporary phone wire problems caused difficulty in initiating the computer link; however, telephone consultation was ongoing while the telemedicine connection was reestablished (within minutes). A brief episode of stuttering transmission occurred during 1 consultation but did not impede the ability to monitor the patient in real time.

Patients and staff uniformly expressed positive statements in posttransfer interview questionnaires. The most common comment from patients and family was the quickness of specialty emergency care and the reassurance of the "live" picture of the stroke specialist at the critical phase of treatment. The general consensus of the BAT members using the system was that the key feature to smooth operation was the close communication between the clinical and technical support teams. All look forward to the next generation of telemedicine technology.

### Discussion

Telemedicine has been defined broadly as "the use of telecommunication technologies to provide medical information and services"<sup>6</sup> and more specifically as "the process by which electronic, visual, and audio communications are used to provide diagnostic and consultation support to practitioners at distant sites, assist in or directly deliver medical care to patients at distant sites, and enhance the skills and knowledge of distant medical care providers."<sup>2</sup> Telemedicine consultation has been incorporated into diverse aspects of modern health care, including home-based care, primary care offices, and operating rooms. In these typically nonacute settings, telemedicine is used for patient monitoring or education. The concept of telemedicine was introduced into the emergency care arena only recently. Chi et al<sup>7</sup> evaluated the appropriateness of incorporating telemedicine systems in EDs. They concluded that the ED is a suitable place for establishing a telemedicine center because telemedicine linkage may decrease unnecessary transfer of patients from the local hospital. In addition, the Telemedicine Emergency Neurosurgical Network (TENN) confirmed the clinical efficacy and cost effectiveness of neurosurgical consultation in a population of 329 at-risk underserved patients.<sup>8</sup> In the TENN review, no transport risks or radiological review discrepancies were identified in the 35 months of data evaluated. Our literature review indicated no reports of telemedicine work in the field of emergency neurology or specifically acute stroke care.

At present, only a few STCs are using telemedicine for acute stroke consultation, and even fewer have reported acute treatment of stroke patients during telemedicine consultation. The Millard Fillmore Gates Circle Hospital in Buffalo, New York, has a telemedicine system consisting of a Sony Trini-Com 3000 Plus model (256 U) with an ISDN line at 256 kHz linked to Millard Fillmore Suburban Hospital 15 miles away.<sup>9</sup> Of 12 patients evaluated via telemedicine consultation in this system, 3 received rtPA. No other institutions have reported the administration of rtPA for acute stroke either in the literature or via presentation.

The primary benefit of a telemedicine system for acute stroke consultation is the provision of specialty resources not available at a community hospital. In our configuration, telemedicine consultation for acute stroke at St Mary's Hospital allowed intravenous rtPA administration in 24% of the patients for whom this technology was used. When all consult requests from St Mary's were considered, 5 of 50 (10%) were treated with thrombolytic therapy via telemedicine, twice the national average.<sup>10</sup> This allowed treatment options not previously available at the remote site. The involvement of stroke care specialists also facilitated the diagnosis of other neurological emergencies, such as intracerebral hemorrhage, subarachnoid hemorrhage, hypoglycemia, and seizure. Through our telemedicine link, these patients had immediate access to neurological specialty consultation, which would have taken hours or days to obtain through the traditional route. Other advantages of this live audiovisual link over traditional telephone consultation include (1) NIHSS score quantification of neurological deficit by a stroke specialist (Most ED physicians found that competence in performing the NIHSS was difficult to maintain because they only rarely saw stroke patients within the first few hours of symptom onset); (2) quantifiable identification of neurological deterioration and provision of immediate feedback on therapeutic strategies; (3) quantifiable identification of patients who had improvement thus did not require rtPA or transfer; (4) the stroke specialist's ability to address risk/benefit questions directly with the family without time delay; (5) direct supervision of the specialty procedure, ie, the mechanics of rtPA administration, by a stroke specialist; (6) the ability to continuously monitor hemodynamic status and neurological examination of the patient after thrombolytic administration until transport team departure; and (7) the ability of the stroke specialist to directly advise the transport team on the therapeutic needs of the patient.

The telemedicine link not only extends specialty expertise but also offers the potential for patients to receive therapy unique to a larger academic center and to enter clinical trials. During postconsultation interviews, staff members and patients acknowledged that the telemedicine consultation process was simple and elevated the level of care provided. A secondary gain was the improved abilities of the community hospital to recognize stroke and increase the speed of basic stroke care provided. This benefit can be attributed to the effect of ongoing staff education and direct mentoring on a case-by-case basis.

In a review of profiles of patient immediate and short-term outcomes, no complications occurred during patient evaluation via telemedicine or during transport to the STC. All patients benefited from initial improvement in symptoms after lytic administration; however, 1 patient later had clinical worsening to baseline neurological findings, consistent with vessel reocclusion.

Other factors also contributed to the success of the system. The clarity of data transmission and ease of use allowed sharp clinical assessments to be made with confidence. Confidence was also bolstered by the close relationship between the clinical support staff and the technology support personnel. Smooth interactions between the 2 specialties elevated the

care provided to patients because the disciplines focused on their specific duties yet came together for the benefit of the patients. Also, initial training and ongoing mentoring on management of acute stroke patients enhanced the care provided to this population by increasing staff awareness of this disease process.

Potential barriers to use of this technology include the initial costs of equipment and staff training. A pitfall associated with our current telemedicine system is the lack of 24-h/d linkage to the specialty consultants because of the fixed location of the equipment. An optimal system would allow real-time audiovisual linkage to the community hospital from any location (hospital or home). We have also realized the challenges of ongoing training needs in response to frequent changes in ED staffing. Episodic refresher courses and orientation of new staff are essential to maintain competencies needed to use the technology for stroke consultation.

We recognize that several limitations and shortcomings exist within this review. The sample size is too small to assess any outcome variables. The method of retrospectively profiling types of stroke patients treated via this evaluation modality at a remote hospital for which a new equipment technology was used is not ideal. No comparisons can be drawn between administration rates in the 2 groups because of the variability among the groups.

The labor-intensive but rare event of administering rtPA to ischemic stroke patients demands the development of stroke specialty consultation systems. Future direction of telemedicine could link multiple community hospitals throughout the state with our regional STC. Links to stroke care specialists' homes are also being considered. We are also testing this technology to transmit audio and video images of patients during ambulance transport to reduce the time to treatment on arrival at the receiving facility.<sup>4</sup> All of these advances are intended to enhance patient access to stroke care specialists and acute stroke care resources.

## Conclusions

Telemedicine has a valuable role in emergency stroke consultation. Specialists can apply their expertise to the evalua-

tion and management of stroke patients through a real-time audiovisual link with remote ED physicians. For telemedicine to influence practice, further study of patient outcomes, effects on hospital cost, and quality control is essential. Unfortunately, the availability of this promising technology will be limited until further funding and reimbursement mechanisms are established.

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