Teleneurology to Improve Stroke Care in Rural Areas : The Telemedicine in Stroke in Swabia (TESS) Project

Andreas Wiborg and Bernhard Widder

Stroke. 2003;34:2951-2956; originally published online November 20, 2003;
doi: 10.1161/01.STR.0000099125.30731.97
Stroke is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231

Print ISSN: 0039-2499. Online ISSN: 1524-4628

Teleneurology to Improve Stroke Care in Rural Areas
The Telemedicine in Stroke in Swabia (TESS) Project

Andreas Wiborg, MD; Bernhard Widder, MD, PhD; for the TESS Study Group

Background and Purpose—Assessing both stroke patients and their CT scans by using a conventional videoconference system offers an interesting opportunity to improve stroke care in rural areas. However, until now there have been no studies to suggest whether this method is feasible in routine stroke management.

Methods—Seven rural hospitals in the southern part of Germany in Swabia were connected to the stroke unit of Günzburg with the use of a videoconference link (Telemedicine in Stroke in Swabia [TESS] Project). The local physicians are free to present every admitted stroke patient to the Günzburg stroke expert, who can assess the clinical status and CT images, thereafter giving therapeutic recommendations. All teleconsultations are rated concerning transmission quality and relevance of telemedicine for stroke management.

Results—A total of 153 stroke patients were examined by teleconsultation. Mean age was 67.5 years. Eighty-seven patients had suffered an ischemic stroke, 9 had an intracerebral hemorrhage, and 17 suffered a transient ischemic attack. Forty patients were revealed to have a diagnosis other than stroke. Duration of teleconsultation was 15 minutes on average. User satisfaction was good concerning imaging and audio quality, and patient satisfaction was very good or good in all cases. Relevant contributions could be made in >75% of the cases concerning diagnostic workup, CT assessment, and therapeutic recommendations.

Conclusions—Teleconsultation using a videoconference system seems to be a feasible and promising method to improve stroke care in rural areas where management in a stroke unit is hindered by long transportation distances. **(*Stroke*. 2003; 34:2951-2957.)**

Key Words: stroke, acute ■ stroke assessment ■ stroke management ■ telemedicine

During the last decade, the importance of specialized so-called stroke units for acute care and early rehabilitation has been demonstrated. It is especially in rural areas, however, that the implementation of stroke units offering all diagnostic and therapeutic procedures for state-of-the-art stroke management is very costly if the whole population is to gain access to this "maximum" level of stroke care.

In regard to this situation, the question arises of whether a telemedicine network connecting general wards in rural community hospitals with a stroke center could improve stroke care significantly by conveying the stroke expertise in the assessment of patients and CT (or MRI) to the emergency physician "on the scene." First trials with general neurological patients in which a videoconference system was used showed encouraging results.[1,2] Even the administration of recombinant tissue plasminogen activator seems possible in a stroke network.[3,4]

After interrater reliability in assessing both patients and CT scans by teleconsultation was shown to be comparable to the examination on the scene in preliminary studies,[5–7] we started a project (Telemedicine in Stroke in Swabia [TESS]) to examine the feasibility, acceptance, and economic consequences of a telemedicine network including a special stroke training program.

See Editorial Comment, page 2957

Subjects and Methods

The 7 cooperating rural community hospitals are all situated in the southern part of Germany in Swabia, where the population outside larger cities is 100 to 150 inhabitants per square kilometer. The first hospital was connected in March 2001 and the last in March 2002 (Table 1). The distance between the hospitals and the stroke unit in Günzburg ranges from 53 to 136 km, with an average transportation time of approximately 80 minutes to reach Günzburg. All hospitals are provided with the possibility of CT scanning and extracranial ultrasound on 24-hour standby, and 3 of them can also offer daytime cerebral MRI. All laboratory examinations (including cerebrospinal fluid analysis), ECG, echocardiography (transthoracic and transesophageal), 24-hour ECG recording, and 24-hour blood pressure recording are available. There is no on-site neurologist available in any of the hospitals.

All hospitals were provided with the videoconference system Sony Contact (cost, approximately $8000), consisting of a portable device including a color video camera and microphone that can be connected to a commercial television monitor. Data were transmitted over 3 parallel integrated services digital network (ISDN) lines at

Received January 30, 2003; final revision received June 13, 2003; accepted July 25, 2003.

From the Department of Neurology and Neurological Rehabilitation, Bezirkskrankenhaus, Günzburg, Germany.

Correspondence to Andreas Wiborg, MD, Department of Neurology and Neurological Rehabilitation, Bezirkskrankenhaus, Ludwig-Heilmeyer-Strasse 2, D-89312 Günzburg, Germany. E-mail andreas.wiborg@bkh-guenzburg.de

***Stroke* is available at http://www.strokeaha.org** **DOI: 10.1161/01.STR.0000099125.30731.97**

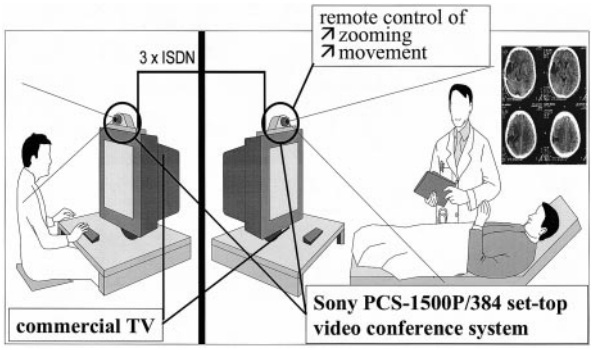
TABLE 1. Hospitals Cooperating in This Study Including Number of Stroke Patients Registered and Number of Teleconsultations

Hospital	Start of Telemedicine Link	Distance, km	Average Transportation Time, min	Beds (Total)	Beds (Medical)	MRI Availability On-Site	Stroke Patients Registered	No. of Teleconsultation (%)
Donau-Ries-Klinik Donauwörth	March 2001	53	53	280	98	Daytime	179	65 (36)
Klinikum Kempten	April 2001	106	71	560	157	24 hours	110	9 (8)
Kreiskrankenhaus Lindau	February 2002	137	92	174	68	No	89	2 (2)
Klinikum Memmingen	March 2002	73	48	535	187	Daytime	2	2
Stauferklinik Mutlangen	November 2001	83	92	405	171	Daytime	137	10 (7)
Kreiskrankenhaus Nördlingen	September 2001	57	70	190	71	No	56	22 (39)
Donau-Ries-Klinik Oettingen	August 2001	73	87	123	67	No	50	43 (86)
Total							623	153 (25)

speeds up to 384 kilobits per second. The video transmission used standard compression algorithms in MPEG-2 standard with a resolution of 360×288 pixels (still picture, 720×576 pixels). The video cameras may be rotated in all directions and offer a ×12 zoom. Both functions (movement and zooming) can be controlled by the remote neurologist (Figure). All of the hospitals have the additional possibility of transmitting CT raw data by using a DICOM standard protocol (Radworks).

According to the study protocol, all departments have the opportunity to present stroke patients and their CT images to the stroke unit in Günzburg via the telemedicine link. To fit best with the "real-life" situation, we decided that the local physician can decide whether and at what time a teleconsultation is demanded. Independent of that decision, however, the physician is obliged to complete a standardized form (Bavarian Workgroup for Quality Assessment [BAQ] form) to assess procedural quality. Collected items are date and time of admission, date and time (or estimate) of stroke onset, primary care, symptomatology on admission, modified Rankin Scale score, modified Barthel Index score, relevant cardiovascular history, diagnostic procedures, monitoring, applied therapies (including physiotherapy and occupational and speech therapy), complications, stroke classification and localization, *International Statistical Classification of Diseases, 10th Revision* (*ICD-10*) code, and date of discharge. Moreover, documentation is required regarding why teleconsultation was considered unnecessary in a form (teleform) developed by the study group (multiple choice between the following: clear diagnostic situation, clear CT scan, no additional therapeutic aspects to be expected, no therapeutic consequences because of patient's unfavorable state, no time, other considerations) (Table 2).

If teleconsultation is demanded and informed consent is given by the patients or their relatives, the local physician calls the neurologist by mobile telephone, who then establishes the videoconference link, which is possible within a maximum of 15 minutes. According to a semistandardized procedure, the physician on the scene first reports



Schematic representation of teleconsultation link between stroke neurologist and rural hospital.

the patient's history, symptoms, and the actual medical findings (eg, laboratory examinations and ECG and ultrasound results). Thereafter, the remote stroke neurologist interviews and examines the patient (depending on the patient's ability to cooperate) with the support of the local physician. In the same session, the corresponding CT scan (for a first impression presented on a conventional x-ray viewer) is assessed concerning the presence or absence of intracerebral bleeding, ischemic signs (including so-called early signs of ischemia), signs of intracerebral edema, and other abnormalities. Finally, the results and therapeutic implications are discussed with the local physician, and, after disruption of the telemedicine link, a written protocol containing presumptive diagnosis, diagnostic/therapeutic implications, and recommendations ("consultation protocol") is transmitted to the local department by fax. Follow-up teleconsultations are possible at any time. All teleconsultations were made by 4 senior neurologists (A.W. [author], N.B., R.K., W.A. [see Acknowledgments]), all of whom have many years of experience in stroke managment. At the rural hospitals, all physicians were introduced to the management of the videoconference system, thus enabling every physician on duty to build up a telemedicine link.

Immediately after the teleconsultation, the teleform must be completed by both participating physicians, ie, the stroke neurologist and the local physician; on this form the relevance of the telemedicine contribution to clinical, CT, and ultrasound assessment and to the therapeutic procedures is rated on a trichotomized scale ("relevant," "moderately relevant," "not relevant") (Table 2). In addition, the imaging quality of both the patient and the CT, the audio quality, the time needed, and the patient's satisfaction are rated on a 5-point scale.

In conjunction with the "pure telemedicine link," all physicians of the cooperating hospitals are invited to periodic quarterly meetings in which new findings concerning differential diagnosis of stroke, assessment of CT in acute stroke, therapeutic aspects, and ultrasound procedures in acute stroke (including practical exercises) are presented. In addition, the nursing staff is educated in all aspects of stroke care (medical problems, nursing, speech therapy, physiotherapy), including diagnosis and management of dysphagia, in annually occurring courses (4 days within 1 month).

For statistical analysis, the χ^2 test was used for comparison of categorical data. For interpretation of ordered categorical data, the χ^2 test for trend was used. The Mann-Whitney U test was used to compare ordinal data; for normally distributed data, the Student t test was applied. The significance level was 0.05 for all statistical testing.

Results

General Data

Between March 2001 and September 2002, data of 623 patients admitted with the diagnosis of stroke were registered in the TESS hospitals. A total of 153 patients underwent teleconsultation (25%). There were no technical

TABLE 2. Items and Possible Ratings for Each Item of the Teleform to Be Filled Out Immediately After Teleconsultation or After Admission of Stroke Patients if Teleconsultation Was Not Performed

Category	Items	Possible Ratings	Filled Out By
No immediate teleconsultation because of ...	• Clear diagnostic situation • Clear CT scan • No additional therapeutic aspects to be expected by teleconsultation • No therapeutic consequences because of patient's state • No time for teleconsultation • Others	Multiple choice (multiple reasons possible)	Local physician
Teleconsultation at a later time point because of ...	• Secondary worsening • Wish to clarify further procedure • Technical problems • Patient in too bad a state on admission • others	Multiple choice (multiple reasons possible)	Local physician
Questions to teleconsultation			
Diagnostic work-up	• Assessment of neurological status; differential diagnostic considerations; stroke localization (anterior or posterior circulation); discussion of additional diagnostic procedures; others	"Relevant" or "moderately relevant" or "not relevant" for each item	Local physician and stroke expert
CT assessment	• Differentiation ischemia–hemorrhage; differentiation cause of hemorrhage; differentiation ischemia (territorial, lacunar, hemodynamic); early signs; elevated intracranial pressure?; others		
Ultrasound assessment	• Extracranial stenosis/occlusion; intracranial stenosis/occlusion; others		
Therapeutic procedures	• Thrombolysis; anticoagulation, antiplatelets; anti-hypotensive treatment; anti-hypertensive treatment; intensive care unit necessary; transport to stroke unit; neurosurgery; vascular surgery; others		
Rating of teleconsultation quality	1. Imaging quality of the patient 2. Imaging quality of CT scan 3. Audio quality 4. Sacrifice of time For patients only (if possible): 1. How content have you been with the examination? 2. How easy was it for you to speak to the doctor on the screen?	From 1=very good to 5=very bad	1) and 2): only stroke expert 3) and 4): stroke expert and local physician

failures. Seventy-seven of the consulted patients (50%) were male. Patients presented by teleconsultation were significantly younger (67.5 versus 75.2 years; $P=0.001$, t test), but there was a comparable range in both groups (patients with teleconsultation were aged 26 to 94 years; patients without teleconsultation were aged 28 to 94 years). Use of teleconsultation differed between the associated hospitals (Table 1), ranging from 2% to 86% of all stroke patients admitted.

Patients Without Teleconsultation

Diagnosis of subjects without teleconsultation was transient ischemic attack (TIA) in 117 cases (25%), ischemic stroke in 181 cases (39%), hemorrhagic stroke in 22 cases (5%), and "apoplexy" without differentiation into ischemic or hemorrhagic in 113 cases (24%). Eight patients (2%) had other diagnoses (1 transient global amnesia, 1 Ménière's disease, 3 subarachnoid hemorrhage, 2 subdural hematoma, 1 intracerebral aneurysm), and in 27 cases (6%) data were missing (data based on the *ICD-10* discharge protocol of the local hospital). Thirty-seven percent of the patients with ischemic stroke or TIA reached the hospital within 3 hours, with 49% having a score on the modified Rankin Scale of ≥ 3, which indicates that stroke in these patients was severe enough to make them potential candidates for intravenous thrombolysis (Table 3).

In most cases videoconferencing was not performed because the local physician expected no additional therapeutic advantages from teleconsultation (71%); in 61% the diagnostic situation was thought to be clear. In 98 cases (30%) the CT scans seemed to be unmistakable, and in 52 cases (16%) the patient's physical state was thought to be so poor that no further consequences could be expected from teleconsultation. In 5 cases (2%), the local physician claimed to have no time for teleconsultation, and in 25 cases other reasons were mentioned.

TABLE 3. Modified Rankin Score on Admission, Taken From 299 BAQ Forms

	Modified Rankin Score (n=299)							
	Missing Data	0	1	2	3	4	5	Total
All patients with teleconsultation	4 (6)	10 (16)	13 (20)	2 (3)	8 (13)	15 (23)	12 (19)	64
All patients without teleconsultation	22 (9)	36 (15)	35 (15)	24 (10)	28 (12)	48 (20)	42 (18)	235
Total	26 (9)	46 (15)	48 (16)	26 (9)	36 (12)	63 (21)	54 (18)	299
Patients without teleconsultation with ischemia or TIA, admission within 3 h	9 (12)	13 (17)	10 (13)	8 (10)	9 (12)	12 (15)	17 (22)	78

*A total of 324 BAQ forms were missing. Data in brackets are percentages.

Patients With Teleconsultation

Of the 153 patients presented by teleconsultation, 87 patients (57%) had an ischemic stroke, 9 (6%) had an intracranial hemorrhage, and 17 (11%) suffered a TIA. Twenty-five patients (16%) had a diagnosis different from the primarily suspected stroke: the most frequent diagnoses were focal epilepsia and Bell's palsy (Table 4), and in 15 patients (10%) the diagnosis remained unclear after teleconsultation but was considered different from the primarily suspected diagnosis of stroke by the stroke expert. Teleconsultation took place within the first 3 hours after admission to the local hospital in 35 cases, within 6 hours in 54 cases, and after 24 hours in 40 cases (missing data: n=37). The time span between first telephone call and start of the presentation was 69 minutes on average (range, 2 to 362 minutes; SD 82.1 minutes), with no difference between acute (<3 hours) or subacute cases. Delay in all cases was due to the local physician's decision regarding the time when teleconsultation should take place.

Rankin scores showed no difference between patients with and without teleconsultation (Table 3). Patients who arrived early after stroke onset at the rural hospital were more often presented for teleconsultation. More patients with teleconsultation had reached the hospital within a 3-hour period (teleconsultation patients, n=46 [58%; 74 data missing]/non-teleconsultation patients, n=86 [39%; 253 data missing]; $P=0.001$, χ^2 test), whereas the patients not presented for teleconsultation arrived significantly more frequently >24 hours after stroke onset (teleconsultation patients, n=6 [8%]; non-teleconsultation patients, n=36 [16%]; $P=0.049$, χ^2 test).

TABLE 4. Diagnosis of Patients After Teleconsultation According to Neurologists' Consultation Protocols (n=153)

	n
Ischemic stroke	87
Territorial	46
Hemodynamic	2
Lacunar	19
Unclear	20
Intracerebral hemorrhage	9
Basal ganglia	5
Lobar	2
Infratentorial	2
TIA	17
Others	25
Bell's palsy	5
Seizure	5
Tumor	4
Migraine	2
Psychogenetic	2
Intoxication	2
Others (1 case each)	5
No stroke, but unclear	15
Total	153

Relevant contributions to stroke management were rated highly by both the local physicians and the neurologists in all categories (Table 5). In the diagnostic workup category, ratings for relevant contributions ranged from 41% to 80% for the local physicians and from 37% to 79% for the neurologists. In the CT assessment category, ratings for relevant contributions ranged from 21% to 47% for the local physicians and from 6% to 48% for the neurologists. Proportions were within the same range for the therapeutic decisions category. In most cases, ratings by the stroke expert and the local physician were similar. If ratings were divergent, it was usually the local physicians who considered teleconsultation to have some relevance, even if the stroke expert did not. In 11 patients recombinant tissue plasminogen activator application was discussed, but thus far, only 2 patients have received intravenous thrombolysis after teleconsultation.

Imaging quality of both patients (mean, 1.9) and CTs (mean, 2.1) was considered good by the stroke neurologists. Audio quality was rated mediocre, especially by the physician on the scene (stroke neurologist: mean, 2.4; local physician: mean, 2.6; $P=0.494$, χ^2 test). Time needed was rated good by the neurologists but significantly worse by their medical partners (stroke neurologist: mean, 1.9; local physician: mean, 2.5; $P<0.0001$, χ^2 test). As far as data were available, patients were satisfied with the tele-examination (mean, 1.5) and primarily commented that it was easy to speak to and cooperate with the remote neurologist (mean, 1.8).

Discussion

To our knowledge, the present study is the first to establish a "telestroke" network in a larger population following the recommendations of Levine and Gorman.[8] It confirms the results of our preliminary studies,[5,6] which have shown that the videoconference-based examination of both patients and their CT scans (so-called teleconsultation) in cases of acute stroke is reliable and practicable and offers relevant contri-

TABLE 5. Ratings of the Contribution of Teleconsultation to Stroke Management Taken From Teleforms That Had to Be Filled Out Immediately After Teleconsultation

	Relevant†		Concordant Ratings‡				Discordant Ratings§		
	Neurological, n (%)	Medical, n (%)	Relevant	Moderately Relevant	Not Relevant	At Least Moderately Relevant	Medically Better	Neurologically Better	Missing Data‖
Diagnostic work-up*	135 (88)	95 (93)							
Neurological examination	121 (79)	82 (80)	73	2	0	99	1	1	53
Differential diagnosis	57 (37)	42 (41)	19	8	3	45	15	2	59
Stroke localization	65 (42)	51 (50)	30	4	1	45	13	2	60
Additional diagnostic measures	92 (60)	68 (67)	42	3	1	74	6	2	55
Others	11 (7)	23 (23)	1	0	2	4	7	0	74
CT assessment*	116 (76)	78 (76)							
Ischemia vs hemorrhage	48 (31)	48 (47)	15	0	2	21	12	4	60
Cause of hemorrhage	9 (6)	21 (21)	4	0	0	5	7	0	59
Cause of ischemia	74 (48)	38 (37)	27	13	1	66	4	1	58
Early signs	31 (20)	23 (23)	9	2	1	17	7	3	63
Elevated intracranial pressure	19 (12)	27 (26)	9	2	1	19	7	1	60
Others	28 (18)	19 (19)	7	0	0	9	3	1	70
Therapeutic decisions*	134 (88)	82 (80)							
Thrombolysis	11 (7)	12 (12)	4	0	3	7	3	2	61
Anticoagulation	106 (69)	58 (57)	53	1	0	73	0	1	53
Antihypotensive treatment	33 (22)	14 (14)	9	6	2	24	0	4	60
Antihypertensive treatment	26 (17)	25 (25)	9	3	2	26	5	3	62
ICU	6 (4)	6 (6)	1	2	2	5	2	1	61
Transfer stroke center	8 (5)	11 (11)	2	2	2	7	0	0	60
Neurosurgery	12 (8)	12 (12)	7	2	2	14	0	0	59
Vascular surgery	1 (1)	1 (1)	0	2	2	2	2	0	61
Others	24 (16)	11 (11)	2	0	0	2	3	0	66

Neurological (n=153) vs medical (n=102) assessment; 51 teleforms (all from medical departments) missing; ultrasound assessment omitted (not performed).

*At least once rated "relevant" throughout the whole category.

†No. of "relevant" ratings per item.

‡Rated "relevant," "moderately relevant," or "not relevant" by both the participating stroke expert and the local physician.

§Rated "relevant" or "moderately relevant" by one and "not relevant" by the other participating physician, divided into whether the local physician ("medically better") or the stroke expert ("neurologically better") rated at least "moderately relevant."

‖Data missing either because of lacking teleforms (51 cases) or because of item not having been rated (rest).

butions to stroke care in most cases from the viewpoint of both the neurologist and the local physician.

Under the supervision of a stroke neurologist, basic medical examination practice is sufficient for the physician on the scene. The necessary preparation time for the 4 neurologists of the Günzburg stroke unit was restricted to only a few examinations, which primarily involved remote camera movement and motion training.

Moreover, the time needed for the complete teleconsultation took 15 minutes on average, which was acceptable for both sides, although the physicians on the scene rated the time needed as somewhat longer. As far as information on the patients' opinions is available, they were satisfied with the way the examination was performed and found it easy to speak with the remote neurologist; only 1 patient refused teleconsultation.

To a remarkably high degree, both the "teleneurologists" and the local physicians rated the contribution of the teleconsultation as important for stroke management. The emergency physician received no relevant information in only 1 case, and in 4 cases the teleneurologist thought that he had given no relevant contribution. In most of the cases, both the neurologist and the local physician assessed the relevance of telemedicine equally; if a rating was divergent, the neurologist tended to be more skeptical than the participating local physician.

The importance of teleconsultation is underscored by the fact that 26% of the patients had diagnoses other than stroke, which had been suspected by the emergency physician. This high number corresponds with previously published data.[9] This casts doubt on the opinion of the local physicians who did not present many stroke patients because they thought the diagnosis was clear.

Until now, only 2 patients have received "teleguided" thrombolysis. In 1 case (male; aged 69 years; stroke onset 45 minutes before hospital admission; no relevant medical history; severe left-sided hemiparesis), thrombolysis following the National Institute of Neurological Disorders and Stroke protocol resulted in a nearly complete recovery. The second patient (male; aged 51 years; stroke onset 2 hours before hospital admission; medical history of hypertension, absolute arrhythmia, and obesity; severe left-sided hemiparesis) showed signs of a secondary hemorrhagic transformation on control CT. He therefore was transferred to the Günzburg stroke unit, where he died 1 week later, following severe pulmonary embolism. Nevertheless, our experience with teleconsultation gives no relevant hints regarding why such thrombolysis should not be performed. This is compatible with the first results from LaMonte et al[4] and with the results of the OSF Network in Illinois,[3] with the latter using only telephone contact. In our opinion, however, we doubt whether telephone and CT alone provide sufficient information for thrombolysis.

Despite the aforementioned possibilities of telemedicine, our actual experiences reveal some basic problems of teleneurological stroke care as well. First, across the associated hospitals, the number of teleconsultations in patients with suspected stroke differed widely, from 2% to 86%. Intense discussions with the physicians involved showed considerable acceptance problems. Despite the conceded improvement in stroke care, the additional time needed (including transporting the patient to the videoconference room, obtaining the patient's consent, and documentation necessities) is hard to accept without additional medical staff in the local hospitals. In future telemedicine programs, these requirements must be considered.

Second, the relatively low frequency of teleconsultations at present results in a lack of familiarity with the method. In our opinion, however, telestroke can only be successful if almost all stroke patients are presented, resulting in teleconsultation being a routine procedure for all physicians on duty. Only then can we expect to reduce the current length of time between a patient's admission and teleconsultation.

Third, although we initiated a continuous education program for both physicians and nursing staff of our associated hospitals, we have the impression that teleneurology, even in combination with regular follow-up consultations, cannot reach the standard of a specialized stroke unit with a trained stroke team in the associated hospitals, as characterized in previous published studies.[10]

We are aware that the relatively high number of missing evaluation forms may have biased some outcome variables and is certainly due to the additional time needed for documentation at the rural hospital. Despite these restrictions, however, we believe that telestroke is practicable and can contribute to the improvement of stroke care in rural hospitals that are too distant from a specialized stroke unit. Whether this results in a better outcome remains to be investigated by further studies, including the long-term follow-up of stroke patients comparing telestroke hospitals and hospitals without such a telemedicine link.

Acknowledgments

The TESS study is supported by the government of Bavaria, Germany, within the Bayern Online project. Participating stroke neurologists (all Bezirkskrankenhaus Günzburg) are W. Aurnhammer, MD; N. Breitinger, MD; and R. Kimm, MD. TESS study collaborators are as follows: W. Berg, MD; S. Parys, MD (Kreiskrankenhaus Lindau); D. Blechschmidt, MD; P. Fakhoury, MD (Kreiskrankenhaus Nördlingen); G. König, MD; A. Pfeiffer, MD (Klinikum Memmingen); J. Sailer, MD; W. Rilk, MD (Kreiskrankenhaus Oettingen); F. Seidel, MD; T. Gallwitz, MD (Klinikum Kempten); K. Weigand, MD; S. Waibel, MD (Stauferklinik Mutlangen); H. Wurm, MD; H-M. Linsenmeyer, MD; U. Issler, MD (Donau-Ries-Klinik Donauwörth).

References

1. Craig JJ, McConville JP, Patterson VH, Wootton R. Neurological examination is possible using telemedicine. *J Telemed Telecare*. 1999;5:177–181.
2. Craig JJ, Chua R, Wootton R, Patterson VH. A pilot study of telemedicine for new neurological outpatient referrals. *J Telemed Telecare*. 2000;6:225–228.
3. Wang DZ, Rose JA, Honings DS, Garwacki DJ, Milbrandt JC. Treating acute stroke patients with intravenous tPA: the OSF Stroke Network expertise. *Stroke*. 2000;31:77–81.
4. LaMonte MP, Bates V, Bahouth MN, Gunawardane RD, Yarbrough KL, Pathan MY, Page CW, Mehlman I, Crarey PE. Safe rt-PA administration for ischemic stroke during telemedicine consultation: poster presentation. *Stroke*. 2000;32:374-a.
5. Wiborg A, Widder B, Riepe MW, Krauss M, Huber R, Schmitz B. Contribution by telemedicine on comprehensive care for stroke patients in rural areas. *Akt Neurol*. 2000;27:119–124.
6. Wiborg A, Huber R, Aurnhammer W, Schmitz B, Krauss M, Riepe MW, Widder B. Teleconsultation in hyperacute stroke: the reliability of evaluating patients and CT by a video conference system. In: Program of the 11th Meeting of the European Neurological Society; April 21–25, 2001; Paris, France.
7. Shafqat S, Kvedar JC, Guanci MM, Chang Y, Schwamm LH. Role for telemedicine in acute stroke: feasibility and reliability of remote administration of the NIH Stroke Scale. *Stroke*. 1999;30:2141–2145.
8. Levine SR, Gorman M. "Telestroke": the application of telemedicine for stroke. *Stroke*. 1999;30:464–469.
9. Harbison J, Hossain O, Jenkinson D, Davis J, Louw SJ, Ford GA. Diagnostic accuracy of stroke referrals from primary care, emergency room physicians, and ambulance staff using the face arm speech test. *Stroke*. 2003;34:71–76.
10. Evans A, Harraf F, Donaldson N, Kalra L. Randomized controlled study of stroke unit care versus stroke team care in different stroke subtypes. *Stroke*. 2002;33:449–455.

Editorial Comment

Telemedicine: The Solution to Provide Rural Stroke Coverage and the Answer to the Shortage of Stroke Neurologists and Radiologists

While the world seems to get "online" at an unbelievable speed, telemedicine is slow to follow. Other than teleradiology, which has been widely accepted in practice for several years, it is puzzling that the use of 2-dimensional live images on a computer or television screen is still being studied. While direct visualization or so-called seeing is believing is in the process of getting the statistic power to prove its worthiness, the world is faced with the increased demand and task to improve stroke care. The TESS project has hopefully provided the last bits of needed information to prove to the world that telemedicine for stroke care works. As Wiborg et al report, telemedicine is easy to set up ("online" within 10 minutes) and operate. It requires a low level of training and is interactive with accurate diagnoses. Furthermore, it assists in making a diagnosis other than stroke (26% in TESS). Despite in TESS the use of telemedicine was only once per consultation, it is certainly conceivable that the system can be used more frequently or as needed. The cost of $8000 for a stroke network center and $500 for each network site is very affordable.

As the TESS project reported, telemedicine offers reliable stroke coverage to rural areas. According to the Hospital Statistics 2002, of 4856 US hospitals reported,[1] >50% of hospitals (<100 bed size) were located in rural areas. These institutions may have been able to provide image studies, but often there was no neurology or radiology coverage. Therefore, establishing a telemedicine link would provide immediate access to neurological expertise.

In addition to lack of stroke care coverage in rural areas, there is currently a shortage of neurologists and radiologists to care for approximately 700 000 new stroke and nearly 1 million new TIA patients every year in the United States alone.[2] These 2 specialties are needed for stroke care because, unlike the diagnosis and management of myocardial infarction, stroke care is much more complicated and there is no biological marker for stroke. Thus, making a timely accurate diagnosis of stroke relies on a detailed history and neurological examination and imaging studies (CT, MRI) with interpretation in a defined time. It therefore demands the availability of a neurologist, radiologist, and imaging study technicians 24 hours a day, 7 days a week. Many healthcare institutions, particularly hospitals located in rural areas, are unlikely to have adequate coverage.

According to the Neurologists 2000 (survey by the American Academy of Neurology), there were 10 038 US neurologists registered, with 83.7% being adult neurologists. Only 42.3% had stroke as their practice focus, and only 47% strongly agreed and felt comfortable about giving intravenous tPA.[3] In addition, according to the 2000 AAN survey, the distribution of the Neurologists indicates that 20% of the US population is without any neurological services. There is also a shortage of radiologists. There are about 25 600 post-training diagnostic radiologists in the United States (survey by the American College of Radiology) and about 73% of these radiologists work full time.[4] More than half of the radiologists indicated that they were overworked. It is unrealistic to speculate that there will be enough trained neurologists and radiologists in the near future to provide adequate care to stroke patients. Establishing telemedicine would in part resolve the "man power" shortage problem.

Telemedicine also fits well within the concept of establishing primary and comprehensive stroke centers. These designated centers will likely receive federal and state financial support. Telemedicine may become an essential part of these centers by providing coverage to their designated network sites.

Lastly, telemedicine may be able to allow other sites within a network to participate in clinical trials. From consenting to follow-ups, all components needed to conduct a quality stroke trial can potentially be achieved by telemedicine. With increased difficulties in enrolling patients in acute stroke trials, telemedicine may be the solution to facilitate more sites to participate in clinical trials.

Despite the benefit demonstrated by telemedicine, several key issues may need to be addressed before its full implementation. These issues include reimbursement for usage, liability coverage, cross-states physician licensing, equipment upgrade, and quality assurances. With the continued shortage of both neurologists and radiologists needed for stroke care, telemedicine offers an affordable, reliable, and timely solution.

David Z. Wang, DO, *Guest Editor*
Director, OSF Stroke Network
Clinical Assistant Professor of Neurology
University of Illinois College of Medicine at Peoria
Chair, Peoria Tri-county ASA Operation Stroke
Peoria, Illinois

References

1. Facilities and Services in the U.S. Census Divisions and States. Hospital Statistics. Chicago, Ill: Health Forum LLC, an affiliate of the American Hospital Association; 2002.
2. American Heart Association. 2002 Heart and Stroke Statistical Update. Dallas, Texas: American Heart Association; 2002.
3. Swarztrauber K, Lawyer BL, and Members of the AAN Practice Characteristics Subcommittee. Neurologists 2000. AAN Member Demographic and Practice Characteristics. St. Paul, Minn: American Academy of Neurology; 2001.
4. Sunshine JH, Cypel YS, Schepps B. Diagnostic Radiologists in 2000: basic characteristics, practices, and issues related to the radiologist shortage. *AJR Am J Roentgenol*. 2002;178:291–301.