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ORIGINAL COMMUNICATION

Telemedicine in acute stroke

Remote video-examination compared to simple telephone consultation

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Abstract *Background* Telemedicine is increasingly being used in acute stroke care. Some of the first studies and network projects are already applying remote audiovisual communication for patient evaluation. Formerly the telephone was the method of choice to contact experts for case discussion. We compared remote video-examination and telephone consultation in acute stroke care. *Methods* Two district hospitals were linked to stroke centers in Northern Bavaria. Patients with symptoms suggestive of an acute stroke were included. Remote video examination (RVE) was provided by live audiovisual communication and access to brain images; telephone consultation (TC) was done via standard telephone using a structured interview. There was a weekly rotation of the two methods. Demographic data and other data concerning process and quality of care as well as outcome 10 days after stroke were recorded and compared between the two groups. *Results* Within the study period 151 consultations were made in acute stroke patients (mean age 66.8 years). 77 patients were seen by RVE and 74 by TC. Total examination times were 49.8 min for RVE and 27.2 min for TC ($p < 0.01$). Patients were more frequently transferred to the stroke center after TC consultation (9.1 % vs. 14.9 %, $p < 0.05$) and had a higher mortality 10 days after stroke (6.8 % vs. 1.3 %, $p < 0.05$). Diagnosis made by TC had to be corrected more frequently (17.6 % vs. 7.1 %; $p < 0.05$). *Conclusions* Creating a network improves stroke care by establishing cooperation between hospitals. Telephone consultation could be a simple method of telemedicine to support cooperation as it is easy and widely available. However, outcome parameters like mortality indicate that remote video examination is superior to TC. Therefore, full-scale audiovisual communication is recommended for remote consultation in acute stroke care.

Key words acute stroke · diagnosis · telemedicine · symptoms · stroke management

Introduction

Use of telemedicine is rapidly growing in acute stroke care. Shortly after the first vision published by Levine and Gorman in 1999 [8], the first studies testing its feasibility were published [12]. Since then, the first experiences in routine use of telemedicine in acute stroke care have also been reported [7, 14]. Telemedicine has been demonstrated to be a safe and effective way to support administration of thrombolysis in smaller hospitals [1]. All these attempts used communication by telemedicine

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to perform clinical examination guided and evaluated by a remote examiner via real-time audio/visual communication mainly using videoconferencing systems. This method was found to be feasible and reliable when testing stroke patients and scoring established stoke scales [9, 12–14]. However, real-time video communication is fairly expensive a high rate of data transmission is needed. Additional costs derive from the organizational impact as a clearly defined process and assistance at the bedside are needed [5]. Until now it has not been proven whether remote videobased examination is really mandatory to guide critical decisions in acute stroke care. Traditionally, in most hospitals a telephone call is used to establish communication with a remote specialist to obtain advice in individual cases. During such a call the treating physician would verbally provide all the data about the specific patient. In cases where a decision is impossible from the data reported, the specialist would have to see the patient personally, thus, requiring a transfer. We compare this traditional method of telecommunication to modern audiovisual linkage in acute stroke care in a prospective study.

Materials and methods

The study was conducted within the project "Stroke Care using Telemedicine in Northern Bavaria" (STENO), a small stroke care network consisting of 2 stroke centers in Nuremberg and Erlangen and 2 local hospitals (district hospitals at Roth and Forchheim, Bavaria, Germany). The STENO project was funded by the Bavarian Ministry of Labor and Social Welfare, Family and Women.

One stroke center is located in a university hospital and another in a large teaching hospital. Both hospitals run a stroke unit assigned by the state government according to national guidelines. Both have direct access to all methods of stroke therapy including neurosurgery or interventional neuroradiology.

The local hospitals are district hospitals responsible for primary and comprehensive care in the fields of general medicine and surgery as well as obstetrics and gynecology. In both hospitals the Departments of Internal Medicine are responsible for treatment of stroke. Each hospital has a stroke ward with 4 monitoring beds. Both hospitals have their own Department of Radiology with CT and MRI scanners available on a 24/7 basis as well as other standard diagnostics such as Doppler ultrasound and echocardiography.

Within the study period of one year, stroke patients admitted to one of the local hospitals with acute onset or unclear and unstable condition were included in the study. Patients were examined in the emergency room as soon as possible after admission. All patients were lying on a stretcher or in a hospital bed and standardized monitoring of vital signs (ECG, noninvasive blood pressure, oxygen saturation) was performed during the whole examination. Patients with decreased consciousness (Glasgow Coma Scale < 8) or severe instability in vital signs were excluded, as well as those cases where urgent therapy such as thrombolysis was required. However, there was a clear protocol for handling patients potentially eligible for thrombolysis. These cases were discussed briefly via telephone, and if inclusion criteria for thrombolysis was likely, the patient was transferred to the stroke center immediately and thrombolysis was started at the center. Those cases were not included in the analysis.

All patients (or their next of kin, if appropriate) gave informed consent before participation. The study protocol was approved by the local ethics subcommittee of the university.

In both local hospitals comprehensive training sessions were held on diagnosis and treatment of stroke and on use of the telemedicine system. Standard operating procedures were established on main aspects of acute stroke care and the process of teleconsultation. During one week, one of the two stroke centers was on duty for all teleconsultations in both local hospitals. In addition, using a week-to-week rotation there was a switch between pure telephone consultation (TC) for one week and full audiovisual consultation using remote video-examination (RVE) the next. As the rotations were cross-linked each stroke center was on duty for both methods of teleconsultation.

Remote video-examination of patients was performed using a novel audio-visual telesupport system (EVITA, Optics Research and Information Ltd, Erlangen, Germany), providing real time transmission of video/audio sequences from the local hospital to the stroke center. Details of the EVITA system and its technical features were previously reported [5].

The remote stroke expert was able to move the camera on site very quickly and exactly by a simple mouse click within the overview image. Remote viewing was on a 17 inch computer monitor presented in a Netscape® browser frame (Fig. 1). Image size and compression quality of the resulting video image was modifiable. In this study, we used 25 images/s in a standard view of 384 × 288 pixels up to 768 × 576 pixels (detail view mode).

To establish audio connection, a central room microphone and loudspeakers were used at the patient's side in the local emergency room, and a headset at the examiner's side at the stroke unit. For data transmission, a multiplex ISDN connection on the standard telephone network was used providing data speed up to 1500 kB/s. Line management was established by ISDN routers; 15 lines were routinely connected for one teleconsultation.

Clinical examination was performed based on the National Institutes of Health Stroke Scale (NIHSS, German version) [4] by the remote examiner.

The remote examiner directed the whole process, giving instructions to the patient and assistant via audio line. Assistance at the bedside was provided by the local physician or a trained nurse.

In one of the local hospitals, images of CT or MRI scans were reviewed by logging on the Picture Archiving and Communication System (PACS, by TIANI Medgraph Co., Brunn, Austria). Using this technique no images were transferred but one could use all data within the local system without loss of quality. In the other hospital, the CT films were scanned by video using the closest zoom and highest resolution of the camera in a 90° angle (Fig. 2). The image review process was standardized for both methods.

Fig. 1 Telemedicine infrastructure at the local hospital. Remote controlled camera connected to the video server and PC. An X-ray viewer is located in a 90° angle to provide optimal view for CT scans

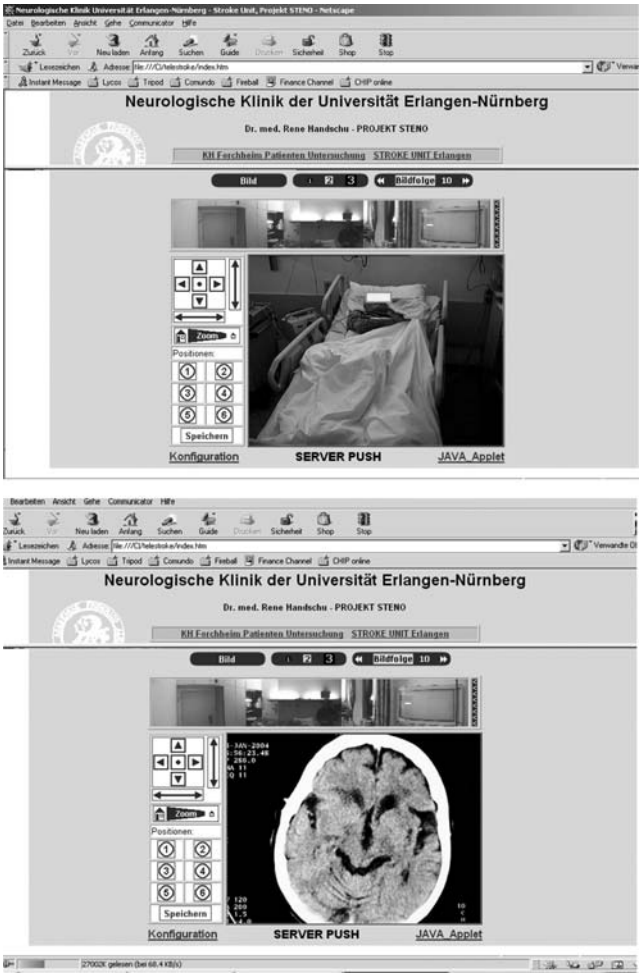

Fig. 2 Patient and CT scan (one slice) viewed by the EVITA video camera

After the examination, a written statement was given by the consulting expert concerning assessment and treatment recommendation.

Telephone consultation was conducted via standard telephone lines or in some cases GSM cell phones. History, symptoms and clinical findings as well as findings from CT (or sometimes MRI) imaging were verbally reported by the local physician to the stroke expert on duty. To guide the discussion a standard checklist covering standard stroke symptoms and clues for history and stroke risk factors as well as concomitant medication was developed and used in each call also for documentation. In addition, recommendations for further diagnostics and treatment were only discussed by telephone.

All remote experts were experienced stroke neurologists with specialization in neuro-critical care. Demographical data as well as characteristics about patients and their clinical course were recorded. Stroke severity was quantified primarily on NIHSS score. As the score was not completely documented in TC, we also used a stroke severity index based on number of symptoms [6]. Case records including final diagnosis were checked by a senior neurologist not involved in teleconsultation.

For comparisons between the video and the telephone group, t-tests were used for continuous variables and chi-square tests for proportional variables.

Primary focus was on the rate of transfer to the stroke center after teleconsultation. Other key objectives were parameters of short-term outcome, such as death and dependency 10 days after stroke, and also quality parameters such as discharge destination, length and type of hospital stay, and change in diagnosis.

Results

During the study period 151 teleconsultations were performed in acute stroke patients (72 male, mean age was 66.8 years ranging from 22–92 years): 77 consults were remote video examinations (RVE) and 74 were telephone consultations (TC). Consultations were started 16.9 hours after onset of symptoms on average (wake-up strokes were treated as symptoms starting when going to bed) ranging from 0.75 to 128 hours. TC and RVE were comparable regarding baseline characteristics and clinical features of patients (see Table 1 for details).

Diagnosis in all teleconsultations was cerebral ischemia in 91 cases, intracerebral hemorrhage in 14 cases, and transient ischemic attack in 11 cases. Another 11 cases remained unclear and 24 cases had a non-stroke diagnosis (Bell's palsy, epileptic seizures syncope, ves-

Table 1 Baseline characteristics for patients seen in telephone consultation (TC) and in remote video examination (RVE)

	RVE	TC	P - value
Number of patients	77	74	
Age years, mean, range	68.9	64.89	0.08
Male %	53.2	41.9	0.07
Comorbidities %			
Hypertension	68.8	70.2	0.70
Diabetes	26.0	28.4	0.68
Atrial fibrillation	31.2	29.7	0.58
Previous stroke/TIA	19.5 (15)	21.6 (16)	0.67
Mean NIHSS score	5.4	5.7*	
Stroke severity index (No. of neurological deficits)			
0–1 % of patients (n)	41.5 (32)	44.6 (33)	0.70
2	32.5 (25)	32.4 (24)	0.69
3	18.2 (14)	14.9 (11)	0.33
4 and more	7.8 (6)	8.1 (6)	0.73
Hospital A	42	39	
Hospital B	35	35	
Diagnosis in consultation (No. of pts.)			
Cerebral ischemia	48	43	0.40
Intracerebr. hemorrhage	9	5	0.07
TIA	6	5	0.57
Non-stroke	8	16	< 0.05
Unclear	6	5	0.7

* In TC NIHSS was scored by the local physician (including missing scores in 21 pts.) while the score was done by the stroke expert in RVE

** cumulative number of the following stroke symptoms: paresis/weakness, aphasia, dysarthria, disturbance of consciousness

tibulopathy, encephalitis, subarachnoid hemorrhage, brain tumor, etc.).

Duration of the pure video examination was 17.8 min (9–35 min), while the phone call itself took 13.6 min (6–30 min). Accounting for all directly related processes like preparation and documentation RVE took 49.8 min (29–62 min) at the stroke center and 44.2 min (35–60 min) at the local hospital, while for TC a mean time of 27.2 min (15–38 min) was spent at the stroke center and 22.3 min (10–29 min) at the local hospital. The difference in total time was significant for the local hospital ($p < 0.01$) and for the stroke center ($p < 0.01$). Video consultations had to be partially stopped and switched to telephone in two cases due to technical reasons. Those cases were treated as VRE. All other consultations, video and telephone were made without major technical problems. Comparing results of RVE and TC non-stroke diagnoses were more frequent in TC than in RVE (26.6 % vs. 10.4 %; $p < 0.05$), while there was no difference in unclear diagnosis (6.8 % vs. 7.8 %).

There was a lower frequency of transfer to one of the stroke centers after RVE (9.1 % vs. 14.9 %, $p < 0.05$). There was no difference in overall length of hospital stay (12.3 d for TC vs. 11.4 d for RVE) but patients after RVE were more frequently admitted to the stroke ward of the local hospital (for a minimum of 24 h) than after TC (59.7 % vs. 45.4 %, n.s.). As a measure of diagnostic accuracy a change in diagnosis from that made by the consulting stroke expert to that written in hospital discharge letters was more frequent after TC than after RVE (17.6 % vs. 7.1 %; $p < 0.05$). Finally, 10 days after stroke mortality was higher in patients after TC (6.76 %) than after RVE (1.29 %, $p < 0.05$) as well as the need for institutional care (5.4 % vs. 2.6 %; $p = 0.58$).

Table 2 Main results comparing telephone consultation (TC) and remote video examination (RVE)

	RVE	TC	
Number	77	74	
Total time for consultation (min)	49.8	27.2	P < 0.01
Length of stay, days	11.4	12.3	n.s.
Admission to stroke ward, % of pts.	59.7	45.9	n.s.
Transfer to stroke center % of pts.	9.1	14.9	P < 0.05
Diagnosis corrected + % of pts.	7.1	17.6	P < 0.05
Outcome 10 days after stroke, %			
Mortality	1.3	6.8	P < 0.05
Institutional care	2.6	5.4	n.s.

+ correction of diagnosis was noted if the final diagnosis in the discharge letter was different from diagnosis made in consultation according to the categories: cerebral ischemia, intracerebral hemorrhage, unclear or non-stroke

Discussion

Telemedicine has already been used for stroke care and its beneficial effect in terms of, e. g., facilitating thrombolysis has been shown. However, it is still not clear what amount or extent of telemedicine is really necessary for augmenting stroke services.

To our knowledge, this is the first prospective trial comparing traditional telephone contact to a combination of image review and remote video-based examination in acute stroke care. La Monte and colleagues reported on video-based and telephone consultations as a mode of telemedicine [7]. However, in their study, telephone consultation was used whenever audiovisual communication was not possible. In the present study a quasi randomized practice was provided by switching methods on a week-to-week rotation. The weekly rotation provided equal level of general stroke care in terms of diagnostics and treatment to all patients included. Additionally, there was the same pattern of referral during the whole study period regardless of the method used. Thus, bias was minimized, but still partially existed because experts and treating physicians at the local hospitals were not generally blinded to the method used; it was not preliminary announced what type of telemedicine was on per week.

The fact that the number of telephone consultation and remote video examinations were almost equal reflects an equal use of both methods by the local hospitals. Subsequently in our cross-over design, the characteristics of patients did not show any significant differences despite a trend to younger age in the RVE group.

Comparison of RVE and TC, first of all, shows that TC is far less time consuming. It takes about half of the time spent on RVE at the stroke center and as well at the local hospital. However, the time at the local hospital does not include the time for the neurological examination performed by the local physician. In case of video examination, the local physician could do just a quick first look, while the precise neurological exam is done together with the stroke expert during the video communication (and included in the total time of the consultation). Moreover TC is not only faster but also easier as access to the telephone is available almost everywhere at least when using mobile phones. In contrast due to data safety and technical reasons, RVE in our study was only possible at one defined place at each stroke center. Subsequently TC seems to be the cheaper method as it is easily provided on an on-call basis.

Contrary to the advantages of TC, some of our data may suggest that teleconsultation using RVE provides a higher level of quality. There was a higher rate of transfer to the stroke center after TC, indicating that consultation by telephone was not sufficient for a reliable assessment in many cases.

A higher level of uncertainty in TC may be also expressed by a change in diagnosis from consultation to discharge that was more frequent in TC. Regarding outcome, there was a difference in mortality and the rate of institutional care between the two groups although groups were comparable regarding patient characteristics. These results are generally in accordance with the findings of Wong et al. [16] who compared telephone consultation, video consultation and teleradiology in neurosurgical patients. In their trial, telephone consultation was also shorter than the other two methods while teleradiology was superior regarding quality of care. The fact that there was no difference between video consultation and the other two methods may be due to an insufficient video system as failure rate was about 30 % in this study.

We did not found clear differences in the therapeutic approach itself between the two groups but there were more patients treated on the normal ward instead of the local stroke ward after telephone consultation. The latter finding may indicate that evaluation and advice given by telephone alone is less accepted by the local physicians compared to a neurological examination performed together with and guided by the stroke expert. The low acceptance may be partially due to the fact that, compared to RVE, there was no written statement sent by the expert after TC. However, regardless of the conclusions, acceptance at the participating hospitals is the cornerstone for the success of any network in stroke care.

There is an ongoing debate about thrombolysis guided by telephone advice from stroke experts and first trials are under way. First experiences of thrombolysis performed after telephone consultation were published by La Monte et al. Our study was not designed to investigate thromboysis itself and, as there were no data on the safety of thrombolysis done after teleconsultation when the STENO project was started, we excluded this condition from our analysis. Yet the data of our study do not support telephone consultation as a valid method of remote support for administration of tPA in acute stroke.

Meanwhile Audebert et al. demonstrated that thrombolysis is safe when given after video-based consultation in a stroke care network [2]. In this study a ten-fold increase in frequency of thrombolysis was reported; however, the rate was still much lower than in a stroke center of the same region [10]. In addition, they were able to show that a network using telemedicine but also continuing education and organizational development can improve quality of stroke care [3]. Our small study did not intend to evaluate the overall effect of a network structure. Nevertheless, we made the experience that education and definition of standards and algorithms as well as structured cooperation are indispensable elements of a stroke care network and have an impact on quality of care regardless of telemedicine. The fact that mortality in the whole study was lower than in-hospital mortality in other studies [11] may underline our belief in a general improvement of any kind from telemedicine and network structure compared to standard care in non-specialized units.

However, our study has a number of limitations. First, the sample size is relatively small to find differences between the two methods. In addition, in this analysis we focused on short-term outcome and parameters within the in-hospital care process. With a varying length of hospital stay some of the measures such as discharge destination are evaluated at different time points. Thus, these differences were found in short-term outcome and may be related to other confounders not recorded. The time interval from symptom onset to teleconsultation was relatively long. One reason for this is the exclusion of cases eligible for thrombolysis.

Conclusion

Creating networks by linking local hospitals to stroke centers will definitely improve stroke care through the cooperation itself and elements like education and quality management. At first view, telephone consultation looks like a simple and inexpensive method of telemedicine supporting such networks that is easily achievable. Nevertheless, compared with high-level real-time video/audio communication providing remote examination of stroke patients, telephone consultation does not seem to be able to accomplish the same improvement in acute stroke care. Whenever possible, stroke networks should establish video-based communication for evaluation of acute stroke cases, especially for remote assistance of thrombolysis.

Future improvement in technology may increase availability and flexibility of high-level real-time video communication and outweigh its disadvantages. Further studies will have to evaluate the value of telephone consultation in certain cases and even when combined with remote access of cerebral imaging data.

Conflict of interest There is no conflict of interest regarding this paper.

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