PAPER

A cohort study of early neurological consultation by telemedicine on the care of neurological inpatients

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Objectives: To find out the effect of early neurological consultation using a real time video link on the care of patients with neurological symptoms admitted to hospitals without neurologists on site.
Methods: A cohort study was performed in two small rural hospitals: Tyrone County Hospital (TCH), Omagh, and Erne Hospital, Enniskillen. All patients over 12 years of age who had been admitted because of neurological symptoms, over a 24 week period, to either hospital were studied. Patients admitted to TCH, in addition to receiving usual care, were offered a neurological consultation with a neurologist 120 km away at the Neurology Department of the Royal Victoria Hospital, Belfast, using a real time video link. The main outcome measure was length of hospital stay; change of diagnosis, mortality at 3 months, inpatient investigation, and transfer rate and use of healthcare resources within 3 months of admission were also studied.
Results: Hospital stay was significantly shorter for those admitted to TCH (hazard ratio 1.13; approximate 95% CI 1.003 to 1.282; p=0.045). No patients diagnosed by the neurologist using the video link subsequently had their diagnosis changed at follow up. There was no difference in overall mortality between the groups. There were no differences in the use of inpatient hospital resources and medical services in the follow up period between TCH and Erne patients.
Conclusions: Early neurological assessment reduces hospital stay for patients with neurological conditions outside of neurological centres. This can be achieved safely at a distance using a real time video link.

Approximately 20% of all medical patients admitted to hospital as emergencies have underlying neurological conditions.[1] In the UK, non-neurologists manage the majority of these patients, with only a small proportion being referred on to a neurologist.[2] This is because of, in part, there being too few neurologists in the UK.[3] The recently published document from the Association of British Neurologists *Acute neurological emergencies in adults* highlights the deficiencies in the UK, in the care of adults with neurological illnesses that are severe enough to warrant urgent admission to hospital, and proposes patterns of care to improve the situation.[3]

We have been investigating whether a neurological consultation service delivered to distant patients by telemedicine is feasible. Such an approach, if shown to be effective, might be of use not only for small rural or other hospitals where visits from neurologists are likely ever to be infrequent or non-existent but also for providing initial care for those patients admitted to district general hospitals where face to face neurological cover can only be provided through the working week. Likewise the technique could be of interest to others, outside of the UK, who are concerned with developing neurological services but are faced with the difficulties imposed by a finite number of neurologists aiming to deliver care to a geographically dispersed population.

Telemedicine has been defined as any medical activity practised when distance is an issue.[4] That telemedicine can be used for patients with conditions affecting the nervous system has been investigated in both neurological[5 6] and neurosurgical settings.[7–11] We have shown that the neurological examination can be interpreted accurately and consistently using a real time video link.[12] In the inpatient clinical setting we have shown that the process is acceptable to all users[13] and, in a small pilot study, that diagnoses and management plans made by teleconsultation are accurate and safe.[14] However, to convince purchasers of health care to invest in teleneurology, as a means whereby neurologists can help care for acutely unwell distant neurology patients, is likely to require evidence of clinical effectiveness and cost effectiveness, as has been stated for other telemedicine applications.[15] To do this we compared the management and outcome of patients admitted as emergencies because of neurological symptoms to two small rural hospitals; in one hospital patients had access to a neurologist using a real time video link and in the other patients were managed as usual.

METHODS

Setting

The Tyrone County Hospital (TCH), Omagh, and the Erne Hospital, Enniskillen, are two small rural hospitals in the south west of Northern Ireland. They serve populations of approximately 62 000 and 57 000, respectively, and are both part of Sperrin Lakeland Health and Community Trust. They are 75 and 85 miles, respectively, from the Royal Victoria Hospital in Belfast—a tertiary referral centre for most of the medical and surgical specialities, including neurosciences. Neither small hospital has a neurologist based in it but at the time of the study a consultant neurologist visited TCH once every 2 weeks and the Erne once every 4 weeks.

Patients

Patients were recruited over a consecutive 24 week period between January 1999 and June 1999. Suitable cases were defined as those patients of more than 12 years of age, who had been admitted to either hospital because of neurological symptoms (box 1), and who did not have other prominent symptoms that would suggest diseases outside of the nervous system. In a previous retrospective study we showed that the case-mix, outcome, and process of management of neurological inpatients in TCH and the Erne were similar.[16]

Abbreviation: TCH, Tyrone County Hospital

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Box 1 Symptoms suitable for study

- Headache
- Alteration of consciousness
- Weakness
- Sensory disturbance
- Dizziness/balance disturbance
- Confusion
- Speech disturbance
- Visual disturbance
- Memory loss
- Tremor
- Neuralgia

Intervention

Suitable patients at the Erne Hospital were managed by usual practice—that is, general physicians cared for them with referral to other specialists as necessary. In addition to receiving usual care, all suitable patients at TCH were offered a consultation with a neurologist using a real time video link. This took place as soon as possible after admission: within working hours through the week and from 9am to 1pm at weekends. A neurological trainee (in the fourth year of a 5 year training programme) or a consultant neurologist (18 years in post) provided the neurological care.

Teleconsultation details

A medium cost videoconferencing unit (Sony PCS 5100 rollabout processor, PCS C300P camera unit, PCS A500 audio unit, McMillan UK Ltd, Belfast) was installed in the clinical room beside the medical wards at TCH and another at the neurological centre. They were connected by three ISDN lines transmitting at 384 kbits/s.

A junior doctor (from a quota of four junior house officers and six senior house officers) at TCH established the video link and presented the patient and their details to the neurologist. The neurologist then interviewed the patient and any available key witnesses. Under the neurologist's direction the junior doctor conducted a neurological examination and any other relevant examination. Relevant radiological images were viewed on an *x* ray box in the clinical room. The neurologist gave their opinion and management plan to the patient and carers if present. The neurological trainee discussed all cases either with the consultant neurologist involved in the study or with the on-call consultant neurologist at the regional neurology centre. A facsimile was sent immediately after teleconsultation to the secretary of the attending consultant physician at TCH. Details included were the presumed diagnosis or differential diagnoses, investigation plan, treatment plan, and follow up plan.

Outcome measures

The primary outcome measure was total length of hospital stay, including any days spent in another hospital. Secondary outcome measures were chosen to compare quality of care (major change in diagnosis, mortality 3 months after the admission date), the use of inpatient hospital resources (investigation rate, transfer rate to other hospitals), and subsequent use of healthcare resources (outpatient follow up details, readmission rate, A&E visits, and GP visits within 3 months). All medical staff at TCH and the Erne hospitals were aware of the outcome measures during the study.

Data collection

Patient details (demographic details, presenting symptoms, initial diagnosis, management plans) were collected at the Erne hospital by one of the investigators (RC). The neurologists (VP, JC) collected similar details on patients at TCH. Information on final diagnosis, length of hospital episode, investigation details, inpatient mortality, and transfer details was collected by reviewing the medical records of all suitable patients at either hospital. Diagnostic details were those recorded in the discharge summaries. The records of all medical patients admitted to TCH during the study period were also analysed by one of the investigators (RC), and patients who fulfilled the inclusion criteria but who did not have a video link were identified. Data identical to that recorded for study patients were extracted for these patients, who as a group were categorised as ''TCH without video link''. Details on 3 month mortality, readmission rate, A&E visits, and GP visits were collected from the patients' GPs who were posted a questionnaire for return.

Ethical approval was obtained from the Queen's University of Belfast local research ethical committee.

Data analysis

Data on length of hospital stay were analysed on an intention to treat basis—that is, all suitable patients admitted to TCH were included for analysis whether or not they had a teleconsultation. For length of hospital stay, same calendar day discharges were counted as a hospital stay of 0 days. We used the z test, Mann-Whitney U test, and χ^2 test for continuous variables that met the requirements for parametric tests, continuous variables that did not, and categorical data, respectively. We used Fisher's exact test for categorical data when less than five events were recorded in a category. Hospital stay was compared using Cox's proportional hazard survival method.[17] This is a model that allows time to an event (time to discharge from hospital) to be compared between groups controlling for multiple independent variables. Variables that were significantly ($p<0.05$) related to time to discharge on univariate analysis were included in the multivariate analysis. Inpatient deaths were right censored. Analyses were performed with SAS Version 8 (SAS Institute Inc, NC, USA).

RESULTS

One hundred and twenty eight suitable patients were admitted to the Erne hospital during the study period. During the same period there were 815 medical admissions to TCH, of which 164 (20%) were suitable for study. One hundred and eleven of these (68%) had a video link. Suitable patients admitted to TCH and Erne presented with significantly different symptoms ($p = 0.023$) mainly because of more cases of alteration of consciousness at TCH and more cases of weakness at the Erne (table 1). TCH patients that had teleconsultation were significantly younger than those who did not ($p = 0.005$). Although Erne patients were older than those admitted to TCH the difference was not statistically significant ($p = 0.115$) (table 1). The median length of teleconsultation was 37 minutes.

Bed stay details

Length of hospital stay was only dependent on age and site of admission, with significantly shorter stay in younger patients (hazard ratio (HR) 0.97; approximate 95% confidence interval (CI) 0.967 to 0.979; $p<0.001$) and those admitted to TCH (HR 1.13; approximate 95% CI 1.003 to 1.282; $p = 0.045$). There was a greater chance of discharge from hospital for those admitted to TCH for all ages and all lengths of stay (fig 1)—for example, 14% of patients at TCH were discharged on the day of admission compared with 0.8% at

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Table 1 Demographic details and presenting neurological symptoms

	TCH+VL n=111	TCH−VL n=53	p Value	All TCH n=164	Erne n=128	p Value
Mean age in years (SD)	52 (23.6)	64 (22.6)	0.005*	56 (23.8)	60 (21.2)	0.115*
Minimum age	14	15		14	18	
Lower quartile	30	47		36	45	
Median age	55	73		61	64.5	
Upper quartile	73	80		75.5	78	
Maximum age	93	93		93	94	
Sex: Male (%)	58 (52.2)	28 (52.8)	1.000†	86 (52.4)	63 (49.2)	0.668†
Female (%)	53 (47.8)	25 (47.2)		78 (47.6)	65 (50.8)	
Symptoms (%)			0.013†			0.023†
Headache	20	13		18	18	
Weakness	21	13		19	28	
Alteration in consciousness	27	35		30	14	
Confusion	6	19		10	14	
Speech disturbance	11	6		10	9	
Incoordination/dizziness	7	11		8	12	
Other	8	3		5	5	

*Calculated with z test; †calculated with χ^2 test.
TCH+VL, Tyrone County Hospital with video link; TCH−VL, Tyrone County Hospital without video link.

the Erne, and 75% and 63% had been discharged from TCH and the Erne, respectively, by the end of the first week (see table 2).

Secondary outcome measures

There were no differences in measures comparing quality of care, the use of inpatient hospital resources, and medical services in the follow up period between TCH and Erne patients (see table 3).

DISCUSSION

We found a significant difference between the two hospitals for the length of hospital stay of patients admitted because of neurological symptoms. Using Cox's proportional hazards survival method, age was seen to be strongly predictive for the duration of hospital stay. Although patients admitted to the Erne hospital were generally older than those admitted to TCH, the site of admission independently predicted for the length of hospital stay with significantly shorter stays in the group of patients who had access to early neurological consultation using a video link. Measures of quality of care were not different between the sites studied. In particular, there were no major changes of diagnoses in the TCH group between video link and 3 month assessment. This confirms our previous work that patients presenting with neurological symptoms can be assessed accurately by distant neurologists using a video link.[14] There were no significant differences in the use of other hospital and community based resources between the groups. This shows that earlier discharge from hospital does not result in the increased use of other health resources. Although the numbers of outpatient visits were similar for the hospitals, neurological follow up was greatly increased for TCH patients. This is not surprising, as in studying all patients admitted with neurological symptoms to TCH we identified a significant number who, although they might benefit from ongoing specialist neurological care, would normally not be referred by the admitting medical teams to the visiting neurologist, probably because of a paucity of neurological services in the area.

Methodological considerations

The main strength of this study is that it was carried out in an actual busy clinical setting. Suitable cases were chosen solely on their presenting symptoms, and patients with neurological conditions were unlikely to have been missed. All participants were also aware of the outcome measures, which considered not only those relevant to the hospital admission but the use of subsequent hospital and primary care based resources.

Notwithstanding the strength of a real life setting, it was a cohort study and the potential problems with this type of study were highlighted afterwards when the different baseline characteristics of the groups were revealed. Inpatient mortality was also significantly higher in the group that did not have access to a video link. However, when other potential measures of severity of illness were compared (number requiring transfer to the regional neurosciences unit, mortality at 3 months, readmission rate to hospital, and A&E attendances at follow up) there did not appear to be appreciable differences between the groups. Although a large randomised trial might have avoided these problems, randomisation was not felt to be practicable in this study—for example, patients admitted to the same hospital with the same presenting symptom could have been randomised to different treatment groups, such that one had early access to a neurologist, the other having to wait on average up to 1 year for a new neurological outpatient appointment. We felt that this would have not been acceptable to patients' families and nurses and doctors at the remote site, and could have led to abuse of a randomisation protocol. Also in studies

Table 2 Bed stay details

	TCH+VL n=111	TCH−VL n=53	p Value	All TCH n=164	Erne n=128	p Value
Total length of stay in days	803	531		1334	1480	
Mean length of stay in days (SD)	7.2 (15.1)	10.0 (20.1)	0.258*	8.1 (16.9)	11.6 (22.3)	0.016*
Median length of stay in days	3	3		3	3	

*Calculated with Mann-Whitney U test.

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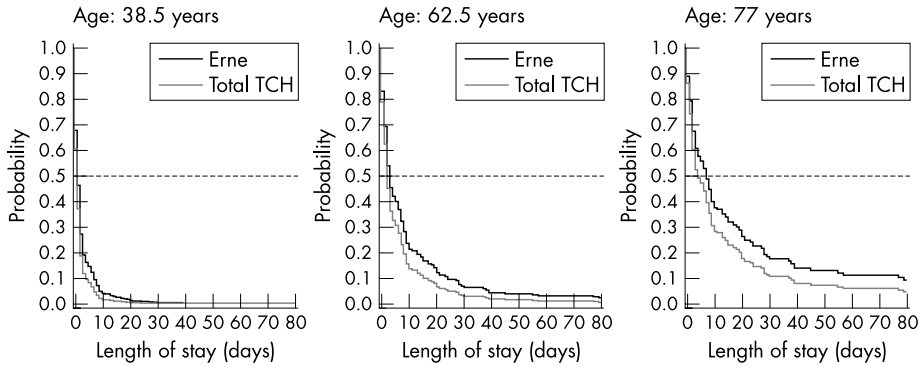

Figure 1 Estimated probability of exceeding a given length of stay, by hospital, for patients of ages 38.5, 62.5, and 77 years.

such as this, even if randomisation was feasible, it is possible that the intervention by its nature is likely to change clinical practice and make comparisons between the ''usual'' and the ''alternative system of care'' difficult.

Not all suitable patients admitted to TCH had a teleconsultation. The reasons for this were various and included discharge from hospital or transfer to another hospital before a video link could be organised. The study was conducted in a busy clinical setting and it was also not always possible to coordinate a teleconsultation because of other clinical commitments at TCH. The study concentrated mainly on measures of process and not all patients had complete follow up data. We were able to collect full data for inpatient measures, with patients' GPs supplying between 78% and 100% of details on follow up measures.

We have reported on patients included in this study for whom teleconsultation was undoubtedly beneficial. In one case, a woman with multiple sclerosis presented with a reduced level of consciousness. This was attributed by resident staff to a toxic confusional state. The diagnosis was changed after teleconsultation to possible non-convulsive status epilepticus that was confirmed with electroencephalogram and which responded to appropriate treatment.[18] In another instance, a patient felt to have a posterior circulation stroke had his diagnosis changed to an acute cervical cord lesion after teleconsultation and this was successfully corrected neurosurgically.[19] We feel these two examples show why for some cases at least our results could not have been replicated simply by using the telephone. In both, not only was history taking incomplete but the relevant clinical signs had been either missed or misinterpreted. To have relied on the information given by telephone would probably have resulted in the neurologist making an erroneous diagnosis and suggesting inappropriate investigations.

Table 3 Secondary outcome measures

	All TCH	Erne	p Value
Number having CT brain scans (n = 292)	69 (42.1%)	65 (50.8%)	0.173*
Number transferred to other hospital (n = 271)	14 (8.5%)	13 (12.1%)	0.445*
Number attending outpatient appointment within 3 months of admission (n = 251)			
Any outpatient visit	61 (39.1%)	34 (35.6%)	0.696*
Medical	22 (14.1%)	32 (33.7%)	<0.001*
Neurological	42 (26.9%)	2 (2.1%)	<0.001*
Inpatient mortality (n = 292)	8 (4.9%)	13 (10.2%)	0.013*
Total mortality at 3 month follow up (n = 244)	10 (8.6%)	15 (11.7%)	0.558*
Major change in diagnosis at 3 month follow up (n = 218)	0 (0%)	2 (1.9%)	0.240†
Number readmitted to hospital within 3 month follow up period (n = 202)	16 (15.0%)	16 (16.8%)	0.862*
Number attending A&E within 3 month follow up period (n = 202)	4 (3.7%)	1 (1.0%)	0.373†
Mean number of GP visits per patient within 3 month follow up period (n = 203)	2.14	2.49	0.519‡

Numbers of patients for whom follow up data are available are in parenthesis. *Calculated with χ^2 test; †calculated with Fisher's exact test; ‡calculated with z test. CT, computed tomography.

Only two neurologists performed the teleconsultations. There is variability in how doctors practise medicine and in this respect neurologists are no different.[20–22] Therefore, it is as yet unknown how generalisable the results of the study will be and this can only be resolved by conducting a bigger trial. From the technological point of view all the staff who used the telemedicine equipment easily mastered the process.

The implications of this study are potentially far-reaching for how neurological inpatients should be managed at hospitals that do not always have access to neurologists on site. We have shown that early specialist neurological consultation reduces hospital stay for these patients without compromising quality of care. How the reduction in bed stay was achieved is open to speculation and is likely to be because of many variables. However, we consider that greater experience and confidence of neurologists in dealing with acute neurological conditions is likely to account for a significant part of the differences observed. In particular, very early or even immediate discharge for those with headaches, once serious causes had been excluded and often without recourse to investigation, seizures, and possible transient ischaemic attacks, accounts for some of the differences observed. That patients presenting as emergencies with these or other neurological conditions are often admitted unnecessarily, and sometimes remain in hospital for longer than is probably necessary, is likely to be well known to any neurologist who provides a neurological consultation service. We have also shown that this problem is not only applicable to small hospitals—similar results are being reported in our own large urban teaching hospital.[23]

The potential for savings from earlier discharge from hospital for patients admitted with acute neurological emergencies is clearly considerable and a detailed economic analysis based on the results from this study is currently being performed. We feel we have shown that the expertise to achieve this can be delivered at a distance using a video link, and that the technique can easily be integrated into clinical care. As proof of this we have found that the system continues to be used with over 50% of all neurological cases admitted to TCH still having a video link since the research study was stopped. For patients currently admitted to hospitals that, because of their size or location, are unlikely

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ever to have a neurologist always on site there is now a means by which specialist neurological care can be accessed.

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CONTRIBUTORS

JC, RW, CR, and VP were involved in the study design. DC offered statistical advice. JC and RC collected the data. JC and DC analysed the data. JC wrote the first draft of the paper. All investigators contributed in the writing of the final draft of the manuscript.

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