CASE REPORT

Remote care of a patient with stroke in rural Trinidad: use of telemedicine to optimise global neurological care

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SUMMARY

We report a patient driven home care system that successfully assisted 24/7 with the management of a 68-year-old woman after a stroke—a global illness. The patient's caregiver and physician used computer devices, smartphones and internet access for information exchange. Patient, caregiver, family and physician satisfaction, coupled with outcome and cost were indicators of quality of care. The novelty of this basic model of teleneurology is characterised by implementing a patient/caregiver driven system designed to improve access to cost-efficient neurological care, which has potential for use in primary, secondary and tertiary levels of healthcare in rural and underserved regions of the world. We suggest involvement of healthcare stakeholders in teleneurology to address this global problem of limited access to neurological care. This model can facilitate the management of neurological diseases, impact on outcome, reduce frequency of consultations and hospitalisations, facilitate teaching of healthcare workers and promote research.

CASE PRESENTATION

Case report

Acute hospital care

A 68-year-old woman was admitted to hospital with acute worsening of a left hemiparesis, decreased responsiveness and slurred speech for the previous 12 hours. The patient had a history of a large ischaemic stroke involving the right parietal lobe in the territory of the right middle cerebral artery, diagnosed 11 years before. She was attending the outpatient medical clinic for ischaemic stroke, diabetes mellitus type II and essential hypertension. There was no history of other medical conditions, surgeries, allergies, use of recreational drugs, alcohol or tobacco. There was a strong family history of cardiovascular disease. Her oral medications included acetylsalicylic acid 81 mg daily, enalapril 10 mg daily, simvastatin 20 mg daily, metformin 500 mg two times a day and gliclazide 80 mg daily. On admission, the patient had a Glasgow Coma Scale (GCS) of 10/15: Eye opening response was positive to pain stimuli (2), best verbal response was inappropriate words (3) and best motor response was movements to localised pain stimuli (5). She was also confused and disoriented to time and place, and did not obey commands. The baseline Mini-Mental State Examination (MMSE) test performed on the second day of admission scored 10/30, showing

decreased temporal and spatial orientation (3), with language (3), registration (2) and recall (2) impairment but abnormal attention and calculation (0), and construction (0) were noted. The blood pressure was 175/98 mm of Hg, heart rate was 106 bpm, respiratory rate was 24 respirations per minute, body temperature was 36.7°C, saturation of oxygen was 100% on room air and patient's body mass index was 35. Neurological examination was significant for global weakness, worst in the left upper and lower extremities, which showed a power of 0/5, increased tendon reflexes, spasticity and hypoesthesia. Babinski's sign was positive in the left side. There was facial palsy but no neck stiffness and the other cranial nerves were intact. The rest of the physical examination was normal. On the second day of admission to hospital, the patient developed a fever with a temperature of 38.9°C, worsening cough and shortness of breath with bilateral basal crepitations.

Extensive medical investigations ruled out metabolic, endocrine, renal, hepatic, cardiovascular, autoimmune, neoplastic and vasculitis diseases. White cell count was $11.4 \times 10^9/L$ and a chest X-ray showed diffuse fine reticular interstitial opacities in both bases of the lung. A CT scan of the brain showed an extensive old infarct of 9.0×3.0 cm involving the right temporal and parietal lobe in the corresponding territory of the right middle cerebral artery. A subtle right para-sagittal hypodensity was seen in the frontal region representing a recent infarct involving the right anterior cerebral artery territory (figure 1A, B).

The patient was assessed in hospital by a neurologist. She was diagnosed suffering from multiple large old and recent ischaemic stroke and aspiration pneumonia. Inpatient treatment included intravenous fluids, oxygen therapy via face mask at 8 L/min continuously, ceftriaxone 2 g intravenous stat dosage followed by 1 g intravenous daily for 7 days, metronidazole 500 mg intravenous three times a day for 7 days, pantoprazole 40 mg intravenous daily for 3 days and simvastatin 40 mg orally daily. Hypertension was treated with enalapril 10 mg orally two times a day and atenolol 50 mg orally daily. Diabetic treatment included metformin 1 g orally twice daily and insulin HR subcutaneous every 6 hours according to a sliding scale appropriate for the elderly. A nasogastric tube was inserted for administration of oral medications, water and 600 mL of half strength feeding two times a day. A Foley catheter was inserted to monitor urinary

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Figure 1 (A): CT scan axial section of the brain taken on second admission to hospital demonstrating an old right extensive ischaemic cerebrovascular accident (CVA) affecting the right temporal and parietal lobe in the territory of the middle cerebral artery. (B): CT scan axial section of the brain taken on second admission to hospital demonstrating a recent right frontal region infarct in the territory of the right anterior cerebral artery—see black arrow.

output. Ted stockings and ripple mattress were supplied and physiotherapy performed three times per week. The patient improved gradually in 7 days and was discharged in wheelchair user with a GCS of 15/15 and a MMSE of 25/30 that showed poor attention and calculation (1), and construction (0).

Remote care

At the request of the patient and caregiver, the remote care of this patient with stroke was monitored continuously 24/7 under the supervision of a qualified general practitioner (GP) with practical training in neurology and the assistance of a caregiver from this admission to hospital to the present date. The caregiver had experience in using a smart phone, a laptop and the internet. The same senior neurologist was available for remote consultation by the GP.

Our patient's home was located in a low income village 60 km away from the GP office. The caregiver was initially trained by the GP to collect, process and transmit the patient's data by the use of a smart phone and a laptop with internet access. The GP and the neurologist also used similar technology.

The patient data consisted mainly of audio, photo images and videos taken by the patient's caregiver according to the physician instructions. During his visits to the patient's home, the GP also collected audio–video data, which were used to exchange with the neurologist. These audio, images and videos were transmitted using the application 'WhatsApp for Android'. The use of text messages and telephone calls were also implemented. A GP electronic signature and stamp were created to sign-seal referral letters, prescriptions and medical investigation requests, which were sent via email and printed remotely at a printing shop. Every morning and evening a text message was sent by the caregiver to the GP stating the condition of the patient, medical symptoms and need for a telephone call. If a telephone call was needed, health interviews of the patient and the patient's caregiver were conducted by the GP over the telephone. Information on patient with stroke health condition, vital signs, random blood sugar, drugs issues, new medical symptoms or limitations of the system were collected and addressed accordingly. The need for photo images, videos, audio recordings, messages, further telephone calls, prescriptions, referrals letters or medical investigation requests were determined and addressed during those initial interviews.

The physician visited the patient at home once every 2 weeks to provide additional training of the patient's caregiver to improve quality of the system, perform physical examination of the patient, administer parenteral medication when necessary, verify that the instructions given remotely were followed accordingly and address further concerns. The remote care of the patient focused on the management of the main modifiable factors that occurred such as multiple crisis of hypertension and hypotension, moderate to severe hyperglycaemic episodes, aspiration pneumonia on three occasions, acute gastroenteritis on three occasions, urinary infection on three occasions and moderate dehydration due to vomiting. The patient required hospitalisation on one occasion to treat a septic shock due to aspiration pneumonia and a seizure episode.

Complications such as seizures, dysphagia, neurogenic bladder and falls were managed as follows: The GP managed all these neurological events with the remote assistance of the senior neurologist via telephone calls and emails. The caregiver recognised the neurological events on presentation because the caregiver had been instructed at the beginning of the remote care about the potential complications. Once the event was recognised, the caregiver called on the GP assistance over a phone call and/or via email. The GP instructed the caregiver on first aid actions for the specific neurological event in order to prevent further complication, dos and don'ts and getting the assistance of a public ambulance service for onsite attention and possible transportation of the patient to the nearest health facility available. Concurrently, the GP called on the senior neurologist for remote assistance that was provided in every circumstance. The GP coordinated initial management of the complicated patient with the caregiver, paramedics and other doctors remotely using our model of teleneurology. During these medical complications: The GP saw the patient directly to verify all instructions were carried out correctly, but there was no need for the neurologist to examine the patient for those reasons. The patient was attended to in a local health centre or at home for the administration of medications, insertion of a nasogastric tube for feedings and oral drugs, insertion or change of a urinary catheter and assessment for falls but she was not admitted to hospital in those circumstances. Seizures were treated by giving 10 mg of diazepam intravenous stat followed by oral loading and maintenance dosage of phenytoin.

Table 1 The National Institutes of Health Stroke Scale (NIHSS) scores

Test	On admission	On discharge
Level of consciousness	2	0
Ask month and age	2	1
Blink eyes and Squeeze hands	1	0
Test horizontal extraocular movements	0	0
Visual fields	2	1
Facial palsy	1	1
Left arm motor drift	4	4
Right arm motor drift	0	0
Left leg motor drift	4	4
Right leg motor drift	0	0
Limb ataxia (FNF/heel-shin)	2	2
Sensation	1	0
Aphasia	2	1
Dysarthria	1	1
Extinction/inattention	1	0
Total Score	23	15

FNF; finger to nose to finger.

We introduced procedures and devices for falling prevention such as proper use of the cane during ambulation, organisation-cleaning of the patient room, toilet set, shower set, bed, chairs, eating table and other patient's environment to prevent falls and head trauma. Bladder training generally consisted of self-education, scheduled voiding with conscious delay of voiding and positive reinforcement. The procedure for the timely evacuation of intestinal content was also taught. Pelvic floor exercises as a technique used to tighten and tone the pelvic floor muscles were not indicated in our patient who had delivered 14 children successfully. Management of diapers and prevention of bedsores were also instituted. Urinary infections were treated without delay. Physiotherapy to prevent-manage dysphagia was instructed. Those exercises included, changing the head position while eating, exercises that retrain the musculature involved with swallowing, strength and coordination exercises for the tongue, lips or jaws. Proper sitting position for feeding and eating, chewing of small pieces of food and taking the time to chew and swallowing to prevent broncoaspiration were also emphasised. The remainder of complications and issues encountered were treated at home using teleneurology.

The patient's outcome was measured by the use of the National Institutes of Health Stroke Scale (NIHSS). The [table 1](#) shows the NIHSS scores and impairments on admission and on discharge.

Although only a moderate recovery occurred in the first week of onset of stroke, a great proportion of recovery occurred between 3 and 6 months later with good functional status at 6 months predicting long-term survival. The NIHSS scores and impairments at 3 months, 6 months, 1 year, 2 years and 3 years were 11 with partial hemianopia (1), no movements of the left arm (4) and left leg (4) and ataxia in two limbs (2).

GLOBAL HEALTH PROBLEM LIST

- ▶ Neurological diseases and injuries are a growing public problem in many countries.
- ▶ Delayed treatment for neurological conditions, for example, stroke or epilepsy is common around the world.
- ▶ Cost-efficient access to primary, secondary and tertiary neurological care is a global health problem.

- ▶ Improved access to neurological care will prevent unnecessary death, morbidity and disability.
- ▶ Unproductive travel time for neurologists and long waiting times to see a neurologist in hospital are reasons for overcrowding and adverse events.
- ▶ Technophobia, cost-efficiency uncertainties, lack of legal framework and fear of medicolegal risks.

GLOBAL HEALTH PROBLEM ANALYSIS

Stroke is the third most common cause of disability and second most common cause of death worldwide and neurological disorders constitute a large and increasing share of the global burden of disease. Rehabilitation play a major role in the outcome of ischaemic stroke and domiciliary care is an important phase of care.^{1 2} Implementation of a remote care monitoring system of patients with stroke using computers, telephones and internet access can facilitate the management of the modifiable factors that impact on the outcome and provide support.²⁻⁴ There is a paucity of information regarding national and subnational policies, programmes and resources for the treatment and management of neurological disorders.⁵ We focus on these issues from a global perspective and review what is published so far on this subject.

We report this case to not only illustrate how this model of teleneurology can be successfully implemented at all levels of neurological care of individuals with severe multiple strokes,^{6 7} but to also collate the available data on the use of teleneurology in the remote care of patients with many other neurological diseases and injuries^{6 8 9} such as multiple sclerosis,^{10 11} dementia,¹² epilepsy,¹³ neurosurgical care,¹⁴ Alzheimer's disease,¹⁵ Parkinson's disease,¹⁶ traumatic brain injury,¹⁷ neuro-ophthalmological conditions,¹⁷ neurophysiological disorders,¹⁷ abnormal movement disorders,¹⁷ post-traumatic headache,¹⁷ children and adolescent neurological diseases,¹⁸ migraine,¹⁹ spinal cord injury,^{20 21} neuro-oncological problems,²² neuropathological problems,²³ stroke t-PA treatment,²⁴ neurocritical care^{25 26} and pain care.²⁷ Furthermore, deep brain stimulation via telemedicine is currently used for patients with essential tremor,²⁸ Parkinson's disease,¹⁶ and primary dystonia,²⁹ and is under investigation for epilepsy, obsessive-compulsive disorder, Alzheimer disease, depression and other movement disorders.³⁰ Thus an increasing and impressive body of evidence has already been documented in this regard.

Use of teleneurology for conditions as mentioned above and also for other critically ill patients,²⁵ has been piloted successfully in Northern Ireland and other regions.^{31 32} Teleneurology consultations has been successfully used via email between two countries such as UK and Bangladesh.³³ Teleneurology by email is considered sustainable, safe, effective and efficient.³⁴ It has demonstrated clinical effectiveness in increasing access to neurological expertise, reducing patient and physician travel time, fostering communication and coordinated care and improving physician productivity. As systems of care and technology evolve, the role of telemedicine in neurological practice is uniquely positioned to add significant value with improved outcomes and cost reduction as measurable goals.³⁵

Projects on teleneurology that require great investments on technology, operational and technical support, and maintenance are prohibitive because healthcare stakeholders want cost-effective systems. The teleneurology model should also consider local and regional factors including experiences and culture in different countries. Many reports have dealt with the cost and efficiency of telemedicine.^{36 37}

The UK government has enthusiastically promoted telehealth as a way to cut NHS costs and improve care.^{38 39}

Table 2 Advantages and disadvantages of teleneurology

Advantages of teleneurology	Disadvantages of teleneurology
There is an increasing and impressive body of evidence in favour of teleneurology.	Technophobia, cost for technology, reimbursement issues, risk of malpractice and absent of a legislation are against factors.
Reduced outpatient visits, travel time, burden on hospitals and expenses. Teleneurology can save lives, time and money.	Direct patient examination and procedures cannot be performed. There is risk of bureaucracy, low quality service and altered doctor–patient relationship.
Increased educational opportunities, continuing medical education, health promotion and supervision.	Political interests and changes could affect long-term outcome of teleneurology.
Virtual clinical rounds, second or specialised or multiple opinions, and easy recruitment of patient into trials.	Requires licensing and registration for practice for out-of-state or offshore physicians using teleneurology.
High customer and healthcare provider satisfaction survey scores especially due to reduction in geographical, ethnic and social and economic disparities.	Customer and healthcare provider satisfaction can be compromised due to loss of confidentiality.

Telecommunication technology has advanced and costs have declined over the past decade and will continue doing so in the near future. Since most families currently have a computer, a smart phone and internet access and a member of the family usually can serve as caregiver,⁴⁰ the only extra expense may be the GP and neurologist professional fees. However, by having the organisational support, physicians could use their own computers, smart phones and internet access service to take care of groups of patients using this model. Doing so, the cost of teleneurology can be reduced. Table 2 summarises the limitations and benefits of teleneurology.^{35 41–47}

The use of this technology for low-income countries to provide support for high-risk patients with stroke has also been recommended by the United Nations, The American College of Physicians, The American Stroke Association and over 85% of leading USA neurology departments.^{48–55} Also, addressing reimbursement issues may facilitate broader application.⁵⁵ Currently, 48 states in the USA and the District of Columbia provide some form of Medicaid reimbursement for telehealth services and 32 states in the USA and the District of Columbia have some kind of private payer policy for telehealth. Medicare.gov states that its system covers reimbursement for telehealth services provided by physicians and nurses only if the patient is physically present at a healthcare or nutritional facility and the communication between the provider and the patient was audio and video recorded.⁵⁶

The two most significant successful initiatives on telemedicine and teleneurology for the Caribbean region are The SickKids-Caribbean Initiative: Enhancing Capacity for Care in Paediatric Cancer and Blood Disorders and The Pan American Health Organization (PAHO)/WHO: eHealth conceptual model and work programme for Latin America and the Caribbean. The first initiative covers six Caribbean countries and has assisted 228 families with 223 consultations and 19 children received free surgeries from 2004 to 2013 in Trinidad and Tobago. The second initiative has provided many activities for the development, implementation and execution of national eHealth strategies in the Americas and the Caribbean.^{57 58} Thus there is some evidence that collaboration at governmental and University level has begun with international institutions as an option for enhanced healthcare delivery.

Our patient was out of the therapeutic window for thrombolysis (3–4.5 hours) using alteplase (rt-PA). In addition, the patient had a previous large stroke, diabetes mellitus and poorly controlled hypertension with an admission NIHSS score of 23, which are considered contraindication for rt-PA. Our use of teleneurology was patient–caregiver driven to serve a public need. Albeit on a limited scale, many GPs are successfully implementing our model around the world by taking telephone calls, emails and supervising care by home visits directly or indirectly but the process needs to be formalised so that the rules of engagement are agreed on. Our GP invested a total of 6.16 hours per patient monthly and the time rate of the neurologist was insignificant: 1 hour/month during management of the patient while in hospital and 5 min/month during the remote care. Based on our experience, we estimate a GP can manage 5 patients daily on average using our model. Under these circumstances, 2 of 25 of those patients will need a session of a neurologist input. So, we feel that our model can be expanded to a large number of patients but in large populations additional staff may be required. Our experience is that the patient, caregiver, GP and neurologist were pleased by the personal interaction, the clinical benefits and the cost of teleneurology in this case.

In conclusion, a teleneurology model assisted our patient, caregiver and us. This patient driven model, born out of necessity and supported by the cumulative global evidence on the subject, suggest that improved access to primary, secondary and tertiary levels of neurological care in remote and underserved regions of the world is a feasible way forward. A larger case series with a control group is obviously necessary and is an area of further research. This is a global issue that requires urgent consensus and actions by stakeholders.

Patient's perspective

After suffering my second stroke, I found myself once again unable to walk and basically took care for myself. I became dependant on a caregiver. Since I live in a rural remote district, it was really a time consuming task for the doctor to provide care to me as often as I needed it. So my doctor began providing care to me via the caregiver by the use of the telephone, computers and the internet. At first, when my caregiver started the home care, using this technology, I was a bit skeptical but I went along because my condition was so bad that I was willing to try anything. So, I gave my consent and continuous support. There were times when I felt like I wouldn't make it but then I would hear my caregiver on the telephone with the doctor and that was really a great source of encouragement for me. He provided useful advice and I was comforted knowing the doctor was easily available. Voice, text and face to face exchanges were reassuring. There were also times when my caregiver had to call the doctor to administer drips and injections to which he promptly responded. However, I can today safely say that even though there were doctors who said my condition was critical and my chances of survival was narrow, today I am still able to move around with a cane, read the newspaper, eat on my own, watch television and still help around the house. For these reasons, I strongly recommend that a lot more doctors use this teleneurology system on a daily basis. I say thanks to my caregiver, my doctor, this teleneurology system and most importantly God for this opportunity to contribute with my case to help people through technology.

Learning points

- ▶ The use of teleneurology to improve access to neurological care, especially in remote and underserved regions of the world, is being accepted globally.
- ▶ Teleneurology can provide specialised neurological care remotely and help to relieve burden on hospitals.
- ▶ New evidence is gradually overcoming the disadvantages of teleneurology.
- ▶ Successful global implementation of teleneurology requires not only willingness and trust by the relevant stakeholders but adaptation to local resources and culture.

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