

Telemedicine and Thrombolysis for Acute Stroke in Northern Ireland

**A report by the European Centre for Connected
Health**

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Preface

The European Centre for Connected Health (ECCH) was established in Northern Ireland in January 2008 by the Minister for Health in the Northern Ireland Assembly, Michael McGimpsey MLA. As part of its remit the Minister undertook to see how telemedicine approaches might improve stroke services. This report, commissioned by the ECCH, is the first step in this process.

There are two relevant reports on stroke services in Northern Ireland which we have considered in preparing this report. A new Northern Ireland stroke strategy, "Improving Stroke Services in Northern Ireland"¹, was announced on 9 June 2008. This report sets time-defined standards for stroke care. The standard for acute care is that 50% of suitable patients should receive thrombolysis within 3 hours of their stroke by 31 March 2011. The latest draft of the Service Framework for Cardiovascular Health and Wellbeing² states that "All patients with suspected acute stroke should have rapid access to specialist assessment, appropriate brain imaging and emergency treatment, including thrombolysis".

We wrote to our colleagues in neurology, elderly care medicine, radiology and emergency medicine asking for their comments on what we were doing and are grateful to those who replied.

The authors have considerable experience of both stroke and telemedicine. Victor Patterson has been a consultant neurologist in Northern Ireland from 1983-2008 and is an Honorary Professor at Queen's University, Belfast. He has been a pioneer in applying telemedicine to all aspects of neurology including acute neurology and has published books and journal articles on the scientific basis underpinning this. Ken Fullerton has been a consultant in Elderly Care medicine, with a special interest in stroke at Belfast City Hospital since 1995, with prior consultant level appointments in Craigavon (1988-95) and the University of Manchester (1986-88). During all of this time he has been closely involved with service development and innovation for stroke patients. He has published regularly on aspects of stroke.

I Executive summary

Stroke is a common and devastating medical condition which has important and costly consequences for individuals, families and local health services. The use of intravenous thrombolysis for patients with cerebral infarction is an important treatment which reduces deaths and disability resulting from stroke and consequently the cost of stroke to health services. Currently the use of thrombolysis in Northern Ireland is extremely low with only about 3% of suitable patients receiving this treatment. The Department of Health Social Services and Public Safety has set standards for this to be improved. Telemedicine has been shown to be an effective, safe and timely way to connect stroke patients to stroke specialists and seems a particularly useful method for the delivery of acute stroke care in Northern Ireland with its comparatively large number of acute hospitals. No other method is likely to be as efficient in its use of available stroke specialists or as equitable in delivering this treatment to stroke patients in rural areas.

II Stroke

Overview

Stroke is the third main cause of death in adults in Northern Ireland, after heart disease and cancer, and the single greatest cause of adult disability. It kills three times as many women for example as breast cancer.

Over 4000 strokes occur in Northern Ireland every year. Of these, approximately one third will make a full recovery, one third will die in the first month and one third will be left with substantial disability and will be dependent on others for everyday activities for the rest of their lives.

Cost

Having a stroke produces direct costs to the NHS such as acute hospital treatment, rehabilitation and nursing home care together with indirect costs to the sufferer and their partner or carer in terms of lost earnings. These have been estimated as a lifetime cost of about £20 000 per stroke or £80 million in Northern Ireland each year.

Differential diagnosis

Other conditions can mimic a stroke and the diagnosis is not always straightforward^{3 4}. Patients may be diagnosed as a stroke when they have another condition and also patients who do not have a stroke may be misdiagnosed as having one. The extent of stroke misdiagnosis rate in Northern Ireland is not known but in unselected acute neurology misdiagnosis is as high as 40%⁵.

Different pathologies

Stroke can be caused by two different pathological processes within the brain. Infarction, in which brain tissue dies due to lack of blood supply, accounts for about 85% of strokes. Haemorrhage, which may be subarachnoid (arising on the surface of the brain) or intra cerebral, accounts for the remainder. It is important to distinguish between the two pathologies because both immediate and long-term management is different. Thrombolysis in the acute stage for example, is only relevant in patients with infarction.

Clinical management

There are a number of important ways in which stroke is managed medically. The first is prevention in which the risk factors which predispose to it are treated. Control of high blood pressure, cessation of smoking and reduction of serum cholesterol are some of these measures and this approach has been responsible for reducing the incidence of stroke over the last 20 years. Acute management of stroke is the subject of this report. After the acute phase come rehabilitation, long-term care and secondary prevention. All these approaches are highly relevant to individual patients with stroke and it is important to optimise each of them in order to minimise the disability and mortality resulting from the current stroke, and to prevent recurrence.

III Thrombolysis for acute stroke

Evidence for benefit

Thrombolysis is the administration of a drug which dissolves recently-formed blood clot. It has been used to treat heart attacks for some years but its importance in treating stroke when given intravenously was first shown in 1995⁶ when, in a large study from North America, alteplase reduced the number of people dying or being left severely disabled from acute stroke caused by cerebral infarction. A review of all the reported evidence by the Cochrane Collaboration⁷ suggests that for patients treated within three hours of stroke, thrombolytic therapy reduces death or dependency (OR 0.66, 95% CI 0.53 to 0.83) with no statistically significant adverse effect on death (OR 1.13, 95% CI 0.86 to 1.48), but increases the risk of symptomatic haemorrhage (OR 3.37, 95% CI 2.68 to 4.22). The National Audit Office has estimated that introducing thrombolysis in England and delivering it to 9% of those suffering from acute stroke would cost around £9.9 million per year, but there would be £26.4 million savings in care costs, mainly through the avoidance of long term disability and dependency⁸. This equates to an annual saving of £ 560 000 in Northern Ireland.

Thrombolysis may also be administered into a cerebral artery in some patients. Intra-arterial thrombolysis is indicated in many fewer patients than intravenous thrombolysis. The evidence for this is less robust⁹ and it and other intra-arterial treatments should only be given in a specialised centre by an interventional neuroradiologist and we will not consider this further in this report.

Practical issues

There are two unique factors about intravenous thrombolysis for acute stroke: first, it must be given within 3 hours of stroke onset and second it has the capacity to do harm to individual patients by causing intracerebral haemorrhage. These two factors have a profound impact on how the treatment is used in everyday practice and raise issues related to patients, doctors and organisations.

Patient-related issues

To avail of the benefits of this treatment, patients must get to the hospital as soon as possible after the onset of their symptoms. Many people don't want to cause a fuss and wait in the hope their symptoms will disappear and others contact their general practitioner rather than the emergency services. There is

a problem for those whose symptoms are noticed on awakening because their symptom onset must be taken as the time they went to bed, which usually precludes thrombolysis. Public awareness campaigns have been launched to increase public awareness of stroke symptoms and to designate stroke as a medical emergency

Organisational issues

Ambulance services need to be aware of the urgency of the situation as do the staff of hospital Emergency Departments. Between arriving at the *door* of the Emergency Department and receiving the intravenous infusion of the thrombolytic drug (*needle*) the patient needs to undergo triage, clinical assessment of their neurological state, have a CT scan of their brain and have it interpreted, have a number of blood tests and their result obtained, have their consent obtained and have a final assessment of their suitability for treatment. *Door to needle* time should be less than an hour so highly efficient organisation is required. Emergency departments receiving acute stroke patients need to have access to clinical expertise and CT scanning 24 hours per day, 7 days per week since stroke is no respecter of office hours. After thrombolysis there must be inpatient beds of appropriate dependency to continue the infusion of the thrombolytic drug, control blood pressure and deal with any complications.

Medical issues

To take responsibility for thrombolysis of a patient with acute stroke a doctor must be confident that the diagnosis of stroke is correct, that it is an infarction and not a haemorrhage and that it meets the selection criteria for the treatment. They must also be aware that their treatment may make the patient get worse and not better. Not all doctors, even those with an interest in neurology or stroke, are comfortable with these requirements. If there is any organisational difficulty it is easier for the doctor not to give thrombolysis. However a study from the USA of the medicolegal aspects of thrombolysis showed that the majority of successful claims arose from failure to give the treatment rather than from side-effects arising from it¹⁰.

Licensing arrangements

Thrombolysis is currently licensed in the UK to be used within 3 hours of acute stroke, but must be delivered by those with appropriate experience in acute stroke care, after appropriate imaging. These criteria are set in the product specification¹¹ and in the National Institute for Health and Clinical Excellence (NICE) guidelines¹². It is estimated that around 10% of acute stroke sufferers would benefit from thrombolysis, but this means that all acute stroke sufferers must be assessed rapidly to differentiate those who would benefit from those most likely to be harmed by the treatment. The earlier after stroke onset that

this treatment can be delivered the better the outcome¹³.

Experience in Northern Ireland

Northern Ireland has a mixed urban/rural population. Recognised specialists in stroke medicine and neurology exist in some major hospitals in the Belfast conurbation, but most of the Northern Ireland population is served by a network of smaller general hospitals for their acute needs, including stroke care. Most do not have sufficient stroke specialists to deliver thrombolysis, other than on an ad-hoc basis. Within Belfast, two hospitals deliver thrombolysis on a regular basis, but there are major difficulties in providing the service out of hours, mainly due to the lack of availability of stroke specialists on individual hospital sites. Discussions are currently taking place about the possibility of delivering a more comprehensive service within Belfast by a combination of service development, appointment of new staff and rationalisation of the points of delivery. Although this might eventually result in better access to Belfast residents, delivering this service only within Belfast raises very significant issues about equity of access for the large part of the Northern Ireland population which lives outside the Belfast conurbation.

A European registry (SITS-MOST) has been used to monitor the use of thrombolysis in acute stroke throughout Europe¹⁴. The United Kingdom (UK) lags significantly behind the rest of Europe in terms of the number of patients who are thrombolysed, and Northern Ireland lags well behind the rest of the UK (Professor K. Lees, personal communication).

Patients thrombolysed in last year

It is estimated that around 10% of stroke patients will benefit from thrombolysis. This means that each year about 400 patients should receive intravenous thrombolysis for acute stroke in Northern Ireland. In the last year in Northern Ireland, nine patients received intravenous thrombolysis in the Belfast Trust (Royal Victoria and Belfast City Hospitals), one in the Ulster Hospital (which is situated within the Greater Belfast area), and one in Daisy Hill Hospital (Newry), a total of 11. In other words 97 % of suitable stroke patients are not receiving a potentially beneficial treatment.

IV Use of Telemedicine in thrombolysis

Definition of telemedicine

Telemedicine is the practice of medicine by means of modern communication technology when the doctor and the patient are not in the same place. Telemedicine is not a new concept as the telephone has been used to deliver such care for many years. The type of telemedicine most relevant to stroke care uses a real-time videolink between patient and doctor. There are also types of telemedicine which are not done in real time which use email or webservers, the latter being particularly important in teleradiology.

Description of telestroke set-up

There are three components to any real-time videoconsultation, the patient's end, the doctor's end and the means of communication.

The patient's end

The patient with a possible stroke suitable for thrombolysis will be in the hospital Emergency department with a doctor and may have had a CT scan of their brain. In the room, which should be well-lit, will be videoconferencing equipment which will transmit audio and video of the patient to the receiving doctor. The receiving doctor will be able to take a history directly from the patient and relatives, watch and direct an examination performed by the doctor who is with the patient, and explain the suitability, risks and benefits of thrombolysis. The CT scan images should be instantly available on a webserver so they can be reviewed by the receiving doctor.

The doctor's end

The doctor must have access to videoconferencing equipment which can both transmit an image of his or her face to the patient's end and also control the movements of the camera there, which is necessary for parts of the examination. Access to the appropriate radiology webservers needs to be available so that the CT scan images can be reviewed. This equipment should be available to the doctor both in their hospital and home. The equipment, and its connectivity to sites at which patients will be assessed, needs to be used or tested regularly.

Means of communication

The two modes of transmission used for clinical videoconferencing are digital telephone lines (ISDN) and the internet (Internet Protocol or IP). The former are fixed telephone lines which incur an installation and rental cost as well as a call cost but provide transmission of near 100% reliability. ISDN at a transmission speed of 384 kilobits per second (kbs) is the gold-standard for

neurological videoconferencing. There are two sorts of IP which can be used; the local NHS system in which internal communication is easily supported but real-time bidirectional communication with the outside is very difficult because of NHS firewalls. IP videoconferencing is possible using commercial broadband suppliers and fixed telephone lines. Installation and rental charges are less and there are no call costs but the system is not as reliable as ISDN. CT images on an NHS webserver are easily accessed within the NHS and are less problematic to access outside the NHS.

Evidence for effectiveness

Acute neurology

Real-time videoconferencing for patients with acute neurological symptoms including stroke has been practised in Northern Ireland since 1999. In a series of papers it has shown to be feasible¹⁵, acceptable¹⁶, safe¹⁷, effective¹⁸ and cost-effective¹⁹, reducing median bedstay from four to three days when compared to conventional district general hospital care.

Acute stroke

Since 1999 there have been a number of published reports describing the use of real-time videoconferencing to allow a stroke expert to give thrombolysis to a stroke patient at a remote hospital. Assessment of stroke using the National Institutes of Health Stroke Scale (NIHSS) has been shown to be accurate when assessed by videolink compared with conventional face-to-face examination²⁰²¹. CT image interpretation by stroke neurologists also shows excellent agreement with the gold-standard of interpretation by a neuroradiologist when both webserver images and DICOM-compressed images were used²². There was perfect sensitivity and specificity for the determination of eligibility for thrombolysis by the stroke neurologist viewing images this way. There have been a number of formal studies from the USA and Europe which have shown that telestroke can achieve similar efficacy to face-to-face studies with no excess of cerebral haemorrhage rates²³⁻²⁷. The door-to-needle time is less with telestroke than in situations where patients were transferred to a stroke centre by helicopter²⁸. Telemedicine by videoconferencing is superior to telephone advice²⁹ and the technique can be learnt easily by previously telemedicine-naive doctors³⁰.

Current telestroke activity

At present there are about 17 telestroke centres in the USA and 11 in Europe who assess about 3500 stroke patients each year and thrombolyse about 700 of these (Audebert H, personal communication). Importantly for any service this means that four out of five patients assessed for thrombolysis will not be suitable and it is important that their medical needs are met. There is no experience of thrombolysis this way in Northern Ireland.

V Possible use of telemedicine for thrombolysis in Northern Ireland

How it might work

The way in which telemedicine services might work is set out below.

There are a number of points which arise from this. First, each step has protocols which have been well-established in other settings. Second, a big advantage is that a limited number of doctors with expertise in acute stroke are required to organise a 24 hour per day, seven day per week service compared to local delivery of acute stroke services at each of the 14 hospitals where stroke patients are admitted at present. Third, uniquely with telemedicine, it is possible to use stroke doctors from outside Northern Ireland, either from other parts of the UK such as Scotland or intercontinentally³¹. This last option may be particularly useful at night since the providing doctor will be in a time zone where it is daytime, and is therefore more likely to be alert. Fourth, the system can coexist with a face-to-face thrombolysis service where one exists, being used only when such a system is not staffed by an on-site acute stroke doctor. Fifth, unexpected absence of a single stroke doctor will have less impact on service delivery.

At the end of the process the patient may be transferred for appropriate care to the Stroke Unit or High Dependency Unit within the hospital or transferred to a hospital with more intensive facilities, a process sometimes called “drip and ship”.

Conventional alternatives

Ad-hoc local thrombolysis.

This is the system in place at present and it has palpably failed to deliver a thrombolysis service throughout N. Ireland. To provide an effective service this way is difficult partly because of the large number of hospitals which receive acute stroke patients but also because of a shortage of physicians with interest and expertise in acute stroke management. This makes it simply not feasible to provide 24 hour care, seven days per week to all eligible patients.

Larger acute stroke centres.

This is a possible solution in the Greater Belfast area where the Royal, City, Mater, and Ulster Hospitals (and possibly also Lagan Valley and Whiteabbey) might conceivably designate one hospital to be a single Acute Stroke Centre to which all patients with suspected acute stroke would be taken by the ambulance service, bypassing nearer hospitals. This solution is not likely to be applicable outside Greater Belfast because of the increased distances and therefore increased ambulance transport times which would be necessary.

Acute stroke centres with helicopter transport.

This is a possible way of making thrombolysis accessible to acute stroke patients living rurally. It could enable stroke centres to be set up outside Belfast but this would still be hampered by the lack of availability of acute stroke doctors.

Comparative quality of care

We have used the six dimensions of quality proposed by the Institute of Medicine in the USA³² to compare the possible solutions to providing thrombolysis for acute stroke in Northern Ireland. Comparisons are set out in Table 1 and indicate that thrombolysis by telemedicine has advantages in most quality dimensions.

Effectiveness and Timeliness.

In the context of a treatment which must be delivered within three hours of the first symptom, these two dimensions are essentially the same. The current system scores low, acute stroke centres score higher for those patients that they treat but the score is less good when the patients they don't treat is taken into account. This will be better when a helicopter is used. A telemedicine system delivered to local hospitals should be timelier and therefore more effective.

Patient-centredness.

Patient acceptability is one part of patient-centredness. Studies with telemedicine are usually favourable³³ and there are insufficient studies of acceptability of helicopter flights. Patient-centredness however also implies having access to the best available treatment and so in this context is the same as effectiveness and timeliness.

Efficiency.

This dimension will take into account the infrastructure and medical staff costs as well as the costs to society of failing to prevent disability. With the current ineffective system these are considerable although it is at least inexpensive to run; however if it was feasible to run on a 24 hours per day, seven days per week basis at all 14 hospitals it would be enormously expensive in terms of medical costs. A single Acute Stroke Centre, like telemedicine, requires a single rota but untreated rural patients will increase societal costs. Multiple stroke centres with helicopters incur large rota costs and colossal infrastructure costs if available helicopters are required although societal costs will be less. Telemedicine requires modest infrastructure costs by comparison to this and societal costs will be less.

Safety.

There is no evidence that there is any difference between assessment face-to-face used in acute stroke centres and by telemedicine.

Equity.

The current system is not at all equitable as patients are selected for treatment based on place of residence and time of presentation. Rural patients are disadvantaged when care is delivered by an Acute Stroke Centre. This is lessened by multiple centres supported by helicopter but telemedicine is

particularly equitable as patients are managed at their local hospital.

	Effectiveness	Timeliness	Patient-centredness	Efficiency	Safety	Equity
Present ad-hoc	3	3	3	3	1	3
Acute Stroke Centre	2	2	2	2	1	3
Acute Stroke Centres with helicopter transport	1-2	1-2	1-2	3	1	1
Telemedicine	1	1	1	2	1	1

Table 1 Quality dimensions of acute stroke management systems (1 = good, 2 = average, 3 = bad)

VI Conclusion

There is clear evidence that acute stroke services in Northern Ireland need to be improved. Currently there are two reports from the Department of Health, Social Services and Public Safety (DHSSPS) of the Northern Ireland Assembly which are germane to this problem. A Service Framework for Cardiovascular Health and Well-Being², which is currently out for consultation, recommends that all patients with suspected acute stroke should have rapid access to specialist assessment, appropriate brain imaging and emergency treatment, including thrombolysis. The DHSSPS Stroke Strategy, Improving Stroke Services in Northern Ireland¹, recommends that, by April 2010, the DHSSPS should put in place a regional managed approach to the integration and delivery of stroke services to ensure equity of access across the region. Both reports set standards but neither is specific about how these standards can be delivered. We have shown that telemedicine is a possible way of delivering these standards in an equitable and efficient manner, throughout Northern Ireland.

Given that thrombolysis reduces death and disability and saves money then it is clearly important to increase the number of people receiving it. A public education campaign may get more people with stroke to hospital earlier but there is little point in this if the facilities in hospital are not able to deal with them. This is presently the case in most hospitals in Northern Ireland. One of the reasons for this is a shortage of local doctors comfortable with the emergency nature of dealing with acute stroke.

We have set out compelling evidence that telemedicine can not only provide a high quality service for patients with acute stroke but also do so with fewer experienced acute stroke doctors. Its practical advantages are first, that it needs many fewer such doctors to provide a service throughout Northern Ireland than face-to-face systems based at individual hospitals and so is likely to be less expensive than any other effective model. Second, if necessary stroke doctors from other parts of the UK or elsewhere can help deliver the service. The necessary skills to practise acute neurology by videolink are easily acquired and the infrastructure costs small compared to the societal costs of poor acute stroke management.

VII Acknowledgements

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