The scope for improvement in hyper-acute stroke care in Scotland

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ABSTRACT

Thrombolysis is associated with reduced disability for selected patients who have suffered ischemic stroke. However only a fraction of all patients who have suffered this type of stroke receive thrombolysis. The short time window of 4.5 h in which treatment is licensed means that rapid care and well-organized pathways are essential. We studied measures to increase the uptake of thrombolysis through a better understanding of the hospital delays which lead to a lack of timely brain scanning and diagnosis. We examine the factors influencing the number of thrombolysed patients, the time between arrival at hospital and the administration of thrombolysis (door to needle time).

Our analysis is based on the Scottish Stroke Care Audit (SSCA) data covering all stroke patients admitted to hospitals in Scotland in 2010, as well as on interviews with stroke care staff in Scotland. The data show significant variation in the speed of scanning, thrombolysis treatment and number of patients receiving treatment among hospitals. In the best performing hospital, 68% of patients arriving within 4 h of stroke onset are scanned in time for thrombolysis compared with 40% on average and 5% in the worst performing hospital.

We model the system as a discrete-event simulation following the patient journey, starting when patients have a stroke and ending at thrombolysis for those who qualify. The simulation results show that just improving the performance of all hospitals to the level of the best performing hospital would (even without improvements in onset to arrival times) increase the thrombolysis rate from 6% (in 2010) to 11% of all admitted stroke patients in Scotland. By 2013 9% of patients were receiving thrombolysis, suggesting there is still room for improvement.

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1. Introduction

Stroke has enormous consequences for individuals and societies. It is a leading cause of death in many countries; in the UK and the US it is the leading cause of disability. A stroke can either be caused by a bleed in the brain (hemorrhagic stroke; about 10%–15%) or a blockage of a blood vessel in the brain caused by a blood clot (ischemic stroke; about 85%–90%). For acute ischemic stroke the early intravenous administration of recombinant tissue plasminogen activator (tPA) to dissolve blood clots (thrombolysis) significantly reduces the risk of disability [1,2]. Thrombolysis has been shown to increase the odds to be symptom-free or only have mild non-limiting symptoms (modified Rankin scale 0 or 1) within three months of the stroke event, especially when given early after stroke onset [2]. Although it is currently the only licensed treatment for acute stroke, thrombolysis rates are still low in many countries.

Thrombolysis carries risks and is usually only appropriate for ischemic stroke patients within a 4.5 h time window after the onset of stroke. Importantly, due to the risk of secondary hemorrhage, thrombolysis is inappropriate for patients with significant comorbidities or pre-existing bleeding risk, such as a hemorrhagic stroke, recent surgery or other predisposing medical conditions. The earlier thrombolysis is given the greater the benefit of the treatment [3,2].

The time window during which thrombolysis can be given depends on an assessment of the diminishing benefits of thrombolysis versus increased risk of causing bleeding as the infarct becomes

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established. In Scotland, current guidelines recommend thrombolysis within 4.5 h from the onset of stroke. This is challenging, given the time taken to recognize symptoms, call emergency services, deliver the patient to a hospital with thrombolysis provision, scan the brain, interpret the scan and decide on the appropriateness of thrombolysis. Only then can treatment be administered. To meet this challenge, the general public needs to understand the signs of stroke and its seriousness, the ambulance service needs to pre-alert accident and emergency departments and transport patients with urgency, and the receiving hospitals need to respond quickly and efficiently.

In this paper we focus on the delays within hospitals. We examine both the factors influencing the overall thrombolysis rate as well as the time from arrival at the hospital to thrombolysis, the "door to needle time" [4]. In particular, we investigate what the potential is to increase the number of people who can be thrombolysed through improvements in treatment availability and the speed of "in hospital" processes.

We have employed a discrete event simulation (DES) approach as this is well suited to model the cumulative effect of the probabilistic delays which impact thrombolysis delivery. Discrete event simulation has previously also been employed for high level models of the overall stroke pathway [5,6], to estimate budget impact of thrombolysis provision [7,8], and specifically the cost-effectiveness of guidelines to reduce hospital processing times in order to increase tPA rates [9]. The application of DES in stroke care spans the whole care pathway from analyzing measures to reduce the time between stroke onset and arrival in hospital [10], measures to reduce in hospital delays [11] to understanding problems around delayed discharges [12].

We have analyzed the 2010 Scottish Stroke Care Audit (SSCA) dataset[1] covering all admitted stroke patients in Scotland (with the exception of Lanarkshire). This dataset includes variables describing patient characteristics, the admitting hospital and the treatment received. Importantly, it also includes the key times describing the patient journey: the time of the stroke, the time of arrival at the hospital, the time of brain scan and, if relevant, thrombolysis. As part of this study, we also conducted 9 semi-structured interviews (see Appendix) of about 45 min each with stroke care staff across Scotland. These included clinical leads responsible for stroke care in different health boards. The interviews covered care delivery to stroke patients along the care pathway including ambulance service, out-of-hours coverage as well as in hospital processes. We asked about information flows between ambulance, A&E and radiology and about possible delays in the pathway and the interpretation of brain scans and about arrangements for out-of-hours thrombolysis services. We also enquired into barriers and incentives around thrombolysis provision.

2. Empirical data analysis

2.1. Stroke care in Scotland

Every year about 8000 patients are admitted to hospital with a stroke in Scotland. About 90% of these strokes are ischemic strokes. The percentage of all strokes that have been treated with thrombolysis doubled from 3% to 6% between 2008 and 2010. This increase was driven by the wider recognition of the value of thrombolysis, and strong policy interest in the expansion of this treatment. It was achieved through better coordination of services

and an expansion of thrombolysis services across the country. However, in 2010 universal access was still limited by the fact that in some hospitals thrombolysis was only offered during part of the day or not at all.

Fig. 1 shows a map of Scottish hospitals showing their thrombolysis provision in 2010: 8 hospitals were not providing the service, 4 hospitals were providing service during work hours only while 19 hospitals were providing 24/7 service.

For some areas the closest hospital with round-the-clock availability of thrombolysis is very distant, given the 4.5 h time constraint. Geography poses a specific challenge in the remote communities of Scotland where the distances (and therefore travel times) to the next hospital with a thrombolysis service can be large. We have analyzed the direct point-to-point aerial distances between the places where the stroke patients in our database live (which is not necessarily the location where the stroke occurred) and the nearest hospital as well as the nearest hospital with 24/7 thrombolysis service. On average a patient is one and a half times as far from a hospital providing a 24/7 thrombolysis service as from their nearest hospital (9.36 km vs. 6.57 km for median values and 18.67 km vs. 11.79 km for average values).

For most places in Scotland (with the exception of some very small hospitals in remote locations in the Highlands and Islands), the main limiting factor in providing a 24/7 thrombolysis service is not so much the availability of a CT scanner and radiographer to perform a brain scan, since there are arrangements for on-call radiographers, but the availability of out-of-hours stroke specialists to interpret scans, diagnose patients and decide on the appropriate treatment. This limitation can be addressed through the use of telemedicine to transmit brain scans and allow teleconsultation with a remote expert. At the time of the study, a number of stroke networks were being considered for this reason (interviews).

Clearly for a 24/7 thrombolysis service to be as effective as possible it will also be important to streamline stroke pathways for out-of-hours services. Elements of such pathways would include a pre-alert by the ambulance service to the hospital when a suspected stroke patient is being transported to the hospital, protocols to quickly identify likely candidates for tPA once the patient has arrived to hospital, measures to minimize delays in alerting an on-call radiographer if required, as well as a prioritization of stroke patients over non-urgent patients if other patients are also waiting for a CT scan.

2.2. Hyperacute stroke care in SSCA data

To better understand the state of stroke care provision in Scotland in 2010, we analyzed the delays in patient pathway using the 2010 SSCA data. First we analyzed the delay between the onset of stroke to hospital admission. The data show that in 2010 only a quarter of ischemic stroke patients reached hospital within 4 h of the onset of stroke. Given the almost inevitable 30 min delay in hospital patients arriving after 4 h are unlikely to be eligible for treatment. Moreover, ischemic stroke patients tend to arrive later than patients with hemorrhagic stroke: 25% of ischemic patients arrive within 4 h, compared with 30% of hemorrhagic patients. So three quarters of those with ischemic stroke were excluded from the possibility of receiving thrombolysis by their late arrival at hospital. In Scotland, attempts have been made to educate the general public about the symptoms of stroke to reduce this delay (the FAST campaign, Stroke Association, 2010), and the ambulance service is requested to reduce the time spent on scene and to transport the patients as quickly as possible to the nearest hospital providing thrombolysis.

As the process after arrival of the stroke patient at the hospital is under its direct control we focus on this part of the process for the

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[1] Data are extracted in each hospital from case notes by trained audit staff. The SSCA feeds back data to each hospital monthly, and publishes an annual report on stroke care in each acute hospital in Scotland.