Case Study: Project STREAM

STRoke detection by Electromagnetic Analysis at radio and Microwave frequencies.

The case for a new type of medical scanner for stroke patients

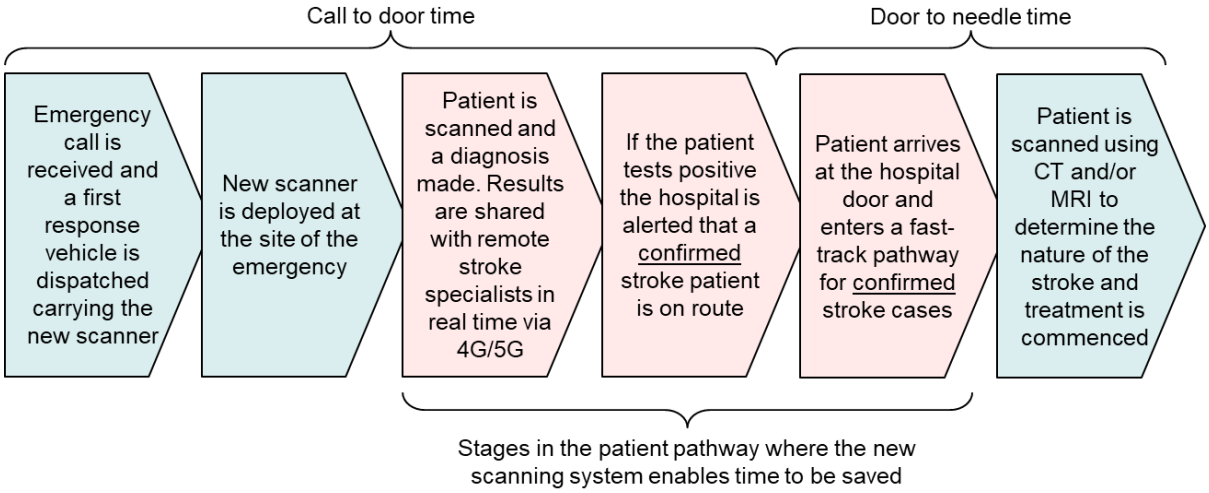
Background

Strokes are the 4th most prevalent cause of death and the leading cause of long-term invalidity in the UK [1]. Around 110,000 people experience a stroke each year and around 1.2M survivors are living with the consequences today. The treatment and rehabilitation for these patients, including the loss of productivity in the work place and the high volume of benefit claims, costs the UK economy around £26bn annually [1]. That figure is projected to reach £75bn by 2035 if the current trajectory is sustained. Given that the total healthcare expenditure in the UK for 2018 was £214.4bn which accounted for about 10.0% of GDP that year [2], it is clear that the cost of stroke alone is a significant percentage.

The scale of that cost is highly dependent on the proportion of stroke patients who survive their initial attack but go on to require protracted treatment and long term rehabilitation. A key influencer in the post-attack outcome for patients is the time that has elapsed between their symptoms first appearing and treatment being commenced. The shorter that period, the better is the outcome and the smaller is the proportion who require protracted and costly long term care. The often quoted mantra in medical circles, “time is brain”, perfectly sums up the criticality of stroke patients receiving treatment promptly in order to save as much healthy brain tissue as possible and lessen long term consequences. Stroke patients who receive treatment within the first hour following their stroke – the so called “golden hour” – have the highest probability of a good recovery, requiring little if any rehabilitation (assuming there are no pre-existing underlying health issues that dominate the outcome). However, once past the golden hour the long term outlook for surviving patients begins to decline, and beyond approx. 4 hours the outlook rapidly diminishes, with some degree of long term invalidity becoming inevitable. Typically around 66% of these patients leave hospital with a long term disability [1].

The current pathway for stroke patients requires them to be transported from the site of their emergency, which in many cases could be their own home or place of work, to an acute stroke unit to receive a CT and/or MRI scan. Only then can a conclusive diagnosis be made on whether the patient has indeed experienced a stroke and which type (Ischaemic: i.e. a clot, Haemorrhagic: i.e. a bleed) and commence the appropriate treatment. Delays, sometimes significant, can occur at several points between the emergency call being made and treatment commencing. In the UK, thrombolysis treatment for an ischaemic stroke (which are about 85% of all cases) is only licensed to be administered to patients within 4.5 hours from the onset of their symptoms [1]. If the time when symptoms began is unknown, or it is known that more than 4.5 hours have elapsed since symptoms began, the treatment cannot be provided. The outlook for those patients is inevitably compromised given that thrombolysis reportedly increases the chance of a good outcome by 30% [1]. If a positive diagnosis can be made at the site of the emergency, the door to needle time (i.e. the time between the patient arriving at the hospital door and treatment being commenced) could be shortened by

the attending paramedics at the site of the emergency alerting the acute stroke unit's specialist clinicians that a confirmed case of a stroke is now in transit. In addition, diagnostic data and images about the patient's condition could be shared with these clinicians in real time during the journey via 4G/5G mobile connections, enabling the stroke unit to be as fully prepared as possible to receive the patient.



This view of the possible is supported in a seminal review published in The Lancet [3]. It states, "Stroke physicians should be engaged not only in the in-hospital phase, but also in the pre-hospital phase of acute stroke management". A shortened door to needle time will help to increase the proportion of ischaemic stroke patients who are eligible to receive thrombolysis. That will help to increase the proportion of stroke survivors who require little or perhaps even no long term care and rehabilitation. Besides that being of huge benefit to those patients, it will also help to reduce the enormous cost of stroke to the nation.

The innovation

Heatley Consulting, a member of the Innovation Martlesham tech cluster at Adastral Park, is researching a new method of scanning that has the potential to transform stroke diagnosis [4]. Uniquely, the scanner can be brought to the patient and a diagnosis made at their location in complete safety. It uses low intensity electromagnetic waves in the radio frequency and microwave bands to detect the presence of a stroke affected region in the brain. No specialist shielding or bespoke high-voltage power supply is required which enables the new scanning system to be operated almost anywhere with no prior planning. The scanning methodology can be implemented using low cost COTS devices throughout and a compact, lightweight, portable construction ensures that it can be carried in ambulances and first response vehicles and quickly deployed at the site of the emergency. Such a scanner could also be widely deployed in hospitals on crash trolleys and operated at the bedside in emergency departments and high dependency wards, and similarly in nursing and care homes where there is a localised elderly population at an increased risk of stroke. The construction and operational carbon footprint of the scanner will be intrinsically low, and the absence of any form of ionising radiation and toxic materials avoids complex and costly end-of-life disposal directives.

Current status

An experimental scanning platform has been constructed that enables the underlying science in the new scanning system to be thoroughly studied and its performance assessed. It has enabled a comprehensive programme of scans to be performed on a suite of test subjects that are materially valid physical models (called phantoms) of a human head containing a stroke affected region in the brain. The size and location of that region can be selected in the phantoms to represent strokes of different severity and depth within the brain. Furthermore, the material contents of the affected region can be selected to represent a stroke caused by a clot (an ischaemic stroke) or a bleed (a haemorrhagic stroke). The results have conclusively demonstrated that the new scanning system is indeed capable of detecting a stroke affected region in the brain. The scans to date have focussed on ischaemic strokes which are about 85% of all cases [1]. Work is now in hand to extend the range of scans to include haemorrhagic strokes, and to determine how small and deeply located a stroke affected region can be and still be reliably detected.

Outlook

The current phase of development is aimed at producing a robust field-deployable concept demonstrator that can be evaluated in a hospital setting. The outcome of that evaluation will inform further refinements to the design, construction and operation of the demonstrator, with a particular emphasis on the clinician user-experience to deliver diagnostic imagery in a manner that is fully fit for purpose. That demonstrator and the refinements will then provide a blueprint for the construction of prototypes to facilitate initial trials.

References

[1] Stroke Association, “State of the Nation - Stroke Statistics February 2018,” 2018.

[2] “Healthcare Expenditure, UK Health Accounts: 2018,” UK Office of National Statistics, Release date: 28 April 2020.

[3] K. Fassbender, C. Balucani, S. Walter, S. R. Levine, A. Haass and J. Grotta, “Streamlining of pre-hospital stroke management: the golden hour,” The Lancet, vol. 12, pp. 585-596, June 2013.

[4] I. El rube’, D. Heatley, M. Abdel-Maguid, “Detecting a Stroke-Affected Region in the Brain by Scanning with Low-Intensity Electromagnetic Waves in the Radio Frequency/Microwave Band”, MDPI Healthcare, vol. 9, no. 9, 9 September 2021.

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