ORIGINAL ARTICLE

Mobile stroke unit triage of patients with a suspected stroke: a novel solution to reducing suspected stroke admissions in busy emergency departments

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ABSTRACT

Background Evaluation of patients with a suspected stroke is one of the most common neurological emergencies requiring rapid, comprehensive assessment by the stroke service to determine patient eligibility for timely reperfusion therapies. Prehospital evaluation may help to improve patient selection and reduce avoidable admissions to overcapacity emergency departments.

Methods and results We report on our early experience of prehospital triage of patients with a suspected stroke using a mobile stroke unit (MSU) equipped with CT scanner in rural Alberta. During the initial 4 months of operation, 28 patients were evaluated by the team in the MSU. Eight patients were within the time window of thrombolysis and were treated with intravenous tissue plasminogen activator in the MSU. No patients suffered haemorrhage or any other complications. Fourteen patients with multiple aetiologies (stroke mimics 6, transient ischaemic attacks 2, subacute stroke outside thrombolysis window 2, intracranial haemorrhage 3 and cerebral contusion 1) were assessed in the field and transferred to the tertiary hospital. Six patients after assessment and imaging were repatriated back to the local hospital as they were deemed stroke mimics or were outside of the reperfusion window.

Conclusions The MSU offers a novel approach to performing timely evaluation and treatment of patients with a suspected stroke in rural settings and may help reduce admissions to overcapacity tertiary care facilities.

INTRODUCTION

The introduction of intravenous tissue plasminogen activator (rt-PA) in the mid-1990s and the more recent evidence that thrombectomy may be highly effective in patients with acute stroke within 24 hours following onset of symptoms have revolutionised management of ischaemic stroke.[1–3] These treatments, especially thrombectomy with clot retrieval, require costly equipment and the expertise of specialised teams found only within comprehensive stroke programmes. In Canada, these programmes are only available in large cities, restricting access to patients from rural communities. In addition, while admission of patients with suspected stroke is one of the most common serious neurological emergencies, many such patients may not have a stroke, fewer than 10% are candidates for intravenous rt-PA and even fewer qualify for thrombectomy.[3] Successful selection of patients for these highly effective stroke treatments is time consuming, labour intensive and requires comprehensive stroke services.

The CT-equipped stroke ambulance, referred to as the mobile stroke unit (MSU), was recently introduced to improve time to treatment of patients with acute stroke.[4 5] Studies in the urban settings have shown that time to treatment can be expedited when the MSU is deployed.[5] The Edmonton Stroke Program recently introduced the MSU in

Canada and it is the first of its kind in the world to focus on a rural setting.

The objective of this 2-year pilot project is to evaluate the safety, feasibility, cost-effectiveness and cost benefit of administering early rt-PA (during transport) to a group of patients who would otherwise encounter treatment delays for ischaemic stroke due to prolonged transfer times from outlying areas to the University of Alberta Hospital (UAH) in Edmonton, Alberta.

The primary objective of this substudy is to evaluate the impact of MSU on reducing unnecessary hospital admissions to a tertiary centre. We report on our initial experience with triage of patients with a suspected stroke using the Stroke Ambulance.

METHODS

The study was approved by the Institutional Review Board at University of Alberta (Pro00037601). The UAH is one of two sites in Edmonton involved in the evaluation of approximately 2800 patients with a suspected stroke presenting annually to the emergency department (ED) and is the only tertiary care hospital for Northern Alberta with endovascular capabilities. In addition, patients suspected of acute ischaemic stroke within Northern Alberta are managed at one of 11 primary stroke centres through a telestroke-assisted thrombolysis network, in operation for over 10 years.[6] The UAH remains the primary referral centre for patients from Northern Alberta who cannot be managed within their home community. These patients account for 20%–25% of the stroke admissions to the UAH annually.

The MSU was implemented at the UAH in February 2017 as the 'first of its kind', novel technology in Canada with the primary objective of expanding timely assessment and treatment of patients with suspected hyperacute stroke residing in communities without timely access to CT imaging in Northern Alberta' (figure 1; stroke ambulance). The MSU is a custom-built ambulance (Demers, Beloeuil, Quebec, Canada) with a portable CT scanner (CereTom; Samsung, Boston, Massachusetts, USA), telestroke equipment (LifeBot, Phoenix, Arizona, USA) and 'point-of care' laboratory to perform a complete blood count, glucose and International Normalised Ratio (INR, (pocHi; Sysmex Canada) measurements. The specialised MSU team consists of a stroke fellow, CT technologist, registered nurse, primary care paramedic and advanced care paramedic. MSU catchment area is within a 250 km radius surrounding the UAH (figure 2). The operational design for deployment of the MSU is shown in figure 3. In brief, the MSU is dispatched by the UAH telestroke neurologist after telephone consultation with the rural ED physician. The Alberta Stroke Program based in Edmonton and Calgary is linked via an acute care hotline to all rural hospitals in the province. The admission of a 'suspected acute stroke' to any of the rural hospital

Figure 1 Mobile stroke unit based at the University of Alberta Hospital in Edmonton. The ambulance is equipped with a CT scanner, 'point-of care' laboratory and telemedicine equipment. The personnel deployed include one stroke fellow, two paramedics and a radiology technologist.

activates a consultation to the stroke consultant on-call. The patient may then be transferred to a nearby primary stroke centre with CT scan facilities and treatment is initiated via a province-wide telestroke programme. The MSU activation is initiated if the UAH is deemed the closest hospital to the rural site. The MSU is incorporated within the existing provincial emergency medical services (EMS) and the EMS is involved in all cases where the MSU is dispatched. MSU travels towards the presenting hospital, approximately half the distance, and meets up at predetermined rendezvous locations with the 'in-bound ambulance'. The predetermined locations for the rendezvous were selected based on the availability of the best wireless connectivity and the locations were on all major highways leading to Edmonton. The patient is transferred into the MSU for an urgent brain CT scan, with images being transmitted to the UAH telestroke neurologist for review in real time. History and neurological examination is completed by the UAH telestroke neurologist via a secure telemedicine link. Management options include treatment with intravenous rt-PA and transport to UAH, supportive care and transport to UAH if necessary, or transfer back to the local referring hospital.

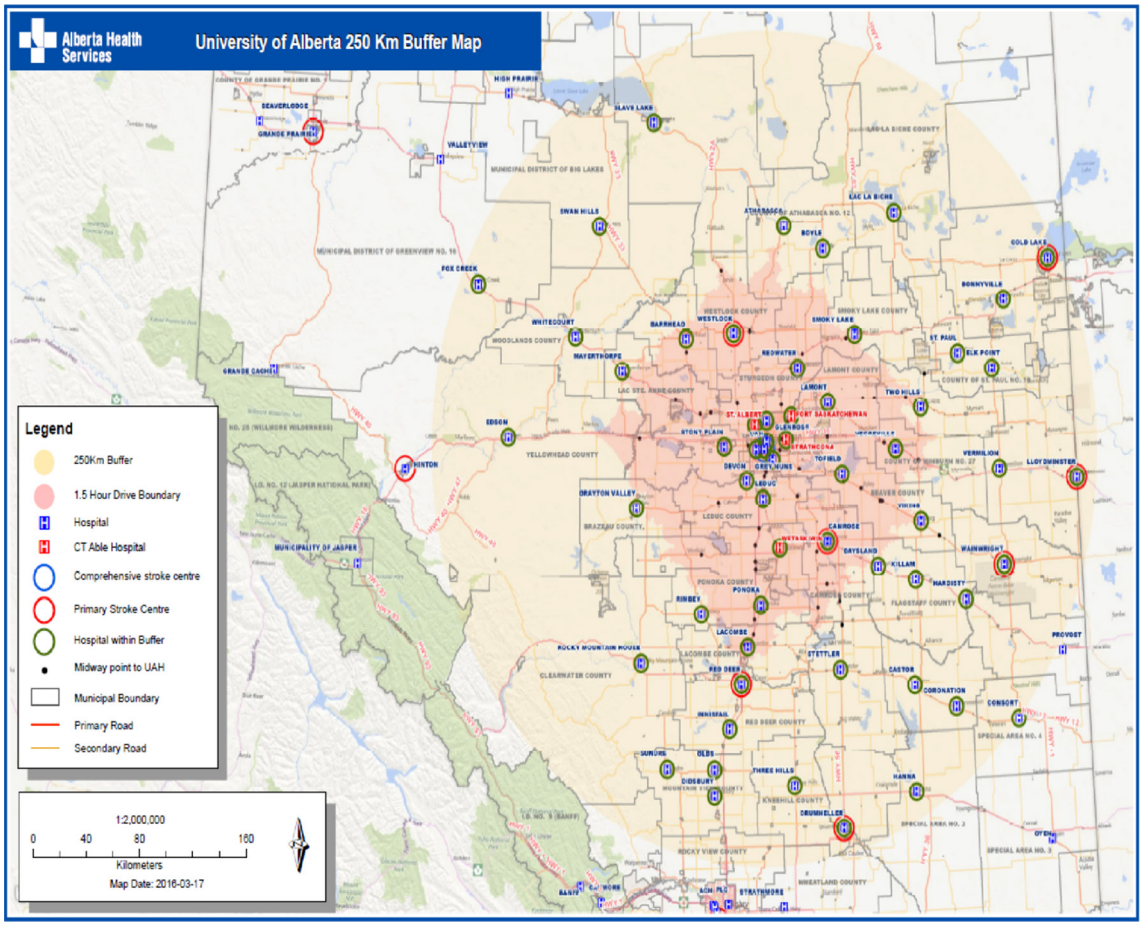

Figure 2 Catchment area for the mobile stroke unit in Northern Alberta. This is within a 250 km radius surrounding the University of Alberta Hospital (UAH). The legend shows the available hospitals with (Primary Stroke Centre) and without CT scans within the region.

RESULTS

Since project implementation, there were 28 calls taken by the stroke team for possible MSU deployment and the ambulance was dispatched 28 times. During these activations, eight patients received treatment of acute ischaemic stroke with intravenous rt-PA and were transported to the UAH for further management. Six patients were transferred back to the local hospital. The details of the repatriated patients evaluated by the MSU are shown in table 1. As is evident, most had minor deficits or were stroke mimics. The baseline and day 90 National Institute of Health Stroke Scale score and modified Rankin score of patients treated in the field with intravenous rt-PA are shown in table 2.

An additional 14 patients were evaluated by the MSU and transferred to the UAH. These included six patients with stroke mimics, two TIAs, three with intracranial haemorrhage (ICH) and one with cerebral contusion secondary to trauma and two strokes outside the rt-PA window. One of the latter two patients received a successful endovascular thrombectomy at UAH. Six patients with a diagnosis of stroke mimics who were brought to UAH included an intracerebral haemorrhage, two migraines, an encephalopathy, haemorrhagic contusion and a subdural haematoma.

DISCUSSION

This is the first report on the deployment of the MSU in the rural setting (phase 1) with a particular focus on the unique role of the MSU as a triage mechanism for evaluation of patients with a diagnosis of 'suspected hyperacute stroke'. Evaluation of MSU-based triaging in the field and potential reductions to tertiary care hospital admissions at UAH for patients with stroke syndromes, including mimics, are examined. Preliminary data demonstrate that approximately 60% of patients assessed in the MSU did not require thrombolysis or further imaging, 25% of which were transferred back to the referring hospitals and received appropriate care close to their home community. There may be opportunities with subsequent calls to more consistently ensure that patients who would not benefit from an admission to a tertiary care centre are immediately transferred back to the referring hospital. Information received on follow-up of patients transferred back to their

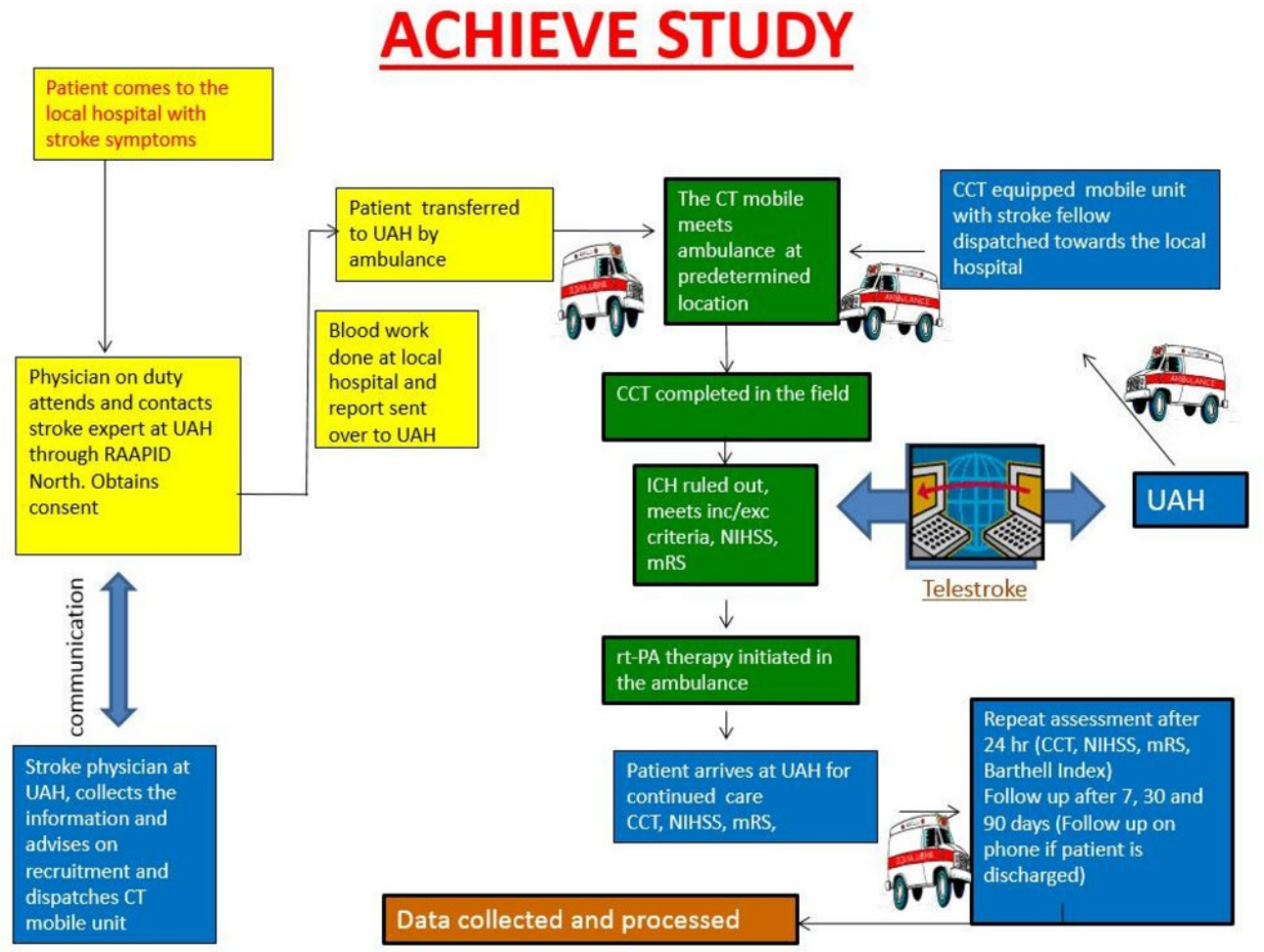

Figure 3 Protocol for deployment of the mobile stroke unit (MSU). After initial conversations between the referring physician in rural Alberta and the stroke neurologist at University of Alberta Hospital (UAH), the MSU is deployed and meets up with the in-bound ambulance at a predesignated location. The patient is transferred to the MSU, examined by the stroke fellow and imaged. The stroke neurologist is in constant contact with the MSU via video link and has access to the imaging as soon as they are processed. Treatment decisions are discussed by the team and the patient transferred back to the in-bound ambulance or brought to the UAH. CCT, Critical Care Transport (EMS); ICH, intracranial haemorrhage; mRS, modified Rankin score; NIHSS, National Institute of Health Stroke Scale; rt-PA, tissue plasminogen activator.

local hospital did not reveal any complications. This information is vital to reducing avoidable admissions to overcapacity EDs.

Acute stroke is one of the most common serious neurological emergencies and, as a result, is a major contributor of acute service use at tertiary hospitals. Previous research has shown that up to 20% of patients suspected of an acute stroke have an alternate aetiology to explain their symptoms.[7] The likelihood of an alternate diagnosis made in the MSU is comparable to the hospital setting.[8] Similarly, while the rates of misdiagnosis are somewhat lower in the ED setting, at least

Table 1 Patients who were evaluated and sent back to their local hospital

Patient	Study no	Date	Age	Sex	Patient location	Distance from UAH (km)/driving time (h:min)	Diagnosis	Disposition
1	1	7 Feb 2017	71	F	Athabasca	149/1h47min	TIA	Home hospital
2	11	31 Mar 2017	41	F	Bonnyville	248/2h48min	Migraine	Home hospital
3	13	13 Apr 2017	78	F	St. Albert	16.3/22min	TIA	Home hospital
4	21	15 Jun 2017	96	F	Edson	206/2h2min	TIA	Home hospital
5	26	30 Jun 2017	81	F	Bonnyville	248/2h48min	TIA	Home hospital
6	27	7 Jul 2017	70	F	Smoky Lake	120/1h30min	Panic attack	Home hospital

TIA, transient ischaemic attack; UAH, University of Alberta Hospital.

Table 2 Baseline and day 90 NIHSS and mRs of patients treated in the field with intravenous rt-PA

Patient	Age	Sex	NIHSS baseline	NIHSS day 90	mRs premorbid	mRs day 90
1	63	F	2	0	0	1
2	68	M	1	0	0	0
3	72	F	4	0	0	0
4	34	M	10	0	0	0
5*	87	F	22		2	6
6	76	F	19	4	0	2
7†	81	F	4	0	2	2
8	48	M	7	1	0	2

*This patient presented with large left middle cerebral artery stroke and had ongoing myocardial infarction (non-ST-elevation myocardial infarction). Her premorbid status included prior myocardial infarction, colon cancer and thyroid cancer. The patient's family decided on end-of-life comfort care right after the patient was transferred to University of Alberta Hospital.
†This patient had oxygen-dependent chronic obstructive pulmonary disease; therefore, her premorbid mRs is 2.
mRs, modified Rankin score; NIHSS, National Institute of Health Stroke Scale; rt-PA, tissue plasminogen activator.

one in five patients admitted with a diagnosis of acute stroke has an alternate diagnosis.[7] Common conditions include seizures, delirium, migraine, peripheral vertigo and conversion disorders.[7] In clinical practice, the diagnosis of a 'stroke mimic' is made following assessment by a consultant and completion of brain imaging. In most circumstances, the evaluation is completed in the ED and very frequently requires a short hospitalisation.

The CT-equipped MSU was first introduced in the management of acute stroke 5 years ago.[9] Currently, more than 10 MSUs are in operation in North America, Europe and Asia.[5] In most models of care, the ambulance operates within city limits and provides first response out-of-hospital acute medical care near the site of the ictal event. Neurologists may be present on MSU or assess the patient remotely via videoconference and remotely review CT images. Thrombolysis is most often administered in the MSU as the patient is transferred to the admitting hospital. The onset-to-needle times for thrombolysis have been very impressive in most of the reported series.[10] The MSU in Edmonton is the first ambulance specifically designed for deployment in the rural setting for a group of patients that would otherwise experience a delay in accessing specialised stroke care (figure 2). Our preliminary experience demonstrates that the MSU can serve as an excellent triage mechanism for patients with a suspected stroke prior to transport to a tertiary care centre. Many such patients do not require admission to the facility and can be returned to their referring hospitals.

While most of the experience with CT-equipped ambulances has been with the treatment of acute ischaemic stroke, the unit has the potential for assessment in other neurological emergencies as well. For example, acute cerebral or subarachnoid haemorrhage can clinically be confused with an ischaemic stroke. Imaging allows for accurate diagnosis in the field, enabling transport to the most appropriate facility for further care. In our series, three patients were diagnosed with large ICH, with the potential for transport back to the referring site as they were not candidates for any additional medical or surgical treatment. In the PHANTOM-S study, referral of ICH to the appropriate hospital increased from 11% to 43% when the imaging information in the MSU revealed ICH.[10 11] Similarly, early diagnosis can help in initiation of time-sensitive therapies in other neurological conditions including brain trauma and status epilepticus.[12] Lastly, the MSU is a costly technology and a detailed economic evaluation of the project is under way. The costs of the vehicle and salary costs for the crew could be offset by a reduction in the costs of disability for those patients who otherwise would not have been treated. Furthermore, costs could also be offset by avoiding unnecessary visits to a tertiary care centre and by avoiding serial ambulance transfers to and back from tertiary care. Also, the MSU crew assists with patient care in the ED and the diagnostic imaging department when not on deployment. In doing so, they provide value and contribute to the efficiency of care even when not on an MSU call.

There are some limitations to our study. The number of cases reviewed is small. We cannot state with certainty that the treatment offered to the repatriated patients was consistent with care at the tertiary facility. We are confident, however, that patient care was not compromised.

In summary, we report on our preliminary experience with MSU in rural Alberta. In addition to successful thrombolysis in the field, the unit can be used as an extension of the stroke service and can triage patients who do not require further investigations at a tertiary care facility. The strategy allows for better use of overcapacity EDs and fewer avoidable admissions to the tertiary care centre.

Correction notice This article has been corrected since it was published Online First. The Funding statement has been amended.

Contributors AS designed the study and wrote the manuscript. SA developed the protocols and reviewed the manuscript. HK developed the protocols, collected patient data and reviewed the manuscript. LM developed the protocols and reviewed the manuscript. KK, GJ, BB, KB and MS helped with recruitment of patients and manuscript review. TJ was the lead of the project and provided critical review of the manuscript.

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