

TeleStroke Oman

Efficacy of TeleStroke Services linking underserved Hospitals in Oman.

Non-Communicable Diseases

Strategic Research Program

Project Proposal

(Submission: 7th Sept 2021)

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Efficacy of TeleStroke Services linking underserved Hospitals in Oman.

Abstract:

Background: Stroke is the 3rd leading cause of mortality in many countries, and is the most common cause of long term disability. Current management of acute ischemic stroke(AIS) involves emergent administration of IV alteplase within 4.5 hours, followed by triage for possible thrombectomy for those with large vessel occlusion. Most peripheral hospitals lack expertise in such management. Telestroke consultations are a useful resource to enhance state-of-art management of AIS in peripheral hospitals.

Aim: This study aims to establish and examine the efficacy of a Telestroke network in Oman involving one or two major 'hub' hospitals in Muscat, linked to five 'spoke' hospitals in the periphery.

Methods: It is proposed to establish a TeleStroke network between one or two central hospitals in Muscat with five peripheral hospitals in Oman which currently have access to CT scans and basic infrastructure for management of AIS patients but do not have a Neurology service. Selected staff from Internal Medicine/Emergency Medicine departments, Nursing, Technical service and support staffs will be trained in the process of assessment and management of AIS patients including the use of IV alteplase. They will also be trained in timely access of a Neurologist on call at the central hospital(s). The Neurologist would conduct a Telestroke based clinical assessment of the AIS patient, review imaging and laboratory results in a timely manner and advice regarding administration of IV alteplase. The main purpose of such consultation would be to recognize eligible patients for administration of IV alteplase safely at the earliest opportunity within 4.5 hours, leading to increased rates of such thrombolysis with expected improved outcomes. Outcomes would be compared among a at least 30 patients with AIS

managed at each of these hospitals prior to initiation of the practice of thrombolysis and at least 20 patients treated each with IV alteplase.

Analysis: A stepped-wedge randomized cluster model will be used to sequentially deploy use of IV alteplase among the peripheral hospitals following a period of training. Rates of use of IV alteplase, clinical outcomes at 3 months ('Good': modified Rankin Score 0-2 **vs** 'Poor': mRS 4-6) and rates of haemorrhage will be compared as primary outcomes. Discharge outcomes, factors influencing outcomes, differences in the rates of IV Alteplase use and complications among different centers will be explored as secondary outcomes. Univariate and logistic regression methods of analysis will be used.

Key Words:

Stroke; Acute ischemic stroke; Telestroke; Telemedicine; Thrombolysis.

Introduction, Literature Review and Analysis of Related Work :

Stroke is the 3rd or 4th leading cause of mortality in many countries, and is the most common cause of long term disability. Acute ischemic stroke management has undergone dramatic developments ever since the introduction of IV alteplase in 1995. Once considered a catastrophe with no reasonable treatment, acute ischemic stroke patients now have a range of treatment options including:

1. IV thrombolysis within 4.5 hours: of onset for all patients with any type of confirmed ischemic stroke.
2. Endovascular thrombectomy up to 6 hours: of stroke onset for patients with large artery occlusion, and
3. Stroke Unit based care.

All these are proven to be significantly effective in terms of reducing mortality and morbidity (~15-50%) as well as reducing the overall cost of care for the community. (Powers et al. 2019). Most countries as well as World Stroke Organization guidelines for management of acute stroke concur on a protocol including the above three interventions (along with many others) (Sacco RL et al, 2013; Powers WJ et al 2018; Boulanger J et al 2018; Berge E et al, 2021). The recently published Oman Stroke Guidelines represent the most current practices supported by good clinical evidence (Al-Ghannami et al, 2020). Hospitals – including SQUH and Khoula Hospital – have developed their own local guidelines in conformity with such guidelines (Fig 1).

In summary, most acute ischemic stroke patients have a central core of infarction surrounded by an area of brain tissue with partial perfusion with arterial blood known as penumbra. The area of infarction initially is likely small, and often may trend to grow out to include much of the penumbra. Most interventions are aimed at re-establishing adequate perfusion to the penumbra, and thus preserving brain tissue and neurologic function. The first effective therapy in this direction was the development of IV alteplase (recombinant tissue plasminogen activator –rtPA) (and recently tenecteplase) in 1995. Early administration of rtPA within 4.5 hours is known to be associated with significant improvement in good functional outcome at 3 months (modified Rankin Score- mRS – 0-2) permitting functional independence, with a small,

acceptable risk of intracranial or systemic haemorrhage (usually <6.4%). This outcome has been confirmed through multiple studies in different countries (Fig 1); outcomes in a Stroke Registry at SQUH involving 1220 patients over the last 10 years also confirm to this outcome.

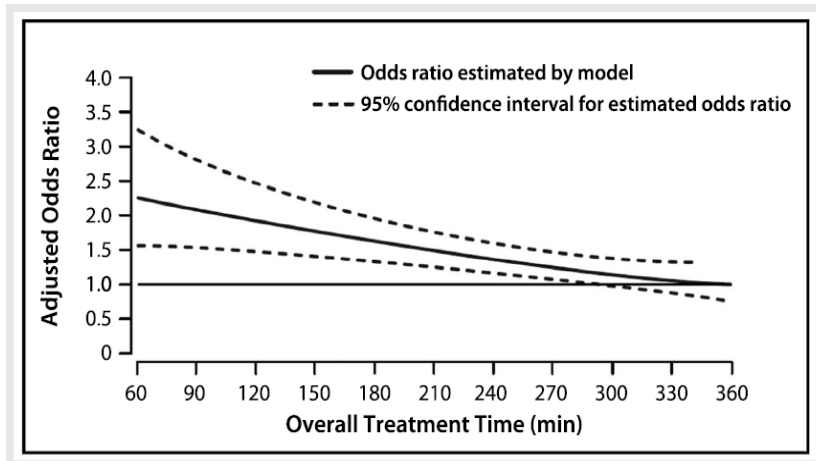


Fig.1. Timeline of beneficial outcome following IV rtPA for acute ischemic stroke, lasting beyond 300 mins from stroke onset. (Powers WJ et al, 2019)

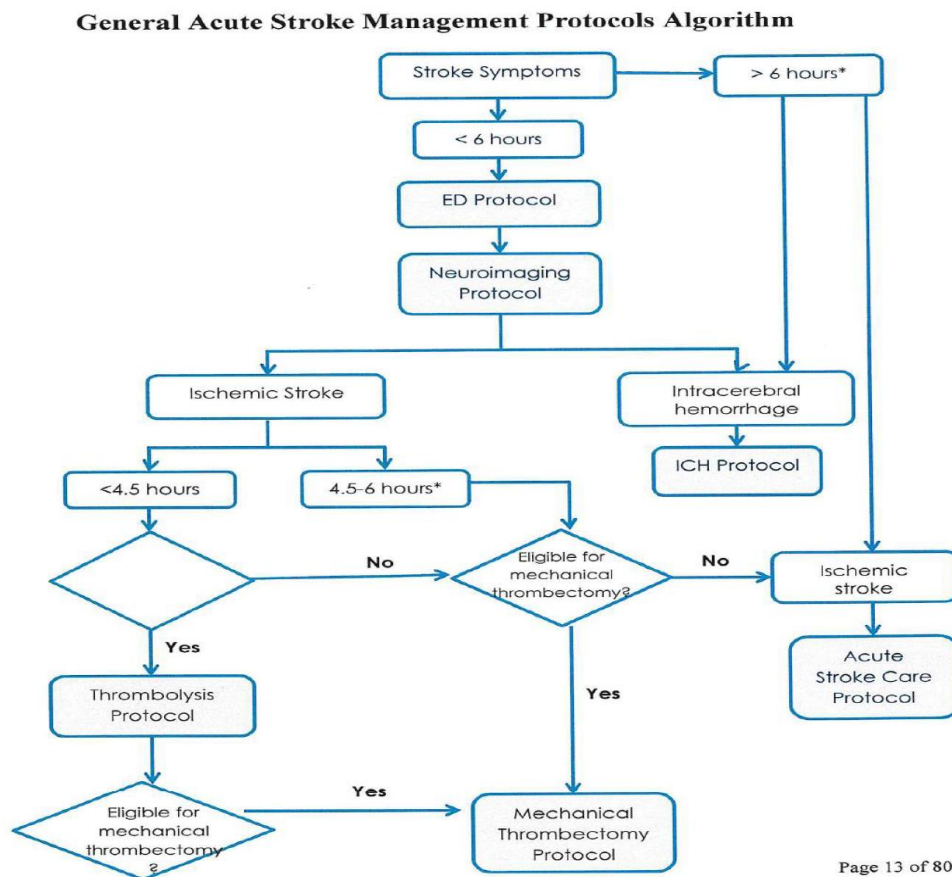
The essential practice for achieving such outcomes is the careful choice of suitable patients with ischemic stroke- who have a significant neurologic deficit with well defined onset, without evidence of either hemorrhage or a large brain hypodensity in the initial CT scan and without risk for haemorrhage. Such patients are then administered IV rtPA over one hour (0.9 mg/kg, maximum 90 mg) and monitored carefully over the next 24 hours for any complications. IV rtPA for acute ischemic stroke is associated with a number-needed-to treat (NNT) for good outcomes of 7-11. With the recent introduction of perfusion brain imaging, selected patients may benefit from thrombolysis or thrombectomy up to 16 to 24 hours. However, all these interventions are time bound in their benefits (Berghe E et al, 2021). As is evident, such timely administration of IV rtPA requires the patient to present to a Stroke-Ready hospital within 1-3 hours of stroke onset.

A subset of all patients with ischemic stroke – usually about 15% overall- who may have a large artery occlusion responsible for the incident stroke are recognized through the use of a CT or MR angiogram performed usually with the initial CT scan. Such patients, after receiving IV rtPA,

are considered for endovascular thrombectomy performed by trained Neuroradiologists, using specifically designed instruments. Such an intervention, initiated within 6 hours of stroke onset, is known to be associated with good neurologic outcomes – of mRS 0-2 among 50-70% of patients. Multiple trials of such endovascular thrombectomy interventions for acute ischemic stroke have demonstrated this to be a very effective intervention, with a NNT for good outcome in the range of 2-4 (Goyal M et al 2016).

Care of patients with acute stroke in the context of a Stroke Unit is now shown to be associated with improved outcomes (low morbidity and mortality) as well as reduced cost of care. Hence this recommendation is a part of most stroke management guidelines. NNT for good acute stroke care in a Stroke Unit is 15 (Berghe E et al, 2021; Powers WJ et al, 2018).

Figure 2.



(Al-Ghannami et al, 2020)

Experience with thrombolysis for Ischemic Stroke in Oman:

Oman has the privilege of having a few hospitals with well developed acute stroke services. Muscat has two institutions which offer advanced stroke care. These institutions have evolved their services over the years with a record of overall outcomes easily matching international standards. Sultan Qaboos University Hospital and Khoula Hospital have been offering thrombolytic therapy for acute ischemic stroke since more than a decade and have established this as a standard of care.

At SQUH, about 15% of about 1220 patients (entered into a Stroke Registry from 2010 to 2020) have received IV rtPA for acute ischemic stroke since the last 10 years, with outcomes similar to those reported in the literature (Gujjar et al, 2021). Among 1220 patients with IS (age: 64 ± 13 years; M:F::63%:37%), Large artery (LA)stroke was the commonest(46%) followed by Small vessel disease(SVD)(26.1%) and Cardio-embolism(CE)(10.4%). 177(14.5%) had dual stroke mechanisms. CE and LA subtypes were associated with higher rates of poor outcomes. Poor outcomes were associated with older age, LA or CE stroke, coma, severe stroke, hemiparesis, evidence of AF or heart disease. On logistic regression analysis, poor outcomes at hospital discharge as well as mean follow up of 12 ± 17 months were independently associated with: older age($p=0.007$); poorer sensorium (GCS)($p<0.001$); type of primary stroke ($p<0.001$), but not with the presence of dual stroke mechanisms. (Table 1) (Gujjar et al, 2021). In the recent past, with the introduction of perfusion CT and MRI, patients have also been offered IV rtPA beyond the conventional window of 4.5 years.

Further, patients with ischemic stroke caused by a large artery occlusion are routinely referred for endovascular intervention at Khoula Hospital, where the development of a team providing efficient 24/7 interventional radiology service has proved to be a major asset for such patients.

Table 1: Stroke Registry (SQU Hospital) 1220 patients entered over 10 years. Comparison of outcomes (Good vs Poor). (Gujjar et al, 2021).

	Total (%)	Good Outcome(%) mRS 0-3	Poor Outcome (%) mRS 4-6	p
n	1220	622 (51%)	598 (49%)	
Mean Age (yrs)	64 + 13	61 + 13	67.3 + 13	<0.001
Male (%)	711 (63.2%)	417 (67%)	354 (59.2%)	0.003
Stroke type:				
Large Artery	560 (46)	250 (40.2)	310 (51.8)	<0.001
Cardio-embolic	127 (10.4)	48 (7.7)	79 (13.2)	
Small vessel dis	320 (26.1)	200 (32.2)	120 (20.1)	
Others	213 (17.4)	124 (19.9)	89 (14.9)	
Dual Stroke mech	177 (14.5)	83 (13.3)	94 (15.7)	0.136 NS
Anterior Circulation	665 (54.5)	334 (53.7)	331 (55.4)	0.3 NS
Posterior Circul	256 (21)	141 (22.7)	115 (19.2)	0.08 NS
Risk Factors:				
HTN	887 (72.7)	452 (72.8)	435 (73)	0.59 NS
DM	641 (53.2)	337 (54.3)	312 (52.3)	0.27 NS
A-Fib	136 (11.1)	40 (6.5)	96 (16.1)	<0.001
IHD	289 (23.7)	136 (21.9)	153 (25.7)	0.07 NS
Other heart dis	143 (11.7)	51 (8.2)	92 (15.5)	<0.001
High Lipids	309 (25.3)	174 (28)	135 (22.8)	0.021
Altered Sensor	404 (33.2)	158 (25.5)	246 (41.1)	<0.001
Hemiparesis	964 (79.1)	470 (75.6)	494 (82.7)	0.006
Aphasia	469 (38.4)	213 (34.3)	256 (43)	0.001
Mean GCS	13.8 ± 2.5	14.7 ± 1.2	12.9 ± 3.2	<0.001
NIHSS admission	9.35 ± 5	6.6 ± 4.4	11.2 ± 4.7	<0.001
Mean BP Sys	158 ± 32	159 ± 32	157 ± 33	0.232 NS
Mean BP Dias	85 ± 18	86 ± 19	84 ± 18	0.1 NS
CT abnormal	870 (72.7)	413 (68)	457 (77.5)	0.001
MRI abnormal	625 (91.8)	356 (89)	269 (95.7)	0.002
Mean RBS	9.4 ± 6	9.7 ± 7.4	9.1 ± 4.9	0.18 NS
Mean HbA1C	7.3 ± 2.4	7.4 ± 2.3	7.2 ± 2.5	0.38 NS
Total Cholesterol	4.4 ± 2	4.7 ± 1.7	4.1 ± 2	<0.001
Triglycerides	1.5 ± 1	1.6 ± 1	1.4 ± 0.8	0.004
ECG abnormal	541 (47.3)	215 (36.8)	326 (58.2)	<0.001
Echocard abnormal	413 (46.8)	189 (42.6)	224 (51.1)	0.011
Holter abnormal	205 (51.8)	131 (50)	74 (55.2)	<0.19 NS
CT/MR Angio Abnor	319 (64.8)	190 (61.7)	129 (70.1)	0.036
rtPA given	164 (13.4)	55 (9.1)	109 (18.5)	NS

District and regional hospitals in Oman have been treating patients with acute stroke, conventionally using CT scan for imaging, and other investigations (eg.ECG, Echocardiography, hematologic studies, tests for vasculitis, etc) for etiologic diagnosis. Most also have access to ICU care. However, as they do not have neurologic services available, they are hampered in providing either in-house timely thrombolytic intervention or advice regarding thrombectomy or other specific interventions for patients who may require them.

While the practice of thrombolysis for ischemic stroke is now routine at SQUH as well as at Khoula Hospital, it has also been recently introduced into few other hospital in Oman where Neurology services were successfully developed – eg. Sohar Hospital, Salalah Hospital and Armed Forces Hospital. With the technological developments at both SQUH and Khoula hospitals in the form of routine availability of MRI, MR angiography, CT angiography and CT/MR Perfusion studies, attempts have been made to administer tPA beyond the conventional window (ie. 4.5 hours from onset) to selected patients. In particular, Perfusion CT scans in such patients may demonstrate the presence of a large stroke penumbra with a relatively small core of infarction – which is considered ideal for administering tPA effectively with beyond the conventional time window (up to 16 or 24 hours), with reasonably good outcomes.

A major limitation for the delivery of optimal care for acute stroke patients in many communities across the world is that such facilities are not near to many patients (for eg. within 1-2 hours of driving distance). Peripheral health care institutions often treat patients with stroke, but may not have a Neurologist in-house to lead and provide standard-of-care interventions such as thrombolysis or advice regarding endovascular thrombectomy. Non-availability of optimal brain imaging, laboratory services, access to IV alteplase, or a Stroke Unit may all be additional limitations (Muller-Barna IP 2016; Sairanen T et al, 2011).

Telestroke:

Telestroke is recognized as a reasonable solution to address several such limitations and has been effectively implemented in many countries, with documentation of good outcomes.

Levine and Gorman introduced the term 'Tele-Stroke' in 1999. Telestroke services have been tested in their ability to support several components of acute stroke care and proven to be equivalent to those services having in-house Neurologists, in terms of ensuring good patient outcomes (morbidity, mortality, cost reduction, etc).

Essentially, a **TeleStroke net work** involves a telemedicine network with communication between two or more medical facilities through any suitable audio-visual communication system, supported by additional systems to enable sharing of the process of clinical assessment, laboratory results and radiologic images (Kepplinger J et al, 2016; Hybert GJ, 2019). Such communication is utilized to source medical expertise and care facilities not available at a peripheral institution, with the purpose of providing optimal, current management. Usually a central hospital with Neurologic service is linked to few or several peripheral hospital using such a network. In the context of encountering a patient with acute stroke, peripheral hospitals establish a tele-medicine link with a university or central hospital with access to Neurologist, Neuro-radiologist, ICU etc on an emergent basis. The contact is usually triggered by the Emergency Medicine Physician at the peripheral hospital, who recognizes a patient with acute ischemic stroke who is eligible for IV rtPA (based on guidelines). A designated and trained Neurologist performs essential clinical assessment (history and physical examination) through the video-link with the assistance of the Emergency Physician, reviews appropriate investigations and CT images to confirm suitability for IV rtPA and assists in counselling the patient / a responsible relative on the benefits of IV thrombolysis. After consent, the Neurologist guides the Emergency medicine team for administering IV rtPA appropriately as well as for subsequent care. Patients recognized to need further emergent care such a endovascular intervention, control measures for a large infarction (or even intervention for a recognized incidental intracerebral haemorrhage) may be advised suitable by the Neurologist. (Muller-Barna IP 2016; Sairanen T et al, 2011)

The main purpose of a Telestroke consultation is to enable timely administration of IV rtPA to suitable patients with acute ischemic stroke with-in the window of 4.5 hours and then take decisions regarding further acute care based on individual patient requirements.

Most centres offering Telestroke have developed in a 'hub and spoke' model, with experts in one (or few) hub providing care and advice to several spoke (peripheral) centres (Demaerschalk BM, 2017; Arbik et al, 2017; Arbik et al 2017(a)). With Telestroke services, the rates of utilising IV rtPA for AIS have greatly increased (2016; Sharma et al, 2019).

Several studies over the past two decades have demonstrated the benefits and efficacy of using Telestroke services in different countries. Most acute stroke management guidelines now make routine recommendations regarding the development and use of Telestroke in underserved communities. The 'Telemedical Project for Integrative Stroke Care (TEMPiS)' study reported on a TeleStroke network in Bavaria, Germany. An initial report evaluated 5696 patients diagnosed with acute stroke admitted to the 10 peripheral hospitals. Of these, 1971 (63%) were treated in the using Telestroke consultations. 44% of patients from network hospitals versus 54% from control hospitals had a poor outcome ($p < 0.0001$). The authors concluded that Telestroke consultation improved acute stroke outcomes significantly. (Audebert HJ, 2006).

A Telestroke network based at the Ochsner Medical Center in New Orleans, USA reported on a large experience of >1000 telestroke consults per year, with 16 min average door to consult initiation and 20 min to completion. The study reported 29% of ischemic stroke patients to have received rtPA, which was an increase by 275%. The Telestroke facility enabled most patients to be treated at the peripheral hospitals with some deserving patients transferred to the central institutions for intensive care or vascular intervention. The authors suggest that Telestroke permitted time sensitive, expert consultation could be effectively provided fulfilling unmet care needs. The models of "drip and ship" and "drip and keep" managements permitted more patients to remain in peripheral hospitals with a deserving few transferred for advanced care. (Commisky P et al, 2017)

Similar safe and reliable outcomes were reported by other studies also (Mueller-Barna IP et al, 2015; Arbik F et al, 2017; Sharma R et al, 2019). In a meta-analysis by Kepplinger et al (2016) of 7 studies totaling 1,863 patients who underwent thrombolysis following Telestroke

consultations, there was no difference in mortality (RR = 1.04, 95% CI 0.74–1.48; $p = 0.806$) or functional independence (RR = 1.11, 95% CI 0.78–1.57; $p = 0.565$) at 3 months. They concluded that IV tPA delivery through telestroke networks is safe and effective.

Several potential risks and barriers to TeleStroke have been recognised and categorized by Arbic et al as administrative, legal, financial or technical. The overall suggestion is to consider each of these in the local context and mitigate / manage them with a practical approach. (Arbic et al, 2017)

On a background of this large and growing experience with Telestroke, several national guidelines support the development of Telestroke services. ((Kepplinger J et al, 2016; Hybert GJ, 2019; Powers WJ et al 2018; Boulanger J et al 2018; Berge E et al, 2021; Al-Ghannami et al, 2018). The American Stroke Association Guidelines in 2019 suggested that “The use of Telestroke /Telemedicine resources and systems should be supported by healthcare institutions and Governments as one method to ensure adequate 24/7 coverage and care of acute stroke patients in a variety of settings”.(Powers WJ et al 2018)

Problem Statement:

This is a proposal to establish and examine the efficacy of a Telestroke network in Oman involving one or two major ‘hub’ hospitals in Muscat, linked to five ‘spoke’ hospitals in the periphery.

Overall, the following observations appear to suggest that Telestroke could be a suitable solution to address the issue of treatment of acute stroke patient in Oman:

- State of art medical care including acute stroke services are well developed in few central hospitals in Oman. These have a strong and durable experience in providing state-of-art stroke management services.
- Many districts and communities in Oman have local/district hospital without a Neurologist.

- However these peripheral hospitals do manage patients with acute stroke using the available resources such as CT scan, basic laboratory services, and medical expertise in the form of Emergency Medicine and Internal Medicine Consultants and Specialists. Most such hospitals have a general ICU.
 - Oman has well developed telecommunications system
 - Oman has a state-managed and well developed health service, with provision of free medical care to the local population.
 - Most hospital also have access to EMS / Ambulance service for patient transport as well as a hierarchical system for referral of appropriate patients to higher medical centers.
 - Development of a telemedicine link between peripheral / district hospitals and central hospitals is feasible.
 - The cost of establishing and managing such a Telestroke network – based on the beneficial patient and community outcomes reported in the literature – is expected to be easily offset by the benefits in terms of lives saved and disabilities prevented.
- (Overall, the cost of managing a patient with severe neurologic deficits is high both for the families and the country; preventing a single incidence of severe neurologic deficits is thus expected to be a major gain).

In the above context, it is proposed to establish a TeleStroke network between one or two central hospitals in Muscat with five peripheral hospitals in Oman which currently have access to CT scans and basic infrastructure for management of AIS patients but do not have a Neurology service. Selected staff from Internal Medicine/Emergency Medicine departments, Nursing, Technical service and support staffs will be trained in the process of assessment and management of AIS patients including the use of IV alteplase. They will also be trained in timely access of a Neurologist on call at the central hospital(s). The Neurologist would conduct a Telestroke based clinical assessment of the AIS patient, review imaging and laboratory results in a timely manner and advice regarding administration of IV alteplase. The main purpose of such consultation would be to recognize eligible patients for administration of IV alteplase safely at the earliest opportunity within 4.5 hours, leading to increased rates of such thrombolysis with expected improved outcomes. Outcomes would be compared among at least 30 patients with AIS managed at each of these hospitals prior to initiation of the practice of thrombolysis and at least 20 patients treated each with IV alteplase.

Aim: This study aims to establish and examine the efficacy of a Telestroke network in Oman involving one or two major ‘hub’ hospitals in Muscat, linked to five ‘spoke’ hospitals in the periphery.

Objectives:

- To identify a **‘hub’ of Telestroke centre** at Muscat, involving Neurologic services at one or two major hospitals (to be finalized).
- To develop **‘spoke’ or peripheral hospital telestroke centres** in five hospitals (Rustaq, Ibra, Buraimi, Ibri, and Sur) by identifying participating teams (Internal Medicine, Emergency Medicine, Imaging, laboratory, Nursing, Technical support etc) in each.
- To train senior Physician led teams in using protocols for Telestroke based acute stroke management – specifically acute intravenous thrombolysis.
- To **educate medical and paramedical teams** in overall acute stroke management and decision making process.
- To **initiate sequentially peripheral centers** for acute stroke thrombolysis to confirm to a **stepped-wedge trial model**.
- To conduct 3-5 mock Telestroke based stroke thrombolysis cycles at each peripheral centre.
- To support and monitor 20 stroke care encounters for thrombolysis at each of the spoke centres.
- **To document** demographic data, stroke type and severity (NIH Stroke Score, GCS), main neurologic deficits, risk factors, discharge outcome (neurologic deficits; NISS; modified Rankin Score) and outcome at 3 months for **2 groups of patients at each center: 30 patients before initiation of stroke thrombolysis; 20 patients after initiation of stroke thrombolysis**.
- To conduct Cost-benefit analysis.
- To **compare outcomes and cost benefit** for cohorts before and after initiation of stroke thrombolysis.

- **Hand over project to a standing committee** managed by participating hospitals at end of project.

Methodology: Implementation Plan and Timeline:

This project's success would be very much dependent on ensuring recruitment of dedicated staff and personnel. At the expert centres in Muscat (one or two hospitals), the team would require participation of Neurologists, Radiologist, and IT specialists to oversee and solve technical issues. At each of the 5 peripheral hospital, the team would need to train 2-3 dedicated senior Physicians from Internal Medicine and Emergency Medicine Departments who will be in-charge of administering tPA. In addition, the Radiology staff providing CT imaging need to be aware of the importance of performing and reporting the CT on urgent basis. Nursing and support personnel with a good background in Stroke care would be very valuable assets. IT specialists in the hospital will as well play an important role in establishing and maintaining the Telestroke technical infrastructure and network.

Once teams are identified, senior medical physicans eg. Consultant or Senior Specialists in Internal Medicine and Emergency Medicine from the peripheral hospitals would undergo training in Acute Stroke Management program focusing of thrombolytic care and related management. This would involve: didactic lectures, Case discussions and hands on sessions for; clinical approach to acute stroke; training on administering NIH Stroke Scale (video sessions; hands on training); evaluation of CT in acute stroke; decision making for stroke thrombolysis; post –thrombolysis care; communication skills (eg. seeking family consent for thrombolysis, communicating on Telestroke Network); etc. In addition related medical and paramedical teams (eg Nursing, Physical Medicine, etc) would be trained in the overall approach to and management of patients with acute stroke as well as post stroke care. These would be delivered in group sessions by staff from the central facilities.

The peripheral centres would be chosen on the basis of availability of essential infrastructure such as CT scan, laboratory facilities, ECG, (echocardiography/ Holter study), ICU facilty, etc. In

addition to these, each unit would be provided the infrastructure for effective and emergent Telemedicine communications using IT facilities (Computers / laptop with suitable audio-video capability; access to methods of uploading imaging and laboratory results; programs for documenting each case encounter and care implemented, etc.). Details of equipment proposed are listed in supplement attached. Adapting a suitable computer application (app) dedicated for Stroke thrombolysis (which are not available either free or commercially) would enable systematic communication, documentation, as well as later analysis of the collected data.

Mock-encounters of acute stroke patients will be practiced (3-5 sessions for each centre), with graded and timed exposure to different clinical situations. These will provide practice to teams to ensure protocols with short door-to-needle timing, as well as trouble-shoot protocol setbacks.

During the course of training, the peripheral centers would be accumulating data pertaining to conventional management of acute ischemic stroke encountered in these hospitals. Data procurement pertaining to at least 30 patients from each center would be encouraged (details mentioned below).

Actual acute stroke care encounters will then be initiated at the peripheral centres in a sequential manner (using a stepped-wedge randomized model described later) with support of expert teams from the main hospitals in Muscat. Eligible patients for this project will be recruited initially only during official working hours. Each encounter will be adequately documented and debriefing sessions will be conducted following encounters/ consultations, for ensuring continued learning for the entire team and improvement in protocols. While post-thrombolysis patients would be managed at the local hospital ICU or High-dependency beds for the initial few days, those recognized to have poor neurologic status or evolving neurologic complications such as intracranial haemorrhage, mass effect requiring decompressive surgery or endovascular intervention will be transferred on priority to a central hospital for expert care. Follow-up consultations by 'spoke' teams with the central teams post-thrombolysis would facilitate such timely interventions.

Each patient so treated will be followed up to 3 months under care of local Physician teams. Demographic data, risk factors, stroke symptoms, stroke severity at presentation (based on NIH Stroke Scale), CT and investigations summary, treatment received, haemorrhage rates, complications encountered, outcome at discharge and outcome at 3 months (both using modified Rankin Score) will be documented.

End points of interest for study:

Primary outcomes:

1. Rate of utilization of IV alteplase thrombolysis for acute ischemic stroke at peripheral hospitals
2. 3 month clinical Outcomes (graded as Good=mRS 0-2; Poor= mRS 3-6) compared among control and rtPA groups.
3. Rates of intracranial or systemic haemorrhage

Secondary outcomes:

1. Discharge clinical Outcomes (graded as Good=mRS 0-2; Poor= mRS 3-6) compared among control and rtPA groups.
2. Time from patient arrival to initiation of Telestroke Consult
3. Door-to-Needle time for administration of rtPA among those who receive it.
4. Rates of initiation of Telestroke Consultations for acute stroke from peripheral hospitals.
5. Frequency of transfers of patients to central hospitals
6. Frequency of ICU admissions required (at peripheral or central hospitals).
7. Estimated cost of care: Comparison among Controls and rtPA Groups.
8. Differences among rates of utilization of Telestroke consults as well as rtPA among the different peripheral hospitals as well as possible factors influencing them will be explored.

Statistical Analysis:

A stepped-wedge randomized model will be used for implementation of this study (Sauter-Zachrisson K et al, 2016). This model would permit initial monitoring of acute stroke management among peripheral hospitals and a step-wise initiation of rtPA administration at the different centers. Details and outcomes of 30 patients will be documented at each center prior to initiation of thrombolysis. After completion of at least 20 patient encounters from each of the peripheral hospitals, the overall outcomes will be analysed.

Continuous variables will be represented using means and standard deviations (or medians and quartiles) and categorical variables using frequencies and percentages. Analyses will be 2-tailed, with a significance level defined at 0.05 and performed using SPSS-21 software. Univariate methods of analysis will be utilized as appropriate for, comparing end-points and outcomes among the two cohorts. Factors independently influencing outcomes will be explored using logistic regression methods of analysis. Cost of management of patients based on telestroke will be compared to estimated cost of management of patients without thrombolysis using conventional methods.

Proposed timeline: (after project approval and funding)

- Identify staff and physical resources at each centre – 1 month
- Train medical, nursing, administrative and IT staff in Telestroke protocols – 3 months
- Procurement of instruments and software: 2 months
- Deploy and install instruments and software - 1 month.
- Acute Stroke Care trial runs (3-5 at each spoke centre) - 2 months
- Begin Acute stroke care (patient) encounters in sequential manner at peripheral centers
 - from 9th month.
- [Monitor and collect data pertaining to 'Control' Stroke cases – 2nd to 9th month]
- Complete 20 encounters at each centre – 12 months.
- Report on outcomes – 3 months

Expected Research Outcomes:

The core expected research outcomes from this project would be:

- Effective development of a Telestroke network linking 2 central hospitals in Muscat to at least 5 selected peripheral hospitals.
- Determine of the frequency of use / increase in use of thrombolysis for acute ischemic stroke episodes in Omani community presenting to peripheral hospitals.
- Efficacy of Telestroke based stroke thrombolysis care – in terms of patient outcomes, complication rates, mortality.
- Estimate of cost of care using Telestroke model.

Significance to Oman and Benefits:

- The main benefit is that of providing a valuable care access through Telestroke for acute ischemic stroke, which is hitherto largely inaccessible to communities under several peripheral hospitals in Oman. This would ensure a major aspect of Stroke care in Oman to be of current international standards.
- Successful implementation of this model may translate to reduced mortality and morbidity due to stroke among such patients at a location of management hitherto not feasible.
- The overall cost-reduction for stroke management expected from such improve outcomes may be expected to more than compensate the cost of implementing and managing such a program.
- This project would provide an opportunity for ongoing skilled man-power development in acute care management, technology of telemedicine as well as telestroke.

Risks / Critical Success Factors:

The main expected Risks to this project are:

1) Funding and Technological issues:

- Lack of adequate **funding** (Need to ensure adequate funding is a major issue; Other Government or Private sector funding sources are being explored).
- Inadequate /**improper TeleStroke technological infrastructure**
- Unsuitable network carrier

2) Personnel

- **Lack of adequate motivation**
- Failure to recruit appropriate staff at each center
- Project fatigue / burnout

3) Medical/ Legal issues

- **Issues with acceptance by patients/ community**
- **Issues with medical errors / responsibilities**

***Mitigation:** Such issues encountered in other countries have been addressed by varied methods using: eg. Community awareness/education; Community leadership buy-in; Patient/family oriented approach in obtaining consent; Emphasis on attempts at delivering State-of-Art medical care; Developing shared responsibility for patient care; Developing awareness in Medical community, etc,

4) Networking related:

- Inadequate training
- Communications failure/ inadequacies
- Development of new technology / communication networks over time (eg 5G).

Key factors to ensure success are:

- Ensuring adequate funding
- Ensuring suitable/up-to-date technologic infrastructure and carrier
- Developing a committed and motivated network.

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