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THE ART OF EXPERTISE IN STROKE TELEMEDICINE: IMAGING AND THE COLLATEROME:

Expertise in Stroke Telemedicine

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Telestroke; expertise; stroke; imaging; collaterome

Expertise in stroke telemedicine leverages advanced technology with the art of medical decision-making garnered from clinical experience in acute stroke. The Pre-Hospital Acute Neurological Therapy and Optimization of Medical care in Stroke (PHANTOM-S) investigators demonstrate the profound impact that specialized stroke pre-hospital triage may have on stroke care, much as stroke unit care changed the nature of stroke management many years ago.¹ The group elegantly studied the role of a stroke ambulance, the STroke-Emergency-MOBile (STEMO), equipped with a CT scanner, point-of-care laboratory testing and specialized personnel, in the delivery of appropriate patients to stroke units based on this novel framework for pre-hospital care. They previously reported an increased the rate of intravenous thrombolysis in ischemic stroke patients and reduced time to treatment using the STEMO.^{2, 3} This prior groundbreaking work on pre-hospital thrombolysis awaits broader validation in analyses of long-term clinical outcomes and overall costs, yet such analyses focus on a relatively small fraction of potential patients triaged with telemedicine in the field. Perhaps more importantly than measuring time to thrombolysis of ischemic stroke patients, in this recent paper they demonstrated the impact of such telemedicine expertise on both ischemic and hemorrhagic stroke patients. STEMO lead to improved delivery of ischemic stroke patients to hospitals with stroke units and hemorrhagic stroke patients to hospitals with neurosurgery capabilities. Interestingly, they also demonstrated a trend to improved outcomes with higher rates of discharge to home following hospitalization. Their work underscores three key points or vital concepts in the future evolution of stroke care: the value of neurological expertise in managing various types of stroke that likely outweighs technological advancements; the integration of imaging as an extension of the clinical examination in real time; and understanding the collaterome or the endogenous neurovascular compensation that dramatically influences the course of patients from the earliest moments after stroke onset.⁴

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Telestroke, or the use of telemedicine in stroke care, has been implemented with a diverse array of technology that has evolved in recent years. The specific technology, such as the STEMO ambulance, has been the main focus of clinical research whereas the value of neurological expertise in acute stroke has been relatively neglected. The art of vascular neurology cannot be reduced to a simple protocol or checklist, especially given the recognized complexity and heterogeneity of acute stroke. Telestroke thrombolysis, in most cases, is powered solely by the assurance of such expertise for a potentially devastating disorder from a remote location at a moment's notice. Despite the retrospective focus on stroke diagnoses, telestroke experts must be adept in managing other neurological emergencies or disorders and discerning stroke mimics. The changing nature of healthcare delivery and focus on long-term clinical outcomes reinforces the need to provide such expertise at the earliest stages after onset of the incredibly dynamic effects of acute stroke. Current technology now enables vascular neurologists to extend their expertise and help improve stroke patient outcomes around the world at any time. Is a mobile CT ambulance such as STEMO necessary to provide such expertise? The PHANTOM-S investigators astutely note that numerous factors beyond the technology contribute to such expertise.¹ The art of stroke telemedicine expertise is rooted in experience and neurological training, not just about an added year in cerebrovascular medicine.⁵ Similarly, the tertiary/quaternary care value of a comprehensive stroke center or stroke unit emanates from such neurological expertise.

The innovation of mobile CT in the PHANTOM-S study insinuates that imaging is the dominant component, rather than a confirmatory diagnostic tool predicated on the clinical aspects of a case. Noncontrast CT findings in a pre-hospital stroke study, however, largely serve to corroborate intracranial hemorrhage or depict subtle early ischemic changes.⁶ Symptom constellation and neurological examination features drive the interpretation of these findings in real-time clinical context, where the majority of noncontrast CT studies are likely unremarkable. Stroke experts have become most proficient and nimble in translating imaging into logical decisions regarding stroke management. Future telestroke paradigms will likely build upon even more sophisticated imaging interpretation for rapid therapeutic decisions. Although the imaging criteria for intravenous thrombolysis are extremely rudimentary, the selection criteria are far more complex for endovascular therapy. After proclamation of positive trial results for thrombectomy, imaging may be necessary to reveal persistent arterial occlusion or substantial tissue at risk on multimodal CT or MRI.⁷ Telestroke models may therefore require synchronous clinical and imaging expertise to direct transfers from a local hospital to interventional center. Delivering such expertise will be important not just for those patients selected for transfer, but also for all other stroke patients that may require other neurological care.

Deciphering the complexity of critical pathophysiology such as the collaterome during acute stroke remains an art, literally defined as a skill acquired by experience, study, or observation. Mounting data confirm that the status of collateral circulation decisively shapes the time course and outcomes in ischemic stroke.⁸⁻¹¹ Neurovascular compensation is also central to hemorrhage evolution in the brain. Infarct growth rate and the pace of hematoma expansion are key measures that differ across subjects due to variable compensation. The collaterome may determine those stroke patients with either fast or slow lesion evolution in

the brain. Currently, we flatten such complexity across all cases and assume that time to treatment is paramount. Time may be a critical measure, but how do we consider the time required to make a difficult decision? The prevailing focus on avoiding time delays in acute stroke has created a disincentive to intervene if complex decisions have taken longer, even under expert eyes. We need to develop quality methods that avoid retrospective assumption of final diagnoses and that the only variable that matters is time to treatment. In sum, the science of decision-making in stroke ignores case complexity and the value of expertise. This precedent is particularly important for stroke telemedicine as we are far from establishing proven selection algorithms for endovascular therapy, despite the enthusiasm engendered by recent news of positive interventional trials.

The PHANTOM-S study raises several important considerations for the art of expertise in stroke telemedicine. Stroke experts must utilize successive advances in technology, embrace imaging to refine clinical diagnoses and understand the extensive influence of the collaterome. Other misconceptions should be unraveled, as stroke is not so simple to obviate expertise and technology is useless without proper implementation.

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