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CARDIOVASCULAR MEDICINE AND SOCIETY

Acute Stroke Intervention

The Role of Interventional Cardiologists

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In the past several years, there has been a paradigm shift in acute stroke care driven by a series of randomized controlled trials demonstrating that timely reperfusion with mechanical thrombectomy (MT) results in superior outcomes compared with intravenous thrombolysis in patients with large vessel occlusion (LVO). This critical advance in stroke management brings meaningful improvement in functional restoration to severely affected stroke patients who otherwise account for a disproportionate amount of health care expense due to their disability and increased mortality.

These studies reaffirm the principle that "time is brain" and that earlier reperfusion results in significantly better outcomes for LVO stroke patients. The process of selecting "the right patient, for the right treatment, at the right time" continues to evolve with imaging techniques to assess the residual viable brain tissue (penumbra) with more accurate patient selection no longer limited solely to the time from onset of symptoms, thereby expanding the numbers of patients who are candidates for reperfusion therapy.

In the United States, approximately 10% of the 675,000 first-time ischemic strokes have LVO and are potential candidates for emergent intervention. Minimizing the delay to reperfusion is the key to optimizing quality-of-life outcomes. Every 10 min of delayed care reduces a patient's disability-free lifetime by approximately 40 days and reduces the net monetary benefit of MT by approximately $10,000 (1).

Our current inability to provide timely stroke intervention to stroke patients living outside of a major metropolitan center brings to mind a principle articulated by the Nobel Laureate Amartya Sen in *Poverty and Famines: An Essay on Entitlement and Deprivation*, explaining that when examining starvation and famines, not only is the supply of food important, but the individuals' ability to acquire food (what he calls entitlement) is a distinct and equally important contributor to famine. The neuroscience community argues that there is no shortage of neurointerventional (NI) specialists to treat the annual volume of LVOs resulting in stroke. What they fail to acknowledge is the geographic maldistribution of these specialists, who are predominantly concentrated in urban academic medical centers (2). In the United States, only 50% of the population has ≤1-h access, by ground transport, to MT stroke treatment-capable comprehensive stroke centers (CSCs). In California, in 2015, only 39% of acute stroke patients were within 1-h of hospitals performing 10 or more stroke interventions per year (3). Even assuming an unrealistic addition of 20 optimally located CSCs per state, one-third of stroke patients would still be left without 1-h ground access for care.

There are several options for improving access to immediate intervention for stroke patients. The first, supported by the NI community, is the "hub-and-spoke model." They suggest developing a national triage system to rapidly transfer stroke patients to highly specialized CSCs. However, there is evidence that even a well-developed hub-and-spoke model is not the best option available for acute stroke reperfusion. An experienced European regional hub stroke center initiated MT in 295 of 324 patients (91.0%) directly admitted to the hub hospital, but initiated MT in only 63 of 91 patients (69.2%) transferred to the hub ($p < 0.001$) (4). One-fourth of patients (24.2%) transferred for MT became ineligible for MT during transfer. There was a 4-fold improvement in the odds

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ABBREVIATIONS AND ACRONYMS

CSC = comprehensive stroke centers

IC = interventional cardiologist

LVO = large vessel occlusion

MT = mechanical thrombectomy

NI = neurointerventional/ neurointerventionalist

STEMI = ST-segment elevation myocardial infarction

for a good clinical outcome in transferred patients who received MT compared with those who became ineligible during transfer. The odds of a transferred patient actually receiving MT decreased by 2.5% for every minute of transfer time. The authors concluded that stroke intervention should be provided at first contact whenever feasible.

A second proposal would expand current NI training programs and offer practicing noninvasive neurologists on-the-job interventional training in order to serve nonurban communities (5). Training more NIs does not appear to be a practical solution because the volume of elective, day-time, intracranial work in nonurban communities simply does not provide enough cases to support the additional NI providers needed to treat acute strokes or to maintain their skills. The difficulty of training a practicing noninvasive neurologist to perform stroke interventions is challenging, if not unrealistic. Moreover, it is doubtful that there is a sufficient pool of noninvasive neurologists to train, given the small numbers of practicing stroke neurologists outside of academic medical centers.

A third option would take advantage of currently available community-based, carotid artery stent-capable, interventional cardiologists (ICs) paired with neurologists to provide timely reperfusion therapy at first medical contact, similar to the proven successful strategy for treatment of ST-segment elevation myocardial infarction (STEMI). In a multidisciplinary needs assessment for stroke intervention, representative stakeholders from neurology, cardiology, vascular medicine, radiology, and neurosurgery concluded, "We suggest taking what has been learned in treating STEMI and apply it to 'brain attacks,' utilizing a multidisciplinary approach" (6) (**Table 1**). In the United States and Europe, efforts to reduce the time to treatment for STEMI have led to expansion of primary PCI centers as opposed to a hub-and-spoke model of transferring patients to urban medical centers without loss of quality.

TABLE 1 Skills Needed to Manage Stroke Patients

Cognitive skills (stroke neurologist)	The fund of knowledge required for stroke care including the natural history and pathophysiology of stroke, diagnostic methods, and treatment alternatives
Technical skills (IC, NI, VS, VM)	Competence in both cerebrovascular diagnostic angiography and interventional skills
Clinical skills (stroke neurologist, NCC)	The active management of stroke patients including complications, interpretation of diagnostic tests, hospital admitting privileges, and the ability to assess the risk-to-benefit ratio for therapeutic options

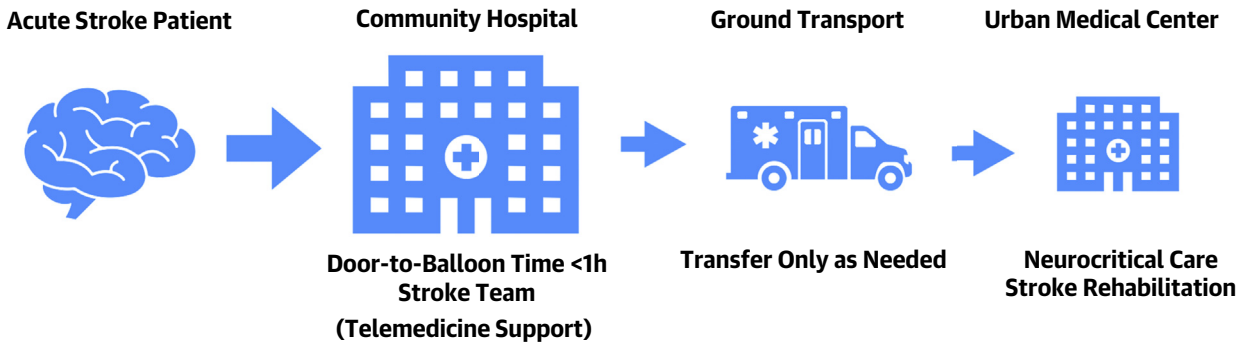
IC = interventional cardiology; NCC = neurocritical care (neurology, anesthesia, and critical care); NI = neurointerventional (neuroradiology, neurosurgery, and interventional neurology); VM = vascular medicine; VS = vascular surgery.

Are experienced ICs capable of achieving stroke outcomes similar to that of our NI colleagues? We compared outcomes of IC versus NI in 124 consecutive acute stroke patients who received MT between 2006 and 2012 (7). The interventional team on call (IC vs. NI), rotated responsibility for stroke call. The IC had extensive carotid stenting experience and teamed with a noninvasive stroke neurologist who was responsible for pre-management/post-management decisions. ICs treated 58 of 124 patients (47%), and NIs treated 66 of 124 patients (53%). There were no significant differences between the 2 groups for age, baseline National Institute of Health Stroke Scale, in-hospital death or 30-day mortality, or a good clinical outcome (modified Rankin score ≤2) at 90 days.

ICs from 3 European centers without NI services treated 84 consecutive acute stroke patients (National Institute of Health Stroke Scale ≥6) with MT in partnership with noninvasive neurologists (8). Angiographic success was achieved in 74% of patients. A good neurological outcome (modified Rankin score ≤2 at 90 days) was achieved in 42% (35 of 84) of patients, with 24 patients (29%) discharged directly home. In patients treated within 3 h of stroke onset, a good outcome was obtained in 54% compared with patients treated later than 3 h with a good outcome in only 31% ($p = 0.031$). These acute stroke interventions, by an IC, achieved results comparable to those from NI centers, suggesting that where local NI services are unavailable, emergent revascularization by an IC, in partnership with a neurologist, is an attractive option. Two recent reports from hospitals without NI availability, 1 from the United States and 1 from Germany, add to the growing body of evidence that carotid stent capable ICs can achieve excellent outcomes for acute stroke intervention in partnership with noninvasive neurologists (9,10).

The argument to be made is not whether ICs should compete with experienced NIs in urban medical centers, but whether timely reperfusion for stroke patients can be extended to communities without timely (≤1 h) access to NI care? Given the lack of highly specialized stroke neurologists outside of academic medical centers, the question is how can we build effective community-based teams? (**Figure 1**). The answer lies in remote technology and telemedicine. The initial assessment, diagnosis, and patient selection are currently available remotely. This remote partnership would allow the local IC to perform a timely intervention and then transfer the revascularized stroke patient for less time-sensitive post-treatment management and rehabilitation.

FIGURE 1 Proposed Model for Community-Based Stroke Care



The stroke patient presents to a local community hospital and is evaluated by the stroke team (neurology could be provided by telemedicine from the urban medical center if not locally available). If endovascular mechanical thrombectomy is indicated, it is performed within guideline-directed door-to-balloon standards by a carotid stent–capable interventionalist (cardiology, vascular surgery, or interventional radiology). Following the emergent revascularization procedure, patients requiring tertiary care may be transferred to the urban medical center.

Although acknowledging there are specific credentialing requirements for vascular territories—that is, coronary, carotid, and lower extremity—once competence has been obtained in that territory, there should not be specific procedure requirements. Once competency has been achieved for cerebrovascular interventions, requiring demonstrated skill for: 1) arterial vascular access; 2) negotiating the aortic arch; and 3) selective cannulation of the internal carotid artery, whether a carotid stent procedure is performed or MT of LVO should not be a barrier.

The data are clear that clinical outcomes for acute stroke patients treated by a team of a neurologist and a carotid stent-capable IC are not inferior to care provided in urban medical centers by NIs. Similar to the successful expansion of local STEMI care, the IC community is in position to meet the growing demand for community-based acute stroke reperfusion. Much like the "heart team" approach for complex structural and heart valve diseases, the collaboration of multidisciplinary "stroke teams" involving neurologists and ICs can extend timely reperfusion for acute stroke patients to communities that lack access to NI specialists. Turf battles are contrary to good patient care. We need to move on to extending emergent stroke care to the underserved communities that need it.

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