The Rapidly Changing Radiological Landscape for Stroke Therapy

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In the past decade, we have shattered windows, rejected dogma, and proven that the untreatable can indeed be treated. We have witnessed unprecedented advances in acute stroke therapy, in large part due to advances in acute imaging. In only a few years, CT-angiography (CTA) has become the standard of care for acute stroke imaging, penetrating even the most remote rural settings, such as the massive northern territory of Nunavut in the Canadian Arctic. In addition, the proliferation of telestroke and teleradiology has allowed a “drip-and-ship” approach to thrombolysis and thrombectomy for the many geographically isolated hospitals.

These rapid changes have forced general radiologists, emergency department radiologists and radiology residents alike to be up to date with the current imaging protocols for acute ischemic stroke (AIS), in particular CTA, and to gain the necessary expertise to provide timely reports during the day, afterhours and on weekends; a requirement that stems from limited or absent neuroradiology staffing, often present in smaller or rural institutions.

In this review, McDonough et al provide a concise and definitive overview of the role of acute stroke imaging. They argue neuroimaging-based triaging of patients for therapy comes down to 3 fundamental concepts: core, clot, and collaterals. Moreover, they highlight the critical elements to effective stroke therapy: speed and efficiency.

Indeed, early diagnosis and treatment of patients with AIS secondary to large vessel occlusion (LVO) are key to limit permanent disability. Given its fast access and wide availability, CT is the imaging modality of choice in the context of suspected acute stroke. The combination of non-contrast CT (NCCT), CTA of the head and neck, and CT perfusion (CTP) is recognized in many stroke centers as the “state-of-the-art advanced imaging” protocol, in particular when images are obtained beyond the established 4.5h window or in the context of wake up strokes. CT perfusion, however, is not consistently available throughout the country, in particular in the rural setting. While the current guidelines recommend CTP for the late time window (>6 h), McDonough et al argue that in their experience multiphase CT angiography (mCTA) is comparable, does not require post-processing, and is less likely to exclude patients that may benefit from late window therapy. In addition, the authors state that CTP is not necessary for clinical decision-making in patients presenting within 6 hours from last seen well and should not delay the use of thrombolytics or endovascular thrombectomy (EVT).

While McDonough et al acknowledge the importance of advanced multimodal imaging with MRI and CTP in late windows in light of the DAWN and DEFUSE 3 trials, they make a compelling case that the made-in-Canada approach of mCTA is easier to implement, is widely available, and is already routinely taught as a core competency in several of the radiology training programs. Multiphase CT angiography is indeed fast, reliable, safe and has been successfully validated for EVT patient selection up to 12 hours. multiphase CT angiography, however, is not being used routinely in many community hospitals and in rural areas, likely due to lack of training of technologists and/or general radiologists on this relatively new imaging technique. This is a minor challenge that should not be difficult to address.

Rapid advances in technology will continue to shape the diagnosis and treatment of patients with AIS. This is already happening with the rise of artificial intelligence, machine learning and automation, which are changing the way imaging diagnosis is obtained. Clinically validated software such as Rapid CTA and Rapid LVO (RAPID 4.9.1 (IschemiaView, Menlo Park, CA)) already allows for quick identification of LVO through fully automated analysis of CT angiography. This software algorithm delivers results within 3 minutes and immediately sends notifications to the stroke team via email, PACS and web apps, thereby expediting triage, appropriate treatments, and ultimately outcomes. Similarly, there are at least 5 automated CTP imaging platforms licensed in Canada, 1 of which (Rapid CTP) has been used in several clinical trials including EXTEND, SWIFT-PRIME, DAWN, EXTEND-IA, AND

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DEFUSE 3. Such software can automatically deliver quantified and color-coded maps that allow quick determination of core infarct and penumbra, usually within 2 minutes, aiding in the selection of appropriate patients for thrombectomy.

Finally, as mentioned by the authors, new opportunities continue to emerge, and the focus has recently shifted from LVOs to medium vessel occlusions (MeVOs). Although the results of non-randomized studies suggest that EVT for MeVOs is possible and safe,\(^5,6\) evidence from prospective randomized controlled trials is still necessary. With CTP and mCTA disrupting the radiology landscape, the neurovascular community is geared for another breakthrough.

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References
1. McDonough R, Ospel J, Goyal M. State of the art stroke imaging: A current perspective. *Can Assoc Radiol J* 2021; 8465371211028823. doi:10.1177/08465371211028823.
2. Albers GW, Marks MP, Kemp S, et al. Thrombectomy for stroke at 6 to 16 hours with selection by perfusion imaging. *N Engl J Med*. 2018;378(8):708-718.
3. Nogueira RG, Jadhav AP, Haussen DC, et al. Thrombectomy 6 to 24 hours after stroke with a mismatch between deficit and infarct. *N Engl J Med*. 2018;378(1):11-21.
4. Goyal M, Demchuk AM, Menon BK, et al. Randomized assessment of rapid endovascular treatment of ischemic stroke. *N Engl J Med*. 2015;372(11):1019-1030.
5. Barchetti G, Cagnazzo F, Raz E, Barbagallo G, Toccaceli G, Peschillo S. Mechanical thrombectomy of distal occlusions using a direct aspiration first pass technique compared with new generation of mini-0.017 microcatheter compatible-stent retrievers: A meta-analysis. *World Neurosurg*. 2020;134:111-119.
6. Hofmeister J, Kulcsar Z, Bernava G, et al. The catch mini stent retriever for mechanical thrombectomy in distal intracranial occlusions. *J Neuroradiol*. 2018;45(5):305-309.