PANEL DISCUSSION

Advancements in Intraprocedural Stroke Imaging

Reviewing the utility of the direct-to-angio/in-room CT approaches in the stroke setting.

With Dorothea Altschul, MD, FAHA, FSVIN, and Eytan Raz, MD, PhD

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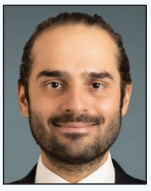

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What is the unmet clinical need most likely to be addressed using direct-to-angio or in-room CT in the stroke setting?

Dr. Altschul: About 87% of all strokes are estimated to be ischemic in nature. In the event of an ischemic stroke with a large vessel occlusion (LVO), time from symptom onset to reperfusion is a strong indicator for clinical outcome and, along with final reperfusion status, the most relevant factor. In the stroke setting, rapid diagnosis and treatment could be facilitated by either direct-to-angio or in-room CT imaging.

In a recent publication by Rai et al, it was estimated that the incidence of acute ischemic stroke (AIS) is 216/100,000 persons/year (95% CI, 199-238) or 718,191 AIS/year in the United States. A vascular occlusion was observed in 21% of patients with AIS (95% CI, 15%-29%).[1] The rate of LVO was 24/100,000 persons/year (95% CI, 19-31) or 80,075 LVOs/year (95% CI, 62,457-104,375). The rate of medium vessel occlusion (MeVO) was 20/100,000 persons/year or 65,798 MeVOs/year (95% CI, 45,555-95,110).

Mechanical thrombectomy procedures are currently performed in 5% of all AISs and 27% of all LVOs and MeVOs. Growth in procedures is estimated to be 5% to 10% over the next several years.[1] There is a possibility that using direct-to-angio or in-room CT could increase the number of mechanical thrombectomies performed, ultimately leading to better outcomes for stroke patients.

Dr. Raz: An unmet medical need is a serious condition for which treatment is not addressed adequately by currently available therapy. Although mechanical thrombectomy has revolutionized the approach to AIS, a favorable clinical outcome has not been achieved in more than 50% of patients in the endovascular arms of the major thrombectomy trials.[2,3] Thus, additional improvement can be achieved. One area to focus on to refine our results is the reduction of clinical stroke onset-to-reperfusion time, with the obvious assumption that this would result in reduced infarct burden and consequently improve functional status.

The direct-to-angio/in-room CT paradigms come into play with this purpose in mind—namely, to reduce the door-to-recanalization time and thus the overall symptom onset-to-reperfusion time.

How are direct-to-angio and in-room CT applied in this setting?

Dr. Raz: These approaches bypass the conventional imaging by performing CT directly in the angio suite, with the main purpose of excluding a hemorrhage or a large, completed infarct. After noncontrast flat-panel cone-beam CT (CBCT) is done, one can either perform flat-panel CTA to identify an LVO or go straight to catheter angiography and treat the LVO. The in-room CT

protocol is very similar but necessitates a special hybrid room with both a CT scanner and an angio suite. These special hybrid rooms are only available in a handful of places and are hard to scale; for that reason, I will mainly refer to the direct-to-angio protocol in this article.

This is a paradigm shift that appears particularly suitable for patients presenting very early after onset or for transfer patients, even though it is also possible for this approach to work in the late window.[4] Refining a direct-to-angio or in-room CT protocol could have broad implications.

The ANGIOCAT randomized clinical trial looked at patients presenting within 6 hours and evaluated the difference between the traditional pathway of receiving the patient in the emergency department (ED), performing the CT/CTA, and then transferring to the angio suite for thrombectomy versus the direct-to-angio pathway.[5] The trial (two-thirds of patients were transferred from another hospital) showed a significant improvement of door-to–arterial puncture time: 18 minutes in the direct-to-angio group compared with 42 minutes for the traditional pathway (odds ratio, 2). The direct-to-angio arm also had improved functional status compared to the conventional pathway arm, as measured by modified Rankin Scale at 90 days.

Dr. Altschul: Stroke guidelines recommend a CT of the head within 20 minutes of the patient's arrival to the ED to assess the brain for established infarcts or alternative diagnoses (eg, hemorrhagic infarction). Advanced CT imaging is still recommended for patients suspected of an LVO (CTA) and/or CT perfusion imaging in the delayed time window presentation (6-24 hours). Newer data challenge those guidelines.[4,5]

"Direct to angio" may refer to several scenarios but all are designed to bypass a conventional stroke protocol evaluation with multidetector CT scanning in the ED. This can be done with direct admissions or transfer-in patients. For the latter group, a CT of the head would have been obtained by the outside hospital, and many stroke centers already have pathways in place for that specific population. CBCT can be performed directly on the fluoroscopy angiography system, reducing the time to groin puncture and, ultimately, time to recanalization.

In-room CT is a multimodality suite with angiography and multidetector CT scanner in the same room, allowing for the most flexibility in room use.

What is the burden of proof necessary to demonstrate utility of this modality (ie, what specific clinical improvement differential)? What outcome, when proven, will drive adoption?

Dr. Altschul: In a direct-to-angio protocol, patient selection is key. In the ANGIOCAT trial,[5] the rate of false-positive direct-to-angio candidates—defined as patients meeting all the inclusion criteria (presentation within 6 hours, Rapid Arterial Occlusion Evaluation Score > 4, and/or National Institutes of Health Stroke Scale > 10) who did not have LVO—was 15.5%. However, it is currently not known if these results are generalizable to all systems of care; the trial also did not include patients presenting in the delayed time window.

As it stands right now, in addition to showing better outcomes, different workflow models will need to be studied inside and outside the hospital. Our tools to accurately determine LVO or MeVO will need to be standardized, and our understanding of infarct progression may need to improve as well.

Dr. Raz: Using prior studies as evidence, including the ANGIOCAT single-center randomized trial, the study by Pfaff et al,[6] and multiple other retrospective studies, we can safely say that the direct-to-angio approach saves approximately 30 minutes on average. Ongoing trials such as WE-TRUST (NCT04701684) and SPINNERS (NCT05458908) are trying to expand on that evidence.

WE-TRUST is a multicenter randomized trial sponsored by Philips that is very similar to ANGIOCAT; the objective is to demonstrate that the direct-to-angio workflow (with CBCT) leads to superior patient outcomes compared to the conventional CT/MR triage workflow. This trial will include 16 sites and plans to enroll 564 patients. Essentially, the goal is to validate the results of ANGIOCAT in a broader population.

SPINNERS seeks to answer whether noncontrast CBCT imaging performed in the angio suite is noninferior to conventional noncontrast CT in sensitivity and specificity for detecting intracranial hemorrhages. Answering this question will likely facilitate a wider adoption of the direct-to-angio protocol.

How do interested centers become involved in using either a direct-to-angio or in-room CT approach? What are the first steps in considering and possibly implementing this protocol?

Dr. Altschul: Each center must decide what its most pressing needs are. There are currently no right or wrong answers. Centers receiving transfer-in patients can start by adapting their workflow to a direct-to-angio protocol with or without CBCT imaging.

In-room CT is a good option for hospitals considering a multispeciality and multimodality expansion, where all emergent/urgent interventional procedures can be housed in one designated emergency angiography room. Such a multimodality approach would allow interventional radiologists, vascular interventionalists, and neurointerventionalists (with or without interventional

cardiologists) to use the room for all time-dependent, emergent/urgent procedures—with another angiography room elsewhere for backup.

In this scenario, one could even visualize a two-way evaluation and treatment of one highly selected suspected LVO ischemic stroke patient on the angiography table receiving CBCT with or without mechanical thrombectomy and another potential pulmonary thrombectomy patient receiving parallel CTA, all in one combined room and preferably located in the ED.

Many hospitals have a single biplane neuroangiography room, and those rooms may not be able to triage a direct-to-angio approach; however, they could be used for backup to the in-room CT room.

Dr. Raz: First and foremost, a machine able to perform CBCT must be available; this is a standard feature of machines produced in the last 15 years or so. Hybrid CT-fluoroscopy equipment is much less available due to cost limitations, and only a few centers can afford it.

It is necessary to have a protocol in place and have experience in reviewing the CT produced by the flat panel, given that reconstructions are usually performed by the physician. This is different from conventional CT in which a dedicated CT tech is usually the one responsible for the task. The image quality will not be the same as traditional CT, and I recommend gaining some experience in using this imaging before embarking on this protocol. There may also be cultural barriers (discussing with the ED and stroke neurologists) and architectural barriers (how far is the angio suite from the ED?) to consider.

If considering this protocol, it would make sense to start applying it to transfers as a first step. This will allow enough time for the neurointerventional radiology team to be on site before the patient arrives. Additionally, an LVO was likely already confirmed on outside CTA, alleviating the issue of performing unnecessary angiography.

What is your impression of the overall status of research with these modalities?

Dr. Raz: The discussed studies strongly suggest that direct-to-angio brings significant advantages in terms of stroke patients' outcomes. Despite the evidence, there are multiple obstacles that will limit a smooth transition in the real-world setting.

The main concern is the availability of a neurointerventional radiology team on site 24/7. This appears to be a big limitation for this model becoming standard throughout. In ANGIOCAT, the main reason for excluding patients was off-hours admission, which did not allow sufficient time for the neurointerventional radiology team to be on site before patient arrival. Other reasons for exclusion were that the angio suite was not available or a prenotification by emergency medical services was not in place. Few neurointerventional radiology practices have enough volume to justify having a team on site during nights and weekends. As a result, it appears much more likely that this model will be mainly used during working hours or for transfers with enough heads-up time.

For safety, we also need to assess and monitor: (1) adverse outcomes, given the potential for an unnecessary catheter angiography procedure, especially if no flat-panel CTA is done after CBCT; and (2) possible medical stability issues in patients leaving the ED to go direct to angio. What happens when a hemorrhage is identified? Would the resources for acute management also be available as they are for the conventional pathway?

Another limitation specific to direct to angio is the image quality of flat-panel CT obtained in the angio suite. Although the sensitivity is reasonable for ruling out significant hemorrhages, it is probably not ideal for ruling out small parenchymal hematoma or small sulcal subarachnoid hemorrhage or adequately assessing ASPECTS (Alberta Stroke Program Early CT Score). Work is ongoing to answer this question (eg, SPINNERS trial).

Dr. Altschul: To update the current stroke guidelines, it will need to be proven that CBCT can replace conventional CT within a currently established stroke pathway. Randomization of mechanical thrombectomy patients to biplane versus monoplane angiography system, if proven safe and efficacious, could help with emergent direct-to-angio procedure room access. Artificial intelligence can improve timely LVO detection and may aid in better triage decisions. ■

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Disclosures
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Dr. Raz: Stockholder, Siemens.