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Computed tomography offers superior visualization of small vessels, such as the intracranial arteries encountered in neuroradiologic imaging. CT is an excellent technique for the initial work-up of intracranial aneurysms (IAs). In this setting, it is also the preferred technique for detection of spontaneous SAH with high predictive value.[1,2] With traditional treatment options such as microsurgical clipping and endovascular coiling[3] and recent advances such as flow-diverting devices[4] and intrasaccular flow disruptors[5,6] to treat unruptured IAs, diagnostic imaging plays a vital role in the initial diagnosis and treatment-planning. After endovascular treatment, longitudinal follow-up and monitoring via imaging were proved valuable as shown in the International Subarachnoid Aneurysm Trial (ISAT).[7] Aneurysm morphology, device integrity, and stent apposition/malapposition are useful indicators for assessing IA recurrence and identifying de novo aneurysms.[8,9] Currently, cerebral angiography is widely used for comprehensive characterization of IAs and treatment-planning.[2,10] This is an invasive procedure that may lead to clinical complications such as puncture-site hematoma, arteriovenous fistula, nerve injury, and pulmonary embolism.[11] Therefore, MRI and CTA have received substantial attention as safe noninvasive alternatives to conventional angiography for IA detection and management.[3]

The American Stroke Association/American Heart Association recommends routine follow-up of unruptured aneurysms using MRI or CTA to monitor morphologic changes for assessing the risk of rupture.[12] Furthermore, CT is commonly used in the acute setting for critically ill patients with a pooled sensitivity for IA detection of 98%.[13] However, detecting small aneurysms (<2 mm) has remained a challenge for CT technologies.[2] With the introduction of photon-counting detector (PCD) CT in clinical practice, unprecedented spatial resolution (up to 110 μm, in-plane) and multienergy "spectral" imaging are made possible,[14] further advancing the clinical utility of CT for neuroimaging tasks. Several studies involving prototype PCD-CT systems and the recent clinical PCD-CT system have explored the benefits of PCD-CT for neuroimaging applications. However, comprehensive reader studies focusing on neurovascular imaging, specifically ultra-high-resolution (UHR) neurovascular imaging, have been scarce. Symons et al[15] demonstrated superior image quality from PCD-CT compared with energy-integrating detector (EID) CT for carotid and intracranial CTA in 16 asymptomatic human subjects using a prototype PCD-CT system equipped with a 0.25-mm detector pixel (at the isocenter).

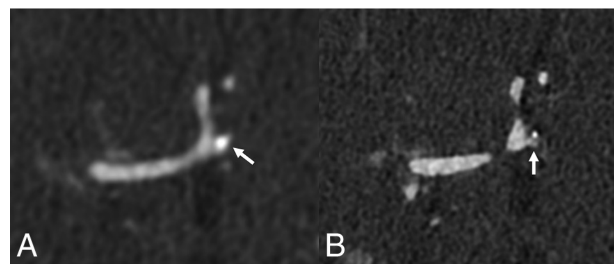

FIGURE Example of a remnant anterior communicating artery aneurysm missed on EID CTA (*A*) and evident on PCD CTA (*B*) in a patient imaged during follow-up after aneurysm clipping. Coronal oblique reconstruction from the EID CTA examination, reconstructed at 0.75-mm section thickness (Qr54 kernel), demonstrates no clear evidence of recurrent aneurysm (*A*, *arrow*) due to relatively lower spatial resolution and blooming artifacts from the aneurysm clip. Coronal oblique image from follow-up PCD-CTA (0.2-mm section, Qr89 kernel) of the same patient clearly shows a small remnant aneurysm (*B*, *arrow*), better depicted due to higher spatial resolution and reduced blooming artifacts.

Since PCD-CT became clinically available in 2021, additional evidence demonstrating the benefits of UHR and multienergy PCD-CT for head and neck imaging has been reported. For instance, UHR PCD-CT can clearly depict infundibulum versus aneurysm,[16] often ambiguous on EID-CT. UHR PCD-CT may also be superior for the detection of tiny recurrent or remnant aneurysms after surgical or other treatment (Figure). Spampinato et al,[17] using virtual monoenergetic images from clinical PCD-CT (standard collimation at 144×0.4 mm) reconstructed at 50 and 60 keV, showed a superior contrast-to-noise ratio (CNR) compared with EID-CT images acquired at 90−100 kV. However, a study by Michael et al[18] revealed that the polychromatic images from PCD-CT outperform monoenergetic reconstructions for diagnostic head and neck CTA. Due to the use of new detector technology and different image types on the first commercial PCD-CT system (NAEOTOM Alpha; Siemens Healthineers), a systematic optimization of imaging and image reconstruction parameters is imperative to take full advantage of the unique technical features of PCDs for neurovascular imaging.

In this study, Tóth et al[22] present results from their preliminary assessment of PCD-CT image quality for visualization of intracranial aneurysms in a small cohort of patients ($n = 10$). PCD-CT scans were acquired at a single tube potential (140 kV) using the UHR collimation (120 × 0.2 mm) and polychromatic images (T3D with x-ray energies between the low-energy threshold and the maximum x-ray energy defined by the tube potential) were reconstructed. EID-CT scans were obtained using varying tube potentials (100–140 kV) and different scanner platforms. The authors measured quantitative parameters such as noise, SNR, CNR, and sharpness by means of the full width at half maximum of line profiles to objectively characterize image quality. Furthermore, 3 radiologists rated PCD-CT and EID CT images for subjective assessment of image quality.

Quantitative results showed that image noise increased with increasing kernel strength (Bv36 to Bv48) on PCD-CT as anticipated. This trend consequently resulted in decreased SNR and CNR at the sharpest kernel and the highest SNR and CNR for the smooth kernel (Bv36). Similarly, vessel sharpness was higher with the sharpest kernel (Bv48) compared with Bv44, Bv40, and Bv36. While comparisons within the PCD-CT group provide objective information across the different kernels, PCD-CT versus EID-CT comparisons for signal, SNR, and CNR pooled across patients are likely confounded due to the use of single tube potential (140 kV) on PCD-CT and variable tube potentials (100–140 kV) on the EID-CT. In addition to the image-reconstruction parameters discussed by Tóth et al, future studies should be aimed at assessing the optimal tube potential that plays an important role in overall image quality for contrast-enhanced examinations.

Qualitative results from this study showed that the readers preferred PCD-CT images reconstructed using Bv44 and Bv48 over EID-CT images, despite having higher noise and lower CNR and SNR compared with the PCD-CT Bv36 kernel. Furthermore, PCD-CT Bv48 images had statistically lower image noise ($P = .012$) in small intracranial arteries and no significant difference in image noise for extracranial and large intracranial locations compared with EID-CT images. Readers preferred Bv48 over Bv36 for aneurysm visualization despite a higher image noise in the former, resulting in a noise-resolution trade-off. However, the iterative reconstruction (quantum iterative reconstruction [QIR]) strength was set to the minimum value of 1 in this study, and further reduction in image noise, if desired, could be achieved by using higher QIR strengths without altering the image texture (noise power spectrum) or spatial resolution as shown in prior studies.[14,19]

This study has a few limitations owing to its pilot nature. First, the sharpest kernel evaluated in this study was Bv48, which is a body-vascular kernel with a 50% modulation transfer function of 5.4 line-pairs per centimeter.[20] This kernel does not leverage the full intrinsic spatial resolution of UHR PCD-CT. Also, dedicated head kernels (eg, head vascular) may be more relevant for imaging IAs. While through-plane resolution was maximized by means of thin 0.2-mm sections, dedicated UHR kernels beyond Bv48 will yield improved in-plane resolution. The average maximum diameter of IAs detected in this study was 3.3 mm. Investigations focusing on smaller aneurysms are warranted to determine the detection limits for IAs using UHR PCD-CT as a reliable and safer alternative to invasive cerebral angiography. Second, to translate the proposed approach to post-IA treatment scenarios where devices such as stents and flow diverters are present, dedicated metal artifact reduction techniques[21] should be investigated to address device-related artifacts. This suggestion is particularly important in the assessment of residual IAs or recurrence using UHR PCD-CT. The study by Tóth et al provides initial insights regarding the potential of UHR PCD-CT for imaging IAs and serves as a foundation for future PCD-CT investigations in neurovascular imaging.

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