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Case Report

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Advanced Detection of a Small Intracranial Aneurysm Using Photon-Counting Computed Tomography Angiography

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ABSTRACT

Using intravenous contrast, photon-counting computed tomography angiography (PCCT-A) provides detailed images of intracranial vessels. We report a case in which PCCT-A revealed a 1.5 mm aneurysm at the bifurcation of the middle cerebral artery that was not seen on magnetic resonance angiography. This case highlights the clinical value of PCCT-A in noninvasively detecting small intracranial aneurysms.

KEYWORDS: Photon-counting computed tomography angiography, Small intracranial aneurysm, Neurovascular imaging, Noninvasive angiography, Middle cerebral artery bifurcation

INTRODUCTION

Intracranial aneurysms are serious cerebrovascular conditions that can have life-threatening consequences if they remain undiagnosed or untreated (19). Widely used imaging tools such as computed tomography angiography (CT-A) and magnetic resonance angiography (MR-A) often lack sufficient spatial resolution, which limits their ability to reveal very small aneurysms (20). Although highly informative, even 2D digital subtraction angiography (DSA) can be hindered by overlapping vascular structures or unfavorable viewing angles in complex regions, such as arterial bifurcations. Therefore, 3D rotational angiography remains the most reliable approach for detecting small aneurysms (25).

In recent years, photon-counting computed tomography (PCCT) has been introduced as a noninvasive technique that markedly improves vascular imaging and may enhance the detection of aneurysms (18). In our institution, after adopting PCCT angiography (PCCT-A) as the routine vascular imaging method in patients with suspected stroke, we observed an increase in the number of aneurysms detected (24). PCCT provides higher spatial resolution, improved contrast between tissues, and fewer artifacts compared to conventional computed tomography (CT) systems (14). These technical advances allow recognition of vascular changes that might otherwise remain undetected with standard imaging modalities (18).

Here, we present a case in which a 1.5 mm aneurysm at the bifurcation of the middle cerebral artery (MCA) was detected incidentally by PCCT-A, and we discuss the potential implications of this observation for clinical practice.

CASE REPORT

A 60-year-old man presented to the emergency department with ongoing hypotension and dizziness. His past medical history was unremarkable, with no neurological deficits or chronic illnesses. A non-contrast cranial CT obtained on a 128-slice SOMATOM AS+ scanner (Siemens, Erlangen, Germany) showed no signs of intracranial hemorrhage or ischemia. How-

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ever, a hyperdense appearance of the proximal basilar artery raised suspicion of possible thrombosis or imaging artifact (8). To investigate this suspicion further, a contrast-enhanced PCCT-A was performed with 70 mL of iodinated contrast material. This examination confirmed patency of the basilar artery with no evidence of thrombus, thereby resolving the concern raised by the initial non-contrast CT. This outcome highlights the advantage of PCCT-A in evaluating vascular patency. Incidentally, a 1.5 mm saccular aneurysm was detected at the bifurcation of the left MCA (Figure 1). The aneurysm was not detectable on MR-A. Given its small size and low aspect ratio, a conservative management approach was adopted with regular follow-ups.

Technical Notes

PCCT is a cutting-edge imaging modality that offers improved spatial resolution, enhanced tissue contrast, and reduced artifacts compared to conventional CT. These features allow the identification of small vascular anomalies that conventional imaging methods may miss.

In this case, the PCCT-A was performed using a NAEOTOM Alpha Photon-Counting CT scanner (Siemens, Erlangen, Germany). The scan protocol used the following parameters: slice thickness of 0.6 mm, X-ray tube voltage of 140 kV, DW of 21.6 cm, 70 mL of Imeron 300 M contrast medium (Bracco, Milan, Italy), and intravenous injection of 300 mg of iodine/mL with a flow rate of 5 mL/s.

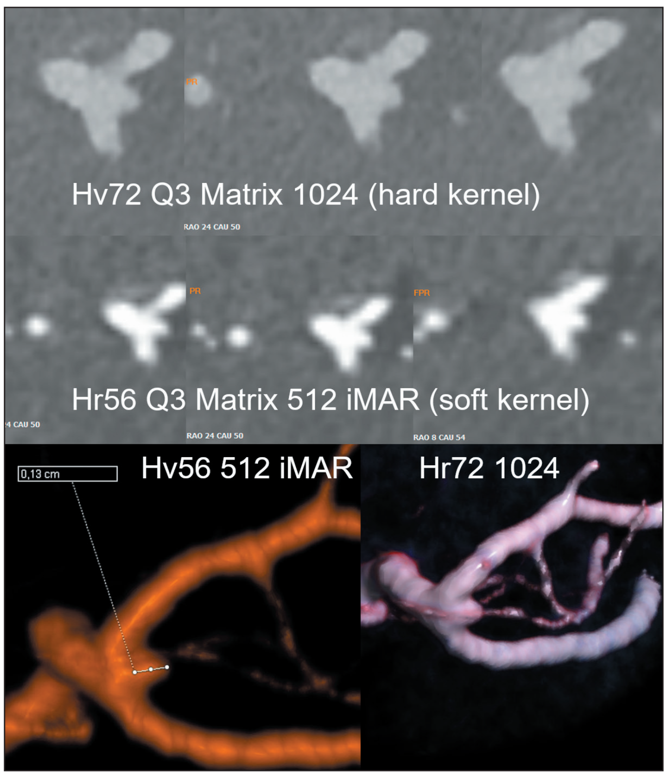

Figure 1: PCCT-A of an aneurysm at the bifurcation of the MCA. Hard and soft kernel (para-coronary) with resulting 3D reconstructions.

The dose length product for this case was 653 mGy*cm (132 effective mAs, CTDIvol*mGy 15.4 L, SSDE 26.00 mGy), which is comparable to or slightly lower than conventional CT-A protocols. These parameters optimized the detection of small vascular structures while minimizing patient radiation exposure. Today, the (theoretically) maximal resolution of PCCT can reach 0.11 mm in-plane (3,23).

DISCUSSION

Identifying small aneurysms remains clinically challenging, as their progression and risk of rupture are not yet fully clarified in the current literature (22). In this setting, PCCT enhances diagnostic confidence by offering superior spatial resolution and clearer delineation of vascular abnormalities compared to conventional CT-A and MR-A (23).

In this case, the detection of the aneurysm was facilitated by the improved spatial resolution and noise reduction capabilities of PCCT-A. Studies have suggested that aneurysms with a size ratio greater than 3 mm and an aspect ratio (the ratio of aneurysm height to neck width) greater than 1.6 are more prone to rupture (28). However, given the small size and favorable aspect ratio of the aneurysm in this case, conservative management was adopted, aligning with current guidelines (10).

Invasive vs. Noninvasive Imaging for Aneurysm Detection

Three-dimensional rotational DSA remains the gold standard for detecting and evaluating intracranial aneurysms due to its unmatched spatial resolution and ability to visualize dynamic vascular processes, such as flow patterns and associated arteriovenous fistulas or malformations. However, its invasiveness carries inherent procedural risks, including arterial injury, hemorrhage, infection, and allergic reactions to the contrast agent. In patients with subarachnoid hemorrhage, a thorough assessment may involve as many as four separate 3D DSA scans, since both carotid and vertebral arteries on each side must be examined individually. This approach inevitably adds to the patient's total radiation exposure (1,27).

In the past, conventional imaging often failed to detect small aneurysms (<3 mm). Indeed, a systematic review revealed a sensitivity of only 61% for CT-A and 38% for MR-A (28). In contrast, PCCT-A offers a noninvasive alternative with moderate radiation exposure that can visualize such small aneurysms and eliminate the procedural risks associated with DSA (16). The photon-counting detector technology enables significantly improved spatial resolution and reduced radiation exposure, offering a safer option for patients who require multiple imaging studies.

He et al. demonstrated that ultra-high-resolution PCCT-A substantially improves diagnostic accuracy and morphological characterization of unruptured aneurysms (9). This enhanced spatial resolution enables a more precise assessment of the shape and size of the aneurysm, both of which are critical for evaluating rupture risk and treatment planning.

The diagnostic performance of PCCT-A has been shown to closely align with that of DSA, the current gold standard. De

Beukelaer et al. demonstrated that PCCT-A provides comparable accuracy in assessing stents, flow diverters, and aneurysms after coiling or clipping, while offering the significant advantage of being noninvasive (5,6).

Another notable feature of PCCT-A is its ability to generate virtual non-contrast reconstructions from contrast-enhanced datasets. Decker et al. validated a novel calcium-preserving reconstruction algorithm, which reliably simulates non-contrast images, potentially eliminating the need for separate non-contrast scans in patients with vascular implants (7).

Regarding follow-up imaging after flow diversion, PCCT-A offers high-quality visualization of the aneurysm lumen and associated thrombus formation. Wei et al. and Marque et al. highlighted the potential of PCCT-A for accurate monitoring of treatment response and long-term outcomes (15,26). Furthermore, Higaki et al. emphasized its value in both pre- and post-operative settings for cranial and spinal vascular pathologies (12).

However, PCCT-A has limitations in assessing associated dynamic vascular processes, such as arteriovenous fistulas and arteriovenous malformations, where DSA remains the superior modality.

Technical Comparisons: PCCT-A vs. 3D DSA

PCCT-A outperforms conventional CT-A in terms of sharpness and signal-to-noise ratio, enabling the detection of small vascular anomalies with greater clarity (23). Compared to 3D rotational DSA, PCCT-A offers competitive spatial resolution and eliminates artifacts caused by overlapping vascular structures. The ability to distinguish blood from iodine enhances the applicability of PCCT-A (2). Additionally, the reduced radiation dose and lower contrast agent requirements of PCCT-A make it a more patient-friendly option for routine screening and follow-up evaluations (13).

However, when combined with cone beam CT, 3D rotational DSA remains the preferred method for assessing dynamic vascular abnormalities and real-time blood flow, which are crucial for evaluating arteriovenous shunts and other flow-related pathologies (28). Despite these advantages, DSA is limited by its inability to detect fully thrombosed aneurysms or aneurysms in border zones, such as small anterior communicating artery aneurysms, which can be more easily detected using PCCT-A (17,24).

Future Implications for PCCT-A in Clinical Practice

Although 3D DSA is still regarded as the gold standard for detecting aneurysms, advances in PCCT-A may gradually shift this perspective. PCCT-A combines noninvasiveness with high spatial resolution and lower radiation exposure, making it an attractive option for routine imaging, particularly in follow-up examinations (4). Its potential role in detecting incidental aneurysms also warrants further study, and the possibility of screening patients at increased risk without exposing them to invasive procedures could be a significant benefit (18).

Nevertheless, PCCT-A has limitations that prevent it from entirely replacing DSA at present. For instance, dynamic processes such as arteriovenous fistulas or flow characteristics are not well visualized with this method. Due to its high temporal resolution, dual-source CT may complement PCCT-A by offering improved visualization of these phenomena (21). Progress in both technologies could help close these gaps and strengthen their contribution to cerebrovascular imaging. Additionally, it remains uncertain whether PCCT-A is sufficiently sensitive to reveal small dissecting or blister-type aneurysms.

Further innovations are also underway. For example, Hernandez-Fajardo et al. reported on color K-edge angiography with gadolinium-based contrast, demonstrating that enhanced spectral resolution may improve tissue differentiation and vascular assessment (11).

CONCLUSION

This case demonstrates that PCCT-A is capable of detecting very small incidental aneurysms that conventional imaging may miss. The improved spatial resolution and reduced noise of PCCT-A enable more accurate assessment, which in turn supports earlier diagnosis, better-informed treatment decisions, and—when appropriate—timely intervention that may help to prevent rupture-related complications. However, the high level of detail inevitably increases the interpretive workload for neuroradiologists, who must carefully evaluate additional subtle findings. While the results of this case are encouraging, further clinical experience and systematic research are required to establish how PCCT-A should be incorporated into everyday workflows. Its role in initial detection, risk assessment, and long-term follow-up of aneurysms remains to be clarified in future studies.

Declarations

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AUTHORSHIP CONTRIBUTION

Study conception and design: HK, SJM

Data collection: HK

Analysis and interpretation of results: HK

Draft manuscript preparation: HK, SJM

Critical revision of the article: EK, ED, DB, MP

Other (study supervision, fundings, materials, etc...): DB

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REFERENCES

1. Agid R, Lee SK, Willinsky RA, Farb RI, terBrugge KG: Acute subarachnoid hemorrhage: Using 64-slice multidetector CT angiography to "triage" patients' treatment. Neuroradiology 48: 787-794, 2006. https://doi.org/10.1007/s00234-006-0129-5
2. Benson JC, Campeau NG, Diehn FE, Lane JI, Leng S, Moonis G, on behalf of the ASHNR Research Committee: Photon-counting CT in the head and neck: Current applications and future prospects. Am J Neuroradiol 45: 1000-1005, 2024. https://doi.org/10.3174/ajnr.A8265
3. Chang S, Benson JC, Lane JI, Bruesewitz MR, Swicklik JR, Thorne JE, Koons EK, Carlson ML, McCollough CH, Leng S: Ultra-high-resolution photon-counting-detector CT with a dedicated denoising convolutional neural network for enhanced temporal bone imaging. Am J Neuroradiol 46: 1188-1195, 2024. https://doi.org/10.3174/ajnr.A8572
4. De Beukelaer F, De Beukelaer S, Wuyts LL, Nikoubashman O, El Halal M, Kantzeli I, Wiesmann M, Ridwan H, Weyland CS: Photon-counting detector CTA to assess intracranial stents and flow diverters: An in vivo study with ultrahigh-resolution spectral reconstructions. Eur Radiol Exp 9: 10, 2025. https://doi.org/10.1186/s41747-025-00550-9
5. De Beukelaer F, El Halal M, De Beukelaer S, Wuyts LL, Wiesmann M, Ridwan H, Weyland CS: Photon-counting CT-angiography to assess intracranial stents and flow diverters in comparison to digital subtraction angiography. Clin Neuroradiol 35: 669-677, 2025. https://doi.org/10.1007/s00062-025-01519-2
6. De Beukelaer F, Wuyts L, De Beukelaer S, Van Hedent S, Nikoubashman O, Wiesmann M, Veldeman M, Pjontek R, Höllig A, Ridwan H, Weyland C: Photon-counting CT-angiography in comparison to digital subtraction angiography for assessing intracranial aneurysms after coiling or clipping. Neuroradiology 67: 2021-2030, 2025. https://doi.org/10.1007/s00234-025-03650-w
7. Decker JA, Bette S, Scheurig-Muenkler C, Jehs B, Risch F, Woźnicki P, Braun FM, Haerting M, Wollny C, Kroencke TJ, Schwarz F: Virtual non-contrast reconstructions of photon-counting detector CT angiography datasets as substitutes for true non-contrast acquisitions in patients after EVAR—Performance of a novel calcium-preserving reconstruction algorithm. Diagnostics 12: 558, 2022. https://doi.org/10.3390/diagnostics12030558
8. Ernst M, Romero JM, Buhk JH, Cheng B, Herrmann J, Fiehler J, Groth M: Sensitivity of hyperdense basilar artery sign on non-enhanced computed tomography. PLoS ONE 10: e0141096, 2015. https://doi.org/10.1371/journal.pone.0141096
9. He N, Lyu H, Zhang Y, Li R, Xu Z, Haacke EM, Cui Y, Li J, Dong H, Han W, Chang R, Hu Z, Zhu C, Yu Z, Lu Y, Jiang H, Yan F: Increased diagnostic accuracy and better morphology characterization of unruptured intracranial aneurysm by ultra-high-resolution photon-counting detector CT angiography. J Neurointerv Surg 18: 835-841, 2026. https://doi.org/10.1136/jnis-2025-023094
10. Hernández-Durán S, Mielke D, Rohde V, Malinova V: Is the unruptured intracranial aneurysm treatment score (UIATS) sensitive enough to detect aneurysms at risk of rupture? Neurosurg Rev 44: 987-993, 2021. https://doi.org/10.1007/s10143-020-01246-x
11. Hernandez-Fajardo CA, Lux F, Doussineau T, Dufort S, Langlois JB, Houmeau A, Gutwinska A, Coulibaly RS, Robert A, Duc GL, Tillement O, Douek P, Si-Mohamed S. Color K-edge angiography with a dedicated gadolinium-based contrast agent for spectral photon-counting computed tomography. Diagn Interv Imaging 106: 421-429, 2025. https://doi.org/10.1016/j.diii.2025.07.001.
12. Higaki F, Hiramatsu M, Yasuhara T, Sasada S, Otani Y, Haruma J, Inoue T, Morimitsu Y, Akagi N, Matsui Y, Iguchi T, Hiraki T: Cranial and spinal computed tomography (CT) angiography with photon-counting detector CT: Comparison with angiographic and operative findings. Jpn J Radiol 43: 143-151, 2025. https://doi.org/10.1007/s11604-024-01661-w
13. Jalal S, Nicolaou S: Advanced imaging technology: Photon counting CT. Can Assoc Radiol J 75: 20-21, 2024. https://doi.org/10.1177/08465371231172738
14. Marcus RP, Feuerriegel GC, Marth AA, Goller SS, Nanz D, Anhaus J, Sutter R: Reducing metal artifacts in clinical photon counting detector computed tomography—A phantom study of an exemplary total hip arthroplasty. Skeletal Radiol 54: 1233-1246, 2024. https://doi.org/10.1007/s00256-024-04820-2
15. Marque T, Dumas V, Agripnidis T, Zhu F, Charbonnier G, Donnard B, Holay Q, Darcourt J, Scarcia L, Guédon A, L'Allinec V, Girot J-B, Marnat G, Forestier G, Bellanger G, Alias Q, Bonnard L, Bourcier R, Allard J, Bretzner M, Coudert R, Rouchaud A, Hak J-F, Lefebvre M, Gerardin E, Papagiannaki C, Burel J: Imaging follow-up of unruptured intracranial aneurysms treated with flow diverter: Insights from a French collaborative survey. J Neuroradiol 52: 101338, 2025. https://doi.org/10.1016/j.neurad.2025.101338
16. McKinney AM, Palmer CS, Truwit CL, Karagulle A, Teksam M: Detection of aneurysms by 64-section multidetector CT angiography in patients acutely suspected of having an intracranial aneurysm and comparison with digital subtraction and 3D rotational angiography. Am J Neuroradiol 29: 594-602, 2008. https://doi.org/10.3174/ajnr.A0848
17. Pourmorteza A, Symons R, Reich DS, Bagheri M, Cork TE, Kappler S, Ulzheimer S, Bluemke DA: Photon-counting CT of the brain: In vivo human results and image-quality assessment. Am J Neuroradiol 38: 2257-2263, 2017. https://doi.org/10.3174/ajnr.A5402
18. Rajendran K, Madhavan AA: Optimizing photon-counting detector CT for imaging intracranial aneurysms. Am J Neuroradiol 45: 1458-1460, 2024. https://doi.org/10.3174/ajnr.A8400
19. Renowden S, Nelson R: Management of incidental unruptured intracranial aneurysms. Pract Neurol 20: 347-355, 2020. https://doi.org/10.1136/practneurol-2020-002521
20. Rustemi O, Alaraj A, Shakur S, Orning J, Du X, Aletich V, Amin-Hanjani S, Charbel F: Detection of unruptured intracranial aneurysms on noninvasive imaging. Is there still a role for digital subtraction angiography? Surg Neurol Int 6: 175, 2015. https://doi.org/10.4103/2152-7806.170029

21. Schmidt B, Flohr T: Principles and applications of dual source CT. Phys Med 79: 36-46, 2020. https://doi.org/10.1016/j.ejmp.2020.10.014
22. Sonobe M, Yamazaki T, Yonekura M, Kikuchi H: Small unruptured intracranial aneurysm verification study: SUAVe study, Japan. Stroke 41: 1969-1977, 2010. https://doi.org/10.1161/STROKEAHA.110.585059
23. Thomsen FSL, Horstmeier S, Niehoff JH, Peña JA, Borggrefe J: Effective spatial resolution of photon counting CT for imaging of trabecular structures is superior to conventional clinical CT and similar to high resolution peripheral CT. Invest Radiol 57: 620-626, 2022. https://doi.org/10.1097/RLI.0000000000000873
24. Tóth A, Chetta JA, Yazdani M, Matheus MG, O'Doherty J, Tipnis SV, Spampinato MV: Neurovascular Imaging with ultra-high-resolution photon-counting CT: Preliminary findings on image-quality evaluation. Am J Neuroradiol 45: 1450-1457, 2024. https://doi.org/10.3174/ajnr.A8350
25. Van Rooij WJ, Sprengers ME, De Gast AN, Peluso JPP, Sluzewski M: 3D Rotational angiography: The new gold standard in the detection of additional intracranial aneurysms. Am J Neuroradiol 29: 976-979, 2008. https://doi.org/10.3174/ajnr.A0964
26. Wei J, Zhang J, Li X: Evaluation of intracranial fusiform aneurysm after flow diverter treatment at photon-counting CT. Stroke 55: e328-e329, 2024. https://doi.org/10.1161/STROKEAHA.124.049448
27. Westerlaan HE, Van Dijk JMC, Jansen-van Der Weide MC, De Groot JC, Groen RJM, Mooij JJA, Oudkerk M: Intracranial aneurysms in patients with subarachnoid hemorrhage: CT angiography as a primary examination tool for diagnosis—Systematic review and meta-analysis. Radiology 258: 134-145, 2011. https://doi.org/10.1148/radiol.10092373
28. White PM, Wardlaw JM, Easton V: Can Noninvasive imaging accurately depict intracranial aneurysms? A systematic review. Radiology 217: 361-370, 2000. https://doi.org/10.1148/radiology.217.2.r00nv06361