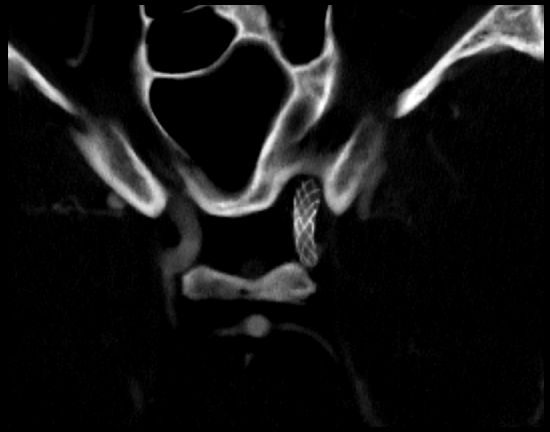
When Less is More: Advantages of Photon-Counting CT in the Vascular Setting





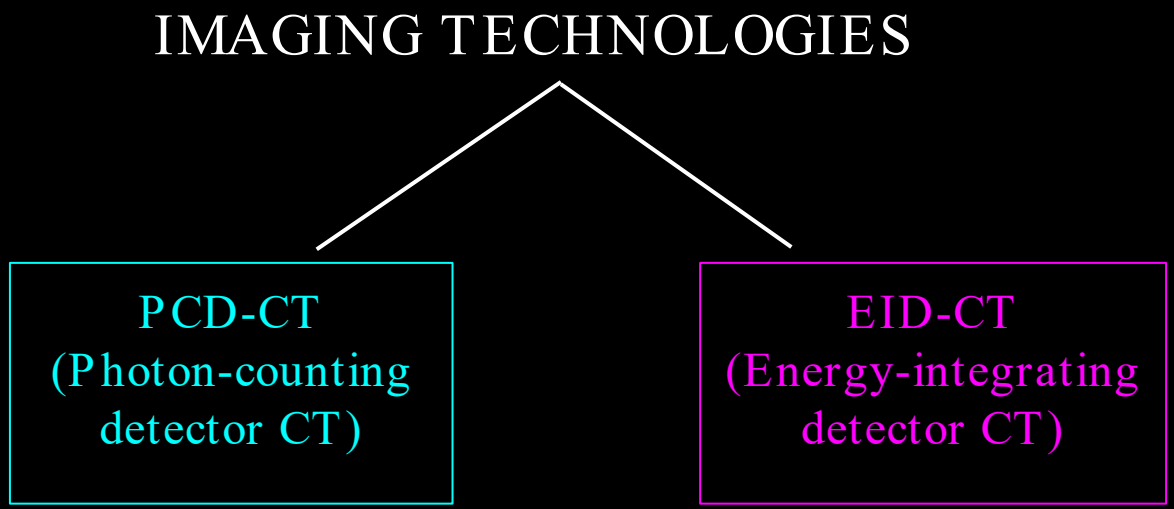
MAYO CLINIC

Mara Jindeel MD, John Murray MD, Johnny Sandhu MD, Dinesh Rao MD, Benjamin Ludwig MD, Richard Beegle MD

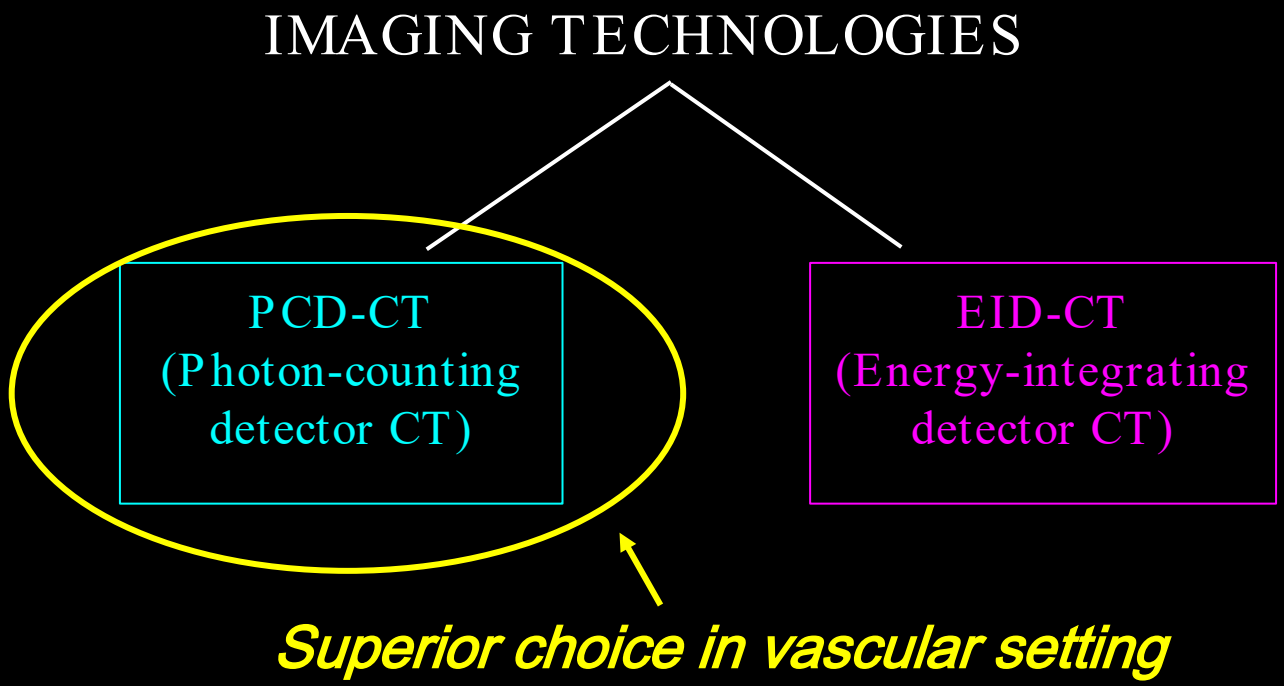
Roadmap

- Overview of PCD-CT and EID-CT
- Learning objectives
- Technical differences between PCD-CT & EID -CT
- Clinical & diagnostic implications
- Example cases
- Conclusion

Overview


IMAGING TECHNOLOGIES
PCD-CT
(Photon-counting
detector CT)
EID-CT
(Energy-integrating
detector CT)

Overview


IMAGING TECHNOLOGIES
PCD-CT
(Photon-counting
detector CT)
EID-CT
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detector CT)
Superior choice in vascular setting

Learning Objectives

- Understand the technical differences between PCD-CT and EID-CT.
- Understand how the differences affect image formation and diagnostic quality.
- Recognize the utility of PCD-CT in the setting of vascular stents.
- Identify, through clinical cases, differences in stent visualization between PCD-CT and EID-CT.

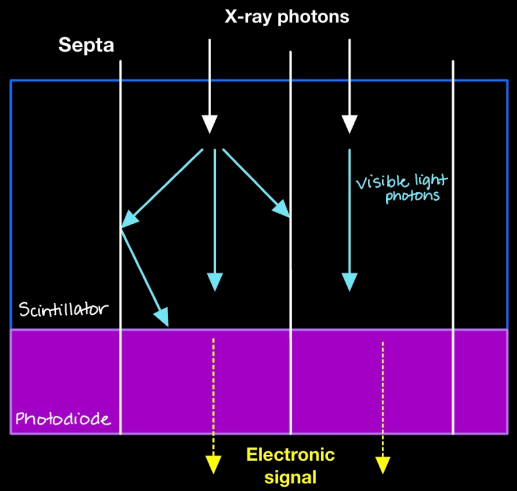
Technical Differences

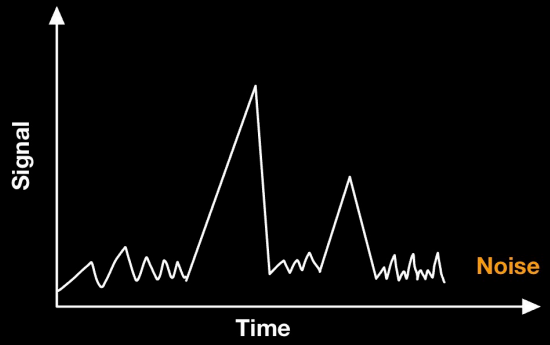
PCD-CT and EID-CT differ fundamentally in how they detect and encode energy (x-ray photons). This profoundly impacts image quality.

PCD-CT: counts each individual x-ray photon and converts it directly into an electrical signal in one step.

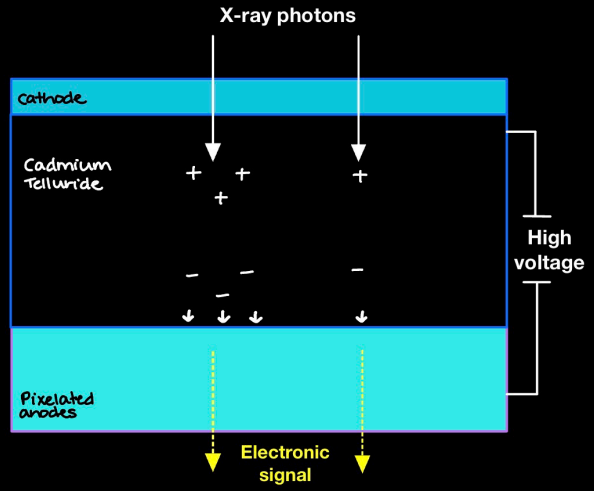
EID-CT: aggregates the energy of all photons, first converting the x-ray photons to visible light, then into an electrical signal that produces an image.

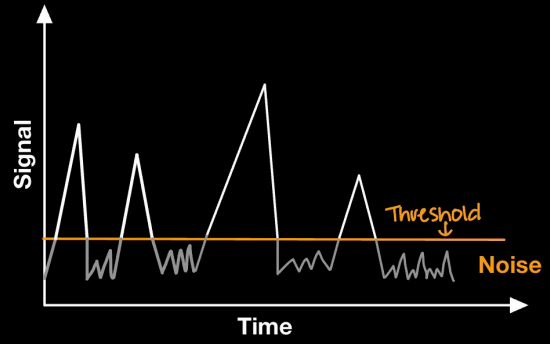
EID-CT





PCD-CT





EID-CT: scintillator converts x-ray photons→visible light→detected by photodiode→converted into electronic signal. *Unable to differentiate between high/low energy photons.*

PCD-CT: semiconducting material absorbs x-ray photons→converts *individual photons* above defined noise threshold into electronic signal.

Technical Advantages of PCD-CT

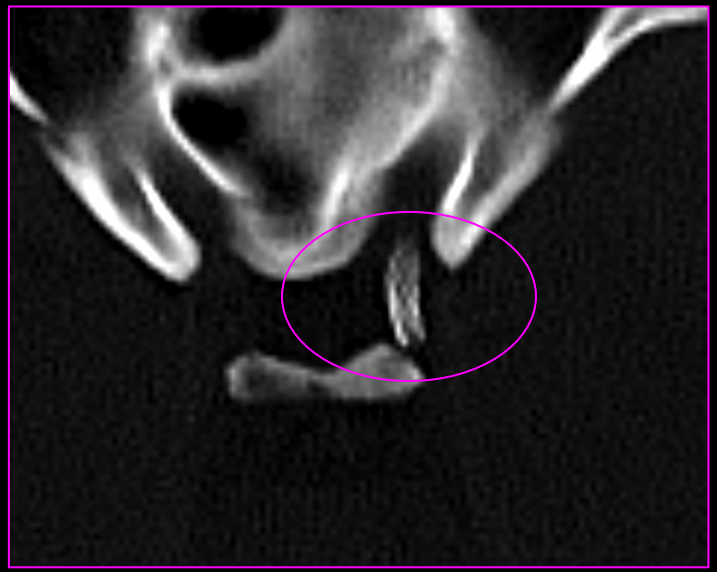
- Equal energy contribution
  - EID-CT high energy photons contribute more to detector signal than low energy photons
  - PCD-CT equal contribution to detector response across the energy spectrum
    - Low energy range near K-edge of Iodine is essential for soft tissue contrast
    - Leads to increase iodine CNR and dose efficiency
- Eliminates the signal below a low energy threshold, rejecting electronic noise and leading to increased SNR
- Does not require septa; therefore, pixels can be smaller, yielding a sharper image with higher spatial resolution (0.2 mm slice thickness and in plane resolution is 110 micrometers).

Diagnostic Advantages of PCD-CT: Intravascular Stents

PCD-CT is especially beneficial in evaluation of intravascular stents.
Small devices and metallic components pose challenges for EID-CT.

- High spatial resolution and reduced image noise
  - improves visualization of the stent lumen, architecture, and adjacent structures
- Artifact reduction
  - facilitates assessment of the surrounding vasculature and leads to more accurate estimation of stenosis (less blooming)
- Sharper image
- Less radiation and potential less contrast usage

Case 1: Internal Carotid Artery Stent Braid



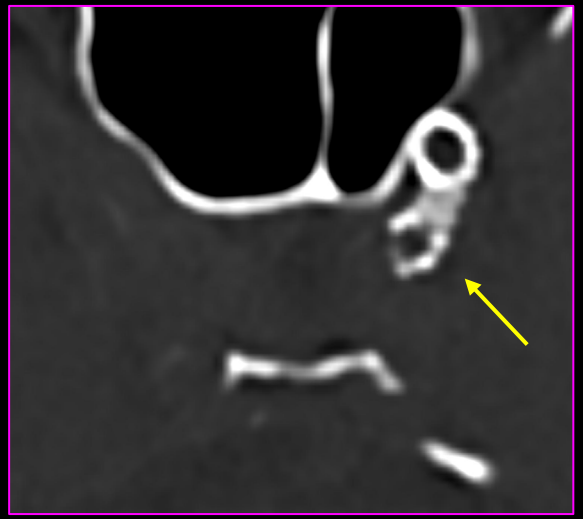
EID-CT



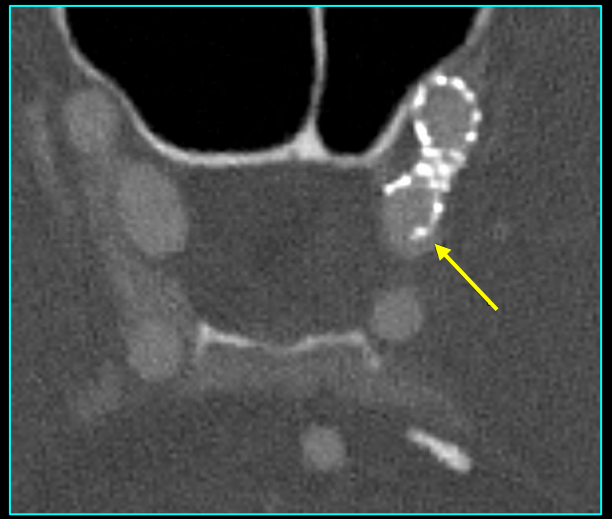
PCD-CT

PCD-CT offers increased spatial resolution with decreased artifact.
Can see each of the struts of the stent braid with PCD-CT.

Case 2: ICA Stent Malposition

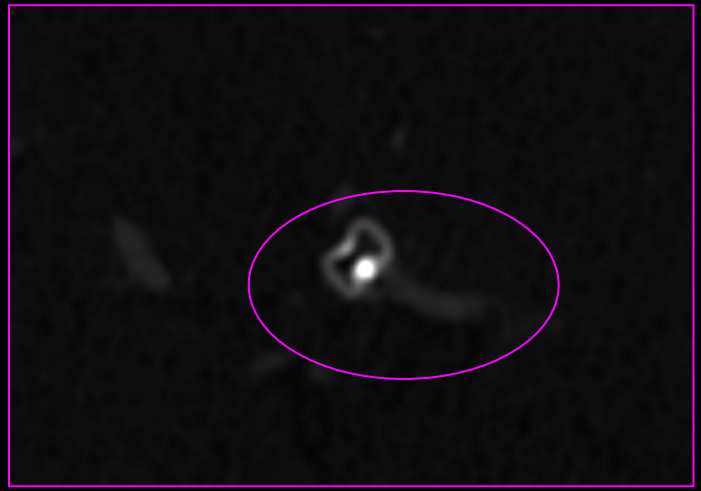


EID-CT: Malposition not visible

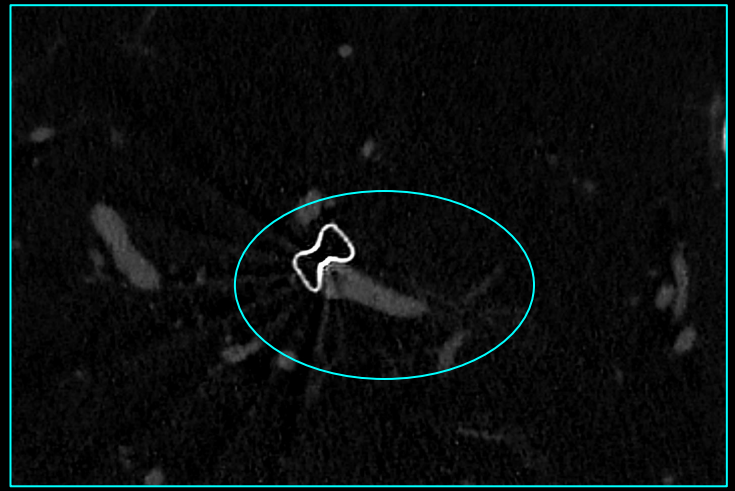


PCD-CT: Proximal end of stent not fully opposed to vessel wall (contrast visible between stent braids and outer wall).

Case 3: Anterior Cerebral Artery Aneurysm Treated with WEB Device.



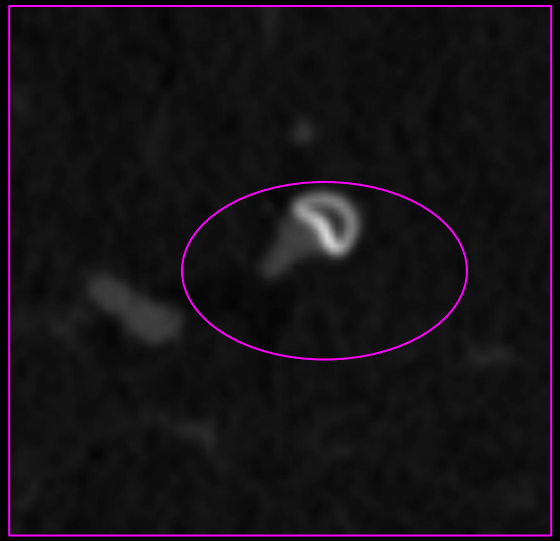
EID-CT



PCD-CT

PCD-CT: Superior image quality with better visualization of the structure of the WEB device.

Case 4: Anterior Cerebral Artery Partially Collapsed Stent



EID-CT



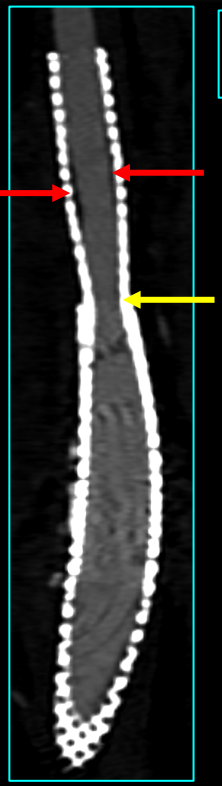
PCD-CT

PCD-CT: Superior image quality with better visualization of the structure of the collapsed stent.

Case 5: Common to Internal Carotid Artery Stent with Narrowing and Neointimal Hyperplasia

EID-CT

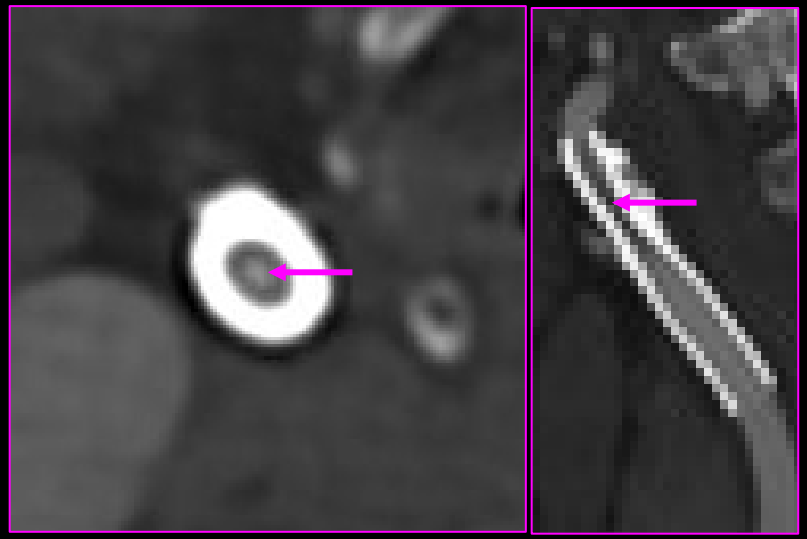




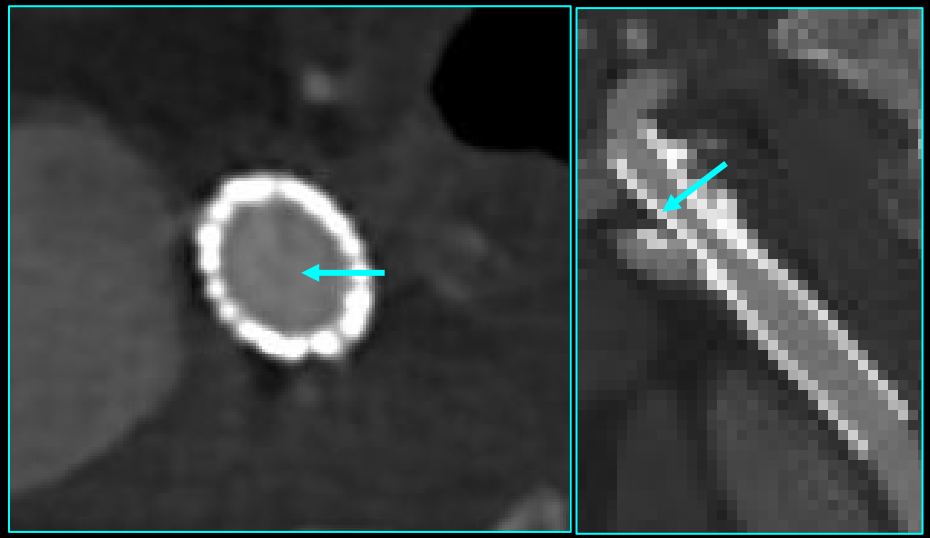
PCD-CT

Compared to EID-CT, PCD-CT better depicts the lumen of the vessel at the level of narrowing allowing for more accurate determination of degree of stenosis (yellow arrow). In addition, can see early signs of neointimal hyperplasia on PCD-CT (red arrows).

Case 6: ICA Stent



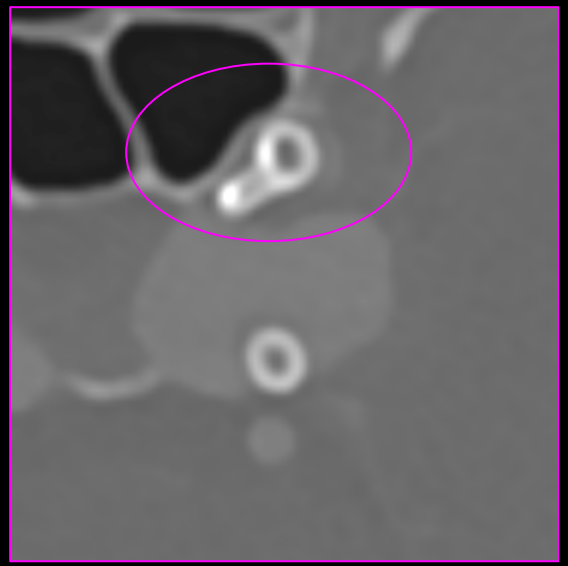
EID-CT



PCD-CT

On the original EID-CT, the ICA stent was questioned to be occluded or severely stenosed. A follow-up PCD-CT was performed clearly showing patency of the stent.

Case 7: Internal Carotid Artery Stent with Stenosis



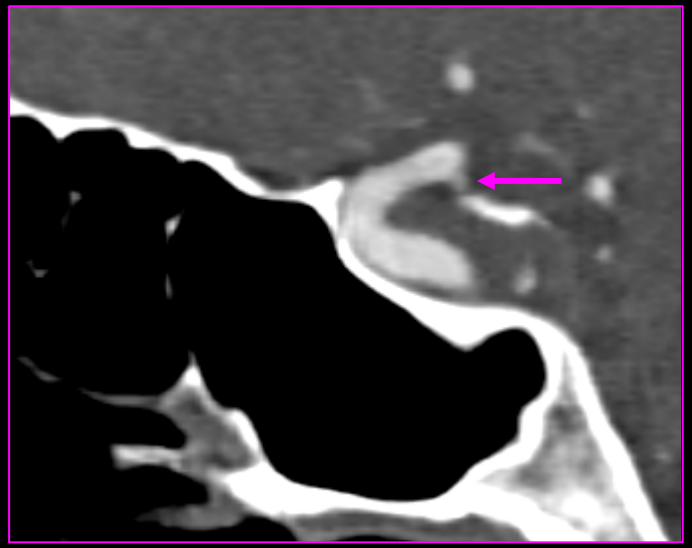
EID-CT



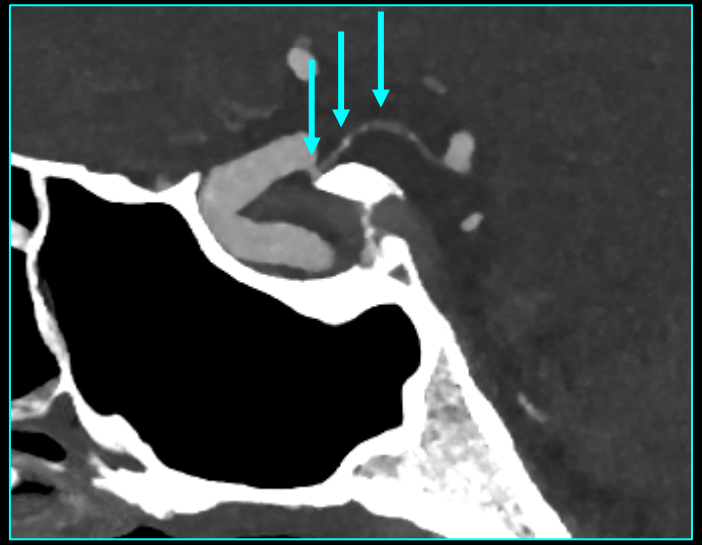
PCD-CT

PCD-CT: Superior image quality with decreased artifact allows visualization of the lumen within the narrowed portion of the stent.

Case 8: ICA Aneurysm vs Infundibulum



EID-CT



PCD-CT

An aneurysm vs infundibulum was questioned on the original EID-CT (purple arrow).
A follow-up PCD-CT was performed which confirmed an infundibulum as the small posterior communicating artery is visualized arising from the apex (blue arrows).

Conclusion

- PCD-CT and EID-CT are fundamentally different imaging technologies.
- PCD-CT advantages:
  - higher spatial resolution
  - sharper image
  - decreased noise and artifact
  - improved diagnostic accuracy and superior image quality
  - Less radiation and contrast usage
- Overall, PCD-CT provides superior visualization of intravascular stents and associated vasculature.

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