MAYO CLINIC

THE UTILITY OF PHOTON COUNTING CT FOR VASCULAR MAPPING OF SPINAL ARTERIOVENOUS SHUNTS

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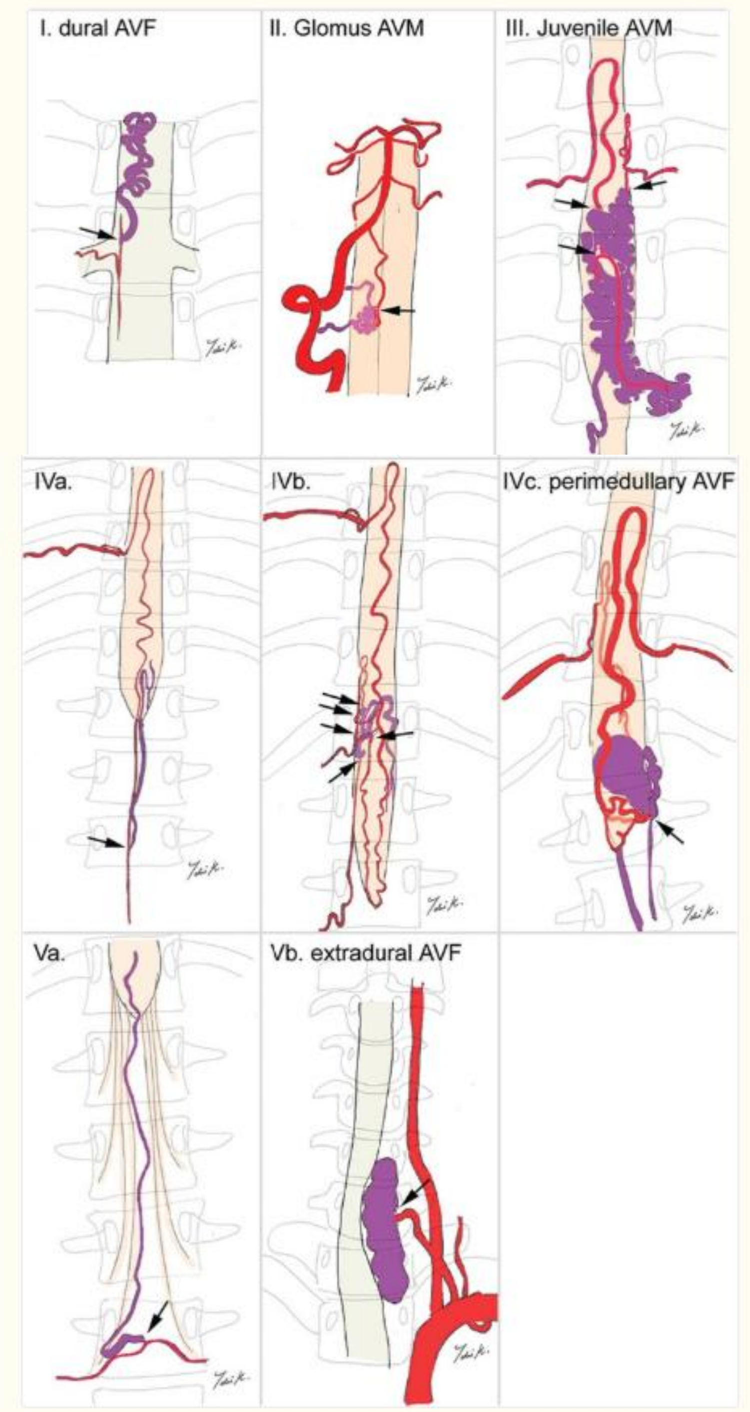
BACKGROUND: SPINAL AV SHUNTS

- Abnormal direct artery–vein connections bypassing capillaries → venous hypertension → myelopathy
- Takai Classification:

Type	Academic name	Subtype	Feeder, AVF, and venous drainage
I	Dural AVF		
II	Intramedullary glomus AVM		
III	Intramedullary juvenile AVM		
IV	Perimedullary AVF	IVa	A single feeder and small AVF
		IVb	Multiple feeders and medium AVFs
		IVc	Multiple feeders and a giant AVF
V	Extradural AVF	Va	w intradural venous drainage
		Vb	w/o intradural venous drainage



IMAGING MODALITIES FOR SPINAL AVMS

CT angiography (CTA)

- **Role:** Rapid, noninvasive **roadmap** to suggest level/side and candidate feeders before DSA
- **Strengths:** Excellent bone detail for **level localization**; good for pre-procedure planning and when MRI is limited/contraindicated
- **Limitations:** Small vessels may be obscured near bone; uses iodinated contrast and radiation; not definitive for classification

MR angiography (MRA)/MRI

- **Role:** Best **screening** tool → detects cord edema/venous congestion and flow-voids; TR-MRA can indicate fistulous flow and side
- **Strengths:** Noninvasive, no radiation; narrows DSA to targeted levels.
- **Limitations:** Lower spatial resolution than DSA

Conventional angiography (DSA)

- **Role:** Definitive test → maps fistula point, feeders, and drainage; enables same-session treatment
- **Strengths:** Highest spatial/temporal resolution; precise classification for planning
- **Limitations:** Invasive (arterial catheterization, contrast, radiation); requires selective injections and expertise

ENERGY INTEGRATING DETECTOR CT (EIDCT) VS PHOTON-COUNTING CT (PCCT)

	EIDCT	PCCT
Physics and Acquisition	Integrates total x-ray energy (scintillator → photodiode)	**Counts individual photons** with energy binning (native spectral)
Image Quality	Good spatial resolution; more noise at low dose; limited spectral unless dual-energy mode	**Higher spatial resolution (~0.2 mm UHR), higher SNR**, low-keV virtual monoenergetic images.
Speed/Workflow	Fast, ubiquitous; standard recon	Similar scan times; **spectral data every scan** reduces repeats/problem-solving scans
Cost/Availability	Lower cost; widely available	**Higher capital/maintenance**; fewer scanners
Other Vascular Advantages	May miss sub-mm vessels near bone; more blooming/beam-hardening	Sharper **tiny-vessel detail**, better iodine conspicuity, fewer bone/metal artifacts

CLINICAL CASE

History:

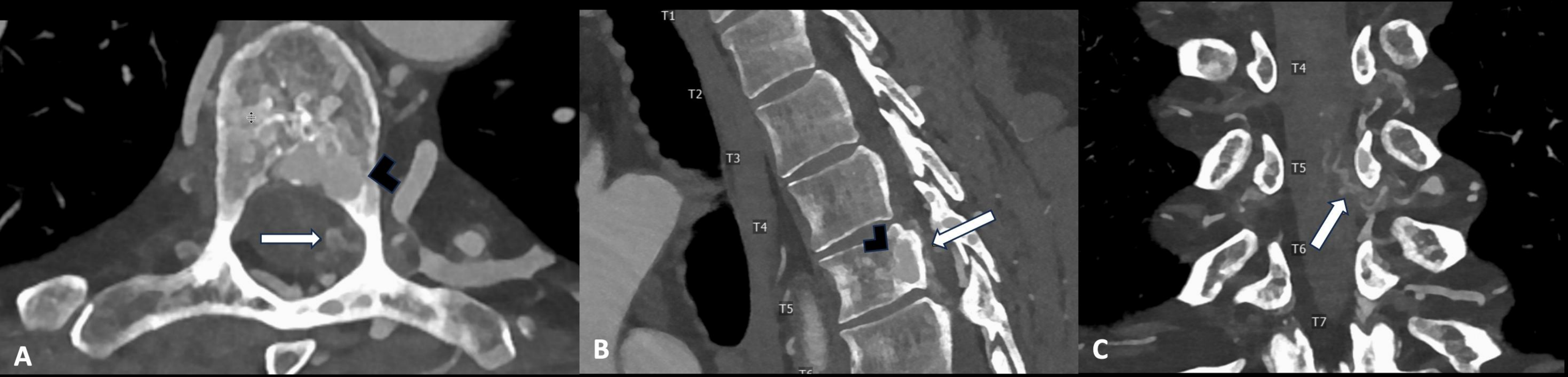
- 40-year-old man with 3 years of progressive neurologic symptoms
- Onset: left toe paresthesia → gradual proximal spread with worsening weakness
- Progression: gait decline to walker dependence; intermittent left-leg tremor
- Distribution: symptoms predominantly left lower extremity; upper extremities asymptomatic
- No constitutional symptoms reported (fever/weight loss not endorsed)

CLINICAL PRESENTATION

Neurologic Exam:

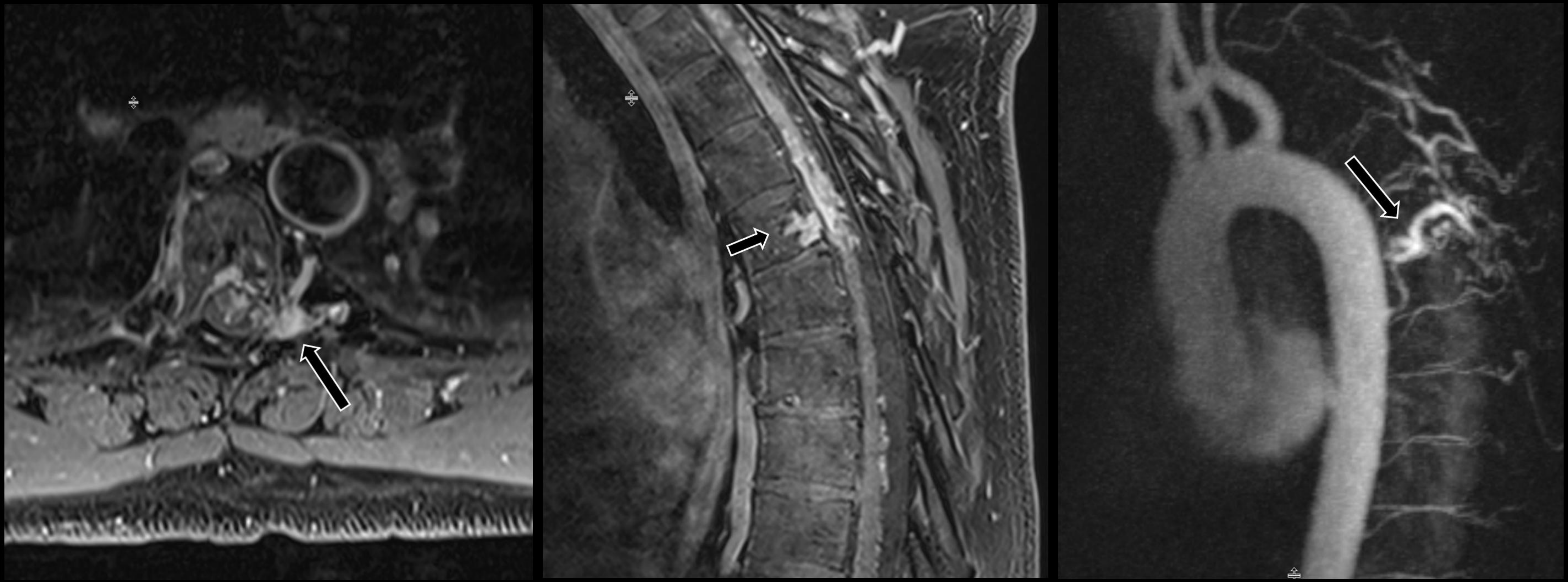
- **Mental status / CN / UE:** normal; upper extremities intact
- **Motor (LLE):** iliopsoas 4+, knee extension 3/5, ankle movements 0/5
- **Tone/UMN signs:** spasticity and clonus in LLE; pathologic reflexes bilaterally
- **Sensation:** diminished in LLE (consistent with progressive myelopathy)
- **Gait:** spastic gait requiring walker; poor distal foot clearance

PATIENT SUBSEQUENTLY UNDERWENT CTA WITH PCCT



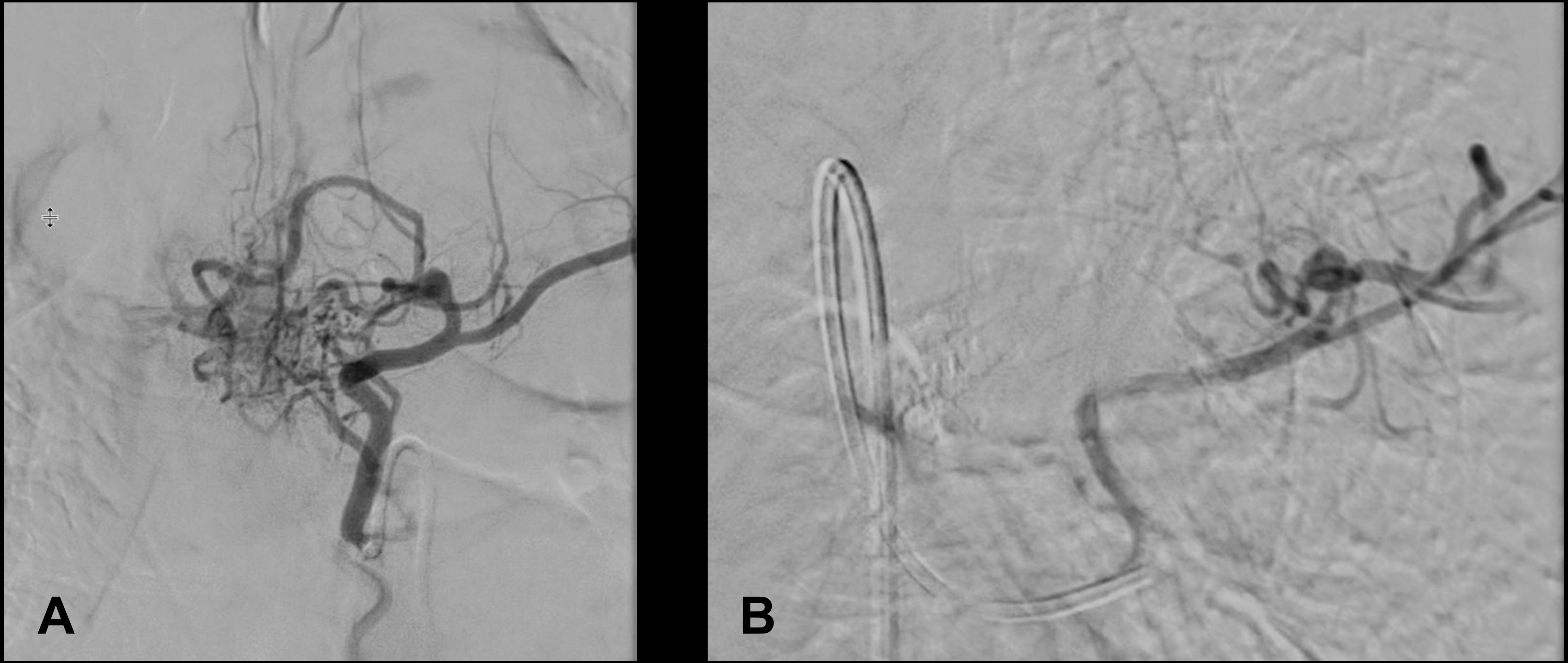
Axial (A), sagittal (B), and coronal (C) multiplanar reformats of PCCT spinal angiogram demonstrate a complex AV shunt centered at the T5 vertebral body (arrow) with main arterial feeders arising from the T5 radiculomedullary arteries, left greater than right. Prominent intraosseous probable venous drainage within the T5 vertebral body (black arrowhead).

THESE FINDINGS WERE CORROBORATED WITH MRA



Axial (A) and sagittal (B) contrast enhanced T1 MRI of thoracic spine demonstrates a spinal vascular malformation (black arrow). There was associated spinal cord edema that was extending from T2-T6 (not shown). Contrast-enhanced spinal MR angiography (C) demonstrates similar findings of complex spinal vascular malformation with major contributors likely arising from the T5 radiculomedullary arteries.

MANAGEMENT



Diagnostic angiogram (A) was performed that showed an extradural AVF with intradural drainage (Type Va) located predominantly within T5 vertebral body, supplied mainly by bilateral T5 segmental arteries with contribution from T4 and T6 segmental arteries. This was treated with percutaneous trans-pedicular transvenous embolization with Onyx of epidural fistula from left T5 pedicle to vertebral body with post-embolization angiogram (B) demonstrating near complete resolution of epidural AVF.

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OUTCOME

- No periprocedural complications
- Early follow-up: improved left-leg sensation and slight strength gains
- Discharged POD#2; rehab + surveillance angiography planned

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TAKE HOME POINTS

- Photon-counting CT (PCCT) provides high spatial resolution, enhanced iodine contrast conspicuity, and higher signal to noise ratio compared to traditional energy integrating detector CT (EIDCT).
- The Takai classification 2017 of spinal AV shunts is based on microvascular anatomy and hemodynamics of AV shunts. This helps guide surgical and endovascular planning based on imaging characteristics.
- Spinal AV malformations can be difficult to diagnose and treat. PCCT's superior vessel detail can help with diagnosis and streamline pre-procedural planning prior to invasive catheter angiography.
- Future Directions: Build PCCT protocols for spine, test against current standards (EIDCT/DSA) in prospective trials, and integrate dynamic PCCT/AI tools to enhance tiny-vessel detection and treatment selection.

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