Intra-arterial catheter Angiography (IACA)

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**Neuroangiography CPT and ICD codes and payment guide** → [see p. D61a >>](http://www.neurosurgeryresident.net/D.%20Diagnostics%5CD60-68.%20Vascular%20examination%5CD61a.%20Neuroangiography%20ICD%2C%20CPT%20codes%20and%20payment%20guide.pdf)

**Cerebrovascular Surgery** → [see p. Op350 >>](http://WWW.NEUROSURGERYRESIDENT.NET/Op.%20Operative%20Techniques/300-399.%20Cranial/Op350.%20Cerebrovascular%20%28open%20techniques%29.pdf)

**IACA** - gold standard study of CNS vessels and great vessels of neck using radiographs during injection of intravascular contrast media.

* angiography is *not useful* in evaluation of peripheral nervous system or neuromuscular diseases.
* first described by Moniz in 1927.

*Digital subtraction venous angiography* is no longer widely used (requires large amounts of contrast + unreliable in detecting plaque ulcerations and in differentiating carotid stenosis from complete occlusion).

Techniques of catheterization

Anesthesia

* mild sedation and local anaesthesia (4-5 mL of lidocaine ± bicarbonates)
* indications for general anaesthesia:
	1. very **anxious / restless** patients
	2. **interventional** endovascular procedures.

Catheter & guidewire

* + - *hydrophilic guidewires* greatly facilitate catheterization of cerebral vessels.
		- choose guidewire of appropriate size; too small guidewire facilitates blood reflux into catheter which can clot and be source of emboli.
		- use soft-tipped J-shaped guidewire (to avoid intimal trauma).
		- advance catheter over wire (to avoid intimal trauma).
		- never advance wire beyond fluoro screen (unless it is going to arm).

Access

* **transfemoral route** (Seldinger techniqueguided fluoroscopically) is used almost exclusively;
	+ - puncture of axillary / brachial a*rtery* or direct cervical puncture of carotid artery are only ***rarely*** performed.
* use clamp and fluoro – clamp tip should be at mid of femoral head.
* palpate femoral pulse, inject local anesthetic, and puncture skin (slightly below groin crease) at 45° angle
	+ - if hitting bone, usually you are too medial
		- if unsuccesful, often withdraw and flush needle with heparin
		- once in artery, advance guideware and do fluoro (if passes to left side of spine, means in aorta); incise skin and dilate with mosquito tip.
		- withdraw needle and advance dilator over wire; pull out wire with unscrewing dilator cap.
		- advance larger wire; pull dilator and advance sheath; pull wire and unscrew sheath cap (if not, it will leak blood)
		- tape sheath with Tegaderm in place; connect heparin line (flush, make sure no air bubbles; check for blood flash back; then set heparin drip at 1 drop/second)
* insertion of **femoral sheath** (not necessary for straightforward cases) is useful in complex cases - change of catheter during procedure is anticipated, or for interventional procedures.
* heparin-coated **guide wire** is passed through hub of needle into lumen of artery.
* pigtail **catheter** over guidewire into ascending aortic arch
	+ - most frequently used catheters are 4F or 5F with tapered J-shaped tip.

After shape, smoothness, and patency of proximal right CCA, right subclavian artery, left CCA, and left subclavian artery are inspected → selective *internal carotid* and/or *vertebral artery* injections.

* usually vessels are cannulated in order – R VA, R CCA, L CCA, L VA.
* 0.035-in guidewire with soft, straight tip is used to exchange pigtail catheter for either simple angle-tip catheter (e.g. one with HN1 shape) or one with more complex hook or short-radius, curved shape.
	+ - guidewire (chosen for exchange) may have variable degree of flexibility in distal several centimeters near tip.
* in *elderly* or those with *significant atheromatous disease* at carotid bifurcation, *carotid bifurcation* should be visualized under fluoroscopy or with angiographic run, before advancing guidewire into internal carotid artery.
* **vertebral**injections are performed with catheter in VA near origin of VA to avoid spasm;
	+ - use manual contrast injection into VA (power injection often dislodges catheter from VA ostia)
		- ***Valsalva maneuver*** during VA run may reflux contrast medium into contralateral VA.
		- very rarely neither VA can be catheterized → inject subclavian artery during ***blood pressure cuff inflation*** (reduces flow of contrast medium down arm).
* once catheter is positioned in appropriate vessel, ***double flush technique*** (withdrawing blood into one syringe and saline flushing from another) is used, to minimize risks of embolism.
* when doing **ECA** angio - inject contrast ***above lingual artery*** (because contrast injection is painful + we dont need opacification there)

After catheterization

* closing device (to use closing device, vessel has to be ≥ 4 mm diameter):
1. boomerang
2. **St. Jude AngioSeal** – online info [>>](http://professional.sjm.com/products/vas/hemostasis-management/vascular-closure-devices/angio-seal-evolution#how-it-works) video [>>](http://videos.sjm.com/pro/product/vas/AngioSealEvolution_Animation_video_040510.mp4)
3. **Perclosure ProGlide** – places purse string in arterial wall
* femoral artery is *compressed* to prevent hematoma – for 5 minutes complete occlusion + 3 minutes partial occlusion + 2 minutes gradual release – total 10 minutes (longer if on Plavix; 30 minutes if no closure device was used).
* patient must remain horizontal flat at least for 2 hours (6 hours if case was complicated or no closure device was used).
* evaluate **puncture site** and **distal pulses** - thigh hematoma, distal emboli (loss of pedal pulses).

Contrast

X-ray contrast

* use *low-osmolality* water-soluble iodinated **contrast media** - either *non-ionic* (better!) or *ionic dimers*. [further discussion about contrast media → see p. D49 >>](http://www.neurosurgeryresident.net/D.%20Diagnostics%5CD45-59.%20Neuroimaging%20%28X-ray%2C%20CT%2C%20MRI%2C%20PET%2C%20MRS%29%5CD49.%20CT.pdf#CONTRAST_MEDIUM)
* standard concentration (for modern digital angiography) - 150 mg *iodine* /ml; higher concentration (up to 320 mg I /ml) may be necessary - for common carotid artery injections, high flow lesions (such as large AVMs).
* contrast is injected manually or with automatic pump:

**internal carotid** / **vertebral artery** digital subtraction angiography - 6–8 ml of contrast medium at rate of 3–5 ml/s;

**external carotid artery** - less forceful & lower-volume injections.

N.B. avoid of iodine contrast in *diabetics who are getting oral antidiabetic agents like metformin* - risk of **lactic acidosis**!!!

Indocyanine green (ICG)

- contrast used intraoperatively (e.g. during AVM surgery).

* peak spectral absorption at about 800 nm.
* binds tightly to plasma proteins (becomes confined to vascular system).
* half-life 150-180 seconds (removed exclusively by liver).

Technique of image acquisition

Today, most cerebral angiography is carried out on **digital subtraction angiography (DSA)** system (but perfectly adequate angiograms can be obtained with **conventional serial film-screen** technology).

* DSA allows injection of contrast medium at *smaller volume and concentration*.

N.B. aortic archstudy is part of standard cerebral angiogram (esp. in evaluation of ischemic cerebrovascular disease - lesions or anomalous vascular origins in region of aortic arch may have impact on treatment planning!)

Projections

**Carotid angiography**:

1. ***lateral view*** - centered on pituitary fossa.
2. ***AP view*** - with petrous ridge projected approximately over *roof of orbit*.
3. ipsilateral 30° ***anterior oblique views*** - most common projection (esp. for investigation of aneurysms).

**Vertebral angiography**:

1. ***lateral view***
2. ***AP view*** - with petrous ridge superimposed on *lower border of orbit*.
3. ***half-axial (Townes) view***
* **biplane angiography** (simultaneous acquisition of two projections) is major advantage in neuroangiography.
* **3D rotational angiography** - ***rotating X-ray tube*** - allows acquisition of volumetric data sets, which are post-processed on computer; following removal of bony structures, high-resolution images of cerebral vessels can be viewed from any angle (e.g. 3D view of aneurysm morphology and its neighboring vessels).

Frame rate

* filming is acquired during *arterial*, *capillary*, and *venous* phases.
* routinely 2-3 images/sec for arterial phase and 1–2 images/sec for venous phase.
* investigation of high flow lesions or certain types of aneurysms benefits from higher frame rates.

Indications

**Angiography** - mainstay for neurovascular investigation *in past*.

* *non-invasive techniques* (Doppler sonography, MRA, CTA) have replaced IACA for number of diagnostic indications.
* current indications for IACA:
	1. integral part of ***interventional procedures***.
	2. aneurysms, AVMs - angiogram is gold standard!
	3. carotid artery disease (to confirm significant stenosis suspected noninvasively; to detect subtle dissections).
	4. documenting patency of basilar artery (after MRA fails to do it)
	5. intracranial vasculitis (MRA / CTA have poor resolution of small vessels).

N.B. angiography also does not reliably image vessels < 0.1-0.5 mm (not helpful in diagnosing lacunar infarctions).

* 1. preoperative to assess tumor vascularity (± preoperative embolization) - glomus jugulare tumors, meningiomas.
	2. to resolve ***discrepancies between two non-invasive methods***.
	3. to identify *artery of Adamkiewicz* prior to aortic aneurysm repair.

Contraindications

1. history of *untoward reactions to contrast media*.

H: well hydration before and after procedure + prednisone 50 mg orally (13, 7, and 1 hour prior to procedure) + diphenhydramine 50 mg orally (1 hr prior to procedure)

1. *recent cerebral ischemia* - may react poorly to angiography (esp. ionic contrast media); IACA is used in thrombectomy / IA thrombolytic treatment for acute stroke(benefits outweigh added risk from contrast media).

N.B. **anticoagulant drugs** do not contraindicate arteriography, provided prothrombin level is within normal therapeutic range.

Preangiography workup

1. **Coagulation studies**: CBC, platelets, PT and PTT.
2. **Renal function**: electrolytes, BUN, creatinine.

Complications

1. **Stroke** (0.5-2.3%; death < 0.1%) due to:
	1. cerebral ***embolism*** from catheter / guidewires
	2. damage to arteries by catheter / guidewire (***spasm***, ***thrombosis***, ***dissection***).
2. Rarely, intracranial aneurysm ruptures (result of injection under high pressure).
3. Local complications - **bleeding**
4. Complications of iodinated **contrast material** (allergic reactions, renal damage, etc).
* greatest morbidity of all imaging procedures - angiography should *never* be carried out if it is clear that results will not influence management!
* *contrast injection is uncomfortable* (warn patient if performed under local anaesthetic):

**external carotid artery** - hot feeling in face, ‘funny taste’ in mouth;

**vertebral artery** - flashing lights in eyes (up to cortical blindness for several days); in *dolichoectasia of basilar artery* - reversible brainstem dysfunction & acute short-term memory loss (due to slow percolation of contrast material - prolonged exposure of brain).

* risks increased in *sickle cell disease* (H: reduce HbSS level to < 20% through transfusions).

Types of Detectable Abnormalities

1. Abnormal size / contour of lumen
2. Abnormal distribution of vessels
3. Abnormal sequences of vascularization (early or late)
4. Displacement of vessels – mass effect.

Spinal Angiography

- costly, time-consuming procedure with definite morbidity!

* dexamethasone (4 mg q6h, start 24 h before procedure) – indications:
	+ - 1. AVM
			2. intramedullary tumor
* uncomfortable and prolonged - generally under general anaesthesia.
* **bladder catheterization** (sphincter function may be impaired).
* IM or IV **spasmolytic agent** - to reduce bowel movement.
* only ***low-osmolar*** contrast agents.
* 5F–7F viscero-femoral catheter is introduced by femoral artery puncture (preferably through sheath).
* slow, gentle injections of 2–3 ml contrast medium into each of posterior intercostal and lumbar arteries on each side.
* AP imaging at 1 frame every 2 s over 10–20 s.
* opacification of corresponding hemivertebra indicates satisfactory injection.
* ventilation is suspended during each series.
* arteries injected:

cervical region - both *vertebral arteries* (near their origins), *deep cervical arteries*.

thoracic region - each *posterior intercostal artery* on each side.

lumbar region - each *lumbar artery* on each side, *median and lateral sacral branches* of internal iliac arteries.

* therapeutic **embolization** may be carried out.

Indications

1. suspected **vascular malformations** or **tumors** of spinal cord, meninges or vertebral column (after positive MRI or myelogram)
2. **investigation of SAH** after negative cerebral angiography (alternative – cervical spine MRI – looking of abnormal T1 flow voids as sign of vascular malformation).
3. demonstration of major arterial supply to spinal cord **before any spinal surgery**.

Contraindication

- patients considered unfit for surgery.

Complication

**-** *deterioration in clinical myelopathy* (relatively common but usually transient).

Interventional Neuroradiology

1. **Thrombolysis / Thrombectomy** of acute arterial or venous thrombosis.
2. **Detachable coil therapy** – for aneurysms (not amenable to standard surgical clipping)
3. **Particulate / liquid adhesive embolization** – for AVM, tumors (preoperative embolization reduces bleeding).
4. **Intraarterial chemotherapy** – for tumors.
5. **Balloon angioplasty** – for stenosis / vasospasm.
6. **Balloon occlusion** – for carotid-cavernous and vertebral fistulas.
7. ***Endovascular treatment*** of vein of Galen malformations.
	* risks are comparable to those of neurosurgery rather than radiology.
	* made possible because of small catheters (as small as 2-3 French) and guide-wires that can be navigated into selected branches of vasculature.
	* whenever CTA is needed (preop or postop), always order CTA head + CTA neck + pCT.

Complications

1. **Radiation damage** (40%; of these, 30% are permanent): hair loss
* exposures > 2 Gy are common in interventional neuroradiology despite modern radiation-minimizing technology.

Catheters

Guide catheter – usually kept in ICA

Microcatheter – reach target

Embolization materials

Onyx

- cohesive (not adhesive)

Coils

* + detachable coils have positive charge - negatively charged platelets and red blood cells are attracted to this site → induce significant occlusion of aneurysms during coiling.

Stents

* + **high radial force**\* **stents** (e.g. balloon-expandable stents) induce significant endothelial injury → more platelet aggregation and thrombus formation.

\*vs. less traumatic **low radial force** nitinol self-expanding **stents**.

Balloons

* + balloon-assisted coil embolization (BACE): use of antiplatelet agents or antiplatelet function testing **prior** to procedure is not supported (Class C evidence); WFITN recommends **post-treatment** aspirin.

Intracarotid Amobarbital (Wada) test

See p. E11 [>>](http://www.neurosurgeryresident.net/E.%20Epilepsy%20and%20Seizures%5CE11.%20Epilepsy%20-%20Surgical%20Treatment.pdf#WADA)

Antiplatelets, Anticoagulants

Antiplatelets – see [p. 1595 (5) >>](http://www.neurosurgeryresident.net/USMLE%202%5CHematology%20%281501-1649%29%5C1595_%285%29.%20Antiplatelets.pdf)

* + if stent is left – heparin for 12-24 hours, continue dual antiplatelet therapy (DAT) with P2Y12 receptor antagonist (such as clopidogrel, prasugrel, or ticagrelor) for **3-6 months** (later, stent becomes covered with endothelium and no longer at risk for thrombosis) + lifelong aspirin.

Closure device (for femoral artery)

Boomerang is preferred – use AngioSeal (leaves collagen foreign body) only if cannot use boomerang:

* 1. “too high stick” – above inferior epigastric artery – cannot apply pressure@
	2. heparin use intraop (i.e. when intervention is done)

After boomerang is applied, change angle to make it work; if fails – hold 30 min manual pressure → flat for 4 hours

Bibliography for ch. “Neurovascular Examination” → follow this [link >>](http://WWW.NEUROSURGERYRESIDENT.NET/Vas.%20Vascular/Vas.%20Bibliography.pdf)

[Viktor’s Notes℠ for the Neurosurgery Resident](http://www.neurosurgeryresident.net/)

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