Intra-arterial catheter Angiography (IACA)

Last updated: June 3, 2019

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NEUROANGIOGRAPHY CPT AND ICD CODES AND PAYMENT GUIDE → see p. D61a >>
CEREBROVASCULAR SURGERY → see p. Op350 >>

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 technique guided fluoroscopically) is used almost exclusively;
  - puncture of **axillary / brachial artery** 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 unsuccessful, often withdraw and flush needle with heparin
  - once in artery, advance guidewire 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 \( \geq 4 \) mm diameter):
  a) boomerang
  b) **St. Jude AngioSeal** – online info >> video >>
  c) **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.
• 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**.
I NTRA-ARTERIAL CATHETER ANGIOGRAPHY

N.B. aortic arch study 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).
  6) preoperative to assess tumor vascularity (± preoperative embolization) - glomus jugulare tumors, meningiomas.
  7) to resolve discrepancies between two non-invasive methods.
  8) 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)

2) *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, *intraparenchymal 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)

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 splasmolytic 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).

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**INTERVENTIONAL NEURORADIOLOGY**

A. Thrombolysis / Thrombectomy of acute arterial or venous thrombosis.
B. Detachable coil therapy – for aneurysms (not amenable to standard surgical clipping)
C. Particulate / liquid adhesive embolization – for AVM, tumors (preoperative embolization reduces bleeding).
D. Intraarterial chemotherapy – for tumors.
E. Balloon angioplasty – for stenosis / vasospasm.
F. Balloon occlusion – for carotid-cavernous and vertebral fistulas.
G. 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 >>

ANTIPLATELETS, ANTICOAGULANTS

**ANTIPLATELETS** – see p. 1595 (5) >>

- 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] >>