Intra-arterial catheter Angiography (IACA)

Last updated: June 3, 2019

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 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):
  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*. further discussion about contrast media → see p. D49 >>
- 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 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, 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

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 >>