Digital Subtraction Angiography a Door Opener for Neurosurgical Residents who want to Perform Neurointerventional Procedures

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ABSTRACT

Digital subtraction angiography (DSA) has been a fluoroscopic golden investigative tool to know the vascular angiography of the brain and spinal cord. The technique in performing this procedure exposes residents in accessing the major vessels, branches of the arch of aorta, selective angiography and diagnosing different vascular anomalies of brain and spine. They are also exposed to the knowledge of different diagnostic catheters, its manipulation, use of dye and radiation exposure and safety. We would like to share our experience in training and disseminating the knowledge of digital subtraction angiography to the residents.

KEY WORDS

Digital subtraction angiography, Neurosurgical residents, Neurointervention

INTRODUCTION

Neurointerventionist at Annapurna Neurological Institute and Allied Science (ANIAS) are neurosurgeons and neuroradiologists. Students are enrolled from an accredited program of Fellowship of College of Physician and Surgeons (FCPS) and are trained in different fields of neurosurgery for a period of three years. During their training, they are taught the basics of performing DSA and assist neurointerventional procedures.[1,2] Neurosurgery residents have also the opportunity to get international exposure in neurointervention and sent for two months of training in renowned foreign institutes internationally. They would learn to access the femoral artery and guide the diagnostic catheters to the vessels of interest aiding to perform angiography. This would make a foundation for neurointerventional procedures and teach them vascular anatomy and flow of vessels in different neurovascular diseases. It will also teach them the planning of performing neurosurgical procedures while knowing its vascular anatomy.

Know your machine

Image acquisition at ANIAS is obtained from Siemens Axiom Artis U. It has almost all the basic necessary features for coiling like road mapping, DSA, fluoroscopy, however, lacks the 3D acquisition feature. The angiography machine can be classified into monoplane and biplane (fig. 1). Although we use monoplane machines, biplane machine aids to decrease the time necessary for procedures, the radiation and the dosages of contrast media.[3] It has a technical advantage of permitting simultaneous imaging of the anteroposterior and lateral planes.

Figure 1. Biplane angiography system (Artis Zee, Siemens, Germany) in Hyogo College of Medicine, Japan.

Radiation exposure and safety measures

Radiation during angiography and interventional procedure can have negative effects depending on the dose of exposure. The rate of skin dose entry in fluoroscopy ranges from 10 to 100 mGy/min (Gy-Gray). Radiation dosage greater than two Gy causes deterministic effects such as skin erythema, alopecia, cataract induction, and sterility, while dosage less than two Gy damages DNA affecting the cellular function.[4] Therefore, radiation exposure should be reduced as much as possible for protecting both patients and the staff. This can be achieved by increasing distance from the source, reducing exposure time, and effective shielding.

Pre-procedure

A complete history of patients with the neurological examination and peripheral vascular examination should be performed. Routine preanesthetic checkup should be done, dye allergy should be tested and renal function test (RFT), bleeding profiles (bleeding time, clotting time, and international normalization ratio) should be noted. Patients should be kept nil per os (NPO) for six hours. Some patients are also prescribed with antiallergen and sedative. Anticoagulants should be stopped after consulting the cardiologist or related experts. Informed consent should be taken.

Positioning

The patient should be informed regarding the C arm and its mobility, the noise on each DSA and the warmth he feels inside his head so he would not have anxiety and cause motion artefacts. Positioning is supine with headrest and hands placed on the side. If a patient is uncooperative the head is strapped, and physical restraints are placed with anesthetic medication like midazolam and fentanyl or in general anesthesia. Continuous vitals monitoring should be done. Nasal prong with oxygen (if the oxygen saturation decreases) and ECG leads are placed. Intravenous access with normal saline and pre-procedure antibiotics (cefazolin) is given. Patient is painted with betadine and draped. The access site is injected with local anesthesia (2% lignocaine).

Emergency drugs like protamine sulphate, hydrocortisone, atropine, anti-allergens, and intubation set are kept as backup to tackle any adverse event encountered during the procedure.

Preparation of catheters

Two bowels should be kept, one with normal saline and another with dye with two 10 ml disposable syringes. Container with normal saline mixed with heparin (2500 IU) where the guidewire and diagnostic catheters are placed. The diagnostic catheters are flushed with a mixture of normal saline and heparin. Surgical blade (no.11) is also kept. 18-gauge puncture needles and 5 F femoral sheath are also flushed (fig. 2).

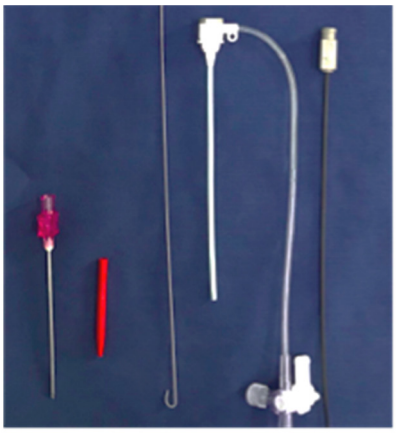

Figure 2. 18-gauge needle, J wire, 5 F short femoral sheath

Know your catheters

- Cordis angled 5 F vertebral catheters are best to access the neck vessels.
- Pigtail 5 F catheters are used to see the outline of the arch of aorta and its branches.
- Terumo Judkins right coronary catheter is used for difficult access.
- Simmons (Sim) catheter or Terumo Mannis headhunter catheter are used to access old aged difficult tortuous vessels (fig. 3).

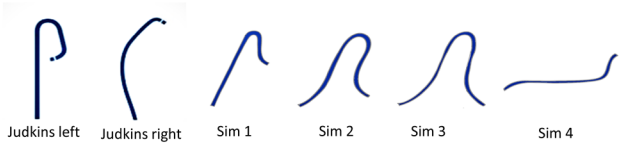

Figure 3. Different diagnostic catheters used during DSA

Wire

Hydrophilic 0.035-inch Terumo guidewire with a soft flexible tip is commonly used.

Technique

Access

In our center right common femoral artery access is performed. Femoral artery location is found by putting a needle in the femoral triangle and taking a fluoroscopy image, the needle should be in the head of femur (fig. 4). Puncture site should aim at the lower quadrant of the femoral head. This will allow enough compression of the femoral artery against the bony prominence of the femur head to achieve hemostasis following the procedure. Palpation of the femoral artery is done using three fingers with fixation of the artery by middle finger. Puncture of the femoral artery is done by 18-gauge needle using single wall puncture with free flow of arterial blood in needle hub. Following this, J wire or 0.035-inch Terumo guidewire is inserted with the help of introducer and the puncture

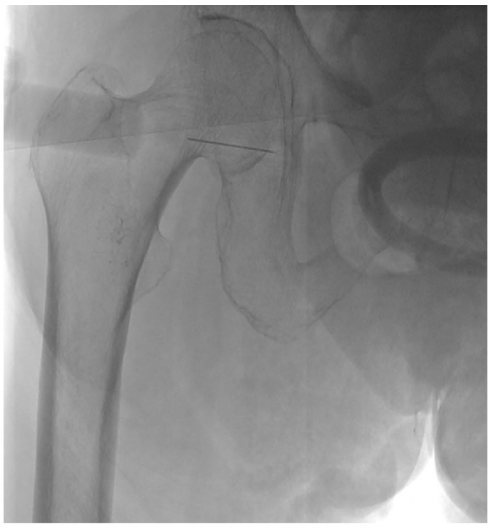

Figure 4. Fluoroscopy showing the tip of needle at head of the femur before puncture.

needle and introducer is removed and replaced with 5f femoral sheath using the seldinger technique giving small skin incision using number 11 surgical blades. Sometimes doppler ultrasound is used to find out the femoral artery. After the femoral sheath is placed heparin loading dose is given (50 to 100 U/kg body weight).[5]

Zero bubbles in irrigation lines

Two infusion pumps with one-liter normal saline are kept ready for continuously flushing the catheters with zero bubbles. "Wet connect" is needed while connecting the sheath to the irrigation line thus preventing the air embolism.

Insertion of diagnostic catheters

Diagnostic catheters are inserted under the support of Terumo guidewire. The guidewire is inserted from the femoral sheath till abdominal aorta along which the diagnostic catheters are inserted using the torqueing technique. The motion between the wire and the catheter should be smooth It should not be introduced together as it may act as a dagger and cause dissection of the vessels. After the diagnostic catheter is inserted into the major vessels keeping in mind the different types and variants of arch of aorta and its branches the guidewire is removed (fig. 5,6).[6] The change in wires and catheters should be performed with great precaution to prevent clot embolus and air embolism by following the wet technique and washing the hub with heparinized saline. Every vessel branch should be accessed after performing a roadmap to prevent vessel dissection.

Flushing the catheter with a dye should be done following "Double flush technique", and there should be flow back of blood from the catheter which denotes the catheter is not blocked with a clot or due to wedging/dissection. Vertebral angiography should be performed with great precaution because it is overly sensitive and is prone to vasospasm and dissection.

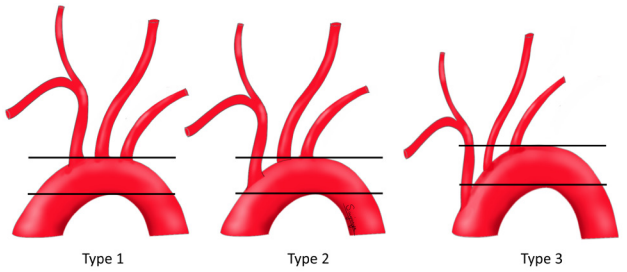

Figure 5. Classification of Aortic arch based on the relationship of the origin of the innominate artery to the outer and inner curvature of aortic arch. Type 2 and Type 3 Arch is difficult to navigate and usually found in old aged patients.

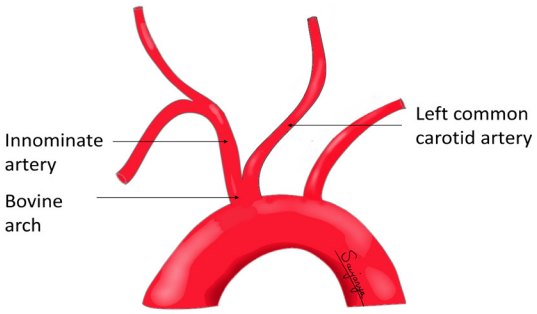

Figure 6. Bovine arch: Common origin of innominate artery and left common carotid artery

Injection of Contrast medium

Contrast medium (CM) improves the visibility of internal organs and structures in X-ray based imaging techniques for diagnosis and treatment. The commonly used CM is based on the chemical modification of a 2,4,6-tri-iodinated benzene ring.

A power contrast injector or mechanical injection can be done; however, power injector is used for accurate rate/volume of contrast injection with stable and better resolution images. Typical injection rate and injection volume of contrast medium during DSA (fig. 7).

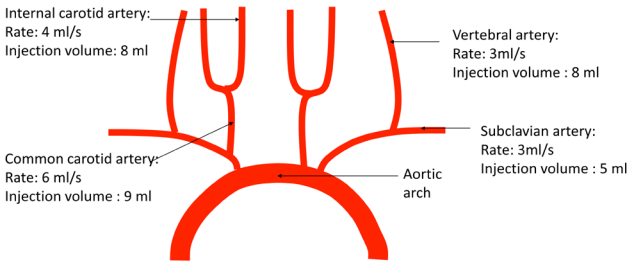

Figure 7. Injection rate and injection volume of contrast medium during DSA

Internal carotid artery (ICA): injection rate: 4 ml/sec and injection volume: 8 ml

Vertebral artery: injection rate: 3 ml/sec and injection volume: 8 ml

Common carotid angiography: injection rate: 6 ml/sec and injection volume: 9 ml

Subclavian artery: injection rate: 3 ml/sec and injection volume: 5 ml

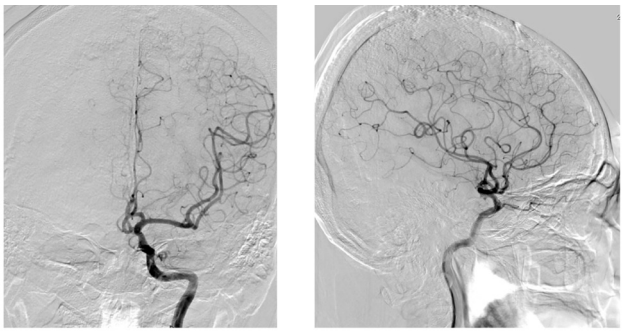

Figure 8. Anteroposterior and Lateral view showing intracranial vasculature following left internal carotid artery angiography

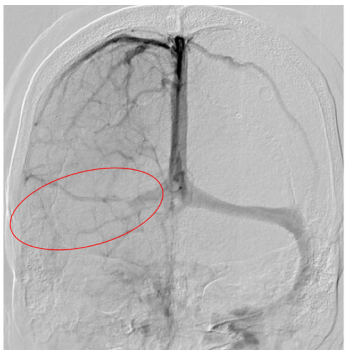

Figure 9. Venous phase following right internal carotid angiography demonstrating occluded right transverse sigmoid (TS) sinus with normal venous flow draining into contralateral TS sinus.

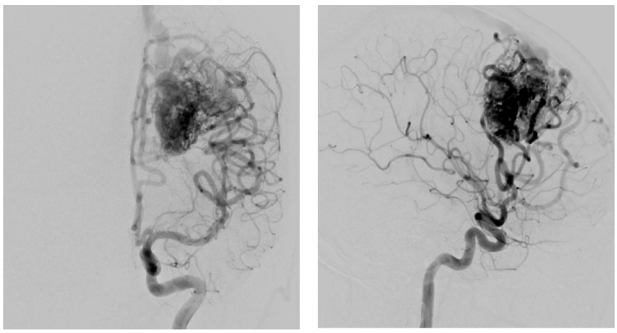

Figure 10. Anteroposterior and Lateral view of Left ICA angiography demonstrating intracranial arteriovenous malformation.

Procedures

While performing angiography at least two views anterior-posterior/oblique/lateral views should be performed (fig. 8). Anterior-posterior circulation angiography, with arterial capillary and venous phase (fig. 9), should be done. Cross circulation through anterior communicating artery (ACOM) and posterior communicating artery (PCOM) by compression technique should also be seen. Lesions whether vascular or tumor should be well studied (fig. 10). Collateral secondaries like pial to pial, pial to leptomeningeal, and pial to dural should be noted. All vascular anatomy should be studied which includes vessel diameter, atheromatous plaque, occlusion by thrombus should be carefully noted.

Anatomic structure and its specific angiographic view

The position of C-Arm will help to localize the individual structure of intracranial vessels. For anterior intracranial cerebral angiography, AP (Townes view) and lateral projections are standard. For specific carotid bifurcation angiography, posteroanterior (PA) and the oblique view is chosen. For internal carotid-cavernous and ophthalmic segments, Caldwell and lateral projections are chosen. While for rest of the ICA, anterior-posterior (AP) (0 degrees) are selected in which superior orbital margin and the petrous bone will overlap and project the supraclinoid ICA, middle cerebral artery (MCA), and anterior cerebral artery (ACA). Also, oblique view (25 to 35 degree) in order to assess ACA, ACOM, and MCA bifurcation. A helpful tip is to position the petrous bones at the level of the mid to lower orbits as a guide. Oblique images at 45 degrees may profile overlapping or redundant arteries. For ACOM imaging, the submental vertex view may be required for optimal visualization. For evaluation of the MCA bifurcation or trifurcation, a Stenvers view or transorbital corresponding oblique view is useful. Similarly, for PCOM, lateral view is chosen.

On the other hand, for vertebral angiography, the standard projections are AP (20 degrees caudal) and lateral projections centered caudally and dorsally to cover the posterior projection. In distinction to the anterior circulation, the petrous bones should be projected at the bottom or below the orbits to best visualize the basilar artery and its branches in the AP dimension (20 degrees caudal).

Post-procedure

The diagnostic catheter is removed under the support of guidewire and fluoroscopy image. The fingers are placed in such a way that the index finger compresses the opening while the middle finger compresses the femoral artery without feeling its pulse. This manual compression is applied for 20 to 25 minutes. Some institutes have percutaneous closure devices too.[7] We should be careful to prevent groin hematoma. The limb is immobilized with a sandbag kept on top of the dressing gauze. Neurological examination should be done before the patient is shifted from procedure room. The patient should be monitored for vitals, urinary output, and groin hematoma. Any new neurological deficit should be informed keeping in mind the complication of angiography. Analgesic and antibiotics are prescribed as required.

Complications

As any procedure complication like groin hematoma (4%), retroperitoneal hematoma, dye allergy, vessel dissection, and neurological deficit due to stroke (2.5%) can occur, rare complications like cortical blindness may occur.[8-10]

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