Overview of imaging modalities for cerebral aneurysms

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August 2008

(Images from BIDMC, PACS.)
Our Patient: Presentation

- Our patient is a 57 y/o woman who reports blowing her nose with a subsequent "worst headache of her life." She describes the headache as pain in a "helmet-like" cranial distribution. She reports a near syncope event and says she vomited once.

- T: 99.3 BP:107/58 HR:84 RR:16 O2Sats: 100% RA.
- No acute distress.
- Alert, oriented, and cooperative.
- CN II-XII intact in detail.
- No focal neurological deficits.

- Mild Kernig's sign: flexion of leg at hip and knee causes pain, spasm, or resistance; a sign of meningeal irritation.
Our patient: Axial C- Head CT

- Foci of increased attenuation in the occipital horns of the lateral ventricles consistent with layering of blood, an abnormal finding.
- Calcified pineal gland, normal.
- Calcification in choroid plexus, normal.

(Images from BIDMC, PACS.)
• Continuing caudally down this axial CT at the level of the frontal sinus...
• Hyperdense layering is apparent along the frontal parietal horn at the Sylvian fissure.
• This image is consistent with subarachnoid hemorrhage.
Subarachnoid Hemorrhage

• Symptoms of SAH result from blood spilling into the CSF and the subsequent increased intracranial pressure and breakdown of blood products.

• Symptoms include an intense headache with rapid onset, vomiting, and altered level of consciousness. Signs of meningeal irritation may also be present.

• CT is the imaging modality of choice for suspected intracranial bleeds.

• Carefully planned lumbar puncture is indicated for the 3% of patients who present clinically with symptoms of SAH but show no signs of bleeding on CT scan.
Management of SAH

• It is quite important to distinguish between SAH due to aneurysmal rupture from other causes of SAH.
  
  – Other causes include: Inflammatory and non-inflammatory lesions of cerebral arteries, vascular lesions of spinal cord, sickle-cell disease, drug abuse, coagulopathy, and tumors. (See appendix E.)

• 85% of SAH are caused by rupture of cerebral aneurysm.
  
  – Intracranial aneurysms are common (1-5% of adults), and rupture accounts for 5-15% of stroke.
  
  – The case fatality after aneurysmal haemorrhage is 50%.
  
  – The most imminent danger is risk of REBLEEDING!!
Imaging Modalities

• Computed tomography angiography (CTA)

• Magnetic resonance angiography (MRA).

• Intra-arterial digital subtraction angiography (IADSA)
CTA

Involves obtaining a normal CT of the head while IV contrast material is injected into a peripheral vein.

- Contrast material is radiopaque so it appears white on the CT image (upper left).

- Serial axial slices of the CT scan are analyzed by a computer program forming a 3-D reconstruction of the vascular anatomy (upper right).

- Benefits: sensitive and noninvasive.

- Limitations: radiation exposure; contrast material may be nephrotoxic or allergenic.

(Images from BIDMC, PACS.)
Our patient:

**Basilar Tip Aneurysm on C+ CT Head**

- Coronal view of the brain in contrast enhanced CTA.

- We see a focal dilatation at the tip of the basilar artery.

- This is a radio opaque, smooth margined, saccular outpouching of the cerebral vasculature.

- C/w intracerebral aneurysm.
Our Patient: CTA Reconstruction

7-mm aneurysm of the tip of the basilar artery

- Posterior Cerebral Artery
- Basilar Artery
- Left Vertebral Artery
- Right Vertebral Artery
- Superior Cerebellar Artery (right)
- Anterior Inferior Cerebellar Artery (left)
- Posterior Inferior Cerebellar Artery (right)

(Image from BIDMC, PACS.)
Companion Patient 1: MRA

- MRA is an imaging technique similar to CTA that does not require the use of IV contrast material.

- The signal obtained depends on the magnetic properties of the area being imaged.

- A magnetic pulse aligns all the protons in a certain area; measuring the amount of time it takes for those protons to return to their pre-magnetized state generates a magnetic resonance signal.

- With a moving substance, such as blood, the protons aligned during the magnetic pulse move out of the area being imaged and non-magnetized protons take their place. This creates a signal void, which is seen as areas of hypointensity on this image.

- Gadolinium can be used to provide enhanced imaging on MRA.

- Benefits: non-invasive, no radiation exposure, IV contrast not required, can be used in patients allergic to iodine-based contrast.

- Limitations: limited spatial resolution, expensive.

(Image from BIDMC, PACS.)
Companion Patient 2:
Intra-arterial digital subtraction angiography (IADSA)

• IADSA is a technique of fluoroscopy used in interventional radiology to visualize blood vessels in the bony environment of the skull.

• A computer program compares x-ray images of the brain before and after radiopaque iodine based dye has been injected via an intra-arterial catheter at the region of interest.

• Tissues and blood vessels on the first image are digitally subtracted from the second image, leaving a clear picture of the arterial network.

• The images can be reconstructed to provide a 3D rotational view.

Benefits: Highest spatial resolution.
Limitations: Costly, invasive, increased risk (0.5% of patients are left with permanent neurological complications).

(Companion Patient 2, C+ IADSA, Images from BIDMC, PACS.)
• An additional benefit of intra-arterial angiography is the capacity to deliver endovascular treatments at the site of pathology.

• Here we see a deployed platinum coil at the site of a previous aneurysm of the anterior communicating artery.
Management of Cerebral Aneurysm

- 50-80% of aneurysms will never rupture during a person’s lifetime

- Risk of rupture is related to size of aneurysm
  - Small aneurysms (<7-10 mm in diameter)
    - Risk of rupture = 0.05% per year
  - Large aneurysms (>10 mm)
    - Risk of rupture = 1% per year

- Risk of intervention (0.5%) outweighs benefit for small aneurysms.
Guidelines for Endovascular Treatment

• Patients **should not** undergo intervention for management of cerebral aneurysm when:
  
  – Aneurysm size <7 mm in diameter
  
  And ...
  
  – Lack of symptoms
  
  – Location of aneurysm at the anterior circulation
  
  – Age older than 64 years old,
  
  – No personal or family history of SAH.

• Patients who **should** be treated:
  
  – Patients younger than 50 years, with symptomatic aneurysm of size >25 mm in the posterior circulation with a personal or family history of SAH.

• In situations between these two extremes, the best treatment decision is often not clear and left to clinical judgment.
Treatment Options

- **Observation:** Serial non-invasive monitoring with MRA, CTA, or even possibly transcranial Doppler ultrasonography.

- **Endovascular Therapy:** Intravascular delivery of a thrombogenic coil completely fills the lumen of the aneurysm, induces the formation of a thrombus, and occludes the aneurysm preventing future rupture.

- **Surgical Therapy:** Surgical placement of a clip at the junction of healthy artery and the neck of the aneurysm.
Our Patient: Follow-Up

• Patient was admitted to neurosurgery for a subarachnoid hemorrhage.

• It was determined that the SAH was secondary to a ruptured basilar tip aneurysm.

• She went to the angiography suite on the day of presentation.

• Angiogram revealed the presence of both a basilar and an anterior communicating artery (ACOMM) aneurysm.

• She underwent coiling of the basilar artery aneurysm that day and she underwent coiling for the ACOMM aneurysm three days later. She tolerated both procedure well.

• She was discharged 8 days after initial presentation.

• Follow up examination at one month showed no focal neurological deficits, and her one month follow-up CTA showed that both aneurysms were coiled and had not recanalized.

• She is currently scheduled for follow up cerebral angiography at 6 months.
Summary

• We learned that the imaging modality of choice for a suspected intracranial bleed is a non-contrast CT.

• We learned that rupture of a cerebral aneurysm accounts for the vast majority of sub-arachnoid bleeds.

• Imaging modalities for cerebral aneurysms include CTA, MRA, IADSA. We viewed examples of each and discussed the risk and benefits.

• Intra-arterial coil embolization can be a highly effective treatment for cerebral aneurysm, but carries some risk.

• Endovascular treatment is indicated for aneurysms >7 mm in size and at high risk of rupture.
Appendix

- B) Most common sites of cerebral aneurysms.
- C) Common sites of cerebral aneurysms (alternate view).
- D) Risk factors for cerebral aneurysm.
- E) Rare causes of subarachnoid hemorrhage.
B) Most common sites of cerebral aneurysms.

Anterior Communicating Artery: 30%
Posterior Communicating Artery: 25%
Middle Cerebral Artery: 20%
Internal Carotid Artery Bifurcation: 7.5%
Basilar Tip: 7%
Pericallosal artery: 4%
Posterior Inferior Cerebellar Artery: 3%

C) Common sites of cerebral aneurysms (alternate view).

D) Risk factors for cerebral aneurysm.

- Polycystic kidney disease
- Coarctation of the aorta
- Anomalous vessels
- Fibromuscular dysplasia
- Connective tissue disorders (eg, Marfan, Ehlers-Danlos)
- High-flow states (eg, vascular malformations, fistulae)
- Spontaneous dissections
E) Rare Causes of SAH.

Inflammatory lesions of cerebral arteries
- Mycotic aneurysms
- Borreliosis
- Behçet’s disease
- Primary angiitis
- Polyarteritis nodosa
- Churg-Strauss syndrome
- Wegener’s granulomatosis

Non-inflammatory lesions of intracerebral vessels
- Arterial dissection
- Cerebral arteriovenous malformations
- Fusiform aneurysms
- Cerebral dural arteriovenous fistulae
- Intracerebral cavernous angiomas
- Cerebral venous thrombosis
- Cerebral amyloid angiopathy
- Moyamoya disease

Sickle cell disease.

Vascular lesions in the spinal cord
- Saccular aneurysm of spinal artery
- Spinal arteriovenous fistula or malformation
- Cavernous angioma at spinal level

Coagulopathies.

Drugs
- Cocaine abuse
- Anticoagulant drugs

Tumours
- Pituitary apoplexy
- Cerebral metastases of cardiac myxoma
- Malignant glioma
- Acoustic neuroma
- Angiolipoma
- Schwannoma of cranial nerve
- Cervical meningiomas
- Cervical spinal cord haemangioblastoma
- Spinal meningeal carcinomatosis
- Melanoma of the cauda equina

(Panel 1. from Jan van Gjin, et al. 2007: “Subarachnoid haemorrhage.” The Lancet.)
Acknowledgement

• Thank you to Dr. Ajith Thomas and  Dr. Gillian Lieberman for their help in the preparation of this presentation.
Bibliography

