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PRACTICE

RATIONAL IMAGING

Investigating suspected subarachnoid haemorrhage in adults

The authors discuss how to decide which imaging methods to use for investigating suspected subarachnoid haemorrhage in adults

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This series provides an update on the best use of different imaging methods for common or important clinical presentations. The series advisers are Fergus Gleeson, consultant radiologist, Churchill Hospital, Oxford, and Kamini Patel, consultant radiologist, Homerton University Hospital, London. To suggest a topic for this series, please email us at practice@bmj.com.

A 52 year old man presented to the emergency department with nausea and vomiting after sudden onset of headache two days previously that had radiated to his cervical spine. He had associated dizziness and had fallen twice. He had no medical history of note, but he smoked. On examination, he had blood pressure 160/88 mm Hg, Glasgow coma score 15, normal reactive pupils, and no other signs or focal neurology. Blood tests showed a mild neutrophilia and mildly raised C reactive protein and cholesterol concentration. His clotting and all other tests were normal.

What should be the next investigation?

The cause of headache needs to be established. In this case the history of sudden onset of headache raises the suspicion of intracranial haemorrhage. Alternative intracranial disease should still be considered because more benign conditions can also give a similar history. In less obvious presentations, as many as 50% of haemorrhages may be misdiagnosed, with failure to obtain the correct imaging accounting for 73% of these cases.[1]

Most (80-85%) primary subarachnoid haemorrhages are caused by ruptured saccular aneurysms. If these are untreated there is a 20-40% chance of rebleeding in the first three to four weeks,[2 3] with about an 80% chance of death or disability.[2]

A perimesencephalic bleed is the next most common cause. In such a bleed, the patient has a relatively specific blood pattern on non-contrast computed tomography, with the main blood burden predominantly anterior to the mid-brain and within the ambient and quadrigeminal cisterns. This type of bleed is treated conservatively and generally has a very good outcome.[4]

There are numerous other non-aneurysmal causes of subarachnoid haemorrhage (table 1).[5] It is often the clinical history and examination that will bring these to the forefront of the physician's mind. The pattern of haemorrhage on a non-contrast computed tomogram may also provide further clues.

In patients who present after major head trauma, a non-aneurysmal distribution of subarachnoid blood—for example, along the convexities—often provides sufficient diagnostic confidence not to investigate for an aneurysm. However, occasionally, the blood pattern does not allow this distinction to be made and vascular imaging is indicated.

Determining the cause of subarachnoid haemorrhage is important for prognosis, risk of rebleeding, and arranging an appropriate management plan.

Computed tomography

Non-contrast computed tomography is the first line of investigation (fig 1). Although this involves ionising radiation (table 2), the acquisition of data is fast and generally well tolerated. This investigation is also highly sensitive at picking up subarachnoid blood; 95-100% on the first day,[1-7] falling to about 58% at five days and less than 50% after one week.[8] By day 10 the blood may have been totally reabsorbed.

Computed tomography not only shows the amount and distribution of blood (which can give an indication of where it originated) but can also show complications associated with haemorrhage, such as surrounding oedema, hydrocephalus, or ischaemic complications of vasospasm. Larger bleeds or those with extension into the brain parenchyma typically present with

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Learning points

- Most non-traumatic subarachnoid haemorrhage is caused by rupture of an intracranial aneurysm
- Computed tomography is very sensitive in detecting acute subarachnoid haemorrhage but should not be relied on as the sole diagnostic investigation
- Lumbar puncture should be done at least 12 hours, after the onset of symptoms
- Computed tomography angiography is sensitive in detecting intracranial aneurysms, but catheter angiography is still the optimal investigation and may still be necessary
- Magnetic resonance imaging may be more sensitive than computed tomography in detecting subacute haemorrhage and is good for delayed presentations

neurological signs and yield a computed tomogram showing a positive result. A negative result in a computed tomogram in a patient with a clinical suspicion of subarachnoid haemorrhage is an indication for further investigation.

Lumbar puncture

Lumbar puncture should be performed when computed tomography does not show blood but the physician suspects subarachnoid haemorrhage.[9] Preferably 12 hours should have passed since the onset of symptoms before performing lumbar puncture. Some evidence exists that lumbar puncture is most useful if clinical presentation is a few days after the haemorrhage.[7] Four tubes of cerebrospinal fluid should be collected, and the first and fourth examined for non-diminishingly raised levels of red blood cells.[1] By using spectrophotometry, a bloody tap can be distinguished from true subarachnoid bleeding by the levels of bilirubin and oxyhaemoglobin in the cerebrospinal fluid.[4] These levels should still be detectable up to two weeks after onset of symptoms.

Computed tomography angiography

Figure 2 shows an example of a computed tomography angiogram.

Discussion with a neuroradiologist is generally advisable before imaging the intracranial vessels. The advancing technology of multidetector computed tomography scanners with sophisticated image reconstruction software has increasingly allowed this technique to be used instead of catheter angiography as the next step in investigating the cause of confirmed subarachnoid haemorrhage. It is relatively quick to do and less invasive than conventional angiography. Information on the venous system is often acquired during this investigation, but if the pattern of blood or clinical history suggests a venous cause, then dedicated venous phase acquisition should also be performed.[5]

If a positive result is obtained, computed tomography angiography can prevent two-step diagnostic catheter angiography (with a local anaesthetic) being followed later by an endovascular procedure (with general anaesthetic) for treatment. A positive computed tomography angiogram allows the neurosurgeon and the interventional radiologist to discuss a treatment plan.

The negative predictive value of computed tomography angiography for detecting an aneurysm has been cited as ranging from 82% to 96% on multidetector computed tomography, with sensitivity and negative predictive value approaching 100% on a “per aneurysm” basis.[10-15] The lower values associated with aneurysms measuring less than 3 mm may be improving with newer techniques and 64 slice multidetector computed tomography.[15 16] Depending on the history and the pattern of blood on the plain computed tomography scan, a negative result on computed tomography angiography may still warrant further investigation.

Conventional catheter angiography

Figure 3 shows an example of a conventional catheter angiogram.

Debate continues over the role of catheter angiography and computed tomography angiography in subarachnoid haemorrhage. If subarachnoid haemorrhage is confirmed and the computed tomography angiogram is negative, then catheter angiography should be considered—the distribution of blood on the plain computed tomogram will often determine if catheter angiography is necessary. If the pattern of bleeding is perimesencephalic then a negative computed tomography angiogram may be enough to exclude a basilar artery aneurysm as the cause.[17] Although some authors suggest this should be the end point of investigation, our current practice in most cases, as in most UK centres, is to proceed to catheter angiography.

Catheter angiography is still regarded as the optimal investigation for aneurysm detection, but it also gives additional information for other vascular causes for haemorrhage. A 1999 meta-analysis cites the combined risk of permanent or transient neurological complication as 1.8%,[18] but this figure may now be lower. [12 19] In our experience, the current rate at our institutions is about 0.5%.

In cases of negative catheter angiography, if magnetic resonance imaging is also negative then, depending on the blood pattern and clinical presentation, we would consider repeating catheter angiography 10-14 days after initial angiography.

Magnetic resonance imaging and angiography

These imaging procedures do not involve the use of ionising radiation (table 2 shows a comparison of doses for various investigations) but require more time and greater cooperation from the patient than does computed tomography as the patient needs to keep still. In the acute setting this is often difficult or not possible. Availability of magnetic resonance imaging out of normal working hours can also be a problem, so it tends to be used in the subacute setting.

In cases of proved subarachnoid haemorrhage where computed tomography angiography and catheter angiography are negative, magnetic resonance imaging is used to search for other causes of subarachnoid haemorrhage (table 1). Magnetic resonance imaging of the spine should also be done when no intracranial cause is found and particularly if the blood pattern is close to the foramen magnum to look for spinal cavernous angiomas or arteriovenous malformations.

Magnetic resonance imaging is more sensitive than computed tomography in detecting subacute haemorrhage, with 91-100% sensitivity from day 5,[20 21] using a gradient echo sequence. This technique can often clearly show the site of haemorrhage, particularly if over a convexity.[5] If the patient presents with no history of trauma but with cortical subarachnoid haemorrhage (?) over the superior convexities on computed tomography, an aneurysm at the circle of Willis is unlikely. In this type of case, if computed tomography angiography is negative, magnetic resonance imaging may be the next appropriate investigation.[5]

Magnetic resonance angiography is used mainly in the follow-up of proved aneurysms. It has a sensitivity of about 94% when the aneurysm is greater than 3 mm in size but as little as 38% for those smaller than 3 mm.[22 23] More recent research using stronger (3 Tesla) magnets suggests that this low sensitivity can be overcome and that these smaller aneurysms may be detected as accurately as with conventional catheter angiography.[24]

Outcome

Our patient had emergency non-contrast computed tomography, which confirmed acute subarachnoid haemorrhage (fig 1). He went on to have computed tomography angiography (fig 2) which showed an aneurysm of 3 mm to 4 mm arising from the junction of the anterior communicating artery and the anterior cerebral artery. This was treated in the endovascular system by coil embolisation (fig 3). The patient made a good recovery.

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Useful reading

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Tables

Table 1| **Some of the possible non-aneurysmal causes of subarachnoid haemorrhage, with the most sensitive imaging investigation**

Aetiology	Most sensitive imaging investigation
Arteriovenous malformation	Catheter angiography
Dural arteriovenous fistula	Catheter angiography
Vertebral dissection	Catheter angiography or magnetic resonance imaging
Cavernous angioma of brain or spine	Magnetic resonance imaging
Vasculitis	Catheter angiography
Amyloid angiopathy	Magnetic resonance imaging
Cerebral venous thrombosis	Magnetic resonance imaging or computed tomography venography

Table 2| Radiation doses at our current institute

Imaging investigation	Dose (dose length product) γGy/m^2
Computed tomography of head (spiral)	1105
Computed tomography of head with computed tomography angiography at circle of Willis	1486
Magnetic resonance imaging	0
Cerebral angiography (1 vessel)	4825
Cerebral angiography (5 vessels)	16 135

Figures

Fig 1 Non-contrast computed tomogram of head showing diffuse subarachnoid blood in basal cisterns (arrow)

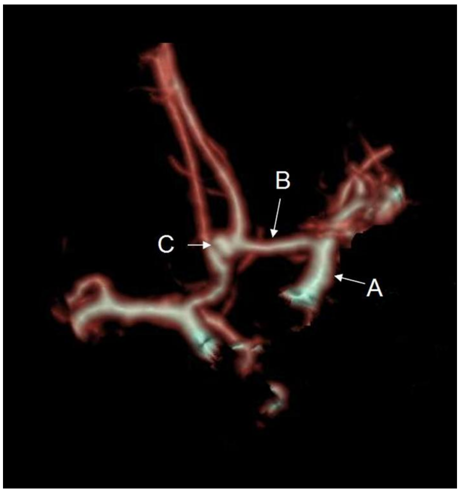

Fig 2 Volume rendered display of the anterior circle of Willis showing the supraclinoid left internal carotid (A), the left anterior cerebral artery (B), and a 3 mm to 4 mm aneurysm involving the ACA-ACOM complex (the junction of the anterior cerebral and anterior communicating arteries) (C)

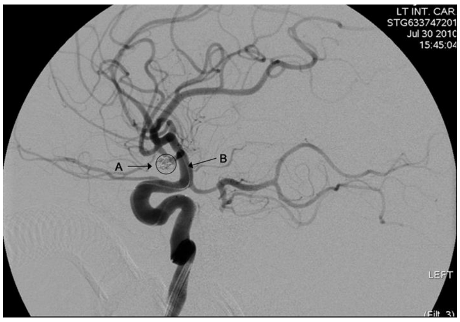

Fig 3 Catheter angiogram via the left internal carotid artery showing a coil in the aneurysm arising from the left A1-A2 junction (A, circled) with a microcatheter in situ to deploy the coil (B)