

SAFETY ALERTS

Checking placement of nasogastric feeding tubes in adults (interpretation of x ray images): summary of a safety report from the National Patient Safety Agency

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This is one of a series of *BMJ* summaries of recommendations to improve patients' safety, based on reports of safety concerns, incident analysis, and other evidence. The articles highlight the risks of incidents that have the potential for serious harm and are not well known, and for which clear preventive actions are available. Following a Department of Health review in July 2010, the National Patient Safety Agency will be abolished and some of its functions transferred to a patient safety subcommittee of the new NHS Commissioning Board. Reports of incidents are, however, still encouraged at www.npsa.nhs.uk.

Nasogastric feeding tubes are commonly used for people such as stroke patients with dysphagia or those on ventilators. They are generally used in the short to medium term (up to six weeks),¹ rather than for longer term feeding, which occurs via gastrostomy tubes, jejunostomies, or gastrostomy buttons.² Although feeding by nasogastric tubes is not routinely captured in activity data, about 170 000 tubes are supplied to the NHS each year.³ Most are inserted safely, but patients can be harmed if the tube is mistakenly inserted into the lungs or later becomes displaced from the stomach. If such errors are not detected before feeding, patients can develop serious complications, such as intrapulmonary feeding and aspiration pneumonia, which can be fatal. The position of tubes should therefore always be checked before feeding is started.

The National Patient Safety Agency (NPSA) issued guidance in 2005 for safe placement and position checking of nasogastric tubes.³ The guidance highlighted the unreliability of certain tests—such as the “whoosh” test (listening for bubbling sounds after air entry) and testing for acidity with litmus paper—and instead recommended testing with pH indicator paper as the first line check. It recommended checking x ray images as the second line test, although not for routine use. Since 2005, staff in England and Wales have reported 21 deaths and 79 cases of harm resulting from feeding into the lungs through misplaced nasogastric tubes. The single greatest cause of harm resulted from misinterpretation of x ray images, which accounted for 45 serious incidents, including 12 deaths. The NPSA therefore issued a further safety alert in March 2011 focusing on safe interpretation of x ray images.⁴ The guidance covers adults and children (not neonates), but this short article, based on the March safety alert, summarises advice for adults only.

A typical incident report reads: “Patient requiring NG [nasogastric] feeding. NG feeding tube resited through night. Portable chest x ray to confirm position of tube was viewed by nightshift ITU CT2 [intensive care staff] who then advised the nurses to commence feeding with NG feed. Patient was fed for approximately 1 and 1/2 hours giving 200 ml of feed. At around 0850 patient became very distressed, hypertensive, desaturating and coughed up NG feed into ventilator tubing. The NG feed was stopped. Duty ITU doctors were alerted to the problem and patient was reviewed. The CXR [chest x ray

image] was reviewed and the NG tube was found to be positioned in the left lung.”

Problems identified by the National Patient Safety Agency

Analysis of incidents involving placement of nasogastric feeding tubes since 2005 suggested that misinterpretation of x ray images was the largest single contributory factor, accounting for about half of all serious incidents and deaths. Other findings indicated that healthcare professionals were not following the original NPSA guidance. Healthcare staff were:

- Feeding patients despite obtaining nasogastric aspirates with a pH of between 6 and 8
- Instilling water down the tube before obtaining an aspirate
- Not checking tube placement by any method
- Not documenting any confirmation of such checks.

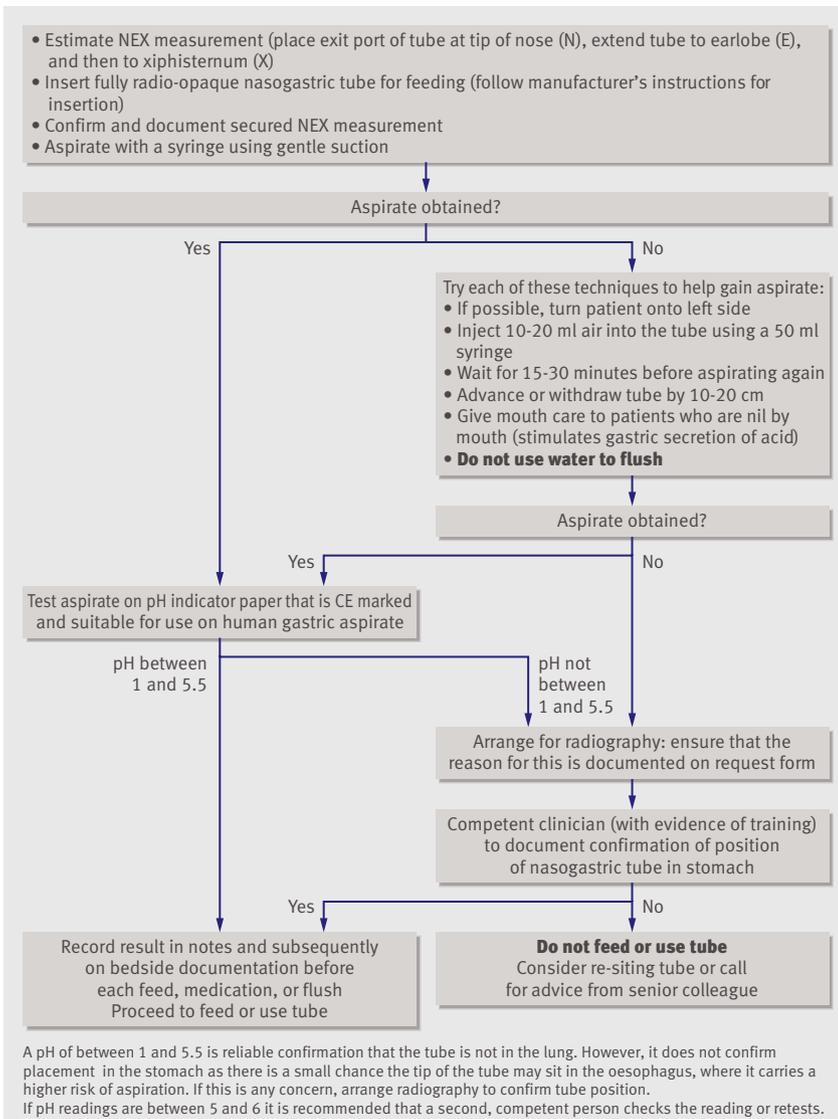
Because of the preventable nature of this harm, the misplacement of nasogastric tubes was confirmed by the Department of Health in March 2011 as being a “never” event—that is, one of a restricted list of serious avoidable events that could incur financial penalties for providers.⁵ Forty one never events relating to misplaced nasogastric tubes were reported between 2009 and 2010, thus confirming problems with interpretation of x ray images and risks in procedures done outside usual working hours.⁶

Early results from an NPSA audit in 2010 suggested great variation among 166 junior doctors at five pilot hospital sites in England and Wales, with low awareness of harm and continued use of unreliable checks such as the whoosh test and testing for acidity with litmus paper. Less than a quarter of the junior doctors were aware of the existing guidance, and less than a third of junior staff surveyed had received formal training on interpretation of x ray images for misplaced tubes.⁷

What can we do?

The NPSA safety alert asked organisations to make systems safer by:

- Identifying a clinical lead to implement actions
- Reviewing policies, training, and competency frameworks



Algorithm for checking placement of nasogastric tubes in adults. Adapted from National Patient Safety Agency⁴

- Ensuring stock of correct equipment (approved pH indicator paper and radio-opaque tubes with clear length markings), and
 - Avoiding placing nasogastric tubes outside usual working hours whenever possible.
- Resources included decision algorithms, placement checklists, and links to an e-learning module for junior staff (www.trainingngt.co.uk).
- Individual clinicians should ask themselves:
- Is nasogastric feeding appropriate for this patient? Do not use this method of feeding if the patient has a high risk of aspiration or any deviation in normal anatomy, such as pharyngeal pouch, strictures, or facial trauma. In these cases, seek advice as fluoroscopic guidance can often be used. Because of the risks of intubation, the decision to feed after assessment of the patient must be agreed by two competent professionals and recorded.
 - Does this need to be done now? Risks are greater at night time, when there is reduced access to a full range of staff and equipment.

- Am I competent to do this? Ensure you have had training in safe insertion and checking, including interpretation of x ray images, and that you are supervised until competent. You can also use e-learning resources such as www.trainingngt.co.uk. If you do not feel confident to do this procedure, ask for help.
- How can I check that the correct amount of tube has been inserted? Use NEX measurement (place exit port of the tube at the tip of the nose (N), stretching it to the earlobe (E) and then down to xiphisternum (X)) and confirm and record the external tube length before each feed to check that it has not moved.
- Do I know how to test for correct placement (figure)? Do not flush tubes or insert any liquid until you can confirm by testing with pH indicator paper (first line) or correct placement by radiography (second line).
- What is a safe pH level? Obtain a nasogastric aspirate: if the pH level is between 1 and 5.5, it is safe to start feeding. To be sure, check with a competent colleague if the reading falls between 5 and 6, because of possible misinterpretations at this level. Always record the result and the decision to start feeding.
- When should I arrange radiography? If no aspirate can be obtained or the pH level is higher than 5.5, request radiography and specify the purpose on the request form so that the radiographer knows that the tip of the nasogastric tube should be visible (that is, the film will be centred lower than for normal chest radiography).
- What should I look for in the x ray image? You need to check that the tube is in the stomach (see box 1 and guidance from the NPSA⁴). Ask a radiologist if you are unsure about this.
- After radiography, have I clearly recorded my decisions and next steps for the patient (box 2)? If the tip of the tube is well into the stomach (see NPSA guidance⁴), it is safe to feed. If the tube looks

Box 1 | Ten pointers for interpreting an x ray image to check for correct placement of nasogastric tube

- Can you see the tube?
- Does the tube path follow the oesophagus?
- Can you see the tube bisect the carina?
- Can you see the tube cross the diaphragm in the midline?
- Does the tube then deviate immediately to the left?
- Can you see the tip of the tube clearly below the left hemidiaphragm?
- If you think the tube is in the oesophagus, can you advance it?
- Has the tube coiled higher up in the pharynx or oesophagus?
- Does the length of tube inserted suggest it should be in the stomach?
- Does the x ray image cover enough of the area below the diaphragm to enable you to see the tube clearly, or does it need to be repeated? To improve contrast and visualisation, you can manipulate the PACS (picture archiving and communication systems) windows

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Previous articles in this series

- ▶ Safer insertion of suprapubic catheters (*BMJ* 2011;342:d924)
- ▶ Essential care after an inpatient fall (*BMJ* 2011;342:d329)
- ▶ Safer loading doses of medicines (*BMJ* 2011;342:d33)
- ▶ Early detection of complications after laparoscopic surgery (*BMJ* 2011;342:d7221)

Box 2 | Example confirmation of radiography results

19 January 2011, 10.30 A Smith—core surgical trainee

- Radiography done at 10.15 today
- Nasogastric tube passed down midline, past level of diaphragm and deviates to left
- Tip is seen in stomach
Plan: Nasogastric tube is safe to use for feeding
A Smith [signature]

misplaced or the position is not clear, it is not safe to feed. If there is any chance that the tube is in the respiratory tract, take it out. You cannot rely on absence of respiratory distress as a sign of correct tube placement.

- What about repeat checks? As tubes can be dislodged, tube placements should be checked at least once daily and before administering each feed or medication. Note that some patients, such as those taking proton pump inhibitors, will have persistently high gastric pH and so daily radiography would be impractical. Provided that the initial placement was appropriately confirmed and no other signs of dislodgement (such as retching or coughing) are present, repeat radiography would not usually be needed as long as the external length of tube remains unchanged. For further details see the NPSA's supporting information⁴ and the 2003 guidelines commissioned by the British Society of Gastroenterology.¹

What else do we need to know?

No existing bedside method for testing the position of nasogastric feeding tubes is completely reliable, and little high quality research has been conducted in this area.⁸ A recent systematic review concluded that a pH level between 1 and 5.5 can exclude the possibility that the tube has been inserted into the lung but not the small possibility that the tube is in the oesophagus, carrying a risk of aspiration.⁹ Thus the review recommended lowering the threshold for pH testing from 5.5 (as in the NPSA 2005 guidance) to 4. However, when the NPSA consulted widely on this proposed change with stakeholders in 2010, they found that the disadvantages of lowering pH threshold seemed to outweigh the benefits. NHS staff expressed concerns about (a) the resulting increase in radiography procedures (leading to greater costs and more patients exposed to both radiation and the associated risk of misinterpretation of the x ray image), as well as access problems for patients in the community; (b) likely delays for patients needing urgent feeding; and (c) the difficulties of obtaining lower pH levels for certain patients, such as those taking prophylaxis for stress ulcers or those needing continuous feeds.¹⁰ The NPSA's advice on the pH threshold therefore remains unchanged.

Further clinical research is needed into different bedside testing methods and outcome. Small studies found that a magnet tracking system (inserting a magnet in the tip of the tube and scanning to confirm position) may hold promise for future use.¹¹ Further work is also needed by manufacturers of pH indicator papers, given the cur-

rent problems reported by staff interpreting results in the critical pH range of 4-6.

How will we know when practice has become safer?

The NPSA asked organisations to comply with key actions (recommendations) by September 2011. All incidents of misplaced nasogastric tubes should be reported as never events, and trend data should show a decrease in avoidable harm over time, with fewer cases of misinterpretation of x ray images. Local organisations can also audit processes (using a placement checklist) by checking the notes for 20 consecutive cases in which nasogastric tubes were inserted against best practice. Future national clinical audits should monitor outcomes and processes to see if safety is improving for patients.

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Provenance and peer review: Commissioned; not externally peer reviewed.

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CORRECTIONS AND CLARIFICATIONS**This Week in Numbers**

In the second item in "The Week in Numbers" in the print issue of 30 April 2011, we gave the wrong paracetamol dose. The maximum dose of paracetamol for adults in 24 hours is 4 g [not 4 mg as was published in this item]. The Clinical Review (*BMJ* 2011;342:d2218, doi:10.1136/bmj.d2218) from which the item was derived stated 4 g.

RATIONAL IMAGING

Investigating suspected subarachnoid haemorrhage in adults

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

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

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) $\mu\text{Gy}/\text{m}^2$
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

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,¹⁻⁶⁻⁷ 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 neurological signs and yield a computed tomogram showing a positive result. A negative result in a computed tomogram in a patient with a clinical

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.

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

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

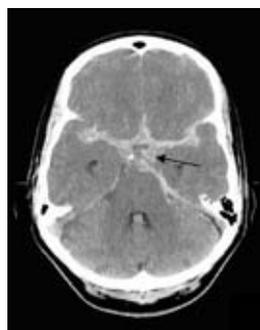


Fig 1 | Non-contrast computed tomogram of head showing diffuse subarachnoid blood in basal cisterns (arrow)

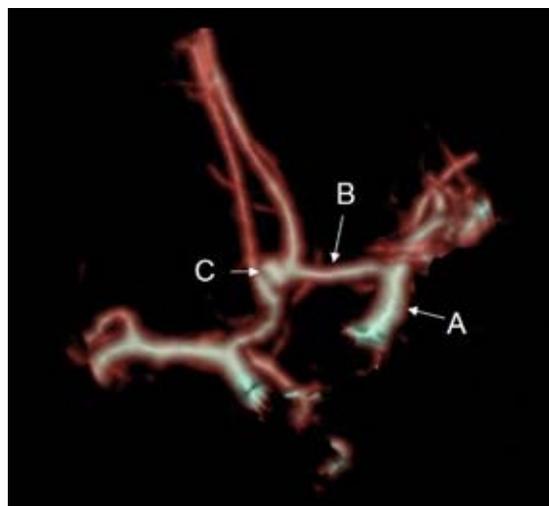


Fig 2 | Volume rendered display of the anterior circle of Willis showing the supraclinoid left internal carotid (A), the left anterior cerebral artery (B), and a 3 mm to 4 mm aneurysm involving the ACA-ACom complex (the junction of the anterior cerebral and anterior communicating arteries) (C)

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.

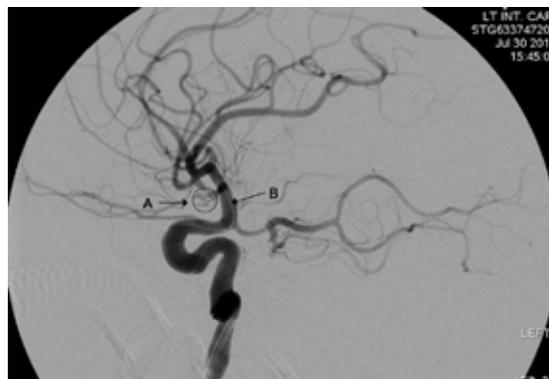


Fig 3 | Catheter angiogram via the left internal carotid artery showing a coil in the aneurysm arising from the left A1-A2 junction (A, circled) with a microcatheter in situ to deploy the coil (B)

USEFUL READING

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Guidelines for the management of aneurysmal subarachnoid hemorrhage. A Statement for Healthcare Professionals From a Special Writing Group of the Stroke Council, American Heart Association. *Stroke* 2009;40:994-1025

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.

Contributors: SCB prepared the manuscript, JM selected the patient and images, SB and JM contributed to editing. SCB is guarantor.

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Patient consent obtained.

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