



## **Acute “head pressure” and the left side of the bell**

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A 32-year old woman presents to the ED complaining of “a pressure in my head” of 3 hours duration. She had been vacationing in Paris and had come directly from the airport in Boston to the ED for these symptoms. She had been fine during the 6 hour flight, but when she picked up her suitcase from the conveyor belt, she felt the abrupt onset of a pressure-like feeling in her head – “like a rush”. The sensation was distinctly unpleasant but she it was not a “headache” and it was not “a pain”. This was accompanied by some momentary dizziness, which on further questioning, seemed to be of the near-syncopal variety. She did not faint and the dizziness passed within 30 seconds.

There was no associated nausea, vomiting, neck pain or pressure, diplopia, facial pain, HEENT symptoms, and she had never had a similar sensation in the past. She telephoned her father, who was a physician at the hospital, and he recommended that she come in for evaluation. He calls you before she arrives and says, “My daughter is extremely anxious, and it’s probably just her anxiety.” During the 90 minutes between the onset of the head pressure and the time you see the patient, her symptoms gradually and partly improve. She gets “migraine” headaches once or twice per month. They are usually peri-menstrual and go away with “two Tylenol or a percocet”. Other than the anxiety and the migraines, she has no significant past medical history.

She is in a room, fully dressed and in a fur coat. On physical examination, she is awake, alert and oriented. His vital signs are T: 98.4 degrees, P: 72, BP: 138/82, and R: 14. Her HEENT exam is completely normal and the neck is supple. The remainder of the general physical examination is normal. His neurological exam reveals a normal mental status, albeit the examiner was unable to test his mathematical abilities. Cranial nerves 2-12 were normal, including the presence of good venous pulsations. Motor was full without pronator drift. Sensation, cerebellar function, gait and reflexes were normal. She is mildly anxious and now that she is feeling considerably better, she wants to go home, having had an extremely long day.

You tell her you would like her to stay for a diagnostic study.

## **Key Clinical Questions**

Should this patient be treated like a patient with a headache?

What elements in the history and physical examination are used to determine which patients with non-traumatic headache should undergo further evaluation?

What is the diagnostic algorithm for diagnosis of subarachnoid hemorrhage (SAH)?

What is the sensitivity of computed tomography in SAH? What are the factors that affect sensitivity?

When is a lumbar puncture (LP) necessary, and what potential limitations does the LP have?

## **Key learning points**

- Some patients with aneurysmal SAH do not have a cataclysmic event. Their headache may not be “worst ever”, their examinations may be entirely normal. As illustrated by this case, they may not even use the word headache. The head symptoms are almost always abrupt in onset and qualitatively different than prior headaches.
- The first step in the work-up for patients with suspicion of SAH is a non-contrast CT scan. While some argue that an LP first strategy would result in better resource utilization, this hypothesis has not been tested clinically.
- If the CT is normal, patients should undergo LP. The most important limitations of the CT include time from onset of headache, size of bleed, and physician misinterpretation.
- The LP should be examined for red blood cells and xanthochromia. In most cases, if both the CT and the CSF are completely normal, no further evaluation is necessary.
- All patients with subarachnoid hemorrhage should have a neurosurgical consultation.
- Subarachnoid hemorrhage

## **Aneurysmal Subarachnoid Hemorrhage**

### **Background, Risk Factors and Epidemiology:**

Subarachnoid hemorrhage is most commonly caused by trauma; however of non-traumatic cases, approximately 80% are due to ruptured aneurysms of the vessels of, and off of the Circle of Willis. In this handout, SAH will refer to those 80% of non-traumatic SAHs caused by ruptured aneurysms. While between 1-6% of the population has aneurysms in the cerebral circulation (number depends on the methodology of the study), only a small minority will ever rupture. Aneurysm formation is thought to be acquired, not congenital. The incidence of SAH varies from 5-10 per 100,000 of population. In the United States, there are approximately 28,000 cases annually.

Risk factors include hypertension, cigarette smoking, alcohol consumption (especially a recent binge), a personal or family history of a ruptured aneurysm, and a variety of connective tissues that affect arterial walls. Asking about a family history is important, since this is one of the strongest risk factors. Although SAH can occur at any age, the peak age is 50 years; sex distribution is roughly equal.

### **Anatomy and Pathophysiology**

Aneurysms can arise from any intra-cranial artery. Approximately 85% arise from the anterior circulation and 15% from the posterior. The most common site is the anterior communicating artery. The size can range from quite small (several millimeters) to so called “giant” aneurysms that are larger than 25mm. They tend to form at branch points in cerebral vessels and although their cause is unknown, most believe that they are acquired because their incidence in children is quite low.

As aneurysms grow in size, the physical forces tend to increase transmural pressure. With rises in arterial blood pressure, leaking or frank rupture may occur. At the moment of aneurysmal rupture, there is a brief spike in intracranial pressure. This spike, if it approaches cerebral perfusion pressure, is what causes the transient syncope that is seen in some patients. It may also cause the retinal hemorrhages that some patients will exhibit.

Once aneurysmal rupture occurs, the blood rapidly disseminates throughout the subarachnoid space. The blood reaches the lumbar theca within hours, and in the largest study that includes data on cerebrospinal fluid (CSF) analysis, blood was found in all 21 patients tapped within 4 hours of the ictus, including 4 within 2 hours. Hemoglobin in the red cells is metabolized in vivo to bilirubin. In vitro, hemoglobin can break down into oxyhemoglobin. These pigmented molecules lead to a yellowish discoloration of the CSF called xanthochromia, which takes between 6-12 hours to develop, although it can develop earlier (see chart 1).

Depending on precisely where the aneurysm sits, and exactly where it ruptures, it is possible for the blood to go exclusively into the subdural or intra-parenchymal spaces, however this is extraordinarily rare.

**Chart 1: CSF results** (Walton, 1955)

<b>Time from ictus (hours)</b>	<b># of cases</b>	<b>Blood present</b>	<b>Xanthochromia present (not present; not recorded)</b>
0-2	4	4	0
2-4	17	17	1 (15 not; 1 NR)
4-6	28	28	16 (9 not; 3 NR)
6-12	40	40	26 (4 not; 10 NR)
12-24	35	32	31 (0 not; 4 NR)
25-72	57	51	53 (0 not; 4 NR)

Aneurysms may cause symptoms by other mechanisms besides rupture. Clot from an aneurysm can migrate distally causing a TIA or stroke. They can press on adjacent structures and act as a mass lesion. The classic example is the third nerve palsy involving the pupil. The pupil is dilated as the aneurysm pushes on the outer surface of the nerve, where the papillary constrictor fibers are located. However because only about 15% of aneurysms arise from the posterior circulation, this “classic” finding is usually absent. Seizures can also result from aneurysms. Last, abrupt headache can occur, from thrombosis, dissection or acute expansion of an aneurysm; this latter event is an uncommon occurrence, which has implications in terms of the diagnostic evaluation of the patient.

**ED Presentation**

It is important for emergency physicians to recognize that, like in the real case presented above, the symptoms evoked by a ruptured aneurysm can vary considerably. There is a bell-shaped curve of presentations. On the “sick” right hand side of the curve are patients who present in coma, or with obvious focal neurological signs in the setting of acute severe headache. The physical examination in this group of patients is by definition abnormal. In the center of the curve are patients who present with the classic “worst headache” of life that starts abruptly, during exercise or an activity associated with a Valsalva maneuver. They may faint or their legs buckle. Vomiting occurs and neck symptoms – pain and/or stiffness – develop. Both of these groups of patients are relatively easy to diagnose. The physical examination in this group may be normal, but

many will have some abnormality, such as meningismus, retinal hemorrhages, a dilated pupil or any other focal or generalized finding.

That said, approximately 30% of patients present on the left hand side of the curve. These patients have less dramatic histories and often normal physical examinations. The headache may not begin abruptly, may not be worst of life, may occur in the context of a pre-existing headache disorder such as migraine or tension headaches (both of which are orders of magnitude more common than SAH), may improve spontaneously or from over-the-counter analgesics.

Patients in this group usually have normal physical examinations and may “look well”. Meningismus is present in about 75% of patients overall and may not exist in this group. Some of these patients without meningismus on physical examination will complain of neck pain or stiffness.

## **Lab Studies**

Routine laboratory studies rarely yield a diagnosis in patients with headache. In that the CT scan is done without intravenous contrast, there is no need for laboratory testing in most patients being worked up for acute headache. In older patients with a question of temporal arteritis an erythrocyte sedimentation rate may help. If carbon monoxide poisoning is a possibility, a CO-Hb level may be diagnostic.

## **Imaging Studies**

Despite the rapid improvements in brain imaging technology, non-contrast CT scan remains the test of choice. It is inexpensive, readily available, and extremely rapid. Clinicians and radiologists have an enormous amount of experience in its interpretation. As well, it may identify alternative diagnoses in some cases. As for most tests in medicine, cranial CT has several limitations in the diagnosis of SAH:

- Timing – the longer the period from the onset of headache, the lower the sensitivity
- Spectrum bias – the smaller the bleed, the lower the sensitivity
- Interpretation bias – physicians may miss subtle findings
- Anemia – with hematocrits of < 30%, acute blood may be isodense with brain
- Technical factors – quality of scan, motion artifact, width and plane of “cuts”

If the CT shows a SAH, the next steps are neurosurgical consultation and cerebrovascular imaging, usually with a traditional catheter angiogram. If the CT is negative however, the next step is to perform a LP. Magnetic resonance (MR) and angiogram (MRA) is another way to assess the brain and its vessels. Since MR hardware and software is continually changing, MR may eventually play a more important role in the diagnosis of SAH. As of

September 2003, it is clearly second line. MRA on the other hand, is being used increasingly to screen for aneurysms.

## **Procedures**

Lumbar puncture is the time honored test for SAH. Before the advent of CT, it was the only test commonly available. Clinicians learned much about LP for SAH in the pre-CT era (see chart 2). There are 3 major findings – presence of blood, presence of xanthochromia and an increase in ICP. I believe it is important to measure the opening pressure, which may help differentiate traumatic tap from true SAH. It may occasionally be helpful in cases of idiopathic intracranial hypertension and cerebral venous sinus thrombosis.

## **Emergency Department Care**

The diagnosis of SAH should trigger a number of steps. Assuming that the ABCs have been attended to, neurosurgical consultation and plans for cerebrovascular imaging must be arranged. The following management issues require addressing, either in the ED or in the ICU. These will not be considered in detail here.

- **Airway**
- **Neurosurgical consultation and transfer**
- **Angiography**
- **Blood pressure control**
- **Analgesia (pain and anxiety)**
- **Vasospasm prevention**
- **Seizure prophylaxis**
- **Volume and hydration issues**
- **ICP: hydrocephalus, and extra-axial or intra-cerebral hematoma**
- **Arrhythmia monitoring**

## **Consultations and Admission**

All patients with SAH should be admitted to the hospital and all should have neurosurgical consultation. In hospitals where the latter is not available, transfer agreements should be in place to facilitate the transfer of SAH patients to a center where neurosurgical expertise is available. These patients are normally admitted to an ICU bed.

## **Summary**

Subarachnoid hemorrhage can present in the absence of the classic worst headache of life with nausea, vomiting, syncope and neurological findings on examination. These mild presenting cases are the most important to diagnose correctly. Emergency physicians

must understand this bell-shaped curve distribution. By taking a very detailed history with attention to the onset, severity, quality of symptom as well as associated symptoms, in all patients presenting with headache, head pressure, and other facial or neck pain, most of these patients with subtle presentations of SAH can be identified. The threshold for the standard work-up (non-contrast cranial CT scan followed by LP if the CT is negative or non-diagnostic) should be low.

## References

### General references:

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### Adequacy of negative CT and LP (in the work up):

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**Diagnostic studies:**

1. Edlow, J.A. and P.C. Wyer, *Evidence-based emergency medicine/clinical question. How good is a negative cranial computed tomographic scan result in excluding subarachnoid hemorrhage?* Ann Emerg Med, 2000. 36(5): p. 507-16.
2. Edlow, J.A., K.S. Bruner, and G.L. Horowitz, *Xanthochromia*. Arch Pathol Lab Med, 2002. 126(4): p. 413-5.
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**Neuro-ophthalmology of cerebral aneurysms**

1. Kasner, S.E., G.T. Liu, and S.L. Galetta, *Neuro-ophthalmic aspects of aneurysms*. Neuroimaging clinics of North America, 1997. 7(4): p. 679-692.
2. Trobe, J.D., *Third nerve palsy and the pupil*. Archives of Ophthalmology, 1988. 106: p. 601-2.

### **Patient Outcome**

The diagnostic procedure was a non-contrast cranial CT scan. The patient agreed to stay for the scan, which showed a small SAH. She was admitted to the neurosurgical service, and early the next morning, had an angiogram which showed a ruptured aneurysm of the anterior communicating artery. The aneurysm’s anatomy was not favorable for endovascular therapy and she was taken to the operating room where the aneurysm was clipped. She had an uneventful recovery.

## Annotated Bibliography

**1. Edlow, J.A. and L.R. Caplan, *Avoiding pitfalls in the diagnosis of subarachnoid hemorrhage*. N Engl J Med, 2000. 342(1): p. 29-36.**

This is a relatively recent review of the diagnosis of SAH. It catalogues 3 general reasons that physicians miss the diagnosis approximately 25% of the time, especially in mildly presenting patients.

**2. Mayberg, M.R., H.H. Batjer, and R. Dacey, *Guidelines for the management of aneurysmal subarachnoid hemorrhage*. Stroke, 1994. 25(11): p. 2315-28.**

This is an official AHA guideline on the treatment of these patients. Although some information is dated, it is the standing guideline, and much of the information on diagnosis is up to date.

**3. Raps, E.C., et al., *The clinical spectrum of unruptured intracranial aneurysm*. Archives of neurology, 1993. 50: p. 265-268.**

Probably the best review of the presentations of unruptured aneurysms, from a series presenting to a referral center.

**4. Linn, F.H., et al., *Prospective study of sentinel headache in aneurysmal subarachnoid haemorrhage*. Lancet, 1994. 344(8922): p. 590-3.**

An excellent prospective study from the Netherlands.

**5. Edlow, J.A. and P.C. Wyer, *Evidence-based emergency medicine/clinical question. How good is a negative cranial computed tomographic scan result in excluding subarachnoid hemorrhage?* Ann Emerg Med, 2000. 36(5): p. 507-16.**

Good review of the issue of sensitivity of cranial CT in SAH, and the issues that impact sensitivity.

**6. Edlow, J.A., K.S. Bruner, and G.L. Horowitz, *Xanthochromia*. Arch Pathol Lab Med, 2002. 126(4): p. 413-5.**

Important survey of North American hospital labs that shows that less than 1% of labs use the method of spectrophotometry to test for xanthochromia.

**7. Trobe, J.D., *Third nerve palsy and the pupil*. Archives of Ophthalmology, 1988. 106: p. 601-2.**

Good, terse expounding of the “rule of the pupil” as it relates to cerebral aneurysms.

## Questions

1. **What percentage of patients with aneurysmal SAH present with meningismus?**
  - a. 100%
  - b. 90%
  - c. 75%
  - d. < 50%
  
2. **What are the factors that affect CT scan sensitivity for SAH?**
  - a. Hematocrit
  - b. Time from onset of headache
  - c. Size of bleed
  - d. Physician experience in interpreting scans
  - e. All of the above
  
3. **The diagnosis of SAH is unusual without the presence of a pupil-involving 3<sup>rd</sup> nerve palsy.**
  - a. true
  - b. false
  
4. **The presence of xanthochromia always takes 12 hours to be present.**
  - a. true
  - b. false
  
5. **Once the diagnosis of SAH is established, whether by CT or LP, the next most important first step is to:**
  - a. Immediately lower the blood pressure by 20%
  - b. Administer nimodipine to prevent vasospasm
  - c. Notify a neurosurgeon to discuss next steps
  - d. Intubate the patient in order to lower the ICP by hyperventilating the patient.

## Answers

**1. Answer c.**

This figure is important to be aware of in the sense that a full 1 patient in 4, with definite SAH will NOT have neck stiffness demonstrable on physical examination. Absence of meningismus should not dissuade one from considering the diagnosis of SAH.

**2. Answer e.**

Physicians must realize that CT does not have a “one size fits all” sensitivity for all comers with SAH. The CT is affected by all of the factors listed, as well as technical factors. For all of these reasons, a negative CT scan does not exclude the diagnosis of SAH.

**3. Answer b.**

Third nerve palsies from aneurysms usually occur in the setting of a posterior communicating artery aneurysm. Since posterior circulation aneurysms only occur in ~ 15% of lesions, the finding of a 3<sup>rd</sup> nerve palsy only occurs in 10-15% of cases. This is another “classic” finding that is frequently missing.

**4. Answer b.**

There are a number of factors that affect xanthochromia. For one, there are different pigments that can lead to the yellowish discoloration known as xanthochromia. Oxyhemoglobin can develop in hours *in vitro*. Bilirubin usually takes longer and only occurs *in vivo*. These two pigments can only be distinguished using spectrophotometry, which the vast majority of hospitals do not use. As well, in older studies, many patients had visible xanthochromia (to the naked eye) in 6 hours.

**5. Answer c.**

Many of the next steps will depend on a variety of factors, almost all of which are dictated by the neurosurgeon who will care for the patients. While the blood pressure MAY need to be lowered, it may not, and the amount may vary. Nimodipine is useful in preventing vasospasm but may be given during the first 12 hours and so it is not a STAT priority. Some patients may require intubation, mostly for airway control, but this is a minority.