Neuroimaging of Headache

Kenneth D. Williams, MD
Disclosures

• Financial: None

• Off Label Product Use: None
Key Points

• Headache is an extremely common symptom.

• Structural abnormalities (Primary HA) are rare.

• Clinical findings suggest the need for imaging.

• Chronic - MRI Brain without & with Gad
  • Acute (ED) - CT Brain without
Headache

- Lifetime Incidence  F 99%  M 94%
- Annual Incidence US  70% population
- 18 Million Outpatient Visits / year  4%
  - Primary Care Top 20 Diagnoses
- 1.2 - 4.5 % of all Adult ED Visits
International Headache Society Classification

- Initial Classification 1988 Update 2004
- Primary Headache Disorders
- Secondary Headache Disorders
- Cranial Neuralgias / Central and Primary Facial Pain / Other Headaches
Primary Headache

• NO OTHER CAUSATIVE DISORDER

• Migraine
• Tension-type Headache
• Cluster Headache & other trigeminal autonomic cephalgias
• Other Primary Headaches
Secondary Headache

• CAUSED BY ANOTHER DISORDER

• New headache occurring in close temporal relation to another disorder that is a known cause of headache.

• Differential diagnosis is over 300 items.
# Primary Headache

<table>
<thead>
<tr>
<th>Symptom</th>
<th>Migraine headache</th>
<th>Tension headache</th>
<th>Cluster headache</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location</td>
<td>Unilateral in 60 to 70 percent; bifrontal or</td>
<td>Bilateral</td>
<td>Always unilateral, usually begins around the eye or</td>
</tr>
<tr>
<td></td>
<td>global in 30 percent</td>
<td></td>
<td>temple</td>
</tr>
<tr>
<td>Characteristics</td>
<td>Gradual in onset, crescendo pattern; pulsating;</td>
<td>Pressure or</td>
<td>Pain begins quickly, reaches a crescendo within</td>
</tr>
<tr>
<td></td>
<td>moderate or severe intensity; aggravated by</td>
<td>tightness which</td>
<td>minutes; pain is deep, continuous, excruciating, and</td>
</tr>
<tr>
<td></td>
<td>routine physical activity</td>
<td>waxes and wanes</td>
<td>explosive in quality</td>
</tr>
<tr>
<td>Patient appearance</td>
<td>Patient prefers to rest in a dark, quiet room</td>
<td>Patient may</td>
<td>Patient remains active</td>
</tr>
<tr>
<td></td>
<td></td>
<td>remain active or</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>may need to rest</td>
<td></td>
</tr>
<tr>
<td>Duration</td>
<td>4 to 72 hours</td>
<td>Variable [30</td>
<td>[should be 15 minutes to 3 hours] 30 minutes to 3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>minutes to 7</td>
<td>hours</td>
</tr>
<tr>
<td>Associated symptoms</td>
<td>Nausea, vomiting, photophobia, phonophobia;</td>
<td>None</td>
<td>Ipsilateral lacrimation and redness of the eye; stuffy</td>
</tr>
<tr>
<td></td>
<td>may have aura (usually visual, but can involve</td>
<td></td>
<td>nose; rhinorrhea; pallor; sweating; Horner’s</td>
</tr>
<tr>
<td></td>
<td>other senses or cause speech or motor deficits)</td>
<td></td>
<td>syndrome; focal neurologic symptoms rare; sensitivity</td>
</tr>
<tr>
<td></td>
<td>[only need GI symptoms or sensitivities to make</td>
<td></td>
<td>to alcohol [only need one autonomic symptom to make</td>
</tr>
<tr>
<td></td>
<td>diagnosis of migraine; not both]</td>
<td></td>
<td>dx of Cluster]</td>
</tr>
</tbody>
</table>
Primary Headache

• The prevalence of headache in the general population is quite high.
  – 70% Annual Incidence  318 Million population
  – At least 222 million headaches / yr
• The presence of a significant structural lesion is very unlikely.
• Scanning every headache every time is not reasonable.
  – 1980  3 Million CT’s  2007  62 Million CT’s
## Financial Costs

<table>
<thead>
<tr>
<th>CPT</th>
<th>Exam</th>
<th>Medicare Hospital Reimbursement</th>
</tr>
</thead>
<tbody>
<tr>
<td>70450</td>
<td>Brain CT without contrast</td>
<td>$169.80</td>
</tr>
<tr>
<td>70460</td>
<td>Brain CT with contrast</td>
<td>$306.28</td>
</tr>
<tr>
<td>70470</td>
<td>Brain CT without and with contrast</td>
<td>$345.33</td>
</tr>
<tr>
<td>70551</td>
<td>Brain MRI without contrast</td>
<td>$370.05</td>
</tr>
<tr>
<td>70552</td>
<td>Brain MRI with contrast</td>
<td>$518.00</td>
</tr>
<tr>
<td>70553</td>
<td>Brain MRI without and with contrast</td>
<td>$609.70</td>
</tr>
</tbody>
</table>

222 Million X $169.80 = $37,695,600,000  
18 Million X $609.70 = $10,974,600,000

Imaging already >$100 Billion / yr of ~ 3 Trillion / yr Health Costs
Radiation Costs

Radiation Costs

Computed Tomography — An Increasing Source of Radiation Exposure


The advent of computed tomography (CT) has revolutionized diagnostic radiology. Since the inception of CT in the 1970s, its use has increased rapidly. It is estimated that more than 62 million CT scans per year are currently obtained in the United States, including at least 4 million for children.¹

By its nature, CT involves larger radiation doses than the more common, conventional x-ray imaging procedures (Table 1). We briefly review the nature of CT scanning and its main clinical applications, both in symptomatic patients and, in a more recent development, in the screening of asymptomatic patients. We focus on the increasing number of CT scans being obtained, the associated radiation doses, and the consequent cancer risks in adults and particularly in children. Although the risks for any one person are not large, the increasing exposure to radiation in the population may be a public health issue in the future.

CT Brain Effective dose 2 mSv
Table 1: Proportion of individuals with a serious abnormality on brain imaging (CT or MRI)*

<table>
<thead>
<tr>
<th>Types of individuals included</th>
<th>Number with serious abnormality/number scanned</th>
<th>% (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Migraine†‡‡ 1-12</td>
<td>2/1086</td>
<td>0.2 [0.02 to 0.7]</td>
</tr>
<tr>
<td>Tension type headache†† 7</td>
<td>0/83</td>
<td>0 [0 to 4.4]</td>
</tr>
<tr>
<td>Chronic headache (not further defined)†‡ 13-17</td>
<td>7/1445</td>
<td>0.5 [0.2 to 1.0]</td>
</tr>
<tr>
<td>Asymptomatic volunteers¶ 18</td>
<td>4/1000</td>
<td>0.4 [0.1 to 0.8]</td>
</tr>
</tbody>
</table>

*To improve clarity, these results are summarised here in a simpler format than that used in the guidelines.
†No abnormal neurological findings on examination.
‡Only those studies which definitely excluded patients with acute headache are included here.
¶A study of the incidental findings on brain MR scans of 1000 asymptomatic volunteers who participated as control subjects in various research projects and whose median age was similar to the individuals included in the studies of headache patients summarised in the guidelines.
CI, confidence interval.

TABLE 2
Recommendations for Neuroimaging in Patients with Nonacute Headache*

**Neurologic examination**
Recommendation—neuroimaging should be considered in patients with nonacute headache and an unexplained abnormal finding on the neurologic examination (Grade B†).

**Neurologic symptoms**
Recommendation—evidence is insufficient to make specific recommendations regarding neuroimaging in the presence or absence of neurologic symptoms (Grade C†).

**Migraine and a normal neurologic examination**
Recommendation—neuroimaging usually is not warranted for patients with migraine and normal neurologic examination (Grade B†). For patients with atypical headache features or patients who do not fulfill the strict definition of migraine (or have some additional risk factor), a lower threshold for neuroimaging may be applied (Grade C†).

**Tension-type headache and normal neurologic examination**
Recommendation—data were insufficient to make an evidence-based recommendation regarding the use of neuroimaging for tension-type headache (Grade C†).

**Effectiveness of CT versus MRI**
Recommendation—data were insufficient to make any evidence-based recommendations regarding the relative sensitivity of MRI compared with CT in the evaluation of migraine or other nonacute headache (Grade C†).

- 1,876 pts 1,243 F 633 M
- 1,432 CT 580 MRI 136 Both
- Significant lesions 22 pts 1.2% CI 0.7-1.8
- HA & Normal neuro exam 0.9% CI 0.5-1.4
- Incidental lesions 14 pts
- 119 MRI with NML CT – 2 pts (+) lesion
- Abnormal neuro exam 42 X likelihood risk

<table>
<thead>
<tr>
<th>Headache diagnosis</th>
<th>Significant abnormalities</th>
<th>% Rate (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Migraine</td>
<td>4/920</td>
<td>0.4 (0.1, 1.4)</td>
</tr>
<tr>
<td>Tension-type</td>
<td>5/665</td>
<td>0.8 (0.2, 1.7)</td>
</tr>
<tr>
<td>Cluster headache</td>
<td>1/20</td>
<td>5 (0.1, 25)</td>
</tr>
<tr>
<td>Post-traumatic</td>
<td>0/69</td>
<td>0 (0, 5.2)</td>
</tr>
<tr>
<td>Indeterminate</td>
<td>7/188</td>
<td>3.7 (1.5, 7.5)</td>
</tr>
</tbody>
</table>
Abnormality Prevalence

- Aneurysms 0.5 – 6 %
- AVM’s 0.015 - 0.8 % (1/7 that of aneurysm)
- Cavernous Malformations 0.06 - 0.47 %
- DVA’s 2.7 %

- Primary Neoplasm 3 / 1000 Healthy Volunteers
- 18 % Incidental Abnormal Findings
- Sinus Mucosal Thickening 13 - 43 % NML
Don’t Want to Miss
Primary versus Secondary

• Clinical Findings
  – HISTORY
  – Physical Exam
    • Neurologic Exam

• Some situations suggest a need for neuroimaging.

• Red Flags
  – First and Worst
Red Flags

- Thunderclap headache – “Worst ever”
- New Onset > 50 years of age (>65y 15% 2^0)
- Headache in a cancer patient
- Headache in an immunosuppressed patient
- New type / Accelerating pattern
- Focal neurologic signs and symptoms
  - Sz / papilledema / cognitive or personality change
Red Flags

• Systemic illness – fever / rash / meningismus
• Headache not responding to treatment
• New headache in a pregnant patient or post-delivery
• Onset with Exertion / Valsalva / Cough / Sex
• Recent travel history
Yellow Flags

- Wakes patient from sleep
- New onset side-locked
- Postural headaches
Pediatric Red Flags

• Headaches that persistently awaken a child from sleep or occurs immediately upon awakening.
• Persistent headache without family history of migraine.
• Headache associated with abnormal neurologic examination.
• Headache associated with seizures.
Pediatric Red Flags

- Persistent headaches of less than 6 months duration.
- Recent onset of severe headache or change in the type of headache.
- Family or medical history of disorders that may predispose one to CNS lesions, and clinical or laboratory findings that suggest CNS involvement.

What Imaging Study is Best?

- It depends on the clinical situation.
- Chronic (Non-acute) setting / Office Visit
  MRI Brain without & with Gad contrast
- Acute setting / ED Visit
  CT Brain without iodinated contrast
May 2014 Update — The latest release of the ACR Appropriateness Criteria® includes four new and 24 revised topics covering a total of 201 clinical conditions.

**Access Appropriateness Criteria**

Best viewed in Firefox 15+, Chrome 15+, Internet Explorer 9+, and Safari 5+
## ACR Appropriateness Criteria

### Neurologic

<table>
<thead>
<tr>
<th>Topic Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ataxia</td>
</tr>
<tr>
<td>Cerebrovascular Disease</td>
</tr>
<tr>
<td>Cranial Neuropathy</td>
</tr>
<tr>
<td>Dementias and Movement Disorders</td>
</tr>
<tr>
<td>Focal Neurologic Deficit</td>
</tr>
<tr>
<td>Head Trauma</td>
</tr>
<tr>
<td>Headache</td>
</tr>
<tr>
<td>Hearing Loss and/or Vertigo</td>
</tr>
<tr>
<td>Imaging in the Diagnosis of Thoracic Outlet Syndrome</td>
</tr>
<tr>
<td>Low Back Pain</td>
</tr>
<tr>
<td>Management of Vertebral Compression Fractures</td>
</tr>
<tr>
<td>Myelopathy</td>
</tr>
<tr>
<td>Neck Mass/Adenopathy</td>
</tr>
<tr>
<td>Neuroendocrine Imaging</td>
</tr>
<tr>
<td>Orbital, Vision and Visual Loss</td>
</tr>
<tr>
<td>Plexopathy</td>
</tr>
<tr>
<td>Seizures and Epilepsy</td>
</tr>
<tr>
<td>Sinonasal Disease</td>
</tr>
<tr>
<td>Suspected Spine Trauma</td>
</tr>
</tbody>
</table>
## ACR Appropriateness Criteria

**Clinical Condition:** Headache

**Variant 1:** Chronic headache. No new features. Normal neurologic examination.

<table>
<thead>
<tr>
<th>Radiologic Procedure</th>
<th>Rating</th>
<th>Comments</th>
<th>RRL*</th>
</tr>
</thead>
<tbody>
<tr>
<td>MRI head without and with contrast</td>
<td>4</td>
<td>See statement regarding contrast in text under “Anticipated Exceptions.”</td>
<td>O</td>
</tr>
<tr>
<td>MRI head without contrast</td>
<td>4</td>
<td></td>
<td>O</td>
</tr>
<tr>
<td>CT head without contrast</td>
<td>3</td>
<td></td>
<td>★★★</td>
</tr>
<tr>
<td>CT head without and with contrast</td>
<td>3</td>
<td></td>
<td>★★★</td>
</tr>
<tr>
<td>CT head with contrast</td>
<td>3</td>
<td></td>
<td>★★★</td>
</tr>
<tr>
<td>MRA head without and with contrast</td>
<td>2</td>
<td></td>
<td>O</td>
</tr>
<tr>
<td>MRA head without contrast</td>
<td>2</td>
<td></td>
<td>O</td>
</tr>
<tr>
<td>Arteriography cervicocerebral</td>
<td>2</td>
<td></td>
<td>★★★</td>
</tr>
<tr>
<td>CTA head with contrast</td>
<td>2</td>
<td></td>
<td>★★★</td>
</tr>
</tbody>
</table>

*Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate
*Relative Radiation Level*
## ACR Appropriateness Criteria

### Variant 2: Chronic headache with new feature or neurologic deficit.

<table>
<thead>
<tr>
<th>Radiologic Procedure</th>
<th>Rating</th>
<th>Comments</th>
<th>RRL*</th>
</tr>
</thead>
<tbody>
<tr>
<td>MRI head without and with contrast</td>
<td>8</td>
<td>See statement regarding contrast in text under “Anticipated Exceptions.”</td>
<td>O</td>
</tr>
<tr>
<td>MRI head without contrast</td>
<td>7</td>
<td></td>
<td>O</td>
</tr>
<tr>
<td>CT head without contrast</td>
<td>7</td>
<td></td>
<td>⭐⭐⭐</td>
</tr>
<tr>
<td>CT head without and with contrast</td>
<td>5</td>
<td></td>
<td>⭐⭐⭐</td>
</tr>
<tr>
<td>MRA head without and with contrast</td>
<td>4</td>
<td>See statement regarding contrast in text under “Anticipated Exceptions.”</td>
<td>O</td>
</tr>
<tr>
<td>MRA head without contrast</td>
<td>4</td>
<td>Perform this procedure in selected cases when vascular disease suspected.</td>
<td>O</td>
</tr>
<tr>
<td>CTA head with contrast</td>
<td>4</td>
<td></td>
<td>⭐⭐⭐</td>
</tr>
<tr>
<td>CT head with contrast</td>
<td>3</td>
<td></td>
<td>⭐⭐⭐</td>
</tr>
<tr>
<td>Arteriography cervicocerebral</td>
<td>2</td>
<td>This procedure is not used as a primary diagnostic tool.</td>
<td>⭐⭐⭐</td>
</tr>
</tbody>
</table>

**Rating Scale:** 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate
### ACR Appropriateness Criteria

#### Clinical Condition: Headache

**Variant 3:** Sudden onset of severe headache ("Worst headache of my life", "thunderclap headache").

<table>
<thead>
<tr>
<th>Radiologic Procedure</th>
<th>Rating</th>
<th>Comments</th>
<th>RRL*</th>
</tr>
</thead>
<tbody>
<tr>
<td>CT head without contrast</td>
<td>9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CTA head with contrast</td>
<td>8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MRA head without and with contrast</td>
<td>7</td>
<td>See statement regarding contrast in text under “Anticipated Exceptions.”</td>
<td>O</td>
</tr>
<tr>
<td>MRA head without contrast</td>
<td>7</td>
<td></td>
<td>O</td>
</tr>
<tr>
<td>Arteriography cervicocerebral</td>
<td>7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MRI head without contrast</td>
<td>7</td>
<td>This procedure may be helpful after CT depending on CT findings. Include FLAIR and GRE or SWI in this procedure.</td>
<td>O</td>
</tr>
<tr>
<td>MRI head without and with contrast</td>
<td>6</td>
<td>Include FLAIR and GRE or SWI in this procedure. This procedure may be helpful after CT depending on CT findings. See statement regarding contrast in text under “Anticipated Exceptions.”</td>
<td>O</td>
</tr>
<tr>
<td>CT head without and with contrast</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CT head with contrast</td>
<td>3</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate

*RRL* Relative Radiation Level
When neuroimaging is warranted, the most sensitive method should be used, and we recommend MRI and not CT in these cases.
MRI versus CT

• No well done controlled comparison studies for headache.

• MRI proven superior for metastasis and many other primary tumors, infection, and leptomeningeal disease.

• CT with or without contrast is an acceptable alternative if MRI cannot be obtained.
MRI versus CT

Fractures
Acute Hemorrhage
Sinus & Mastoid Disease

Table 5: Imaging Modality of Choice to Investigate Causes of Headache

<table>
<thead>
<tr>
<th>MRI preferred</th>
<th>CT preferred</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vascular disease</td>
<td>Fractures (calvarium)</td>
</tr>
<tr>
<td>Cerebral infarction</td>
<td>Acute hemorrhage (subarachnoid, intracerebral)</td>
</tr>
<tr>
<td>Venous infarction</td>
<td>Paranasal sinus and mastoid air cell disease</td>
</tr>
<tr>
<td>Neoplastic disease</td>
<td>Draw between MRI and CT</td>
</tr>
<tr>
<td>Primary and secondary brain tumors (especially in posterior fossa)</td>
<td>MR Angiography/CT Angiography</td>
</tr>
<tr>
<td>Skull base tumors</td>
<td>Vasculitis (large and medium sized vessels)</td>
</tr>
<tr>
<td>Meningeal carcinomatosis and lymphomatosis</td>
<td>Intracranial aneurysms</td>
</tr>
<tr>
<td>Pituitary tumors</td>
<td>Carotid and vertebral artery dissections</td>
</tr>
<tr>
<td>Infections</td>
<td>MR Venography/CT Venography</td>
</tr>
<tr>
<td>Cerebritis and brain abscess</td>
<td>Cerebral venous thrombosis</td>
</tr>
<tr>
<td>Meningitis</td>
<td></td>
</tr>
<tr>
<td>Encephalitis</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td></td>
</tr>
<tr>
<td>Chiari malformation</td>
<td></td>
</tr>
<tr>
<td>Cerebrospinal fluid hypotension with pachymeningeal enhancement and brain sag</td>
<td></td>
</tr>
<tr>
<td>Foramen magnum and upper cervical spine lesions</td>
<td></td>
</tr>
<tr>
<td>Pituitary apoplexy</td>
<td></td>
</tr>
<tr>
<td>Rare encephalopathies with headache (CADASIL, MELAS, SMART)</td>
<td></td>
</tr>
</tbody>
</table>

Seminars in Neurology 2010;30:131-144.
Intravenous Contrast

- Both MRI and CT will have an improved sensitivity for disease with contrast **BUT**
  - MRI  Nephrogenic Systemic Fibrosis
  - CT    Contrast Induced Nephropathy
  - Both  Contrast Reaction History
### ACR Appropriateness Criteria

#### Variant 12: New headache in pregnant woman.

<table>
<thead>
<tr>
<th>Radiologic Procedure</th>
<th>Rating</th>
<th>Comments</th>
<th>RRL*</th>
</tr>
</thead>
<tbody>
<tr>
<td>MRI head without contrast</td>
<td>8</td>
<td>MRI is the modality of choice, however use of CT depends on local availability.</td>
<td>O</td>
</tr>
<tr>
<td>CT head without contrast</td>
<td>7</td>
<td>Use of CT depends on local availability and is helpful if there is a high suspicion for acute intracranial hemorrhage.</td>
<td>⭐⭐⭐</td>
</tr>
<tr>
<td>MR venography head without contrast</td>
<td>6</td>
<td></td>
<td>O</td>
</tr>
<tr>
<td>MRA head without contrast</td>
<td>6</td>
<td></td>
<td>O</td>
</tr>
<tr>
<td>MRI head without and with contrast</td>
<td>5</td>
<td>Pregnancy is a relative contraindication to gadolinium administration. Reserve this procedure for urgent medical necessity only. See statement regarding contrast in text under “Anticipated Exceptions.”</td>
<td>O</td>
</tr>
<tr>
<td>CT head with contrast</td>
<td>3</td>
<td>This procedure is for urgent medical necessity only.</td>
<td>⭐⭐⭐</td>
</tr>
<tr>
<td>MRA head without and with contrast</td>
<td>3</td>
<td></td>
<td>O</td>
</tr>
<tr>
<td>CT head without and with contrast</td>
<td>2</td>
<td></td>
<td>⭐⭐⭐</td>
</tr>
<tr>
<td>CTA head with contrast</td>
<td>2</td>
<td></td>
<td>⭐⭐⭐</td>
</tr>
</tbody>
</table>

**Rating Scale:** 1, 2, 3 Usually not appropriate; 4, 5, 6 May be appropriate; 7, 8, 9 Usually appropriate

*Relative Radiation Level*
Welcome to CEBM

Welcome to the website of the Centre for Evidence-Based Medicine in Oxford in the UK.

Our broad aim is to develop, teach and promote evidence-based health care and provide support and resources to doctors and health care professionals to help maintain the highest standards of medical activity.

Learn more about EBM and the CEBM.

EBM Tools & Resources

Current Courses & Workshops

What's New

- New Cochrane Review published
- Centre work appears in Cochrane Journal Club
- P&T Plot, graphic presentation of trials
- EBM in Practice video (Glaziov)
- Diagnostic Tests video (Heneghan)

CEBM Blog

Discover the truth behind the research findings that affect healthcare at
TrustTheEvidence.net
## CEBM Levels of Evidence 2

<table>
<thead>
<tr>
<th>Question</th>
<th>Step 1 (Level 1*)</th>
<th>Step 2 (Level 2*)</th>
<th>Step 3 (Level 3*)</th>
<th>Step 4 (Level 4*)</th>
<th>Step 5 (Level 5)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>How common is it?</strong> (E.g., Pre-test probabilities)</td>
<td>Most relevant local and current random sample survey (or censuses)</td>
<td>Systematic review of current surveys</td>
<td>Systematic review of local non-random sample</td>
<td>Systematic review of case-series appraisal, based on limited/undocumented experience, or based on mechanisms</td>
<td>Opinion without explicit critical appraisal, based on limited/undocumented experience, or based on mechanisms</td>
</tr>
<tr>
<td><strong>Is this test accurate?</strong> (Diagnostic accuracy)</td>
<td>Systematic review of cross sectional studies</td>
<td>Systematic review of cross sectional studies With consistently applied reference standard and blinding</td>
<td>Systematic review of non-consecutive studies, or studies without consistently applied reference standards.</td>
<td>Systematic review of case-control study, or cross-sectional study with non-independent reference standard</td>
<td>Opinion without explicit critical appraisal, based on limited/undocumented experience, or based on mechanisms</td>
</tr>
<tr>
<td><strong>What will happen if we do nothing?</strong> (Prognosis)</td>
<td>Systematic review of inception cohort studies</td>
<td>Inception cohort studies</td>
<td>Cohort or control arm of randomized trial</td>
<td>Systematic review of case-series or randomized controlled trials</td>
<td>Opinion without explicit critical appraisal, based on limited/undocumented experience, or based on mechanisms</td>
</tr>
<tr>
<td><strong>Does this treatment help?</strong> (Treatment Benefits)</td>
<td>Systematic review of randomized trials or n-of-1 trial</td>
<td>Randomized trial or (exceptionally) observational studies with dramatic effect</td>
<td>Non-randomized controlled cohort/follow-up study</td>
<td>Systematic review of case-control studies, historically controlled studies</td>
<td>Opinion without explicit critical appraisal, based on limited/undocumented experience, or based on mechanisms</td>
</tr>
<tr>
<td><strong>What are the COMMON harms?</strong> (Treatment Harms)</td>
<td>Systematic review of randomized trials or n-of-1 trial</td>
<td>Systematic review of nested case-control or dramatic effect</td>
<td>Non-randomized controlled cohort/follow-up study</td>
<td>Case-control studies, historically controlled studies</td>
<td>Opinion without explicit critical appraisal, based on limited/undocumented experience, or based on mechanisms</td>
</tr>
<tr>
<td><strong>What are the RARE harms?</strong> (Treatment Harms)</td>
<td>Systematic review of case-control studies, or studies revealing dramatic effects</td>
<td>Randomized trial or (exceptionally) observational study with dramatic effect</td>
<td>Case-control studies, historically controlled studies</td>
<td>Case-control studies, historically controlled studies</td>
<td>Opinion without explicit critical appraisal, based on limited/undocumented experience, or based on mechanisms</td>
</tr>
<tr>
<td><strong>Is early detection worthwhile?</strong> (Screening)</td>
<td>Systematic review of randomized trials</td>
<td>Randomized trial</td>
<td>Non-randomized controlled cohort/follow-up study</td>
<td>Case-control studies, historically controlled studies</td>
<td>Opinion without explicit critical appraisal, based on limited/undocumented experience, or based on mechanisms</td>
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</tbody>
</table>

[http://www.cebm.net]
## CEBM Grades of Recommendation

<table>
<thead>
<tr>
<th>Grade</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>consistent level 1 studies</td>
</tr>
<tr>
<td>B</td>
<td>consistent level 2 or 3 studies <em>or</em> extrapolations from level 1 studies</td>
</tr>
<tr>
<td>C</td>
<td>level 4 studies <em>or</em> extrapolations from level 2 or 3 studies</td>
</tr>
<tr>
<td>D</td>
<td>level 5 evidence <em>or</em> troublingly inconsistent or inconclusive studies of any level</td>
</tr>
</tbody>
</table>

http://www.cebm.net
The Evidence Quality is Low

2.3 INVESTIGATIONS

D Neuroimaging is not indicated in patients with a clear history of migraine, without red flag features for potential secondary headache, and a normal neurological examination.

Magnetic resonance imaging (MRI) and computerised tomography (CT) can identify neurological abnormalities incidental to the patient’s presenting complaint, which may result in heightened patient anxiety and clinician uncertainty. Further investigation and treatment of incidental abnormalities can cause both morbidity and mortality and investigation should generally be reserved for patients with “red flag features”.

D In patients with thunderclap headache, unenhanced CT of the brain should be performed as soon as possible and preferably within 12 hours of onset.

C Patients with thunderclap headache and a normal CT should have a lumbar puncture.

Subarachnoid blood degrades rapidly. Performing CT brain imaging as soon as possible maximises the chance of accurate diagnosis. Even timely CT brain imaging may not pick up subarachnoid blood, so lumbar puncture is also required. Lumbar puncture should be delayed till 12 hours after headache onset.

Diagnosis and management of headache in adults / Scottish National Guideline
What does the patient really want?

• In one survey 60% feared serious disease.
  – Family member or friend with brain tumor
  – Internet search with “Dr. Google”

• 17% Neuroimaging studies ordered because patient expects it or medicolegal concerns.

• “Above all patients want someone who is interested in their headache and who will listen to their story.”
Non-acute Headache
Primary Care Setting

• The great majority are Primary Headaches.
  – Migraine / Tension Types – Normal Neuro Exam
    • Neuroimaging not indicated

• Red or Yellow Flags – Neuroimaging Advised.

• Neuroimaging Advised.
  – Cluster Headaches
  – Trigeminal Autonomic Cephalgias

• MRI Brain without and with Gadolinium
Reality Check

Rate has tripled from 1995 (5.1%) to 2010 (14.7%)
Expenditure is $3.9 Billion over 4 years

ABIM – Choosing Wisely

Don’t do imaging for uncomplicated headache.

Imaging headache patients absent specific risk factors for structural disease is not likely to change management or improve outcome. Those patients with a significant likelihood of structural disease requiring immediate attention are detected by clinical screens that have been validated in many settings. Many studies and clinical practice guidelines concur. Also, incidental findings lead to additional medical procedures and expense that do not improve patient well-being.
Acute Headache
Emergency Department Setting

• Greater concern for Secondary Headache
  – 19 – 43 % are Secondary
  • Acute intracranial bleed
  • Venous sinus thrombosis
  • Arterial dissection
  • Infection – meningitis, encephalitis
  • Acute hydrocephalus

• Patients come to ED because:
  Worst / New Sx / Last Straw for Treatment
Acute Headache
Emergency Department Setting

• The imaging study of choice is CT Brain without contrast

CT Brain without contrast

• Best and fastest for acute blood.
• Rules out mass effect pre LP.
  – Does not exclude elevated ICP.
• Baseline for later exams if required.
Thunderclap Headache

Sudden and severe headache with maximal intensity at onset.

Panel 1: Causes of TCH
- Subarachnoid haemorrhage
- Sentinel headache
- Cerebral venous sinus thrombosis
- Cervical artery dissection
- Spontaneous intracranial hypotension
- Pituitary apoplexy
- Retroclival haematoma
- Ischaemic stroke
- Acute hypertensive crisis
- Reversible cerebral vasoconstriction syndrome
- Third ventricle colloid cyst
- Intracranial infection
- Primary thunderclap headache
- Primary cough, sexual, and exertional headache

Figure 1  Algorithm for the evaluation of headache disorders. (Copyrighted and used with permission of the Mayo Foundation for Medical Education and Research.)
Thunderclap Headache

• Subarachnoid Hemorrhage #1 cause of TCH.
  – 11 – 25 % of TCH is SAH
  – SAH 10 - 15 % die pre treatment
  – Up to 50 % mortality & only 25 % fully recover
  – About 30,000 cases annually USA

• Headache is the #1 symptom of SAH.
  – 50 – 70% patients

• 10-50% SAH report Sentinel Bleed or Warning Leak.
  – 25 – 50 % were misdiagnosed
Non-traumatic SAH

- 5 % of “Strokes” are SAH
- 1 – 4 % ED headaches
- 85 % Aneurysm Rupture
- 10 % Non-aneurysmal perimesencephalic hemorrhage
- 5 % Other

Saccular Aneurysms
CT for SAH

• Keys are – Time Since / Amount / Hemoglobin

• Positive CT (Expert interpretation)
  – 98+ % < 12 hours
  – 93 % 12 - 24 hours
  – 74 % Day 3
  – 50 % at 1 week
  – 30 % at 2 weeks

• After a few days MRI may be more sensitive
CT Positive for SAH

- LP is not required.
- CTA versus DSA
  - CTA only
  - Both
  - DSA only
- Clip versus Coil
  - Location
  - Patient age
  - Available operators
What if SAH Suspected but CT is Negative?

- Lumbar Puncture is the recommended next step in evaluation.
- WHEN? Xanthochromia is best detected after 12 hours. Do you wait 6 to 12 hours?
- Traumatic taps – 9 - 20%.
  - Last tube clearance is not helpful
  - Immediate exam for xanthochromia
  - Retap one level up
Xanthochromia

- Most sensitive after 12 hours – bilirubin from RBC breakdown
- Spin down immediately
- Visual inspection
- Spectrophotometry
  95 – 100 % sensitive 14 d
  450-460 nm
- 3 w 70-90 % 4 w 40 %

Rebleeding Concern

• 10 – 50 % SAH had a Sentinel Bleed.
  – Milder headache up to 8 weeks prior.
  – < 1 week between in 18 % Danish Aneurysm Study
  – Hemorrhage or pain from acute expansion / dissection ?

• Confirmed SAH
  – 4 - 15 % Rebleed within first 24 hours.
  – Then 1 - 2 % / day Rebleed next 4 weeks.

• Is it safe to wait 6 to 12 hours for the LP ?
CTA / MRA / Catheter Angio

- Some suggest routine CTA before LP.
- 0.5 – 6 % prevalence of aneurysm in pop.
- MRI / MRA Delayed presentation.
- Catheter Angio needs something (+) first.

- CT Brain without / CTA / LP
- 131 Eligible / 116 Enrolled / 106 Complete
- 1 of 106 Positive CT Brain without +CTA/DSA
- 105 Negative CT Brain – 2 (+) LP +CTA/DSA
- 103 Negative LP – 3 (+) CTA (2+ @DSA)
  – 1 False Positive CTA
- Consider aneurysm symptomatic with 8.3 X relative risk of rupture vs asymptomatic (per Rinkel).
- Note 100 of 103 CTA’s were Negative

From the American College of Emergency Physicians Clinical Policies Subcommittee (Writing Committee) on Critical Issues in the Evaluation and Management of Adult Patients Presenting to the Emergency Department with Acute Headache:
Jonathan A. Edlow, MD (Chair)
Peter D. Panagos, MD
Steven A. Godwin, MD
Tamara L. Thomas, MD
Wyatt W. Decker, MD

5. Is there a need for further emergent diagnostic imaging in the patient with sudden-onset, severe headache who has negative findings in both CT and lumbar puncture? Patient Management Recommendations

Level A recommendations. None specified.

Level B recommendations. Patients with a sudden-onset, severe headache who have negative findings on a head CT, normal opening pressure, and negative findings in CSF analysis do not need emergent angiography and can be discharged from the ED with follow-up recommended.

Level C recommendations. None specified.
# ACR Appropriateness Criteria

<table>
<thead>
<tr>
<th>Clinical Condition:</th>
<th>Headache</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Variant 3:</strong></td>
<td>Sudden onset of severe headache (“Worst headache of my life”, “thunderclap headache”).</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Radiologic Procedure</th>
<th>Rating</th>
<th>Comments</th>
<th>RRL*</th>
</tr>
</thead>
<tbody>
<tr>
<td>CT head without contrast</td>
<td>9</td>
<td></td>
<td>4</td>
</tr>
<tr>
<td>CTA head with contrast</td>
<td>8</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>MRA head without and with contrast</td>
<td>7</td>
<td>See statement regarding contrast in text under “Anticipated Exceptions.”</td>
<td>O</td>
</tr>
<tr>
<td>MRA head without contrast</td>
<td>7</td>
<td></td>
<td>O</td>
</tr>
<tr>
<td>Arteriography cervicocerebral</td>
<td>7</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>MRI head without contrast</td>
<td>7</td>
<td>This procedure may be helpful after CT depending on CT findings. Include FLAIR and GRE or SWI in this procedure.</td>
<td>O</td>
</tr>
<tr>
<td>MRI head without and with contrast</td>
<td>6</td>
<td>Include FLAIR and GRE or SWI in this procedure. This procedure may be helpful after CT depending on CT findings. See statement regarding contrast in text under “Anticipated Exceptions.”</td>
<td>O</td>
</tr>
<tr>
<td>CT head without and with contrast</td>
<td>5</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>CT head with contrast</td>
<td>3</td>
<td></td>
<td>3</td>
</tr>
</tbody>
</table>

**Rating Scale:** 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate

*RRelative Radiation Level*
Who needs MRA / CTA?

- Subarachnoid Hemorrhage
  - ? TCH
- Headaches associated with
  - Cough
  - Exertion
  - Sexual Activity
- Familial Aneurysm History
- MR Venography – CVST suspected
  - Hypercoagulable States / Pregnancy
Familial Aneurysm History

- Saccular Aneurysms
  - 90% Sporadic
  - 10% Familial – ADPKD, FMD, Marfan, ED IV
- First Order Relatives with Proven Aneurysm
  - Parent / Sibling / Child
- Obtain MRA or CTA When
  - Asymptomatic (Screening) – 2 FOR’s or ADPKD
    - Start 20y 5y FU if NEG then q 5-10y Stop 60-70y
  - Symptomatic (Headaches) – 1 FOR
“Sinus Headache”

- Nasal symptoms and facial pain are common with migraine.
- American Migraine Study II – 42% of patients with migraine as defined by IHS have received a diagnosis of sinus headache from a physician.
- Self-diagnosed sinus headache is often migraine.
“Sinus Headache”

• No correlation between pain severity and mucosal disease location or extent.
• No correlation between site of disease by imaging and site of pain.


• 13 -43 % Mucosal thickening in “normal” population.
“Sinus Headache”

• IHS – Chronic sinusitis is not validated as a cause of headache or facial pain unless relapsing into an acute stage.

• Acute Rhinosinusitis - Cause of headache if associated with:
  – Purulent nasal discharge & fever
  – Air-fluid levels / frothy secretions by CT

• Chronic debilitating headache is unlikely to be of sinus origin.
Key Points

• Headache is an extremely common symptom.

• Structural abnormalities (Primary HA) are rare.

• Clinical findings suggest the need for imaging.

• Chronic - MRI Brain without & with Gad

• Acute (ED) - CT Brain without