Approach to Acute Headache: A Flipped Classroom Module for Emergency Medicine Trainees

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ABSTRACT

Audience: This module is designed for emergency medicine trainees. Though it focuses on those early in their career (medical students and junior residents), it is applicable to all emergency medicine learners.

Introduction: In the United States, headache is the fifth most common primary complaint of patients presenting to the emergency department and can be the primary symptomatic manifestation of many life-threatening illnesses. The emergency physician plays a unique role in diagnosing and managing these patients. The emergency physician’s two major responsibilities are to relieve headache pain and to ensure that life-threatening causes are diagnosed and treated.

Objectives: At the end of this module, the learner will be able to: 1) list the diagnoses critical to the emergency physician that may present with headache; 2) identify key historical and examination findings that help differentiate primary (benign) from secondary (serious) causes of headache; 3) discuss the indications for diagnostic imaging, lumbar puncture and laboratory testing in patients with headache; 4) recognize life-threatening diagnoses on CT imaging and CSF examination; 5) describe treatment strategies to relieve headache symptoms.

Methods: This module includes a complete flipped classroom module. Learners are responsible for viewing a 20-minute video prior to the 30-minute small-group, case-based didactic discussion portion. The learners are assessed with multiple-choice question assessments, for low stakes retrieval practice or spaced practice. This could alternatively be run as a team-based learning session, with the pre- and post-tests used as an individual or group readiness assessment test, and the small group exercises converted to a group application exercise.

Topics: Headache, subarachnoid hemorrhage, migraine, occult trauma, meningitis, temporal arteritis, carbon monoxide toxicity, acute glaucoma, cervical artery dissection, space occupying lesion, idiopathic intracranial hypertension.
Learner audience:

- Level of learners:
  - Medical Students
  - Interns
  - Junior Residents
  - Senior Residents
  - Other _______________

Time required for implementation:
Learner responsible content (LRC): 20 minute video
Pre-test: 15 minutes (can be done asynchronously)
Didactic portion (Small group discussion): 30 minutes
Post-test: 15 minutes (can be done asynchronously)

Recommended number of learners per instructor: An unlimited number of learners can watch the video. Based on existing literature, we recommend small groups of 5-8 for the in-class case discussion.¹

Recommended pre-reading for facilitators: The in-class discussion leaders only need to read the “Instructor Handout,” which will guide them through the cases to be discussed. No further preparation is needed for emergency medicine faculty members.

Technology necessary: Learners will need access to YouTube to watch the video asynchronously. No technology is required for the didactic portion of the module.

Objectives: At the end of this module, the learner will be able to:

1. List the diagnoses critical to the emergency physician that may present with headache.
2. Identify key historical and examination findings that help differentiate primary (benign) from secondary (serious) causes of headache.
3. Discuss the indications for diagnostic imaging, lumbar puncture and laboratory testing in patients with headache.
4. Recognize life-threatening diagnoses on CT imaging and CSF examination.
5. Describe treatment strategies to relieve headache symptoms.

Linked objectives, methods and results:
Current didactic schedules built upon hour-long, lecture-based presentations have significant limitations.²⁻⁷ The flipped classroom model provides an alternative in which students absorb a short lecture asynchronously, then use class time to focus on application, simulation, case-based, or problem solving exercises.⁵⁻⁷ This module is ideally implemented as part of the
USER GUIDE

ACGME required weekly didactic requirement. It provides an approach to a commonly encountered emergency department chief complaint that is a part of the standard-setting ABEM Model of the Clinical Practice of Emergency Medicine: acute headache.8

Learners are introduced to each of the 5 objectives during the asynchronous video. The learners then apply what they know to specific cases. During the case-based small group discussion, learners are asked to list their differential diagnosis for headache (Objective 1). They discuss the key features of the history and physical to differentiate between each cause of headache (Objective 2). Discussion leaders then ask what testing the learners would order and why (Objective 3). Learners then interpret test results, recognizing life-threatening diagnoses (Objective 4). Finally, learners propose treatment strategies (Objective 5). This process is repeated with a second case.

Topics: Headache, subarachnoid hemorrhage, migraine, occult trauma, meningitis, temporal arteritis, carbon monoxide toxicity, acute glaucoma, cervical artery dissection, space occupying lesion, idiopathic intracranial hypertension.

Results and tips for successful implementation: The in-class portion of the module can occur in the same room as previously scheduled didactics, though if desired, separate rooms for each small-group may be optimal. We recommend groups of five to eight learners; though local faculty availability will likely guide the size of each group. The session could alternatively be run as a team-based learning session, with the pre- and post-tests as individual and/or group readiness assessment tests and the small group discussion questions as a group application exercise (followed by a whole class discussion of pre-/post-test and group application exercise answers).

Learners will access the asynchronous video through the JETem YouTube channel (https://youtu.be/RNWPWmBugiI). An instructor should send an email to the participants with a link to the video approximately five days before the planned didactic conference; we recommend that the instructor send another reminder email two days prior to the didactic session.

The assessments can be used in several ways:

- The pre-test can be given before releasing the video link or at the start of the didactic session (as an individualized readiness assessment, iRAT and/or group readiness assessment test, gRAT).
- The post-test can be given after watching the video module, as a gRAT, or several days later as a tool for spaced retrieval practice.
Based on our experience, spending 15 minutes for each assessment consumed valuable “in-class” time and decreased excitement for the module.

If this is the learners’ first experience with the flipped classroom, it is important to clearly explain the importance of the pre-class preparation, in order to avoid confusion or decreased participation during the didactic session.

Associated content:
1. Learner Responsible Content, video link: https://youtu.be/RNWPWmBUgiI
2. Headache Pre-test
3. Headache Post-test
4. Headache Learner Handout
5. Headache Pre-test Key
6. Headache Post-test Key
7. Headache Instructor Handout

Pearls:
Please see instructor guide

References/Suggestions for Further Reading:
the clinical practice of emergency medicine. Acad Emerg Med 2014 May;21(5):574-598.
Instruct learners to watch the following video prior to the didactic session. We recommend sending the link one week in advance, with an email reminder two days before the didactic session.

Video link: https://youtu.be/RNWPWmBuiI
1. A 45-year old female with a past medical history of migraine headaches presents to the Emergency Department with a severe frontal headache. The patient reports that she was exercising this morning, approximately 8 hours ago, when she felt a sudden onset severe headache associated with nausea and vomiting. She notes that typically her migraines are occipital, gradual in onset, and fairly mild. Physical exam reveals an uncomfortable appearing female with no focal neurologic deficits. CT scan of the brain is unremarkable. Which of the following studies is the next best step in establishing the diagnosis?
   a. CT angiogram
   b. Lumbar puncture
   c. MR angiogram
   d. MRI brain

2. A 45-year old female with no past medical history presents to the Emergency Department with daily headaches over the past month. The patient states the headaches are most severe in the morning and then gradually subside throughout the day. She denies fevers, chills, nausea or vomiting, or any recent trauma. She has no history of migraines or headaches in the past, and states no one at home is sick. She became concerned because she reports that the intensity of the headaches has gradually increased over the past week and her ibuprofen is losing its efficacy. Vital signs are unremarkable, and physical exam, including a neurologic exam, is unremarkable. Urine dipstick and pregnancy tests are negative. Which of the following is the most appropriate next step in management?
   a. Administer high flow oxygen by face mask
   b. Discharge home with opioid for breakthrough pain
   c. Order non-contrast CT head
   d. Perform lumbar puncture
LEARNER MATERIALS

Headache Pre-Test

3. A 35-year old female presents to the Emergency Department with one day of severe headache associated with nausea but no vomiting. The headache started in the morning and gradually progressed throughout the day. The patient reports seeing bright lights in the periphery of her vision prior to headache onset, which has occurred in several past similar headaches. The patient denies fevers or recent infectious symptoms. Complete physical exam including neurologic exam is unremarkable. Which of the following is the most appropriate next step in management?
   a. CT head
   b. Lumbar puncture
   c. Metoclopramide
   d. Morphine

4. A 25-year old male is brought in by ambulance after being struck on the right side of the head with a baseball bat. At triage, the patient endorses a severe headache and significant nausea and vomiting. The patient’s mental status rapidly deteriorates and he is rushed back to the resuscitation area. Physical exam is significant for a large right parietal hematoma, as well as a right fixed and dilated pupil. Which of the following is most likely to be injured in this patient?
   a. Cerebral artery branch
   b. Cerebral bridging vein
   c. Meningeal artery branch
   d. Temporal artery

5. A 24-year old HIV positive male non-compliant with his medications presents to the Emergency Department with headache and fever for 4 days. Vital signs: BP 138/79, HR 116, RR 20, T 102.2F (39.0C). Physical exam reveals a cachectic male who is alert and oriented but has significant nuchal rigidity on exam. He has no neurologic deficits and the remainder of the physical exam unremarkable. Which of the following is the most appropriate next step in management?
   a. Antibiotic initiation followed by CT head and lumbar puncture
   b. Antibiotic initiation followed by lumbar puncture
   c. CT head followed by lumbar puncture and then antibiotic initiation
   d. Lumbar puncture followed by antibiotic initiation
LEARNER MATERIALS
Headache Pre-Test

6. A 75-year old female presents to the Emergency Department with severe right-sided headache over the past week. The headache was gradual in onset but has continued to worsen over the past several days. The patient reports that her headache is particularly painful when chewing and she is unable to eat due to the pain. She denies fever, nausea or vomiting. Physical exam is negative for any focal neurologic deficits, but reveals tenderness to palpation on the lateral aspect of the forehead. Failure to treat this disease appropriately may lead to which of the following feared complications?
   a. Blindness
   b. Cerebral venous sinus thrombosis
   c. Ischemic stroke
   d. Intracerebral hemorrhage

7. A 23-year old male is brought in to the Emergency Department by his family for severe headaches, vomiting, fever, and bizarre behavior over the previous 24 hours. Initial vital signs: BP 137/84, HR 115, RR 22, T 102.2F (39.0C). Physical exam is remarkable for an altered male who is unable to fully cooperate with a neurologic exam. However, he appears to move all four extremities without deficit. The patient demonstrates significant pain with range of motion of his neck. A CT head is performed and is unremarkable. CSF analysis from your lumbar puncture reveals the following: glucose 60 mg/dL, protein 150 mg/dL, 250 WBC/uL with 85% lymphocytes, 4,050 RBC/uL. Gram stain is negative, and the CSF is also sent for culture. Which of the following is the most appropriate next step in management of this patient?
   a. Administer acyclovir, ceftriaxone and vancomycin IV
   b. Administer ceftriaxone and dexamethasone IV
   c. CT angiography and neurosurgery consultation
   d. No antibiotic coverage and observation for results of CSF culture

8. A 43-year old female with a history of diabetes presents to the Emergency Department with 6 days of gradually progressive severe headache. She describes the headache as a throbbing pain involving her entire forehead associated with nausea. She denies any fever, recent infectious symptoms, or trauma. Physical exam reveals an uncomfortable, obese female with an otherwise unremarkable exam, except fundoscopic exam with loss of spontaneous venous pulsations bilaterally. The patient has no neurologic or visual deficits. Which of the following is the next best step in management of this patient?
   a. CT angiography head
   b. CT non-contrast head
   c. MR brain with diffusion weighted imaging
   d. MR brain with venography
9. A 44-year old female presents to the Emergency Department with a bitemporofrontal headache that started 4 days ago. The pain is constant, but nonexertional. She also endorses the sensation of a vice-like squeezing of her head. She denies fevers, chills, nausea, vomiting, or recent trauma. She states having had several of these episodes over the past few years. Vital signs: BP 141/86, HR 93, RR 18, T 98.7°F (37.0°C). On physical exam, cranial nerves are intact, and the patient has normal sensation and strength in all 4 extremities. Reflexes are 2+ bilaterally to all extremities. Visual acuity is normal, and her intra-ocular pressure is 18 mmHg in both eyes. Fundoscopic exam is unremarkable. Which of the following is the next best step in management of this patient?
   a. CT head
   b. Discharge with NSAIDs
   c. Erythrocyte sedimentation rate
   d. High-flow oxygen

10. A 65-year old male with no past medical history presents to the Emergency Department with sudden onset of severe headache that started this afternoon while on his afternoon walk just as he entered a dark store. He describes the headache as the worst of his life. The headache is right frontal involving his forehead. He also reports right-sided blurry vision. Physical exam reveals an uncomfortable appearing male. Neurologic exam is unremarkable other than a right-sided mid-range pupil that is minimally reactive to light. Which of the following tests is most likely to confirm the diagnosis in this patient?
   a. CT angiogram
   b. Erythrocyte sedimentation rate
   c. Fluorescein staining
   d. Ocular tonometry
LEARNER MATERIALS

Headache Post-Test

Name: ________________________________

1. A 51-year old female presents to the Emergency Department with a sudden onset severe headache for 2 hours, associated with nausea and vomiting. Physical exam reveals an uncomfortable appearing female. However, there are no focal neurologic deficits and the remainder of the physical exam is unremarkable. Vital signs: BP 156/78, HR 110, RR 18, T 98.7F (37.0C). CT scan of the head shows diffuse subarachnoid hemorrhage. Which of the following agents is most likely to improve outcome in this patient?
   a. Labetolol
   b. Nimodipine
   c. Nitroglycerin
   d. Nitroprusside

2. A 77-year old male with a history of diabetes, hypertension, hyperlipidemia, and seasonal allergies presents to the Emergency Department with a chief complaint of sudden onset of left frontal headache, nausea, and blurry vision. Neurologic exam reveals no deficits other than a left mid-range pupil, which is minimally reactive to light. The remainder of the physical exam is unremarkable. Intra-ocular pressure is 50 mmHg on the left, 18 mmHg on the right. Which of the following of the patient’s medications likely contributed to this presentation?
   a. Diphenhydramine
   b. Labetolol
   c. Metformin
   d. Simvastatin

3. A 68-year old female presents to the Emergency Department with progressive left-sided headache over the past two weeks. The pain was gradual in onset but has progressed significantly and is now severe. It is particularly painful when the patient chews her food. Physical exam reveals an uncomfortable appearing female, however her physical exam, including a complete neurologic exam, is unremarkable other than tenderness to palpation over the lateral aspect of her forehead. Laboratory analysis, including a complete blood count and metabolic panel, is unremarkable other than an elevated erythrocyte sedimentation rate. Which of the following comorbidities is most likely to be found in this patient?
   a. Lupus erythematosus
   b. Polymyalgia rheumatica
   c. Polymyositis
   d. Raynaud's phenomenon

LEARNER MATERIALS
Headache Post-Test

4. A 42-year old male presents to the Emergency Department with a severe headache. He reports that over the 10 days each evening he has had a sudden onset severe headache lasting about 30 minutes and then resolving. The headaches are on the right side of the head only over the temporal area. Physical exam reveals an anxious appearing male with right-sided ptosis and conjunctival injection. The remainder of the physical exam, including a complete neurologic exam, is unremarkable. Visual acuity is intact. Which of the following is the most appropriate next step in management of this patient’s condition?
   a. CT head followed by lumbar puncture
   b. High flow oxygen
   c. Metoclopramide
   d. Pilocarpine

5. A 19-year old male student with no past medical history presents to the Emergency Department with 24 hours of headache, nausea and vomiting, and fever. He denies trauma, numbness or weakness, or travel. Physical exam reveals an anxious and uncomfortable male who is alert and oriented but has photophobia and nuchal rigidity. He has no neurologic deficits. Fundoscopic exam, although difficult, reveals clear disc margins bilaterally. The remainder of the physical exam is remarkable only for tachycardia and fever. The nurses note that, while they secured peripheral IV access, the patient has become more agitated. Which of the following is the most appropriate next step in management?
   a. Antibiotics
   b. CT head
   c. Lumbar puncture
   d. MRI brain

6. A 35-year old male is brought in by ambulance after a bicycle accident. He was riding without his helmet when he was struck on the side by another bicyclist. Per paramedics, the patient was initially communicative. However, his neurologic status declined on transport to the hospital. On presentation, the patient has a GCS of 5. Physical exam is significant for a large right parietal hematoma as well as a right fixed and dilated pupil. Which of the following findings on noncontrast CT head is most consistent with this patient's presentation?
   a. Diffuse petechial hyperdense lesions along gray-white junction
   b. Extra-axial hyperdense collection that does not extend beyond suture lines
   c. Extra-axial hyperdensity collection that is crescent-shaped
   d. Hyperdense collection outlining the cerebral sulci
7. A 55-year old female with a history of hypertension and breast cancer, s/p resection and in remission for several years, presents to the Emergency Department with a daily headache for the past week. She has no other medical problems and denies a history of significant headaches in the past. She states the pain is worst in the morning and then gradually improves throughout the day. She denies fever, infectious symptoms, or trauma. Triage vital signs: BP 188/99, HR 87, RR 14, O2Sat 100%, T 98.7F (37.0C). Strength, sensation, reflex, cranial nerve, and cerebellar testing are unremarkable. The oral opioid pain medication administered at triage has not improved her pain. Which of the following is the most appropriate next step in management?
   a. CT head
   b. Labetalol IV
   c. Mannitol IV
   d. Serum CA-125 level

8. A 22-year old pregnant female at 24 weeks gestation presents to the Emergency Department with a severe headache that developed gradually over 24 hours. She denies fever, other infectious symptoms, or trauma. Vital signs: BP 165/91, HR 85, RR 18, T 98.7F (37.0C). During the physical exam, the patient has a 30 second generalized tonic-clonic seizure that resolves without medication. In addition to consulting obstetrics, which of the following is the most appropriate next step in management?
   a. Emergent CT head
   b. Lorazepam IV
   c. Labetalol IV
   d. Magnesium sulfate IV

9. A 35-year old HIV positive male with a last known CD4 count of 80 cells/uL presents to the Emergency Department with three days of gradually progressive headache, nausea and vomiting, and fever. CT head is negative for mass, shift, or bleed, so a lumbar puncture is performed. CSF analysis reveals an opening pressure 70 cm H2O, glucose 40 mg/dL, protein 100 mg/dL, and WBC count 40 cells/uL with a mononuclear predominance. Which of the following is the most likely cause of this patient’s presentation?
   a. Cryptococcus neoformans
   b. Mycobacterium tuberculosis
   c. Neisseria meningitidis
   d. Streptococcus pneumonia
10. A 43-year old female with a history of diabetes presents to the Emergency Department with 6 days of gradually progressive severe headache. She describes the headache as a throbbing pain involving her entire forehead associated with nausea. She denies any fever, recent infectious symptoms, or trauma. Physical exam reveals an uncomfortable, obese female with an otherwise unremarkable exam, except fundoscopic exam with loss of spontaneous venous pulsations bilaterally. The patient has no neurologic or visual deficits. MRI brain is read unremarkable. Lumbar puncture reveals opening pressure of 43 cm H2O. CSF analysis is unremarkable. Which of the following is the next best step in management of this patient?

a. Acetazolamide
b. Optic nerve sheath fenestration
c. Prednisone
d. Serial lumbar punctures
Headache: Case # 1

Ms. Jones is a 32-year old woman with a history of migraines, who presents with left sided head and neck pain. She states that the headache developed over the course of a few seconds after her yoga class. She describes it as aching in quality. She states that the headache is similar to previous migraines.

PMH: unremarkable, PSH: s/p tonsillectomy at age 5, SH: occasional alcohol, Meds: occasionally takes Excedrin migraine

PE: T 36.8, BP 130/85, HR 84, RR 18, O2 saturation 98% on RA.
GEN: She is in NAD
CV: RRR, no m/r/g
CHEST: Lungs clear to auscultation bilaterally
NEURO: Left pupil is 2mm smaller than the right and there is slight ptosis of the left eyelid. Remaining neurologic exam normal

ED Course: She feels much better after receiving prochlorperazine 10mg IV

What is your differential diagnosis?

What is the significance of the asymmetric pupil and ptosis?

Does a response to therapy have diagnostic value?

How should this patient be evaluated?
Would your differential diagnosis and evaluation plan change if she were 8 months pregnant?

What would be the most likely etiology if she had ptosis and a dilated pupil?

What neurologic exam finding frequently accompanies Idiopathic Intracranial Hypertension?
**Headache: Case #2**

Ms. Smith is a 31-year old female who presents with “bad headaches” on and off for 1 month. She denies nausea and vomiting. She complains of photophobia and left eye blurriness. She denies fevers and chills. The nursing notes state that she gets them every night when she goes to bed. There is no history of trauma. She has been taking aspirin as needed for pain.

PMH: unremarkable. PSH: cholecystectomy and a c-section. SHx is positive for tobacco. Medications: acetaminophen and aspirin, as needed

PE: T 36.4, BP 137/94, HR 61, RR 22 and O2 saturation of 99%.
GEN: She is an obese woman in NAD
HEENT: PERRL
CHEST: CTA
CV: RRR
ABD: Soft NT, ND
NEURO: Alert and oriented X3.

ED Course: She receives 10 mg prochlorperazine, 25 mg diphenhydramine and 4 mg of morphine (all IV). She felt better and was discharged home on norco as needed.

**What other historical features and PE findings would you like to know?**

**What tests would you order?**

**What is your differential diagnosis?**

**What is the significance of her improvement with narcotics and dopamine antagonists?**
Headache: Case #2 Continued
She presents to the same ED 8 days later complaining of feeling worse. She states her pain is more severe when she is in bed. She denies nausea and vomiting. She has no fever, chills, cough, chest pain, dysuria, joint pain, focal weakness or rash.

PE: BP 129/88 | Pulse 74 | Temp 36.3 °C (97.3 °F) (Oral) | Resp 21 | Ht 5' 3" (1.6 m) | Wt 104.327 kg (230 lb) BMI 40.75 kg/m2 | SpO2 99% |
GEN: She is in no distress, judgment/insight appropriate
HEENT: Normal conjunctiva, normal oropharynx and oral mucosa
CHEST: Normal respiratory effort
CV: regular rate and rhythm, no m/r/g
ABD: Soft NT/ND,
NEURO: She follows commands appropriately and has a normal gait, PERRL, EOMI, no CN deficits, normal motor and sensory exam, no nuchal rigidity.

**How should she be further evaluated?**

**What is your differential diagnosis?**

**How would the differential diagnosis change if she were elderly?**