Case 27-2019: A 16-Year-Old Girl with Head Trauma during a Sailboat Race

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Chief Complaint

- 16-year-old girl admitted to hospital experiencing headache, dizziness, balance problems, fatigue, irritability, and difficulties with sleep and concentration
  - Experienced these symptoms after an accident during a sailboat race
Patient History
Patient History

- Lives with parents and brother in a suburban area of New England
  - Noted as excellent student
- Brother diagnosed with attention deficit-hyperactivity disorder (ADHD)
- No family history of headaches, learning disabilities, depression, anxiety, or seizures
Patient History

- Patient had several sports related injuries
- No allergies and took no regular medications
- Has experienced dizziness and extended headaches before
History of Current Illness

- Patient was struck and her boat capsized
  - Patient was dazed and confused but was helped back into the boat
- Patient and teammates were knocked out of boat a second time, and this time the patient lost consciousness for several minutes
- Upon return to shore and arrival of medical services, patient was awake and talking although confused
  - Agitated and resisted care in the ambulance
11 Days Before Admission

- Patient reported feeling confused, dizzy, unsteady, and possessed a headache
- Results of neurologic examination and examination of the neck were normal
- Radiographs of the cervical spine were normal
- Patient was discharged in the care of her parents
How many views of the cervical spine are usually performed?

A. 3
B. 7
C. 5
D. 8
E. 2
Upon admission
Presentation upon admission

- Patient could not recall ambulance ride or sailing accident
- Reported dizziness, balance problems, fatigue, and difficulty sleeping
- Unable to concentrate on her summer reading and could not read a full page without losing focus
What form of amnesia is the patient likely experiencing?

A. Anterograde
B. Retrograde
Vitals

- Rated headaches 3 on a scale of 1-10 with 10 being most severe
- Patient was alert and answered questions appropriately
- Neck was normal with normal range of motion
- Cranial nerves II through XII were normal
- Photophobia was present
- Patient experienced pain with upward gaze
- Moving the head caused dizziness
- Patient swayed mildly on a Romberg test
Which of these is not a standing position on a Romberg test?

A. Feet apart
B. Feet together
C. Feet tandem
D. Feet semi-tandem
Labs and Imaging
Lab Tests Performed

- Blood Panel
- Blood Clotting Function Test
- Dual-energy CT Angiography of Head
The complete blood count, prothrombin time, and activated partial-thromboplastin time was normal.

Other blood tests results that were deemed important included: Electrolytes, Calcium, Glucose, Urea nitrogen, Creatinine levels

All levels were determined to be normal and within reference range, these values are shown on next slide.
**Reference Ranges 16 year old Female**

### Blood, Plasma, and Serum Chemistry Studies

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Normal Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Albumin, serum</td>
<td>3.5-5.5 g/dL (35-55 g/L)</td>
</tr>
<tr>
<td>Alkaline phosphatase, serum</td>
<td>36-92 U/L</td>
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<tr>
<td>&amp; Fetoprotein, serum</td>
<td>0.20 ng/mL (0.20 ng/L)</td>
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<tr>
<td>Aminotransferase, alanine (ALT)</td>
<td>0-35 U/L</td>
</tr>
<tr>
<td>Aminotransferase, aspartate (AST)</td>
<td>0-35 U/L</td>
</tr>
<tr>
<td>Ammonia, plasma</td>
<td>40-80 μg/dL (23-47 μmol/L)</td>
</tr>
<tr>
<td>Amylase, serum</td>
<td>0-130 U/L</td>
</tr>
<tr>
<td>Antinuclear antibody, serum</td>
<td>– positive: titer of greater than, equal to 1:160</td>
</tr>
<tr>
<td>Bicarbonate, serum</td>
<td>23-28 meq/L (23-28 mmol/L)</td>
</tr>
<tr>
<td>Bilirubin, serum</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>0.3-1.2 mg/dL (5.1-20.5 μmol/L)</td>
</tr>
<tr>
<td>Direct</td>
<td>0-0.3 mg/dL (0-5.1 μmol/L)</td>
</tr>
<tr>
<td>Blood gases, arterial (patient breathing room air)</td>
<td></td>
</tr>
<tr>
<td>pH</td>
<td>7.38-7.44</td>
</tr>
<tr>
<td>Pco2</td>
<td>35-45 mm Hg</td>
</tr>
<tr>
<td>Po2</td>
<td>80-100 mm Hg</td>
</tr>
<tr>
<td>Oxygen saturation — 95% or greater</td>
<td></td>
</tr>
<tr>
<td>Blood urea nitrogen</td>
<td>8-20 mg/dL (2.9-7.1 mmol/L)</td>
</tr>
<tr>
<td>Calcium, serum</td>
<td>9-10.5 mg/dL (2.2-2.6 mmol/L)</td>
</tr>
<tr>
<td>Carbon dioxide content, serum</td>
<td>23-28 meq/L (23-28 mmol/L)</td>
</tr>
<tr>
<td>Chloride, serum</td>
<td>98-106 meq/L (98-106 mmol/L)</td>
</tr>
<tr>
<td>Cholesterol, plasma</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>150-199 mg/dL (3.88-5.15 mmol/L)</td>
</tr>
<tr>
<td>Low-density lipoprotein (LDL)</td>
<td>Less than or equal to 130 mg/dL (3.36 mmol/L), desirable</td>
</tr>
<tr>
<td>High-density lipoprotein (HDL)</td>
<td>Greater than or equal to 40 mg/dL (1.04 mmol/L), desirable</td>
</tr>
<tr>
<td>Complement, serum</td>
<td></td>
</tr>
<tr>
<td>C3</td>
<td>55-120 mg/dL (550-1200 mg/L)</td>
</tr>
<tr>
<td>Total (CH50)</td>
<td>37-55 U/mL (37-55 kU/L)</td>
</tr>
<tr>
<td>Creatine kinase, serum</td>
<td>30-170 U/L</td>
</tr>
<tr>
<td>Creatinine, serum</td>
<td>0.7-1.3 mg/dL (61.9-115 μmol/L)</td>
</tr>
<tr>
<td>Electolytes, serum</td>
<td></td>
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<tr>
<td>Sodium</td>
<td>136-145 meq/L (136-145 mmol/L)</td>
</tr>
<tr>
<td>Potassium</td>
<td>3.5-5.0 meq/L (3.5-5.0 mmol/L)</td>
</tr>
<tr>
<td>Chloride</td>
<td>98-106 meq/L (98-106 mmol/L)</td>
</tr>
<tr>
<td>Bicarbonate</td>
<td>23-28 meq/L (23-28 mmol/L)</td>
</tr>
<tr>
<td>Fibrinogen, plasma</td>
<td>150-350 mg/dL (1.5-3.5 g/L)</td>
</tr>
<tr>
<td>Folate, red cell</td>
<td>160-855 ng/mL (362-1937 nmol/L)</td>
</tr>
<tr>
<td>Folate, serum</td>
<td>2.5-20 ng/mL (5.7-45.3 nmol/L)</td>
</tr>
<tr>
<td>Glucose, plasma</td>
<td>Fasting, 70-100 mg/dL (3.9-5.6 mmol/L)</td>
</tr>
<tr>
<td>γ-Glutamyltransferase, serum</td>
<td>0-30 U/L</td>
</tr>
<tr>
<td>Homocysteine, plasma</td>
<td>Male: 4-16 μmol/L; female: 3-14 μmol/L</td>
</tr>
<tr>
<td>Troponins, serum</td>
<td></td>
</tr>
<tr>
<td>Troponin I</td>
<td>0-0.5 ng/mL (0-0.5 μg/L)</td>
</tr>
<tr>
<td>Troponin T</td>
<td>0-0.10 ng/mL (0-0.10 μg/L)</td>
</tr>
<tr>
<td>Urea nitrogen, serum</td>
<td>8-20 mg/dL (2.9-7.1 mmol/L)</td>
</tr>
<tr>
<td>Uric acid, serum</td>
<td>2.5-8 mg/dL (0.15-0.47 mmol/L)</td>
</tr>
<tr>
<td>Vitamin B12, serum</td>
<td>200-800 pg/mL (148-590 pmol/L)</td>
</tr>
</tbody>
</table>

**Normal PT Values:** 10-12 seconds (this can vary slightly from lab to lab)  
**Normal PT Values:** 30 to 45 seconds (this can vary slightly from lab to lab)  
**Normal INR Values:** 1 to 2
What is the purpose of a prothrombin time (PT) test?

A. To determine if the consistency of the blood plasma is within range
B. To evaluate speed of blood clotting via the extrinsic pathway
C. To test for specific clotting factors present with in the blood
D. To determine if the patient needs to undergo a blood transfusion
E. To evaluate speed of blood clotting via the intrinsic pathway
CT Scan

Due to an overuse of CT when evaluating young patients for concussions, strict guidelines have been established to guide practicing physicians.
Dual-Energy CT Scan

-The Patient was determined in the risk category and a Dual-Energy CT Angiography was ordered

-There was no evidence of Skull Fracture or Vascular injury

-A Dual energy CT scan, a technique which uses two-separate x-ray energy spectra to view materials. These images can be overlapped to form a variety of images, which can give higher image quality and multiple viewpoints of one image
Normal Dual Energy CT Angiography Results

*Images shown are not from patient, taken from Dual CT Angiography Studies*
Clicker Question #5

CT Scans can be used to detect all of the following except,

A. Bone Fractures
B. Vascular Irregularities
C. Damaged Ligament
D. Tumors
E. Liver Disease
Differential Diagnosis
Concussion

- A minor traumatic brain injury resulting from fast acceleration/deceleration of the head
  - Often from a traumatic hit to the head (or the entire body)
  - No abnormalities shown by computed tomography (CT) or magnetic resonance imaging (MRI)
- The patient experienced at least 1 traumatic hit to the head (possibly 2 within a short period of time).
- The patient was also diagnosed with a concussion 3 years earlier, which could worsen symptoms
- The patient was already diagnosed with a concussion at the first hospital
Concussion

- Common symptoms of concussion (all typically short-term)
  - Headaches
  - Loss of consciousness at the time of the injury
  - Amnesia (memory loss) around the time of the injury
  - Drowsiness, confusion, appearing dazed
  - Dizziness and balance problems
  - Difficulty sleeping
  - Photophobia (sensitivity to light) and sensitivity to sound
  - Difficulty concentrating
  - Changes in mood, behavior, or personality
    - Was agitated and resisted treatment immediately after injury

- Diagnosis requires a patient to have just a few of these symptoms
  - This patient had all of these symptoms except sensitivity to sound.
Concussion

But some of the patient’s symptoms cannot be explained by this diagnosis:

- 11 days after the accident:
  - The patient experienced “pain with upward gaze”
  - Mental-status examination: orientation, immediate and delayed recall, attention, and language were normal
  - Symptoms usually gone after 1-2 weeks, but many symptoms persisted

- Ocular and Vestibular problems:
  - Visual pursuit movements impaired
  - Balance issues
  - But these symptoms fit diagnosis of a type of concussion: “vestibular and ocular concussion”

- Drainage of clear fluid from the nose
Cerebrospinal fluid (CSF) leak

- Caused by a rupture in the meninges surrounding the brain
- Signs of CSF leak that are seen in this patient:
  - Drainage of clear fluid from nose or ears
    - From nose in this patient
  - There was a traumatic hit to the head
  - Headaches
- What doesn’t support this diagnosis:
  - No basilar skull fracture or vascular injury shown by dual-energy CT angiography
- Nasal fluid is typically analyzed, but this couldn’t be done because did not leak during appointment in hospital
Choose the correct statement(s) about a cerebrospinal fluid leak.

A. It is often treated by endonasal endoscopic surgery.
B. It can lead to meningitis.
C. Common diagnostic tests include a pledget study and a CT cisternogram.
D. It sometimes causes tinnitus.
E. All of the above
Benign paroxysmal positional vertigo (BPPV)

- Symptoms of BPPV that this patient has (all typically in episodes of <1 minute)
  - Dizziness
    - can be mild or intense
    - Usually after specific changes in position of the head
  - Balance issues
  - A feeling that you’re spinning

- Causes:
  - Cause often unknown
  - Sometimes caused by a hit to the head, either severe or minor
  - Less common: damage to inner ear (vestibular system)
Benign paroxysmal positional vertigo (BPPV)

- What does not fit with this diagnosis:
  - The patient also had ringing and pressure in the ears
  - Most common in people who are at least 50 years old

- Dix-Hallpike maneuver
  - Procedure used to diagnose BPPV: involves lowering the patient’s head (image on the right)
  - resulted in abnormal eye movements, which supports this diagnosis.
Attention deficit/hyperactivity disorder (ADHD)

- Long-term condition with at least one of these two characteristics:
  - Inattention:
    - Difficulty keeping sustained focus, being easily distracted
    - Possibly have trouble remembering tasks that need to be done
  - Hyperactivity-Impulsivity:
    - Moving a lot, difficulty sitting still, and impulsive actions

- Diagnosis is based on:
  - Ruling out other causes of these symptoms and analysis of a patient’s long-term behavior
    - Criteria listed in Diagnostic and Statistical Manual of Mental Disorders, 5th edition

- Suspected when all of the patient’s symptoms resolved except difficulties with cognitive tasks
Attention deficit/hyperactivity disorder (ADHD)

- **Risk factors the patient has:**
  - Genes (The patient’s sibling has ADHD).
  - Brain injuries

- **A targeted neuropsychological assessment found:**
  - At least mild difficulties with:
    - attention and vigilance, working memory (a type of short-term memory)
  - Normal or better than normal:
    - Memory, processing speed, executive functioning, vocabulary, nonverbal reasoning, and reading skills

- **Interviews with patient and mother showed:**
  - Many symptoms of inattention and mild symptoms of hyperactivity, since patient was young
  - These symptoms interfere with the patient’s overall functioning.
Attention deficit/hyperactivity disorder (ADHD)

- What doesn’t support this diagnosis:
  - Starts before age 12 and is usually diagnosed as a child
  - Diagnosis usually requires that the person has fallen behind others their age due to symptoms, and this patient is described as an excellent student

- Risk factors the patient does not have
  - More common in males
  - Low birth weight
  - Mother smoking, using alcohol/drugs, or exposed to environmental toxins during pregnancy
Which of these is not a common symptom of ADHD?

A. Impulsiveness  
B. Hyperventilation  
C. Poor planning  
D. Trouble multitasking  
E. Inability to focus
Final Diagnosis, Treatment, & Clinical Importance
At this point, what would you guess is the patient’s diagnosis?

A. Concussion
B. Attention-deficit/hyperactivity disorder (ADHD)
C. Cerebrospinal fluid leak
D. Benign paroxysmal positional vertigo (BPPV)
E. Vestibular impairment
Final Diagnosis:

Concussion, benign paroxysmal positional vertigo (BPPV), and attention-deficit/hyperactivity disorder (ADHD).
Treatment for concussion

Due to diagnosis of concussion, the patient was advised to:

- Rest at home and avoid strenuous activity (including sports) for 3-5 days
- Take fewer classes than normal in school
- Follow an incremental exercise regimen
- Sleep at night (avoid naps) at regular times and to take melatonin before sleeping (due to sleep schedule becoming abnormal)
- Take acetaminophen for headaches that interfere with sleep (no more than 2-3x/week)
- Physical therapy for recovery from exertion intolerance and balance problems
The patient was prescribed acetaminophen. Which of these statements about acetaminophen is FALSE?

A. High doses can lead to liver failure.
B. It is the most commonly used pain/fever medication in the U.S.
C. Studies have associated acetaminophen with increased risk of kidney cancer.
D. Acetaminophen has 3 main metabolic pathways.
E. Acetaminophen inhibits the function of cyclooxygenase (COX) enzymes.
Treatment for benign paroxysmal positional vertigo (BPPV)

- Epley maneuver was performed by physical therapist
  - After performing this maneuver 4 times, the symptoms of dizziness and spinning were completely resolved
Resolution

- BPPV resolved by the patient’s 2nd appointment with the physical therapist.
- The patient continued physical therapy for 7 visits over 3 months for vestibular and ocular impairment, then was discharged with complete resolution of these symptoms.
  - These treatments consisted of progressive exercises/exertion training and the patient was eventually able to perform at maximal exertion without symptoms.
- Following physical therapy, the patient nearly reached full resumption of school and sports but showed cognitive difficulty with reading and test taking—> patient referred for neuropsychological assessment and diagnosed with ADHD.
Treatment for ADHD

- Patient was given academic accommodations
  - Provision of distraction-free environments for tests & examinations
  - Extended time for tests & examinations
- Patient and her family were given additional resources to facilitate:
  - Learning skills
  - Executive function skills
  - Organization skills
The drugs most commonly prescribed for ADHD are known as stimulants. Which neurotransmitter(s) do these affect?

A. Serotonin
B. Dopamine and Norepinephrine
C. Glutamate and Serotonin
D. GABA (gamma-aminobutyric acid)
E. Acetylcholine
Clinical Relevance

- Head injury is a high risk for young athletes
  - 1.8-3.6 million sports-related concussions/year
- Normally, patients resume normal cellular neurometabolic activity 1-2 weeks following a concussion
  - But, in 10-20% of concussion cases, symptoms persist past 2 weeks
- Symptoms of concussion are not unique to concussions
  - Similar to symptoms caused by depression, anxiety, insomnia, life stress, and pain
- Manifestation of concussion symptoms and recovery trajectories are modified by many factors, so sometimes multiple diagnoses are needed.
  - In this case, the patient was diagnosed with a concussion but also had preexisting but undiagnosed ADHD.
  - This case shows the importance of considering other conditions that may show similar symptoms to concussions, magnify the symptoms of concussions, or affect the recovery from concussions.
Clinical Relevance

- It is notable that there are differences between sexes in the clinical manifestation and diagnosis of ADHD
  - When first diagnosed, girls tend to be at a older than boys (patient’s brother was diagnosed with ADHD, while the patient was not).
  - Girls with ADHD often have greater internalizing symptoms (i.e., inattentiveness) and may have better coping strategies that mask symptoms.
- This study helps highlight the importance and role of neuropsychology in informing differential diagnosis and management decisions for concussions.
  - Without neuropsychology, the patient’s ADHD would have gone undiagnosed.