

Carbon Monoxide Poisoning

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Submitted: April 30, 2016; Accepted: June 3, 2016; Electronically Published: July 15, 2016; <https://doi.org/10.21980/J8KH59C>

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ABSTRACT:

Audience: This oral boards case is appropriate for all emergency medicine learners (residents, interns, and medical students).

Introduction: Carbon monoxide (CO) is a colorless and odorless gas that typically results from combustion. It binds hemoglobin, dissociating oxygen, causing headache, weakness, confusion and possible seizure or coma. Pulse oxygen levels may be falsely elevated. Practitioners should maintain a high index of suspicion for carbon monoxide poisoning. If caught early CO poisoning is reversible with oxygen or hyperbaric oxygen therapy.

Objectives: By the end of this oral boards case, the learner will: 1) demonstrate ability to evaluate a patient with altered mental status and discuss the differential diagnosis of a patient with altered mental status and weakness, 2) recognize the signs and symptoms of carbon monoxide poisoning, 3) demonstrate the ability to manage treatment of a patient with carbon monoxide poisoning.

Method: Oral boards case

Topics: Carbon monoxide poisoning, toxicology, carboxyhemoglobin, altered mental status, oral boards, hypoxia, pulse oximetry.



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Learner Audience:

Medical students, interns, junior residents, senior residents

Time Required for Implementation:

Case: 15 minutes

Debriefing: 10 minutes

Learners per instructor: 1-3

Topics:

Carbon monoxide poisoning, toxicology, altered mental status, oral boards, carboxyhemoglobin, hypoxia, pulse oximetry

Objectives:

By the end of this oral boards case, the learner will:

1. Demonstrate ability to evaluate a patient with altered mental status and discuss the differential diagnosis of a patient with altered mental status and weakness.
2. Recognize the signs and symptoms of carbon monoxide poisoning.
3. Demonstrate ability to manage treatment of a patient with carbon monoxide poisoning.

Linked objectives and methods:

This oral board case allows learners to have a simulated first-hand experience managing a patient with carbon monoxide poisoning. Completion of the oral board case allows learners to evaluate a patient with altered mental status, recognize the associated risk factors, review the appropriate differential, and appropriately diagnose and manage carbon monoxide (CO) poisoning (objectives 1-3).

Debriefing the case will allow the instructor to clarify any confusion or gaps in knowledge on the diagnosis and management of patients with carbon monoxide poisoning and the evaluation and differential diagnosis for patients with altered mental status.

Recommended pre-reading for instructor:

- Thompson TM. Inhaled toxins. In: Adams JG, Barton ED, Collings JL, DeBlieux PM, Gisondi MA, Nadel ES,

eds. *Emergency Medicine: Clinical Essentials*. 2nd ed. Philadelphia, PA: Elsevier; 2013:1308-1313.

- Nelson LS, Hoffman RS. Inhaled toxins. In: Walls RM, Hockberger RS, Gausche-Hill M, et al. eds. *Rosen's Emergency Medicine: Concepts and Clinical Practice*. 8th ed. Philadelphia, PA: Elsevier; 2014:2036-2043.
- Weaver LK. Clinical practice. Carbon monoxide poisoning. *N Engl J Med*. 2009;360(12):1217-1225. doi: 10.1056/NEJMc0808891

Results and tips for successful implementation:

- The case was initially presented as oral board case in a small group setting with approximately 20 emergency medicine residents. We received positive feedback from residents who found the case useful and interesting. The case was difficult for novice learners, but more straightforward for advanced learners.
- Novice learners will require more prompting to discover key pieces of history (kerosene lamp) and order appropriate diagnostic testing (carboxyhemoglobin level).
- While this case is best done as an oral boards case, it can also be done as a simulation case or small group session.
- It is important to debrief the case with the learner after completion of the case or provide post-case reading material.

Pearls:

- Carbon monoxide is a colorless and odorless gas that is typically produced by hydrocarbon combustion, such as auto exhaust, smoke inhalation, improper heating systems, or poorly ventilated fuel-burning devices such as kerosene lamps. Accidentally poisoning is seen more frequently in cold climates and winter months.
- Carbon monoxide binds to hemoglobin with greater affinity than oxygen, and then forms carboxyhemoglobin, this leads to decreased/impaired oxygen transportation, resulting in hypoxemia
- Symptoms are typically non-specific and general such as headache, malaise, nausea, dizziness, and confusion. Patients' skin and lips may appear "cherry red."
- Severe poisoning can cause neurological symptoms such as seizures, syncope, coma, myocardial ischemia, and arrhythmias.
- Pulse oximetry will display a falsely elevated oxygen saturation. Obtain a venous or arterial blood gas for true oxygen saturation and carboxyhemoglobin level. Venous blood is sufficient to detect elevated carboxyhemoglobin levels.¹



USER GUIDE

- High carboxyhemoglobin levels suggest CO poisoning, but low levels do not rule out exposure and high level of suspicion is needed, such as in families who have flu-like symptoms or pets that are also ill.
- Treatment starts by removing the patient from the source, then starting the patient on 100% oxygen by non-rebreather mask.
- Patients who are comatose, have seizures, altered mental status, or show signs of myocardial ischemia will likely need intubation and mechanical ventilation, and may benefit from hyperbaric oxygen therapy.
- Patients who are pregnant should also receive hyperbaric oxygen therapy.

References/suggestions for further reading:

1. Trouger M, Gallagher EJ, Tyrell J. Relationship between venous and arterial carboxyhemoglobin levels in patients with suspected carbon monoxide poisoning. *Ann Emerg Med.* 1995;25(4):481-483.
2. Thompson TM. Inhaled toxins. In: Adams JG, Barton ED, Collings JL, DeBlieux PM, Gisondi MA, Nadel ES, eds. *Emergency Medicine: Clinical Essentials.* 2nd ed. Philadelphia, PA: Elsevier; 2013:1308-1313.
3. Nelson LS, Hoffman RS. Inhaled toxins. In: Walls RM, Hockberger RS, Gausche-Hill M, et al. eds. *Rosen's Emergency Medicine: Concepts and Clinical Practice.* 8th ed. Philadelphia, PA: Elsevier; 2014:2036-2043.
4. Weaver LK. Clinical practice. Carbon monoxide poisoning. *N Engl J Med.* 2009;360(12):1217-1225. doi: 10.1056/NEJMcp0808891



FOR EXAMINER ONLY

Oral Case Summary

Diagnosis: Carbon Monoxide Poisoning

Case Summary: 58-year-old female with headache and weakness. She had traveled to her family cabin yesterday to clean it in preparation for a family vacation. Today she called her daughter stating she wasn't feeling well. According to her daughter she sounded confused on the phone. On further history, the daughter does note her mother told her she found several dead mice on the cabin floor. When she arrived to the cabin today to check on her, it was very warm; she had to turn the Kerosene heater off. The patient is confused, and has 4/5 strength in all extremities with an unsteady gait and dysmetria on finger-to-nose examination.

Order of Case: The learner should take a history, including sufficient details to include the dead mice and Kerosene heater. They should perform a physical exam including a complete neurologic examination. Given the acute altered mental status, the learner should consider an appropriate differential, in particular carbon monoxide poisoning. They should order a carboxyhemoglobin (COHb) and place the patient on oxygen. Given the acute neurologic changes, they should admit the patient to the hospital and consult a specialist for possible hyperbaric oxygen treatment.

Disposition: Admission

Critical Actions:

1. Perform a complete neurologic examination.
2. Perform a point-of-care blood glucose.
3. Order an arterial blood gas including carboxyhemoglobin level.
4. Start patient on 100% oxygen via non-rebreather.
5. Admit the patient to the hospital for oxygen therapy or transfer for hyperbaric oxygen.



FOR EXAMINER ONLY

Historical Information

Chief Complaint: “I feel weak and tired”

History of present illness: A 58-year-old female with a history of hypertension who presents after her daughter found her this morning complaining of headache, weakness and fatigue. The daughter states that this morning the patient called her to say that she wasn't feeling well. When the daughter arrived at the family cabin, she found the patient sitting on the kitchen floor, sweating and holding her head complaining of a headache. The patient was unable to stand up and the daughter had to support her mom to get her to the car. She brought the patient to the emergency department immediately.

The patient reports feeling well two days ago, but has been feeling very tired and sad since last night. She states that she traveled to the family cabin two days ago to prepare for a family vacation. While cleaning the cabin she found several dead mice. She states that yesterday morning she felt well, but just gradually began to feel generally weak. She increased the temperature on her heater to “full blast” because she thought maybe she was just cold. She denies exacerbating or relieving factors. She denies any fevers, chest pain, shortness of breath, syncope, seizure, nausea, or vomiting.

The daughter reports that the patient is normally independent and sharp, but today seems very confused; the daughter notes that when she arrived to the cabin today, it was very hot in the cabin; she states that she had to turn off the old kerosene heater.

Past Medical history: Hypertension and anemia

Past Surgical history: Cholecystectomy, total abdominal hysterectomy

Patients Medications: Hydrochlorothiazide and simvastatin

Allergies: no known drug allergies

Social history: Lives alone but is very active

- Smoking: no
- Tobacco: no
- Drug use: occasional

Family history: Mother with coronary artery disease and myocardial infarction in her 80s. Father with diabetes, hypertension and coronary artery disease in his 70s.



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Physical Exam Information

Vitals: Heart rate (HR) 73 Blood Pressure (BP) 126/69 Respiratory rate (RR) 20
Temperature (T) 36.9°C Oxygen saturation (O₂Sat) 97%

Weight: 60kg

General appearance: patient appears stated age, lethargic, lying on the gurney

Primary survey:

- **Airway:** speaking in full sentences
- **Breathing:** no apparent respiratory distress, no cyanosis
- **Circulation:** warm skin, normal capillary refill

Physical examination:

- **General appearance:** alert, oriented to self and place, moderately lethargic
- **HEENT:** within normal limits
 - **Head:** within normal limits
 - **Eyes:** within normal limits
 - **Ears:** within normal limits
 - **Nose:** within normal limits
 - **Throat:** lips appear very red, there are no lesions; the oropharynx is clear
- **Neck:** supple neck, no nuchal rigidity
- **Chest:** within normal limits
- **Cardiovascular:** within normal limits
- **Abdominal/GI:** within normal limits
- **Genitourinary:** within normal limits
- **Rectal:** within normal limits
- **Extremities:** within normal limits
- **Back:** within normal limits
- **Neuro:** alert, oriented to self and place, follows commands, generalized weakness 4/5 in all extremities, no focal motor deficits, normal sensory examination, normal reflexes, unsteady gait, abnormal finger to nose, +dysmetria
- **Skin:** pale, no rashes, no edema
- **Lymph:** within normal limits
- **Psych:** poor concentration, no suicidal ideation, homicidal ideation, visual hallucinations, or auditory hallucinations



FOR EXAMINER ONLY

Critical Actions and Cueing Guidelines

1. **Perform a complete neurologic examination.**

The learner should complete a full neurologic examination assessing for deficits.

2. **Perform a point-of-care blood glucose.**

The learner should recognize that the patient is altered. All patients with altered mental status should be promptly assessed for hypoglycemia.

a. Cueing Guideline:

If the learner has not yet addressed the glucose, the examiner may cue them by having the nurse ask “Doctor, would you like to order any tests?”

3. **Order an arterial blood gas including carboxyhemoglobin level.**

The learner should order an ABG to check a carboxyhemoglobin level

a. Cueing Guideline:

If the learner has not yet addressed this issue, the examiner may cue them by having the nurse ask “What are you worried about in this patient, doctor?”

4. **Start patient on 100% oxygen via non-rebreather.**

The learner should place the patient on 100% oxygen via non-rebreather to treat the carbon monoxide poisoning.

a. Cueing Guideline:

If the learner has not yet placed the patient on 100% oxygen, the examiner may cue them by having the daughter ask “What’s wrong with her? What can we do to fix it?”

5. **Admit the patient for oxygen therapy or transfer for hyperbaric oxygen.**

The learner should recognize that the patient will require admission to the hospital for further management. Given the neurologic deficits, considering transfer of the patient for hyperbaric oxygen therapy is also appropriate.

a. Cueing Guideline:

If the learner has not yet admitted the patient, the examiner may cue them by having the nurse ask “What is the disposition for the patient?”



ORAL BOARDS ASSESSMENT

Carbon Monoxide Poisoning

Learner: _____

Critical Actions:

- Perform a complete neurologic examination
- Perform a point-of-care blood glucose
- Order an arterial blood gas including carboxyhemoglobin level
- Start patient on 100% oxygen via non-rebreather
- Admit the patient to the hospital for oxygen therapy or transfer for hyperbaric oxygen

Summative and formative comments:

Milestones assessment:

	Milestone	Did not achieve level 1	Level 1	Level 2	Level 3
1	Emergency Stabilization (PC1)	<input type="checkbox"/> Did not achieve Level 1	<input type="checkbox"/> Recognizes abnormal vital signs	<input type="checkbox"/> Recognizes an unstable patient, requiring intervention Performs primary assessment Discerns data to formulate a diagnostic impression/plan	<input type="checkbox"/> Manages and prioritizes critical actions in a critically ill patient Reassesses after implementing a stabilizing intervention
2	Performance of focused history and physical (PC2)	<input type="checkbox"/> Did not achieve Level 1	<input type="checkbox"/> Performs a reliable, comprehensive history and physical exam	<input type="checkbox"/> Performs and communicates a focused history and physical exam based on chief complaint and urgent issues	<input type="checkbox"/> Prioritizes essential components of history and physical exam given dynamic circumstances



ORAL BOARDS ASSESSMENT

Carbon Monoxide Poisoning

Learner: _____

	Milestone	Did not achieve level 1	Level 1	Level 2	Level 3
3	Diagnostic studies (PC3)	<input type="checkbox"/> Did not achieve Level 1	<input type="checkbox"/> Determines the necessity of diagnostic studies	<input type="checkbox"/> Orders appropriate diagnostic studies Performs appropriate bedside diagnostic studies/procedures	<input type="checkbox"/> Prioritizes essential testing Interprets results of diagnostic studies Considers risks, benefits, contraindications, and alternatives to a diagnostic study or procedure
4	Diagnosis (PC4)	<input type="checkbox"/> Did not achieve Level 1	<input type="checkbox"/> Considers a list of potential diagnoses	<input type="checkbox"/> Considers an appropriate list of potential diagnosis May or may not make correct diagnosis	<input type="checkbox"/> Makes the appropriate diagnosis Considers other potential diagnoses, avoiding premature closure
5	Pharmacotherapy (PC5)	<input type="checkbox"/> Did not achieve Level 1	<input type="checkbox"/> Asks patient for drug allergies	<input type="checkbox"/> Selects an appropriate medication for therapeutic intervention, considering potential adverse effects	<input type="checkbox"/> Selects the most appropriate medication(s) and understands mechanism of action, effect, and potential side effects Considers and recognizes drug-drug interactions
6	Observation and reassessment (PC6)	<input type="checkbox"/> Did not achieve Level 1	<input type="checkbox"/> Reevaluates patient at least one time during the case	<input type="checkbox"/> Reevaluates patient after most therapeutic interventions	<input type="checkbox"/> Consistently evaluates the effectiveness of therapies at appropriate intervals



ORAL BOARDS ASSESSMENT

Carbon Monoxide Poisoning

Learner: _____

	Milestone	Did not achieve level 1	Level 1	Level 2	Level 3
7	Disposition (PC7)	<input type="checkbox"/> Did not achieve Level 1	<input type="checkbox"/> Appropriately selects whether to admit or discharge the patient	<input type="checkbox"/> Appropriately selects whether to admit or discharge Involves the expertise of some of the appropriate specialists	<input type="checkbox"/> Educates the patient appropriately about their disposition Assigns patient to an appropriate level of care (ICU/Tele/Floor) Involves expertise of all appropriate specialists
22	Patient centered communication (ICS1)	<input type="checkbox"/> Did not achieve level 1	<input type="checkbox"/> Establishes rapport and demonstrates empathy to patient (and family) Listens effectively	<input type="checkbox"/> Elicits patient's reason for seeking health care	<input type="checkbox"/> Manages patient expectations in a manner that minimizes potential for stress, conflict, and misunderstanding.
23	Team management (ICS2)	<input type="checkbox"/> Did not achieve level 1	<input type="checkbox"/> Recognizes other members of the patient care team during case (nurse, techs)	<input type="checkbox"/> Communicates pertinent information to other healthcare colleagues	<input type="checkbox"/> Communicates a clear, succinct, and appropriate handoff with specialists and other colleagues Communicates effectively with ancillary staff



Stimulus Inventory

- #1 Patient Information Form
- #2 Electrocardiogram (ECG)
- #3 Basic metabolic panel (BMP)
- #4 Liver function tests (LFTs)
- #5 Complete blood count (CBC)
- #6 Lactate
- #7 Urinalysis, urine toxicology, urine pregnancy test
- #8 Tylenol level
- #9 Aspirin level
- #10 Arterial blood gas, carboxyhemoglobin level
- #11 Computed tomography (CT) of the head
- #12 Chest X-ray



Stimulus #1

Patient Information

Patient's Name: Mrs. Mary Hunt
Age: 58
Gender: Female
Chief Complaint: "I feel weak and tired"

Person Providing History: Patient and her daughter who brought her in

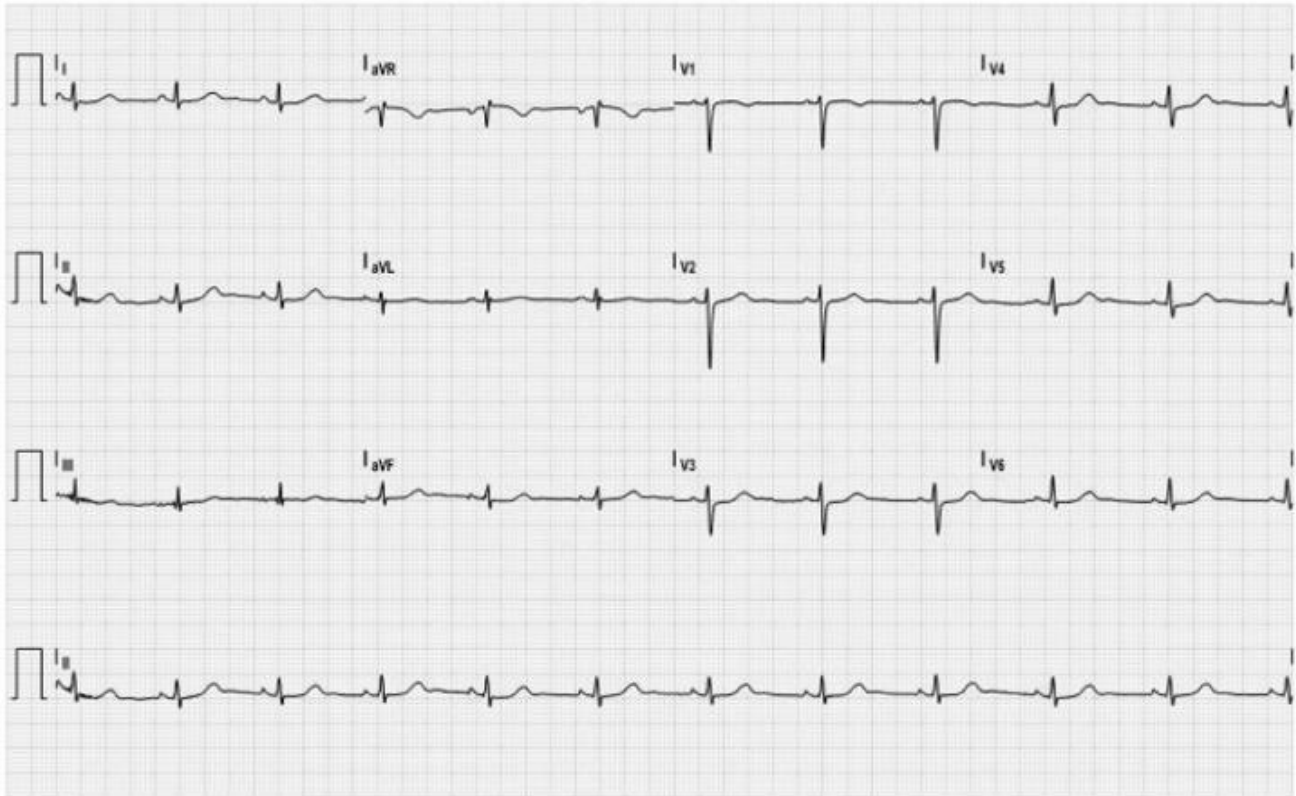
Vital Signs:

Temp: 36.9°C
BP: 126/69
P: 73
RR: 20
O₂sat: 97% on room air
Weight: 60kg



Stimulus #2

Electrocardiogram





Stimulus #3

Basic metabolic panel

Sodium (Na)	135 mEq/L
Potassium (K)	3.3 mEq/L
Chloride (Cl)	104 mEq/L
Carbon dioxide (CO₂)	20 mEq/L
Blood urea nitrogen (BUN)	15 mg/dL
Creatinine (Cr)	1.0 mg/dL
Glucose	204 mg/dL



Stimulus #4

Liver function tests

Albumin	4.2 g/dL
Total Bilirubin	0.3 mg/dL
Aspartate aminotransferase (AST)	20 u/L
Alanine aminotransferase (ALT)	22 u/L
Alkaline Phosphatase (Alk Phos)	70 u/L



Stimulus #5

Complete blood count

White blood cells (WBC)	$9.3 \times 10^3/\text{mm}^3$
Hemoglobin (Hgb)	12.7 g/dL
Hematocrit (Hct)	39.4%
Platelets	$217 \times 10^3/\text{mm}^3$



Stimulus #6

Lactate

Lactate **2.5 mEq/L**



Stimulus #7

Urinalysis, urine pregnancy test, urine toxicology

Appearance	Clear
Color	Yellow
Glucose	Neg
Ketones	Neg
Specific gravity	1.05
Blood	Neg
pH	6.1
Protein	Neg
Nitrite	Neg
Leukocyte	Neg
WBC	0/high powered field (HPF)
Red blood cells (RBC)	0/HPF
Squamous cells	0/HPF
Bacteria	None
Urine pregnancy	Neg
Urine toxicology	Neg



Stimulus #8

Tylenol level

Tylenol level <10 mcg/mL



Stimulus #9

Aspirin level

Aspirin level <10 mg/dL



Stimulus #10

Arterial blood gas

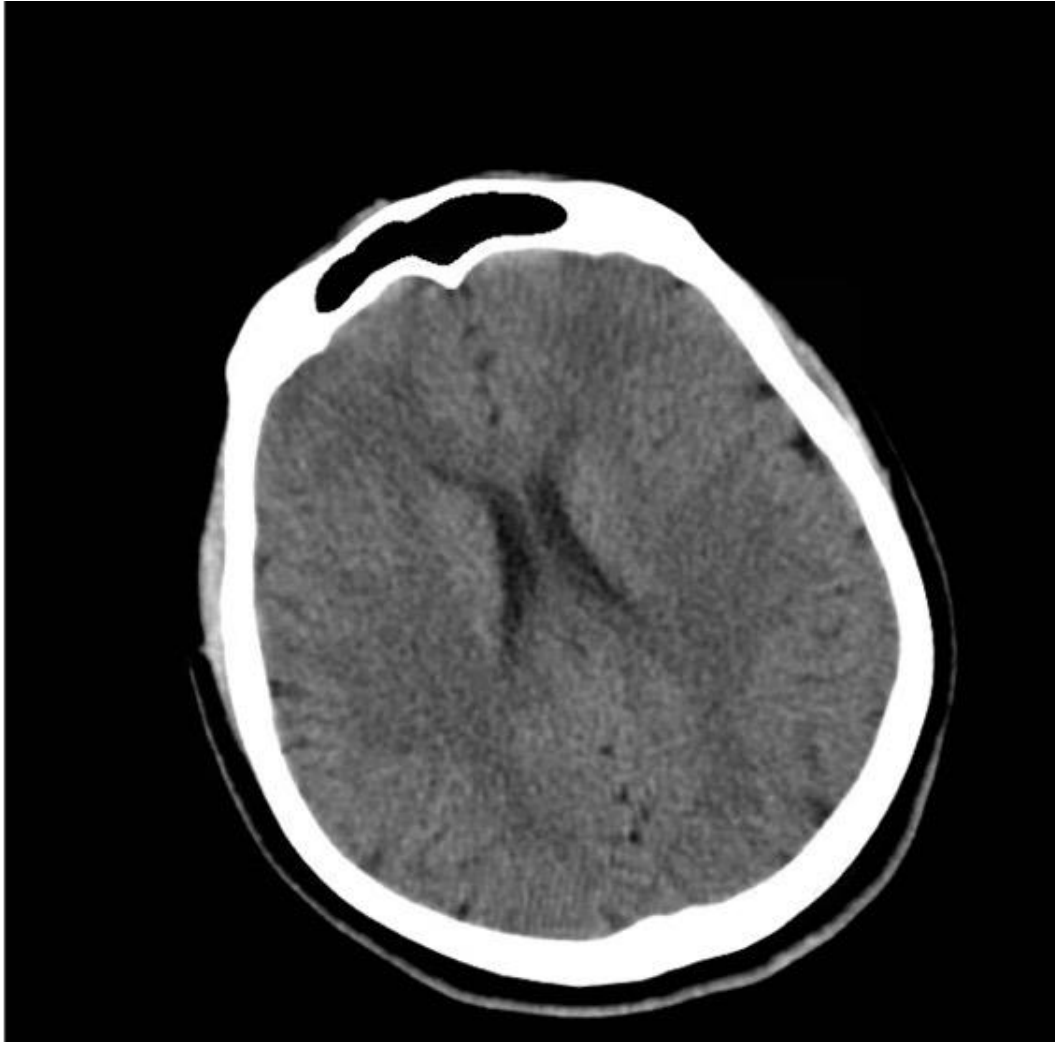
Drawn on room air

pH	7.367
pCO₂	43 mmHg
pO₂	96 mmHg
HCO₃	22 mEq/L
O₂sat	96%
COHb	19%
MetHb	0%



Stimulus #11

CT Head





Stimulus #12

Chest X-ray

