

Case Study "While you were sleeping "

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An Interrupted Case Study on Sleep Apnea

The case study on Obstructive Sleep Apnea is intended to stimulate critical thinking on the part of the students and to assist students in understanding the role of the chemoreceptors and their influence on the respiratory center in the medulla oblongata.

Target Students: This case study is designed for undergraduate biology majors enrolled in a two semester Anatomy & Physiology course.

Case Teaching Notes:

Objectives:

- Define obstructive sleep apnea
- Using basic knowledge of respiratory system; describe how the pCO₂, pO₂ and pH are affected by the cessation of breathing
- Understand the role of the chemoreceptors in altering the breathing pattern
- Discuss the role of the breathing centers of the brain to arouse the patient and to reinitiate the breathing rhythm
- Analyze the impact of apnea on other organ systems.
- Graph interpretation with the goal of formulating conclusions

Classroom Management

This case study is a type of interrupted case study. Case study would be implemented within 30 minute sessions during consecutive lecture periods. The class is broken down into groups of 5-6 students. Students appoint a facilitator within their group to keep the discussion focused and a recorder to record the information for the group. Students would be given case study scenarios 1, 2, 3 or 4 on consecutive days. A 15 minute discussion within their discussion groups to answer questions following each scenario. Students would be permitted to use their text books. The discussion time is followed by a 15 minute class discussion wherein individual groups contribute their findings and interpretations. The instructor can then reinforce the correct interpretations and guide students regarding any misconceptions along the way.

Day 1

As Marsha slowly regained consciousness, she became aware of the sights and sounds of the crowd around her. “What happened?” she asked.

Someone in the crowd, identified himself as Jim, an EMT. He said that her car had veered off the side of the road onto the shoulder and hit a tree.

Martha quickly tried to raise herself off the ground but sank back in pain. Jim gently lowered her shoulders and told her that she needed to lay still until they could put her on a stretcher. “You may have neck or back injuries”, Jim said “and it looks like you may have broken your leg so I need for you to lie very still”.

“What about my children?” Martha screamed. She suddenly remembered that they had been sitting in the back seat. “They are fine” Jim reported. “They were safely buckled in the back seat and their seat belts prevented any injuries. The large engine in the Lumina absorbed most of the force of the impact.”

Martha relaxed as she heard a chorus from somewhere beside her “Mommy, we’re OK”. “Thank heavens” Martha said. “I know that I felt a little sleepy but I don’t remember what happened next.”

Thinking back, Martha, a 49 year old woman, realized that she had been feeling very tired lately. She found that she often needed an afternoon nap these days. She had a hard time keeping up with the energy of her 7 year old son Todd and 5 year old daughter Sasha. “I guess that I just don’t have the same old pep that I used to have” she admitted to herself. She also knew that, at 200 lbs on a 5’7” frame, she had put on a little weight. “I have just been too tired to exercise” she told her doctor at her last visit when he had suggested that she would do well to loose a couple of pounds. “I only wish my husband wouldn’t awaken me every time I snore” she told him, “what I need is a good night’s sleep”.

Marsha’s attention was drawn back to the present as the EMT’s quickly loaded the stretcher into the waiting ambulance. They sped onto the highway which was busy with traffic at 3:00 p.m. in the afternoon. When they arrived at the emergency room, the physician immediately ordered X-Rays of Marsha’s spine and leg.

Questions for discussion:

1. What are some of the symptoms Marsha had?
2. If you were the physician in the ER, what are some questions which you would ask Marsha in order to shed more light on the cause of the accident?
3. Make 2 columns on a sheet of paper. In the first column list which tests that you think the physician would perform in addition to X-Rays, and in the second column mark beside each test what parameters you would be testing for.
4. List some possible diagnoses of Marsha’s condition.

Part II The Test results:

Marsha's physician, Dr. Chris Reeves, reported that her spinal X-Rays showed no damage due to the accident. He told Marsha "Your right tibia and fibula were fractured and you suffered a mild concussion". We will perform surgery to set the bones, fit your leg with a cast, and after a few days rest and a little help with crutches, you can be up and about again."

After her surgery, Marsha's physician sat down to discuss the issue of her fatigue. Dr. Reeves told her that her blood values indicated that her thyroid hormone levels as well as other hormone levels were normal. He said that her blood chemistry was fairly normal but that her hematocrit was 51% and her blood pressure was 135/95 mm Hg.

Dr. Reeves said "these values in addition to your weight and snoring indicate that you may have obstructive sleep apnea. Marsha was surprised. "Can you explain what that is?" Marsha asked.

Dr. Reeves explained the condition and then he said "I am recommending that you participate in a sleep study at the hospital. They will monitor several parameters while you are sleeping and evaluate whether you suffer from periods of apnea while you sleep".

"Oh no!" Marsha replied, "I can't stand to wear a face mask to bed. I have seen pictures of people wearing them and, not only would I scare my kids, I would not be able to sleep. Besides, how romantic, can that look? I will look like an alien".

Dr. Reeves responded "you would do well to take your condition seriously. If you have obstructive sleep apnea, not only does it cost you sleep and lead to fatigue, this condition is likely to cause long term cardiovascular problems down the road. Some people even begin to experience arrhythmias or irregular heart beats. You may also encounter distraction issues when you try to concentrate and some loss of memory. You have just seen how falling asleep while driving, has endangered both you and your children. Marsha, this is nothing to kid around about".

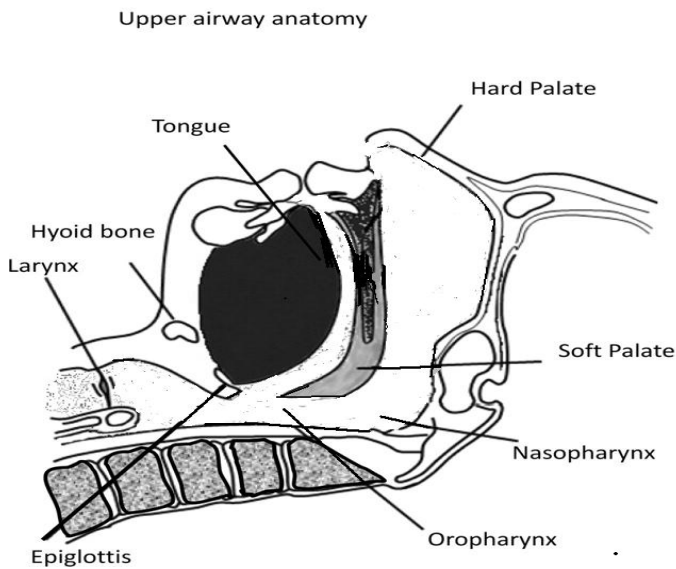
"All right, Dr. Reeves, but I don't like it one bit. How do they expect me to sleep in a strange bed in a clinic hooked up to wires everywhere on my body and with someone watching me and listening to me all night?"

"Don't worry, Marsha" responded Dr. Reeves, "just do the best that you can. It may make a big difference in your lifestyle if you can improve your energy."

Questions:

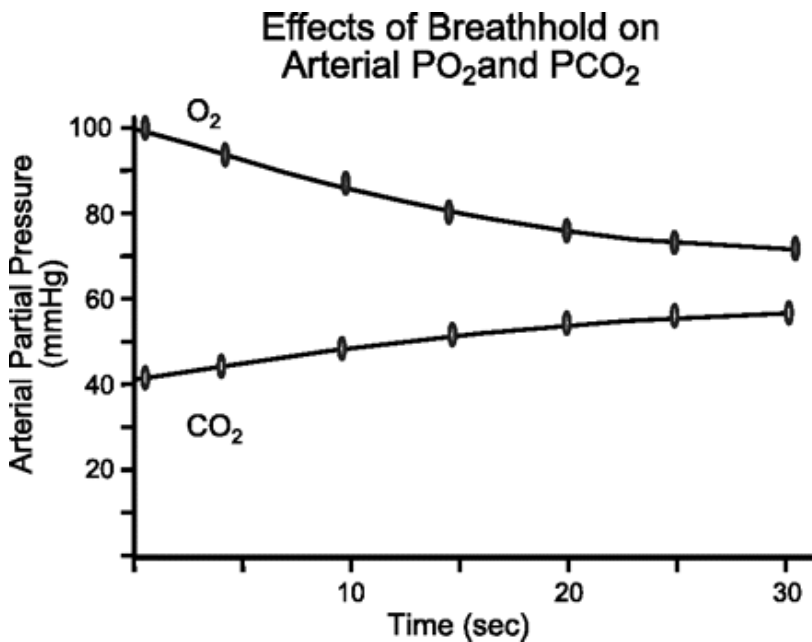
1. Define the term sleep apnea.
2. Can you consciously produce apnea right now? How?

3. Using the diagram below, mark where an obstruction might occur during sleep apnea.



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4. List the anatomical structures which may cause an obstruction in the pharynx while sleeping.

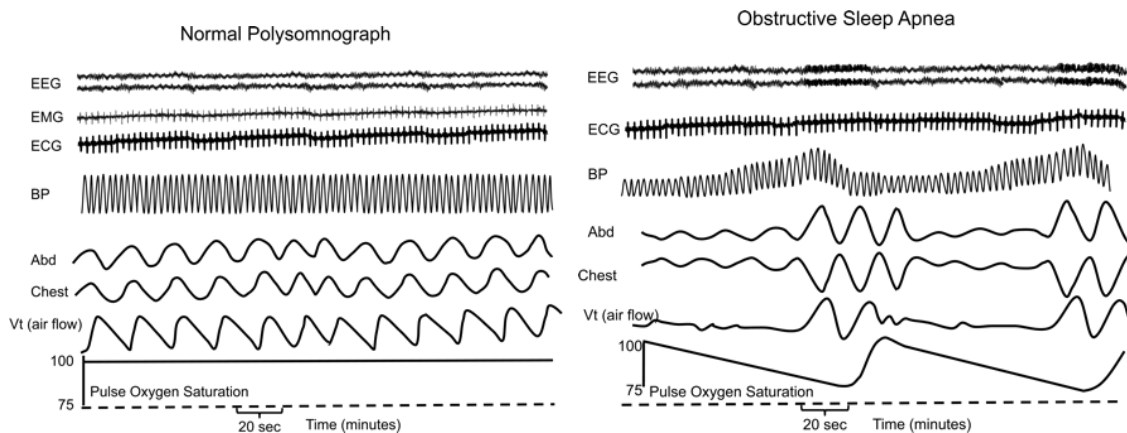


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The graph above shows estimated changes in the arterial PO₂ and PCO₂ during 30 seconds of apnea.

5. What changes have occurred to the PO₂ in 30 seconds of apnea?
6. What changes have occurred to the PCO₂ in 30 seconds of apnea?
7. State the equation for the transport of CO₂ in the blood.
8. What would happen to the H⁺ content of the blood as a result of the apnea?
 - a. increase
 - b. decrease
9. The changes in the CO₂ content of the blood due to apnea would lead to
 - a. acidosis
 - b. alkalosis
10. Apnea is associated with
 - a. hypoventilation
 - b. hyperventilation
11. Where are the peripheral chemoreceptors located?
12. To which substance are the chemoreceptors most sensitive?
 - A. low PO₂
 - B. high PCO₂
13. As a result of chemoreceptor activity what would you predict would be the response of the respiratory center in the brain?
14. It appears from the results of Marsha's hematocrit, that she may have polycythemia. Explain how this could be a compensatory effect for her condition.

Part III: The Sleep Study



[reproduced with permission from the American Physiological Society, Levitsky, M., Advances in Physiology Education, 2008]

The above recordings are taken from a normal polysomnogram (left) and a recording with a 20 second interval of sleep apnea (right). EEG, electroencephalogram; EMG, electromyogram; ECG, electrocardiogram; BP, arterial blood pressure; Abd, abdominal motion; Chest, rib cage motion; Vt, air flow. Note that abdominal and rib cage motion are in phase during breathing on left recording. Following the 20 seconds of apnea (right recording) the patient is aroused enough to resume breathing.

1. What change occurred to the blood pressure during sleep apnea?
2. What change occurred to the heart rate (ECG) during sleep apnea?
3. What change occurred to the oxygen saturation of the blood during sleep apnea?
4. The “diving reflex” may be induced during apneic events. This means that bradycardia is initiated while diving in a pool as a means of limiting cardiac oxygen demand to the heart.
Do you see evidence of this reflex in this person’s ECG recording?
5. Note that both abdominal and chest or rib cage movements are made during apnea but are not “in phase”. How do you interpret this finding?
6. How would you explain that abdominal and chest movements continue yet there is no air flow to the lungs?
7. Which system of the body is activated in order to arouse the body?
 - a. sympathetic
 - b. parasympathetic
8. Normally, the system of the body activated during arousal would ____ heart rate.

- a. increase
 - b. decrease
9. With arousal, the patient would
- a. hyperventilate
 - b. hypoventilate
10. Do you see any changes in the EEG or brain waves during the 20 seconds of apnea?
If so, why would this change occur? _____ -
11. In children who die suddenly in their sleep under the age of 1 year old (SIDS or Sudden Infant Death Syndrome), the research suggests that possibly there are abnormalities in the brainstem of these infants such that normal stimulation of the medulla oblongata which controls breathing is not functioning. Perhaps the brain is not responding to signals given by the chemoreceptors to increase the breathing rate. Looking at the EEG pattern in this individual does the brain seem to be responding to the low oxygen or high carbon dioxide signals of the chemoreceptors?
12. Apnea causes a rise in pulmonary resistance – vasoconstriction of the pulmonary capillaries in the area low in oxygen. Which chamber of the heart would enlarge as a result pumping blood against the high resistance of the vessels in the lungs?
- a. right ventricle
 - b. left ventricle
11. Marsha's blood pressure as recorded by her doctor at 135/95 mm Hg is
- a. normotensive
 - b. hypertensive
 - c. hypotensive
12. Research studies have indicated that there is an association between sleep apnea and cardiovascular disease. Based on the findings above, what indications do you have that this is occurring?
13. Draw a graph with time on the horizontal line (about 1-60 seconds) and breathing movements on the vertical axis showing tidal volume around 500 ml and vital capacity about 4500 ml. Draw a line to show the results you would expect for a healthy student, using inhalation as an upward deflection of the line and exhalation as a downward deflection of the line. Using a normal breathing rate of about 15 breaths per minute or 1 breath per 4 seconds. Now draw a second line on the same graph showing what the graph might look like for a person with 20 seconds of sleep apnea somewhere in the middle of the time line.

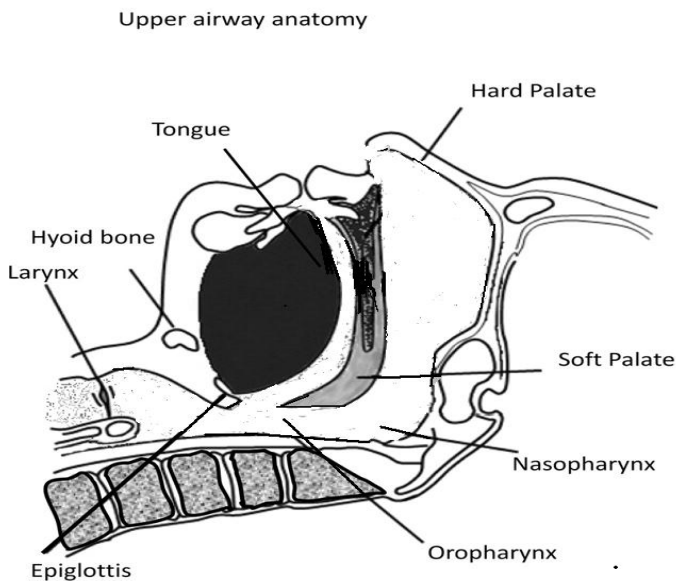
Part IV: The Remedy: The CPAP

Marsha finally conceded that, in order to achieve a good night's sleep, she was willing to try the CPAP equipment. Anna, a respiratory therapist visited her at home and brought a mask with pieces called "pillows" which fit into her nasal openings and which covered her mouth as well. Martha said to Anna "I don't know how I will ever get used to wearing this and actually sleep, but I will give it a try". Anna replied "although it may take a couple of months, you will eventually find that you sleep more peacefully than before".

Marsha did try and after a period of about a month and a half she found that she actually missed wearing it if she fell asleep without it. She would wake up and reach for the hose. "I find the sound of the air passing through the hose to be rather calming" she told her husband. "I think that this will work out well for me."

CPAP stands for **continuous positive airway pressure** and this piece of medical equipment as a means to alleviate the symptoms of obstructive sleep apnea.

1. By using an arrow on the diagram below, show how continuous positive airway pressure removes the obstruction to air flow in the pharynx region. Show the pathway of the air under pressure.



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2. The force which normally inflates the lungs (Think of Boyle's law) is

- a. negative pressure
- b. positive pressure

3. Does the CPAP change the force by which the lungs normally inflate?

- a. yes
- b. no

4. Which part of the airway system is not held open by rings or plates of cartilage?

- a. trachea
- b. bronchi
- c. terminal bronchioles
- d. alveoli

5. A person with asthma, an obstructive lung disease, also experiences a blockage in the airways. In which part of the airway system is the blockage due to asthma? Due to sleep apnea?

Asthma obstruction _____ where and due to what _____

Obstruction in sleep apnea _____ where and due to what _____

Reference:

Levitzky MG. Using the pathophysiology of obstructive sleep apnea to teach cardiopulmonary integration. *Adv Physiol Educ* 32:196-202, 2008.

6. Fill in the flow chart below using the sleep apnea event as the start. Indicate hypoventilation, rise in $p\text{CO}_2$, hyperventilation, stimulation of peripheral chemoreceptors, response of respiratory center in the brain, and any other parameters to respond to the sleep apnea.

