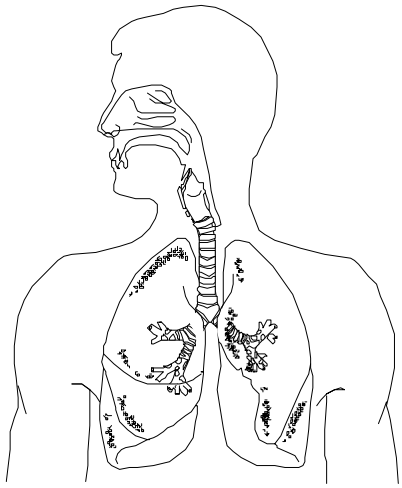
Pittsburgh EMS Pre-Hospital Care Monograph



$$CO_2 + H_2O \leftrightarrow H_2CO_3 \leftrightarrow H^+ + HCO_3^-$$

Hyperventilation

This monograph is dedicated to the professional men and women of Pittsburgh EMS.

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November 1998
C:/Hyperventilation

Hyperventilation
Syndrome versus Sign of something more serious

Quite often, we are called upon to care for somebody who is reportedly hyperventilating. As Paramedics, we have been taught that hyperventilating is a "psychological problem", and the treatment includes calming and reassuring the patient, and having them breathe into a paper bag. We have not been taught how to differentiate between hyperventilating and the Hyperventilation Syndrome. We commonly see the two as the same disorder. Have we been making accurate assessments of the condition, or simply dismissing the disorder as an anxiety attack?

> **The truth is that 50% of the patients that have been treated as Hyperventilation Syndrome are actually hyperventilating for reasons other than an anxiety disorder. Treating them as Hyperventilation Syndrome could have dire consequences.**

Definitions

The 1997 version of Taber's Cyclopedia Medical Dictionary defines hyperventilation as: Increased minute volume ventilation which results in a lowered carbon dioxide (CO2) level in the blood (hypocapnia). It is a frequent finding in many disease processes such as asthma, metabolic acidosis, pulmonary embolism, and pulmonary edema, and also in anxiety-induced states. This is usually accompanied by marked anxiety." Other definitions include, "Overbreathing to the extent to eliminate CO_2 at a rate faster than it is produced by the body." and, "A patient who is breathing too rapidly and too deeply." These definitions lead to a lot of confusion, and contribute to misdiagnosis of a patient 's condition.

Recent research shows that hyperventilating and Hyperventilation Syndrome are two markedly different disorders.

- **Hyperventilation** is a sign that can be observed in patients with a variety of medical disorders.
- **Hyperventilation Syndrome** is a clinical diagnosis.

Hyperventilation can be the result of various medical disorders, whereas Hyperventilation Syndrome is usually an end result of a severe "Anxiety Attack", or "Panic Attack". As late as 1992, published treatment protocols for Paramedics have included having the patient breathe into a paper bag. This has proven to be of little or no help, and recent research shows that it could indeed be very dangerous.

Pathophysiology

To understand the differences between hyperventilation and hyperventilation syndrome, it helps to understand the pathophysiology involved. In the acute situation, hyperventilation produces a rapid decline in arterial CO_2 and a rise in pH. Decreased CO_2 stimulates the "fight or flight" response. The acid-base balance becomes more alkaline (respiratory alkalosis). Decreased CO_2 also stimulates the smooth muscles to contract, leading to decreased cerebral and coronary blood flow. As the arterial CO_2 continues to fall, and stored CO_2 is released from the cells, intracellular alkalosis develops. The kidneys increase the excretion of bicarbonate (HCO_3). The negatively charged HCO_3 ion is balanced with the positively charged Magnesium (Mg) in the urine. Deficiency of Mg causes the kidney cells to produce Hydrogen (H^+) ions to balance the HCO_3. The end result is intracellular acidity, extracellular alkalinity which then pushes the body to hyperventilate. This is a vicious cycle.

Respiratory System

The effect of hyperventilation on the respiratory system is primarily on the blood buffer system. Seventy percent of the carbon dioxide present in the blood is carried as a bicarbonate ion (HCO_3). The overall reaction for the bicarbonate formation occurs as follows:

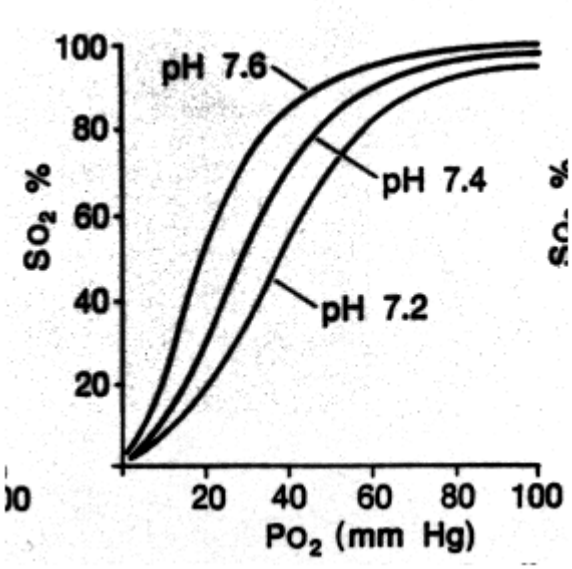
$$\mathbf{CO_2 + H_2O \longleftrightarrow H_2CO_3 \longleftrightarrow H^+ + HCO_3^-}$$

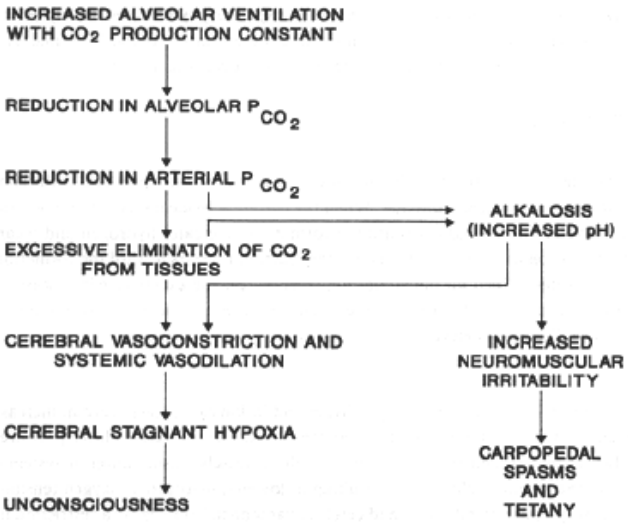
The major influence determining the direction in which the above reaction proceeds is the concentration of CO_2 in the blood, or partial pressure of carbon dioxide. When the carbon

dioxide levels in the blood increase, the reaction proceeds to the right, toward the formation of greater hydrogen and bicarbonate ions. When the carbon dioxide level decreases, the reaction reverses toward the formation of carbon dioxide and water. When an individual hyperventilates, the excessive elimination of carbon dioxide causes a reduction in the hydrogen ion concentration that is too rapid for the blood buffer system to replace. The pH is elevated and a respiratory alkalosis ensues.

Cardiovascular System

Hyperventilation causes tachycardia, increased cardiac output leading to decreased systemic vascular resistance and mean arterial pressure. Hyperventilation also causes vasoconstriction of the cerebral and coronary arteries. The constriction of the cerebral arteries combined with decreased systemic resistance causes a decrease in cerebral blood flow, which in turn causes various symptoms (dizziness, blurred vision, feeling of impending doom, anxiety, etc.) The reduced coronary blood flow results in lowered myocardial O_2 tension. The oxyhemoglobin dissociation curve is shifted upward and to the left (the Bohr effect). This shift increases the capacity of the blood to on-load O_2 on the lung level, but restricts the off-loading of the O_2 at the tissue level. The combined effect of restricted blood flow and increased O_2 binding results in hypoxia in the brain and heart (which could lead to unconsciousness).





The effects of hyperventilation.

If CO_2 elimination exceeds the body's production of CO_2, the arterial CO_2 falls. Given the constant rate of CO_2 production, an increase in CO_2 elimination leads to a decrease arterial CO_2, known as Hypocarbia.

Nervous System

Hyperventilation and the resulting elevated pH cause an increased sensitivity and irritability of neuromuscular tissue. This increase in pH is manifested by tingling and numbness of the extremities and mouth, and muscular spasm and tetany. The tingling usually precedes muscular spasm and tetany. The hands and feet may exhibit carpopedal spasm Carpopedal spasm is involuntary muscular contraction of the hands and feet. It can be caused by hypocalcemia and is commonly encountered during hyperventilation because the lowered carbon dioxide alters the level of ionized calcium.

Muscle spasm usually occurs when the $PaCO_2$ is 20mm Hg or less (normal $PaCO_2$ is 40mm Hg). In more severe hypocapnia, with the $PaCO_2$ <15mm Hg, the whole body stiffens (tetany) due to contraction of skeletal muscle.

ABG Review

Normal PaO_2: 75-100mm Hg

Normal PO_2: 100mm Hg

Normal $PaCO_2$: 35-45mm Hg

Normal PCO_2: 46

Normal pH: 7.35-7.45

In a patient who is hyperventilating, the arterial O_2 can increase to 120mm Hg, and the $PaCO_2$ can decrease to <35mm Hg. Carpopedal spasm occurs with a $PaCO_2$ 15-20mm Hg. The pH can increase to >7.45. In a patient with chronic hyperventilation a near normal pH but abnormal arterial CO_2 may be present.

Causes of Hyperventilating

Hyperventilating may be the result of various causes. Remember 50% of the patients that we see that are tachypnic (rapid respiration) and/or hyperpnic (deep respiration) are hyperventilating from causes other than anxiety. Hyperventilating may be the result of: fever, medications (ASA, thiazide diuretics), pulmonary embolus, pain, metabolic acidosis (DKA, uremia, sepsis), CNS disorders (meningitis), renal failure and dialysis, diarrhea, vomiting, liver failure, brain lesions (CVA, tumors, trauma), cardiac problems (AMI, CHF, MVP, PAT), respiratory problems (COPD, asthma (especially pediatrics), pneumothorax), inhaled or ingested toxins (methanol, amphetamines, cocaine, sniffing glue), hypoxia, and finally anxiety.

When all the medical causes can be eliminated, only then is a diagnosis of Hyperventilation Syndrome made. As Paramedics, we cannot check the pH or ABGs of a patient, therefore, in most cases, it is impossible for us rule out all medical causes of hyperventilating. In <u>some</u> situations, we can make educated guesses that a person's hyperventilating is the result of anxiety, or a "panic attack", but we cannot make that determination in <u>all</u> patients who present with tachypnea or hyperpnea. We must remember to be vigilant in looking for other causes of the hyperventilating.

Current Treatment of Hyperventilation Syndrome

It used to be thought that calming, reassuring, and having a hyperventilating patient breathe into a paper bag was the proper treatment. Only part of that form of treatment is correct. Due to the increased O_2 binding in the blood, breathing into a paper bag is contraindicated and supplemental O_2 is needed. At the same time calm and reassure the patient, as you attempt to learn the cause of the hyperventilating. Although it has not been addressed here, the signs and symptoms of hypoxia are quite similar, and it is difficult to distinguish between the two.

Therefore, the treatment should be the same. Remember, as Paramedics, we can only make a tentative diagnosis of Hyperventilation Syndrome, and not a definitive diagnosis.

Treatment

- Check ABCs, lung sounds, and begin to calm and reassure the patient.
- Obtain a Pulse-Ox as early as possible. Hypoxia can cause hyperventilating.
- Start the patient on supplemental O_2.
  Additional oxygen is not going to increase the arterial CO_2 to normal, but it may help overcome the Bohr effect (O_2 binding) and deliver more O_2 to the cells and tissues. The symptoms seen with hyperventilation syndrome are not due to an excess of oxygen, but secondary to a decreased carbon dioxide level.
- Encourage the patient to breathe normally. Encouraging a patient to take slow deep breaths will only continue the hyperventilating, as they may switch from tachypnea to hyperpnea. Still the patient needs supplemental oxygen.
- Place the patient on a cardiac monitor. Remember that some very dangerous heart conditions can cause the patient to hyperventilate.
- Attempt to find the cause of the hyperventilation, and treat it appropriately. In diabetic patients, obtain a Chem-Strip, as Diabetic Ketoacidosis can cause hyperventilation.

If the above measures do not reverse or alleviate the hyperventilating, consider a hidden cause that needs to be evaluated at the hospital, and transport the patient.

Special Considerations

Pediatric asthma patients may not present with wheezing, they may present with only tachypnea that was preceded by an episode of coughing.

Diabetic Ketoacidosis may present with tachypnea, as the body attempts to regulate the acid-base balance.

The most common sign of pulmonary embolus is tachypnea. Chest pain that is indistinguishable from angina may also be present.

Liver failure may present with tachypnea due to shunting of venous blood to arterial blood, and further complicated by unusual circulating metabolites due to malfunction of the liver.

Myocardial infarction may present with tachypnea due to increased levels of catecholamines. Also, hypoxia can stimulate ventilation and induce respiratory alkalosis.
In cases like uremia, sepsis, and shock, acid production is increased and may cause tachypnea. This is similar to DKA discussed earlier.
Bicarbonates are depleted in chronic renal insufficiency, diarrhea, vomiting, and the use of thiazide diuretics. Acute changes in plasma bicarbonate levels may not be immediately reflected in the brain, causing hyperventilation that persists for a time in uremia after plasma acidosis is corrected by dialysis.
Use of stimulants (amphetamines, cocaine, and even caffeine), as well as the ingestion of methanol, can cause tachypnea.
Head trauma and CVAs can cause tachypnea.
An aspirin overdose may lead to tachypnea.
Hyperventilating may precipitate seizures and asthma attacks.

Summary

Hyperventilation, as in tachypnea and hyperpnea, is a clinical sign, and not a diagnosis. Hyperventilation Syndrome is a clinical diagnosis of a collection of signs and symptoms that is made after **all other causes of tachypnea and hyperpnea have been eliminated.**
Paramedics need to be alert in looking for the cause of hyperpnea and tachypnea, and not to dismiss the signs as a psychological disorder or panic attack. We must be aware that we cannot usually eliminate **all** the causes that may lead to a person's rapid and/or deep respiration. Therefore, we should treat these patients as having potentially serious medical conditions.

Scenarios

Scenario 1

EMS is called to care for a 20-year-old male, who fell from a loading dock. The man fell about 9-10 feet, resulting in a fracture to the left femur. Exam shows ABCs to be intact, an obvious fracture to the left mid-shaft femur. The patient has not tried to look at his leg. No other sign of injury is noted on exam. A co-worker tells you that they each had two beers at lunch a half an hour ago. You and your partner explain to the patient that you will need to immobilize his leg with a traction splint, as it appears to be fractured. You cut away the patients pants leg, and he suddenly becomes anxious, and tachypnic when he sees his leg. Your partner tries to calm and reassure the patient, but it has no effect. The patient becomes extremely anxious, tachypnic, repeatedly stating that he can't breathe, and gasping for breath.

1. At this point what should you assume has happened to your patient?
    A. Nothing, he's just panicking at the sight of his broken leg, and hyperventilating.
    B. He's had more to drink than his co-worker stated, and he is intoxicated.
    C. He's thrown an embolus that has lodged in his lung.
    D. He's becoming unreasonable in reaction to the increased pain.

2. What is the next step in treatment?
    A. Place an O_2 mask on the patient without supplemental oxygen to help him retain O_2.
    B. Continue with immobilization, but hold off on the Nitrous, as he is intoxicated.
    C. Apply O_2, then rapid immobilization and transport to the hospital.
    D. Restrain the patient, then continue with immobilization.

The correct answer is 'C' for both questions. In long bone fractures sometimes a embolus of fat finds it's way into the blood stream, and then to the lungs. This is one type of Pulmonary Embolism. The appropriate treatment is high flow O_2, and rapid transport to a trauma center. This is truly a **Life Threatening** condition. Sometimes during childbirth, an embolus of amniotic fluid finds it's way into the blood stream. This also results in a pulmonary embolism.

Scenario 2

You are called for a 63-year-old female. She states that she is short of breath, and experiencing chest pain. Exam shows that she appears very anxious; skin color and temperature is normal and dry; lungs are clear and equal. The First Responders have placed the patient on O_2 @ 4 l/m by cannula. Her vital signs are P-124, strong/regular, R-32 regular/normal, B/P-112/54, SpO_2 @ 100%. She states that onset of the pain and dyspnea was when she learned that her 14-year-old nephew had taken the car for a "joy ride". You attempt to calm and reassure the patient, but have little effect. The patient is becoming more anxious, stating that she needs more oxygen, and is becoming agitated with your efforts to calm her. She does not allow you to obtain an EKG reading, and states "It's obvious that you are not going to take care of me!" at which point she gets up, goes to the family car, and her husband drives her to the hospital.

1. What is happening with the patient?
    A. She is hyperventilating, and unreasonable.
    B. She is abusing the system, and only wants sympathy.
    C. She needs to be placed on Xanax.
    D. Unknown, the exam has not been completed.

2. What are some possible conditions/complications with this patient?
    A. She could be having a MI.
    B. She could be suffering from coronary vasospasm.
    C. She could be experiencing Hyperventilation Syndrome.
    D. All of the above

The answer is 'D' for both. A thorough exam needs to be completed before any tentative diagnosis can be made. It is possible that this patient is indeed experiencing Hyperventilation Syndrome, but that tentative diagnosis cannot be made without ruling out all other causes. This patient could be having a Myocardial Infarction, or suffering from a coronary spasm, or an overdose of her medication. One thing to remember, coronary spasms can themselves cause hyperventilating, and hyperventilating can produce a coronary spasm. It's like the "chicken or

the egg" argument, which comes first? Hyperventilating most certainly does not help alleviate a coronary spasm though.

Continuing Education Quiz

1. The simple act of hyperventilating, in a patient with normal lungs, can increase the arterial O_2 to or above _____mm Hg.
   A. 80
   B. 100
   C. 150
   D. 200

2. Which of the following is (are) true?
   A. Administering supplemental oxygen to a patient that is hyperventilating significantly lowers the arterial CO_2 and should be avoided.
   B. Having a patient breathe into a paper bag is the proper initial treatment for hyperventilation while attempting to determine the underlying cause.
   C. Pediatric asthma patients may not present with wheezing, they may present with only tachypnea.
   D. All of the above.

3. Hyperventilation Syndrome is a conclusion based on rapid respiratory rate and:
   A. Presence of carpopedal spasms.
   B. Dizziness and numbness of the hands and feet.
   C. Elimination of more serious conditions.
   D. Carpopedal spasms with seizures.

4. Confusion, agitation, or combativeness, in the presence of respiratory distress, can be associated with:
   A. Medication overdose.
   B. Pneumonia.
   C. Hypoxemia.
   D. Hyperventilation Syndrome.
   E. All of the above.

5. Hyperventilation may be precipitated by:
   A. Pulmonary embolism
   B. Pain
   C. Stimulants
   D. Head trauma
   E. All of the above

Name_____ Date_____ Con Ed #_____

Please circle the correct answers and return this answer sheet to the Training Division.

1. A B C D

2. A B C D

3. A B C D

4. A B C D E

5. A B C D E