NATIONAL CENTER FOR CASE STUDY TEACHING IN SCIENCE

Water Can Kill?
Exploring Effects of Osmosis

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Part I – Three True Stories

Case 1: Jennifer Strange [1,2]

Jennifer Strange was a 28-year-old mother of three who entered a radio contest to try to win a Nintendo Wii game system for her children. As part of KDND's "Hold your wee for a Wii" contest, Jennifer drank bottle after bottle of water for hours without urinating.

Initially, Jennifer seemed to be having fun, joking lightheartedly with the radio hosts and obligingly downing an 8-ounce bottle of water every 15 minutes. As the hours passed, however, she developed a splitting headache and dizziness. Finally, she couldn't take it anymore and ran to the bathroom and vomited.

Jennifer called her boss to say that she was going home for the day because her headache was excruciating and she was too sick for work. Jennifer's mother found her that afternoon, dead in her home.

Case 2: Cassandra Killpack [3]

After a 3 ½-week trial, a jury found Jennete Killpack, 29, guilty of killing her 4-year-old adopted daughter Cassandra by forcing approximately a gallon of water down the girl's throat in an attempt to discipline her.

A few hours after the "hydro-discipline," the Killpacks called the paramedics because Cassandra was unresponsive. The paramedics delivered her to the hospital, where she died later that day. Medical investigation found that Cassandra's brain was swollen and the concentration of sodium in her blood and tissues was far below normal.

Case 3: James McBride [4]

James McBride, a 25-year-old police officer, died after a 12-mile bike ride that was part of a training course. Over the course of the ride, James drank roughly three gallons of water that he brought with him in a pack.

During a session that focused on how to dismount a bike, an instructor noticed that McBride looked ill and asked him to sit down. McBride complained of dizziness and nausea, and then vomited. Officers initially thought he might have suffered heat stroke. Unaware that James had already consumed so much water, they gave him more water to cool him down while he sat out of the exercise.

When another officer hurt himself during the exercise, an ambulance was summoned. The paramedics noticed that James was convulsing and continuing to vomit, so they brought him to the hospital. He died in the hospital the next day.

Questions

1. What sort of environment (hypertonic, isotonic, hypotonic) does consuming excessive amounts of pure water create in the body fluid that surrounds your cells? What effect would this have on your cells?
2. What types of symptoms did Jennifer, Cassandra, and James have in common? Which organ or tissue seems to have been most affected?
3. Keeping in mind your answers to questions 1 and 2, what do you think the immediate cause of death was for Jennifer, Cassandra, and James?
4. If you suspected that a patient's symptoms were caused by the condition suffered by Jennifer, Cassandra, and James, what kinds of test would you run to confirm your suspicions?
5. Once you knew the cause of their symptoms, what kind of emergency treatment might you try for a patient like Cassandra or James if you were the doctor in charge of their care?
6. Why do you think doctors administer a saline solution instead of pure water to dehydrated patients?

References

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3. Split verdict surprises and stuns the Killpacks. *Deseret News*. October 13, 2005. http://www.deseretnews.com/article/630152910/Split-verdict-surprises-and-stuns-the-Killpacks.html.
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Part II – Facts about Hyponatremia

Jennifer, Cassandra, and James died due to a condition known as hyponatremia—a sodium imbalance in the body fluid and cells. More details are given on the Hyponatremia Fact Sheet.

Questions

1. During periods of intense activity, your body releases an antidiuretic hormone called vasopressin that causes the body to retain water (by decreasing the amount of water that is expelled in urine). Why does this make endurance athletes particularly vulnerable to developing hyponatremia?
2. What might put desert-dwellers in danger of developing hyponatremia? How can they avoid this danger?
3. Babies and small children are at much greater risk for developing hyponatremia than adults. Why is this?
4. Just how much brain swelling are we talking about? The volume of a human brain is normally about 1,200cm^3. The concentration of solutes in the cerebrospinal fluid (the fluid that surrounds the brain and other parts of the central nervous system) is normally about 300mM.
    a. Normally, what is the concentration of solutes in your brain cells? Please explain your reasoning.
    b. If the concentration of solutes in the cerebrospinal fluid fell to 280mM due to overconsumption of water and loss of electrolytes through sweating, what would happen?
    c. Estimate how much the brain would swell due to osmosis if the concentration of the cerebrospinal fluid fell to 280mM. In other words, find what the new volume of the brain would be once equilibrium was reestablished. Assume that (i) the cerebrospinal fluid is constantly replenished, so its solute concentration won't change; (ii) only water is passing across the cell membranes into brain cells (not solutes); and (iii) the volume of the brain is mostly water.

Hyponatremia Fact Sheet

Source: The following information is from the article "Hyponatremia" in A.D.A.M. Medical Encyclopedia*, April 14, 2013, at http://www.ncbi.nlm.nih.gov/pubmedhealth/PMH0001431/.*

Hyponatremia is a metabolic condition in which there is not a high enough concentration of sodium in the body fluid surrounding cells.

Causes, Incidence, and Risk Factors

Sodium is found mostly in the body fluids outside of cells (though there is some sodium inside of cells). When the concentration of sodium in the body fluid drops, this creates a hypotonic environment outside of cells; this results in water moving into cells, causing them to swell. Most cells in the body can handle slight swelling, but brain cells cannot because they are confined by the skull bones. Brain swelling (pressing the brain tissue against the skull) causes most of the symptoms of hyponatremia.

Hyponatremia is the most common electrolyte disorder in the United States. Causes include burn, congestive heart failure, diarrhea, excess urination (due to a diuretic), kidney diseases, liver cirrhosis, excess sweating, and vomiting.

Symptoms

Common symptoms of hyponatremia include confusion, decreased consciousness, hallucinations, coma, convulsions, fatigue, headache, irritability, loss of appetite, muscle spasms or cramps, muscle weakness, nausea, restlessness, and vomiting.

Signs and Tests

The following laboratory tests can be done to confirm hyponatremia:

- Comprehensive metabolic panel, including blood sodium concentration.
- Osmolality blood test (which checks the concentration of solutes in the blood).
- Osmolality urine test.
- Urine sodium test.

Treatment

If an underlying condition is causing the sodium/water imbalance, then treating the underlying condition may correct the imbalance.

Depending on the exact cause of the hyponatremia, treatments may include administering a saline solution through an IV, temporarily restricting water intake, and/or providing medications to relieve the symptoms.

Expectations/Prognosis

The outcome depends on the condition that is causing the problem. Acute hyponatremia, which develops in under 48 hours, is usually more dangerous than hyponatremia that develops slowly over a period of days or weeks (chronic hyponatremia).