NATIONAL CENTER FOR CASE STUDY TEACHING IN SCIENCE

Hell's Bells!

Misuse of Jimson Weed *(Datura stramonium)* and Anticholinergic Intoxication

by
Ann T. Massey
Department of Biology
The University of Virginia, Charlottesville, VA

Part I – Presentation

A mother brought her 15-year-old son to the emergency department (ED) of their local hospital because of bizarre behavior, including what seemed to be hallucinations. The mother had been advised by a neighbor that several local youths had also been taken to the hospital after ingesting wild flowers and then exhibiting similar alarming behaviors. She found some flowers and seeds in her son's bedroom and brought them with her.

In the ED, the patient was restless, shaking, and pacing incessantly. His vital signs (see Table 1, next page, for normal values) included:

- *Oral temperature:* 99.3 °F
- *Blood pressure:* 153/77 mmHg
- *Heart rate:* 154 beats per minute
- *Respiratory rate:* 24 breaths per minute

Pupils were dilated. Mucous membranes were dry. Bowel sounds were decreased. Extremities were warm to the touch.

Results for a toxicology screen were negative for alcohol, benzodiazepines (anti-anxiety drugs like Valium® and Xanax®), amphetamines (stimulants like those found in diet pills or in drugs used to treat ADHD), marijuana, opiates (narcotic pain relievers) and phencyclidine.

"Aha!" said the physician, Dr. Wilkinson, on seeing the flowers and seeds. "Jimson weed!" (See Figure 1 below.)

Figure 1. Jimson weed (*Datura stramonium*). A flower, leaves, and seed pods are seen on the left; a closeup of the characteristic spiky seed pod with seeds is seen on the right. *Credits:* © Kagab4 | Dreamstime.com, ID 288769431; © Anastasiia Malinich | Dreamstime.com, ID 195581371.

Table 1. Normal vital signs for adults.*

Vital Sign	*Value*
Temperature	97.8 °F to 99.1 °F (36.5 °C to 37.3 °C)
Blood Pressure	90/60 mm Hg to 120/80 mm Hg
Pulse	60 to 100 beats per minute
Respiratory Rate	12 to 18 breaths per minute

*Adapted from Cleveland Clinic, <https://my.clevelandclinic.org/health/articles/10881-vital-signs>.

Questions

1. What do we know about this patient?

2. What do we need to know?

3. Physicians use the responses of various organs systems to make conclusions about what might be wrong with a patient. List some of the organ systems that are providing information about what is wrong with this boy (refer to your list of "what do we know" in your answer to Question 1 above).

4. What is Jimson weed? (Other names include thornapple, mad apple, hell's bells, and angel trumpets.) Why do you think the physician in the ED needs to know what plant this is? (You might find the National Poison Control website helpful: https://www.poison.org/.)

Part II – Acetylcholine and Anticholinergics

"These kids will put anything into their bodies to try to get high," said Dr. Wilkinson. "A lot of these plants have compounds that are anticholinergic."

"Anti-what?" asked the boy's mother.

"Anticholinergic. It means that these compounds block the ability of acetylcholine, a neurotransmitter that nerve cells use for communication, to work on different target cells. Acetylcholine tells muscle cells to contract, which lets you move your body. It works a little differently at organs in the body so they can function correctly. This blockade has lots of effects in some organ systems, and we can see them in your son. Some people might hallucinate or feel high, which is why they eat the plants."

The mother replied, "I'm afraid I don't understand. Do you mean that the nerves can't communicate with the rest of the body? It looks to me like there's too much communication. He's so upset, and so hot!"

Dr. Wilkinson responded, "Well, you're partly right. It might be better to say that when acetylcholine can't work, other neurotransmitters get out of balance. That's what brings about some of the symptoms that we see in organs like the heart and gut. That's why we measure vital signs like heart rate and blood pressure."

Dr. Wilkinson is describing the activity of the *somatic* nervous system, which innervates skeletal muscle, and the *autonomic* nervous system, which innervates smooth muscle in most airways, blood vessels and hollow organs, glands, and cardiac muscle. Acetylcholine is a neurotransmitter that is found in both systems.

Questions

5. (a) Complete the "ball-and stick" schematic in Figure 2 (below) to compare the structure of the autonomic and somatic nervous systems. You can use the image for the somatic nervous system as an example. The colored circles represent the cell bodies of the motor neurons that are found in the brain or spinal cord. The effectors are shown at the right of the figure: skeletal muscle for the somatic nervous system, and smooth muscle, cardiac muscle, and glandular tissue for the autonomic nervous system. Draw the neurons and synapses that are necessary for impulses to reach the autonomic effectors in both sympathetic and parasympathetic divisions of the ANS. Be sure you identify the neurotransmitter that is being released any place there is communication between cells. *Note:* the diagram shows only motor or efferent pathways to the effectors.

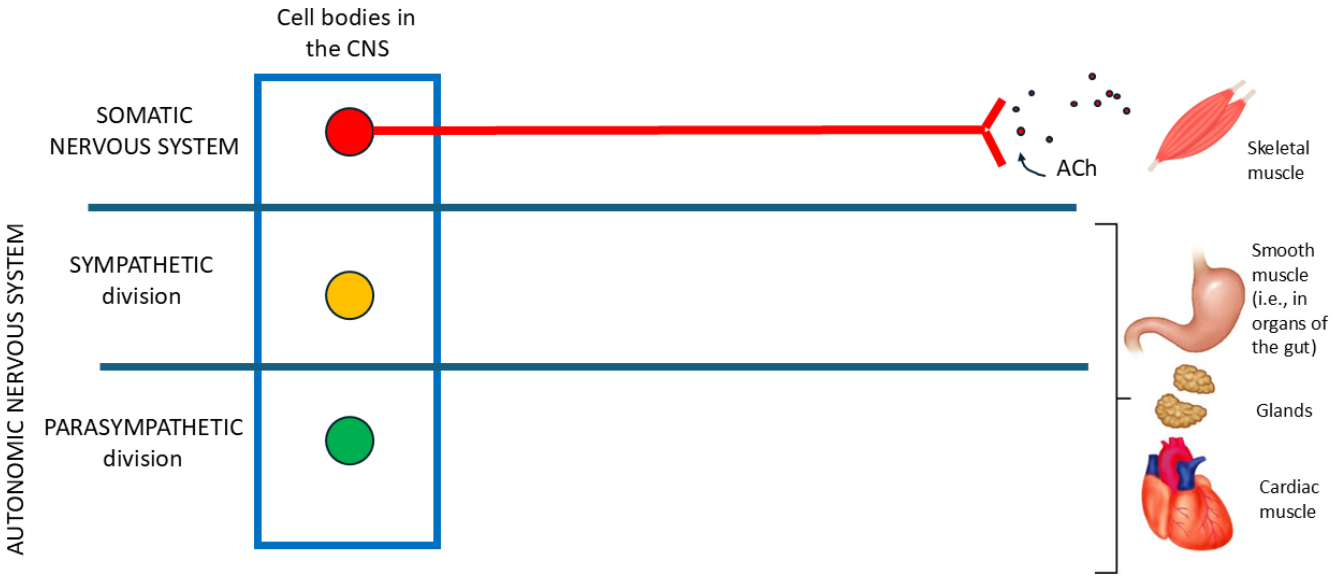

Figure 2. A schematic that compares the motor pathways to effectors in the somatic and autotomic nervous systems.

(b) How do you classify the receptors that are responding to these neurotransmitters? Use at least two descriptors: *cholinergic* vs. *adrenergic; muscarinic, nicotinic, alpha,* or *beta.*

(c) Complete Table 2 (below) with descriptions of the somatic and autonomic motor pathways.

Table 2. A summary of the motor pathways of the somatic and autonomic nervous systems.

	Somatic Nervous System	*Autonomic Nervous System*
Motor output pathway: how many neurons and synapses?		
Neurotransmitters in the motor pathway		
Effectors		

6. Where are receptors for acetylcholine found in the body? (Are they associated with a particular region or division of the nervous system?)

Part III – Autonomic Tone

"Oh, I think I'm starting to understand," said the mother. "So it's like a balance between good neurotransmitters and bad neurotransmitters, is that right? So when there is more good neurotransmitter, the body is normal, but sickness happens when there's not enough good neurotransmitter?"

"Hmmm," replied Dr. Wilkinson, "I don't usually think of anything in normal healthy people as being good or bad. Maybe think about it as neurotransmitters that produce activity and action, and neurotransmitters that produce rest and relaxation."

"So, is there a place where it's just right? Like Goldilocks? Not too much activity, not too little activity, just the right amount?"

"I think you're starting to get the hang of this," said Dr. Wilkinson with a smile.

"Autonomic tone" is the state of balance between the sympathetic and parasympathetic divisions of the autonomic nervous system. In organs that are innervated by both sympathetic and parasympathetic neurons ("dual innervation"), the effects tend to oppose each other. The baseline activity, or the activity of an organ or gland at rest, tends to reflect activation by both divisions. The hypothalamus can increase or decrease the sympathetic or parasympathetic activity as needed (for example, sympathetic activation is increased when a person experiences a threatening situation, and parasympathetic activation is increased after a meal). Generally, when the activation of one division is increased, the other division appears less active.

Dual innervation with opposing responses means that the autonomic nervous system can provide fine control of the activities of organs and glands. By comparison, the somatic nervous system has less ability to control muscle contraction.

Table 3 (next page) represents the effects of both sympathetic and parasympathetic activation of some selected effectors.

Questions

7. A "fight or flight" response is seen when the sympathetic nervous system is highly activated following a frightening stimulus. Using Table 3 (next page), what kinds of responses would you expect to see in the effectors listed in the table?

8. Could any of the signs observed by the physician (recorded in your answer to Question 1) be the result of anticholinergic compounds acting at target cells? Which ones and why?

Table 3. Effects of autonomic activity on selected effectors.*

EFFECTOR	*SYMPATHETIC STIMULATION*		*PARASYMPATHETIC STIMULATION*	
	Receptor	*Effect*	*Receptor*	*Effect*
Eyes / pupils				
Radial muscle of iris	α1	Contraction of the muscle produces dilation (mydriasis)		
Sphincter (circular) muscle of iris			Muscarinic	Contraction of the muscle produces constriction (miosis)
Ciliary muscle	β2	Relaxation for far vision	Muscarinic	Contraction for near vision
Heart (ventricle)	β1	Increased heart rate; increased contractility (force of contraction); increased rate of conduction of electricals signals	Muscarinic	Decreased heart rate; decreased rate of conduction of electrical signals
Arterioles				
Skin	α1	Constriction		No innervation
Kidneys	α1	Constriction		
Skeletal muscle	α1, β2	Constriction(α1); relaxtion (β2)		
Airways (smooth muscle)	β2	Bronchodilation	Muscarinic	Bronchoconstriction; increased secretions (like mucus)
GI tract organs (stomach and intestine)	α1, α2, β2	Decreased motility and tone; sphincter constriction	Muscarinic	Increased motility and tone; sphincter relaxation; increased secretion from digestive glands
Urinary bladder	α1, β1	Constriction of the urinary sphincter; relaxation of the smooth muscle wall of the bladder	Muscarinic	Relaxation of the urinary sphincter; contraction of the smooth muscle wall of the bladder

*Adapted from:

McCorry, L.K. (2007). Physiology of the autonomic nervous system. *American Journal of Pharmaceutical Education* 71(4): 78. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1959222/>

Tortora, G., & B. Derrickson. (2018). The autonomic nervous system. In *Principles of Anatomy and Physiology,* 15th ed., pp. 526–47. John Wiley and Sons. ISBN-13: 978-1-119-32064-7.

Part IV – The Antidote

"So, the anticholinergic compounds in the plants are preventing…," Dr. Wilkinson started. At that moment, his pager went off.

"Stay right here," the doctor continued. "I need to check on another patient who's having a problem. I'll have the pharmacy prepare the antidote medication and we should have your boy back on his feet shortly." He ran out of the exam room to take care of a patient in cardiac arrest.

Questions

9. What was the doctor going to say about the anticholinergic effects of the plants? Write out his response about the role of acetylcholine to the boy's mother.

10. Which of the agents in Table 4 (below) could be the "antidote medication" that the doctor is going to administer? Why?

Table 4. Possible antidotes?

Medication	*Action (What does it do to receptors in the body?)*	*Is this a possible antidote?*
Physostigmine (Antilirium®)		
Atropine (Atro-Pen®; Atropine Care®)		
Epinephrine		
Pseudoephedrine (Sudafed®)		