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Approach to Pediatric Toxicology and Ingestions

Developed by Breanne Paul and Dr. Andrea Robb for PedsCases.com.
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Introduction

Hi there, my name is Breanne Paul and I am a rural family medicine resident at the University of Alberta. This PedsCases podcast was developed with the help of Dr. Andrea Robb, a pediatric emergency medicine physician and Assistant Clinical Professor at the Stollery Children's Hospital and University of Alberta in Edmonton, Alberta, Canada.

Today's podcast will focus on an introduction to pediatric ingestions and pediatric toxicology. By the end of this podcast, I hope that you will:

1. Recognize common toxidromes
2. Develop an initial management approach to pediatric ingestions
3. Discuss appropriate investigations for pediatric ingestion presentations

Remember, each child and their toxicological presentation is unique. The purpose of this podcast is to provide an overview of toxicology and ingestions in young children. For more information about specific presentations and ingestions, check out some of the other content on PedsCases.com

Case

Let's start with a case. You are a senior medical student working a shift in your local emergency department. Your next patient is a 3-year-old female, Wren, brought in by her father. Grandma is visiting from out of town and was watching Wren and her younger brother while mom and dad were out for dinner. Grandma was cleaning up and found Wren playing in the spare bedroom. Wren had opened the old pill bottle that Grandma uses for medications while she travels. Grandma doesn't know the names of all the pills she takes or how many were in the bottle.

Grandma takes medication for her high blood pressure and cholesterol, and also for when her heart flutters and beats really fast. She has diabetes and has been on

metformin for a long time. She takes a medication for heartburn and for her knee pain from osteoarthritis. They think the pain medicine is Tylenol but they're not sure.

Now what?

Toxidromes

Before we dive into the approach, we'll review four major toxidromes, and their respective signs, to provide some context for the future discussion. By considering changes in vital signs, level of consciousness, pupils, bowel sounds, and skin condition, many ingestions can be differentiated into different toxidromes.[1] A toxidrome is a constellation of findings, based on these signs, in the context of an ingestion. The purpose of classifying ingestions into one of these toxidromes is to provide a framework for investigation and management, based on the likely toxin. Four main toxidromes are **sympathomimetics**, **sedative/hypnotics**, **anticholinergics**, and **cholinergics**.[2]

Sympathomimetics increase sympathetic tone and drive a "fight or flight" response.[2] They speed the body up. Imagine someone about to fight - they are tachycardic, hypertensive, sweaty and agitated, with large reactive pupils. Drugs like cocaine and methamphetamines are sympathomimetics.

Opposite of sympathomimetics would be sedative/hypnotics, including opioids.[2] These slow the body down. These drugs can cause respiratory depression, bradycardia, hypotension, small or "pinpoint" pupils, and a decreased level of consciousness. Examples of substances that fall into this class include opioids like codeine and fentanyl, and others like benzodiazepines and ethanol.

Anticholinergic medications reduce parasympathetic tone by competitively inhibiting acetylcholine at its muscarinic receptors.[3] This leads to a similar constellation of symptoms to sympathomimetics with some differentiating features, such as large unreactive pupils and dry skin. The anticholinergic toxidrome is classically referred to as the "Alice in Wonderland" toxidrome[3]. The symptoms can be remembered with a mnemonic: *hot as a hare, red as a beet, dry as a bone, full as a flask, mad as a hatter, and blind as a bat*. They become hot because the toxin stops them from sweating. Their skin then becomes red and flushed due to cutaneous vasodilation as a means to try and dissipate that heat. They are dry because they stop sweating and body secretions are reduced; thus, they are also "full" with urinary retention as both the detrusor muscle and urethral sphincter are under muscarinic control. The "mad as a hatter" comes from muscarinic blockade in the CNS which leads to delirium, hallucinations, and anxiety. Finally, the "blindness" is caused by pupillary dilation and ineffective accommodation which leads to blurry vision. Many drugs have anticholinergic effects, including antihistamines and tricyclic antidepressants.

On the contrary, cholinergic ingestions enhance parasympathetic input so they slow everything down and can increase bodily secretions.[4] This can be remembered by a couple mnemonics: the Killer Bs (bradycardia, bronchorrhea, bronchoconstriction) and SLUDGE (salivation, lacrimation, urination, defecation, GI upset, emesis). A classic example of a cholinergic toxin is organophosphate pesticides.

Keeping these toxidromes in mind, we will now review the initial approach in the context of a known ingestion. Remember that co-ingestions are common, and that many single drugs will have mixed effects, so not all ingestions will fit nicely into one toxidrome.

General Approach: ABCDE + Antidote

Like with any patient, your assessment begins at the door and should always start with vitals and the ABCDEs. The primary assessment of a toxicology patient is similar to the classic primary survey of any other patient,[5] which is covered in previous PedsCases episodes and elsewhere. Despite being discussed sequentially, aspects of the primary survey, secondary survey, history, and initial investigations often occur simultaneously, if possible. As early as is practical, your local poison control center should also be consulted, as needed, to assist with assessment and management.[2]

There are a few key additions to the classic primary assessment when dealing with ingestions. The classic ABCDEs remain the same: airway, breathing, circulation, disability, and exposure. Remember, don't forget to check the glucose as part of your assessment for disability. In toxicology, we also add an extra D, an extra E, and an antidote.[5] The extra D stands for decontamination and the extra E stands for enhanced elimination. Lastly, is the consideration of an antidote, if a known antidote for the ingestion exists. An overview of decontamination, enhanced elimination, and antidotes will be discussed next.

While the mainstay of toxicologic management is good supportive care, decontamination, enhanced elimination, and antidotes are options to be considered based on the individual presentation. Decontamination refers to the removal of a substance to prevent further absorption and subsequent harm.[5] As is summarized in Bryant and Singer, the method of decontamination is specific to the route and substance involved.[5] For example, ocular toxins can be irrigated with saline, while clothing containing dermal toxins should be removed. Gastrointestinal decontamination comes in a few flavours. Activated charcoal binds toxins and prevents bioavailability. However, it does not work for a number of substances, works best immediately following ingestion, and is dangerous if aspirated. Whole-bowel irrigation is another method of gastrointestinal decontamination, which has the patient use polyethylene glycol until there is clear effluent per rectum. One benefit of whole bowel irrigation is that it may be effective beyond the window of activated charcoal. Other methods of decontamination that can be employed include multidose activated charcoal, gastric lavage, and surgery. Further details regarding specific decontamination methods will not

be discussed further in this podcast as decontamination is complex and the choice to use decontamination is subject to many factors. To reiterate, not all patients require decontamination. If decontamination is used, the method should be carefully chosen based on patient characteristics, the substance involved, and when and how the exposure occurred. Poison control is available to guide practitioners on the appropriate use of decontamination, including selecting which patients would benefit from decontamination.

The purpose of enhanced elimination is to accelerate the removal of a toxin, in order to reduce the clinical effects of the ingestion.[5] Like decontamination, enhanced elimination is not always necessary, or possible, and depends on the patient, the substance, and the circumstances of the ingestion. Multidose activated charcoal can be used, but is only effective for toxins that recirculate in the enterohepatic circulation. Alkalinization of the urine is another method which can be used, typically for salicylates such as ASA. Hemodialysis can also be used for some toxins, including toxic alcohols, salicylates, and some anti-epileptics. Again, details regarding specific methods of enhanced elimination will not be covered further in this podcast.

Antidotes can be employed if the toxin is known and an antidote exists.[5] Antidotes work in a variety of ways and the method of action is specific to that toxin-antidote pair. One example of an antidote is naloxone for opioid overdose. Naloxone is an opioid antagonist and displaces the opioid on the mu receptor, thereby reversing its effects. If the toxin is unknown, but specific clinical features are present, a trial of an antidote can be attempted in consultation with poison control.[2] For example, many practitioners would give a dose of naloxone in a patient presenting with a sedative/hypnotic toxidrome and respiratory depression.

Back to the case: Wren is sitting on dad's lap. It's late and she's tired and cranky. He moves over to the bed while the nurse places her on monitors, collects a full set of vitals, and inserts a large-bore IV. She got quite upset with the IV insertion but was easily consoled by dad. He tells you that Wren was found with the pill bottle over an hour ago. On initial assessment, Wren is awake and looks tired, but is interactive. She is maintaining her airway with a respiratory rate of 24 and a saturation of 99% on room air, with good air entry bilaterally and no work of breathing or adventitious sounds. Her heart rate is 110 with a blood pressure of 102/62. Her precordial exam is within normal limits with no extra beats or murmurs. Her capillary refill is one second and her peripheral pulses are equal bilaterally. Wren's GCS is 15/15 and her pupils are equal at 3mm and reactive. Her deep tendon reflexes are 2+ and symmetric, with no clonus, and she has normal strength and sensation to all 4 limbs. Her point of care glucose is normal. As you move through exposure, you notice no rashes or other injuries, and her skin looks well-perfused. Her temperature is normal. As the identity of the substance is not yet known and Wren is currently asymptomatic, further decontamination, enhanced elimination, and the provision of an antidote are deferred until further information can be gathered.

Secondary Assessment

Similar to other presentations, a thorough assessment of a poisoned patient includes a history and focused physical exam. The history is vital to your overall management of an ingestion. This can be sought from a caregiver or someone present at the scene of the ingestion who can communicate any information about pill bottles, etc. In addition to the SAMPLE history, focused questioning around the ingestion is helpful.[5] Obviously, knowing what, when and how much of a substance was taken is significant. As many toxins have a dose-dependent relationship, the exact quantity should be sought. If the exact quantity is unknown, the maximum possible ingestion should be assumed. For example, if there were previously 5 pills in a bottle, and now there are 3, assume 2 were ingested, even though that may not be the case. The amount of time that has passed since the ingestion is also important. Keep in mind that in some substances, the effects are immediate, while in others, the effects are delayed. The amount of time since ingestion is also helpful as it may help decide what, if any, methods of decontamination, enhanced elimination, or antidotes are available. Route of exposure is important as most ingestions are oral; however, inhalation, ocular, and dermal are also possible. It is also helpful to know if the ingestion was accidental, as is common in younger children, or intentional, which is more likely in the adolescent age group.

The purpose of the focused physical exam is to assess for any other injuries or conditions a patient may have and to gather more information about the ingestion to aid in your management. For ingestions, signs to pay particular attention to, in addition to the vital signs, are the eyes (including pupillary size and response to light), bowel sounds, and skin condition.[1] Deep tendon reflexes and hypertonicity are also important.[1] While they are not part of the classic toxidrome, they are useful in certain ingestions, such as serotonergic medications. These signs are important because they help differentiate between toxins and will help you decide what further management is necessary.

Applying this to our case, we already know that Wren is alert and oriented and her vitals are normal, including her respiratory rate, oxygen saturation, heart rate, blood pressure, and temperature. Her pupils are equal and reactive and her bowel sounds are present. Her skin looks well perfused and she is not diaphoretic. She is not hypertonic.

On further discussion with dad, he states that Wren was found at least 90 minutes ago with the open bottle. Grandma had all her pills mixed in a bottle so they aren't sure what, if anything, Wren took. Mom and Grandma are en route with Grandma's medication list but haven't arrived yet. There were no other open bottles or cupboards when they found Wren playing in the bedroom. Therefore, you order initial investigations:

Initial Investigations

Like your exam and history, the purpose of investigations is two-fold: to identify potential ingestions and to determine the severity of clinical effects. Many toxins cannot be tested for or quantified in a timely fashion. As such, a "tox screen" isn't useful acutely; instead, investigations are used to act as data points in the overall clinical picture.

A point of care glucose should be done in all patients with a potential ingestion, as hypoglycemia is a potentially life threatening complication and glucose can help differentiate between potential ingestions.[2] Similarly, an ECG should be ordered on all patients to screen for certain toxins.[2] The ECG can guide you with respect to the toxidromes using the heart rate, but certain toxins also have classic ECG findings. For example, sodium channel blockers, like tricyclic antidepressants and local anesthetics, can cause a wide QRS and a prolonged QT. While these findings are not specific to these substances, finding these abnormalities in the right clinical context would indicate that a significant ingestion has occurred and requires immediate treatment to prevent ongoing toxic effects.

A venous or arterial blood gas should be ordered as acid-base status and lactate are relevant in multiple ingestions.[2] Electrolytes, whether serum or from the blood gas, are also used to calculate the anion gap and osmolar gap. A high anion gap metabolic acidosis is found in multiple toxins, including toxic alcohols, iron, and salicylates. The osmolar gap can then be calculated to screen for toxic alcohols. Many toxins are metabolized in the liver so liver enzymes should be ordered to screen for both acute hepatotoxicity and toxicity that occurs later in the course of the ingestion, like in a Tylenol overdose.[2] Some ingestions, in and of themselves, will alter the INR and PTT, such as some anticoagulants, but coagulation is also affected by severe liver damage. Likewise, many toxins require adequate renal function for clearance and can cause acute kidney injury, so assessing creatinine and urea is indicated.[2] As ethanol, ASA, and acetaminophen ingestions are common, and results are often readily available, they should be ordered in all undifferentiated toxicologic patients.[2] Remember, an acetaminophen level is only interpretable 4 hours after an ingestion using the Rumack-Matthew nomogram, so the timing of ingestion must be considered. This is by no means an exhaustive list of all the potential investigative findings or the corresponding substances; however, offers a reasonable starting point.

To summarize the investigations, all patients should have a point care of glucose, and an initial ECG, in addition to bloodwork. For bloodwork, a VBG and other basic labs should be obtained, including creatinine, sodium, potassium, urea, liver enzymes, coagulation studies (INR, PTT), ethanol level, ASA level, and acetaminophen level. Other tests may be included, as clinically indicated.

In Wren's case, her ECG is unremarkable. This is reassuring and makes sodium-channel blockers, like tricyclic antidepressants, less likely. Her point of care glucose is

normal, making beta-blockers, calcium channel blockers, and insulin secretagogues unlikely. Her VBG is also normal, which makes a salicylate or toxic metformin ingestion less likely. Her other labs are pending.

Mom and Grandma arrive at this time, visibly distraught, but carrying the pill bottle with all of Grandma's medications in it and her medication list. It's difficult to tell how many are missing as some of them are taken more than once per day. She did recently switch from regular Tylenol to Tylenol 3s for her arthritis.

Based on Wren's asymptomatic picture, it is difficult to tell what she took, if anything. However, it is important to assume she did ingest one of the pills and observe her for a safe period of time until all medications on Grandma's list are expected to have reached their serum peak and cause any expected clinical effects.[5] Her remaining labs are reported: her CBC, creatinine, electrolytes, liver enzymes, and coagulation studies are normal. Her ASA, acetaminophen, and ethanol levels are also normal. At this point, you still don't know if she took a pill, and if she did, what it was. After a period of safe observation based on the medications on Grandma's list, and teaching around the proper storage of medications, Wren is discharged home.

Prevention

Ingestions in children are an important source of injury. They occur in a bimodal distribution, with the first peak occurring in toddlers, as children begin to interact more with their environment, and then later in adolescence, often as intentional ingestions.[5] Prevention is key. For younger children, a number of factors contribute to accidental ingestions, including improper storage of substances and medications, increasing mobility and curiosity, and transient caregiver distraction.[5] When the child is stable, this should be discussed with the caregivers, with the goal being education and preventing future ingestions.

Review

Now that we've addressed the case, let's review some important points:

- Toxidromes are a constellation of signs that can help narrow down a potential toxin, and inform investigation and management
- Four major toxidromes include sympathomimetics, sedative/hypnotics, anticholinergics, and cholinergics. These can be differentiated by considering changes in level of consciousness, vital signs, pupillary size and response, bowel sounds, and skin condition
- The resuscitation priorities in an ingestion are the same as any other patient, the classic ABCDEs, with a few additional features specific to toxicology: decontamination, enhanced elimination, and an antidote.

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- Investigations for undifferentiated ingestions should include: a point of care glucose, an ECG, in addition to blood work. Lab work usually includes a VBG, glucose, creatinine, sodium, potassium, urea, liver enzymes, ethanol level, ASA level, and acetaminophen level. Additional tests, such as a CBC and coagulation studies, are often ordered if clinically appropriate.
- Accidental ingestions in toddlers are caused by a number of factors, including improper storage of substances and medications, increasing mobility and curiosity, and transient caregiver distraction. Prevention is key to reducing these events.

That brings us to the end of this PedsCases podcast on pediatric ingestions. Thanks for listening, and stay tuned for more PedsCases!

References

1. Kloss B. Approach to the poisoned patient [Internet]; 2020 Nov 3 [cited 2020 Nov 30]. Available from https://litfl.com/anticholinergic-toxidrome/
2. Mangus C, Canares TL. Toxic ingestions: initial management. Peds in Review. 2018;39(4):219-221. DOI: 10.1542/pir.2017-0119
3. Kloss B. Anticholinergic toxidrome [Internet]; 2020 Nov 3 [cited 2020 Nov 30]. Available from https://litfl.com/anticholinergic-toxidrome/
4. Helman A, Austin E, Sayal A, Petrosoniak A, Swaminathan A, May N. EM quick hits 2 – organophosphate poisoning, TXA for hemoptysis, metacarpal fracture rotation, abdominal stab wounds and pediatric IV cannulation [Internet]. Emergency Medicine Cases; 2019 Feb [cited 2020 Nov 30]. Available from https://emergencymedicinecases.com/em-quick-hits-february-2019/
5. Bryant S, Siger, MD. Management of toxic exposure in children. Emerg Med Clin N Am. 2003;21:101-119.

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