NATIONAL CENTER FOR CASE STUDY TEACHING IN SCIENCE

Rolling Through the GI Tract

by

Nalini V. Broadbelt[1], Janvi Patel[2], Alexys Fonseca[3], and Laura Pickell[4]

[1]School of Arts and Sciences, MCPHS University
[2]College of Optometry, Pacific University
[3]School of Physician Assistant Studies, MCPHS University
[4]Department of Health Sciences, Carleton University

Part I – Bad Food?

It was a sunny day in May and Janvi opened the windows to let the fresh air into the house. She decided it was time to begin her spring cleaning. She finally had a day off without her five-year-old son Arin, so she wanted to take advantage of every second. Janvi was dancing around her kitchen when she was interrupted by her phone ringing. As she picked up her cell phone, she realized the call was from the daycare center her son attended. Miss April, his teacher, told Janvi that Arin had been complaining about his stomach hurting shortly after the daily playtime and afternoon snack session. "Not another flu!" she thought to herself; Arin had already brought home several infections from daycare this year. She quickly changed, grabbed the thermometer, and drove to the daycare.

Janvi picked up Arin and as she walked to the car, she asked him how he was feeling. He said, "Not so good, Mama." At the car she took his temperature, and the reading was 97.3 °F, no fever. She wondered if it was just something he ate. Throughout the car ride home he kept repeating "tummy hurts," then he began to cry and scream. He was now doubled over in pain, holding his belly. "This can't be good. I've never seen him in so much pain," Janvi thought. Feeling very worried, she decided not to take a chance and pulled back onto the highway to take him to the North Shore emergency room (ER). As she drove, she wondered if Arin had eaten something spoiled or if it was a new food allergy.

Janvi tried questioning Arin on the ride to the ER, but as his pain seemed to worsen, she began to feel frantic. What did he eat!?

Questions

1. Which organ(s) in Arin's body might be responsible for his pain?

2. Based on your response, consider the roles these organs—and others in the gastrointestinal (GI) tract—play in digestion. Using the word bank provided below, match each structure to its correct function.

   Word bank:

   a. Esophagus
   b. Stomach
   c. Oral cavity
   d. Small intestine
   e. Pharynx
   f. Large intestine

   ____ Mechanical digestion starts here; food enters and then as a response saliva is secreted from the salivary glands and a bolus forms.

   ____ Arrange in order the letters that determine how ingested material would reach the stomach.

____ Part of the alimentary canal that connects throat to stomach which allows the bolus to be transported.

____ It is divided up into three continuous regions, duodenum, jejunum, and ileum and most of the chemical digestion occurs here.

____ Links the oral cavity with the esophagus.

____ Primarily absorbs water, electrolytes, and vitamins. Partly digestive food then becomes feces which exit through the anus.

____ The bolus is mixed with secretions and acid allowing chyme to be formed.

3. If Arin's stomach pain is related to abnormal gastric secretions or dysfunction of specific gastric cells, what might be the underlying cause? Using your knowledge of the cell types in the stomach and their secretions, analyze how an imbalance (overproduction or underproduction) of any of these substances could contribute to Arin's symptoms.

4. What substances would be digested in Arin's stomach?

5. If what Arin ingested continued past his stomach to exit the body:
   (a) On Figure 1 (next page), number and label the structures in anatomical order that food would pass through from the stomach to the anus. Be sure to include both the parts of the small intestine and the parts of the large intestine, including flexures.
   (b) Circle and label three major sites where sphincter muscles control the movement of food.

6. To allow for the sequential movement of material through the digestive tract, Arin's digestion depends on coordinated contractile activity regulated by the myenteric plexus, which is a key component of the enteric nervous system responsible for controlling GI motility. Different regions of the GI tract exhibit specialized patterns of contractions to propel and mix food effectively during digestion.
   (a) Based on Arin's digestive journey, identify which organ(s) of the GI tract is primarily responsible for each of the following types of motility:

   - mixing or peristalsis waves and retropulsion:
   - swallowing:
   - segmental contractions:
   - peristalsis:
   - haustral churning and mass movement:

   (b) Which tunic (serosa/adventitia, muscularis, submucosa, mucosa) of the GI wall would be responsible for these movements?

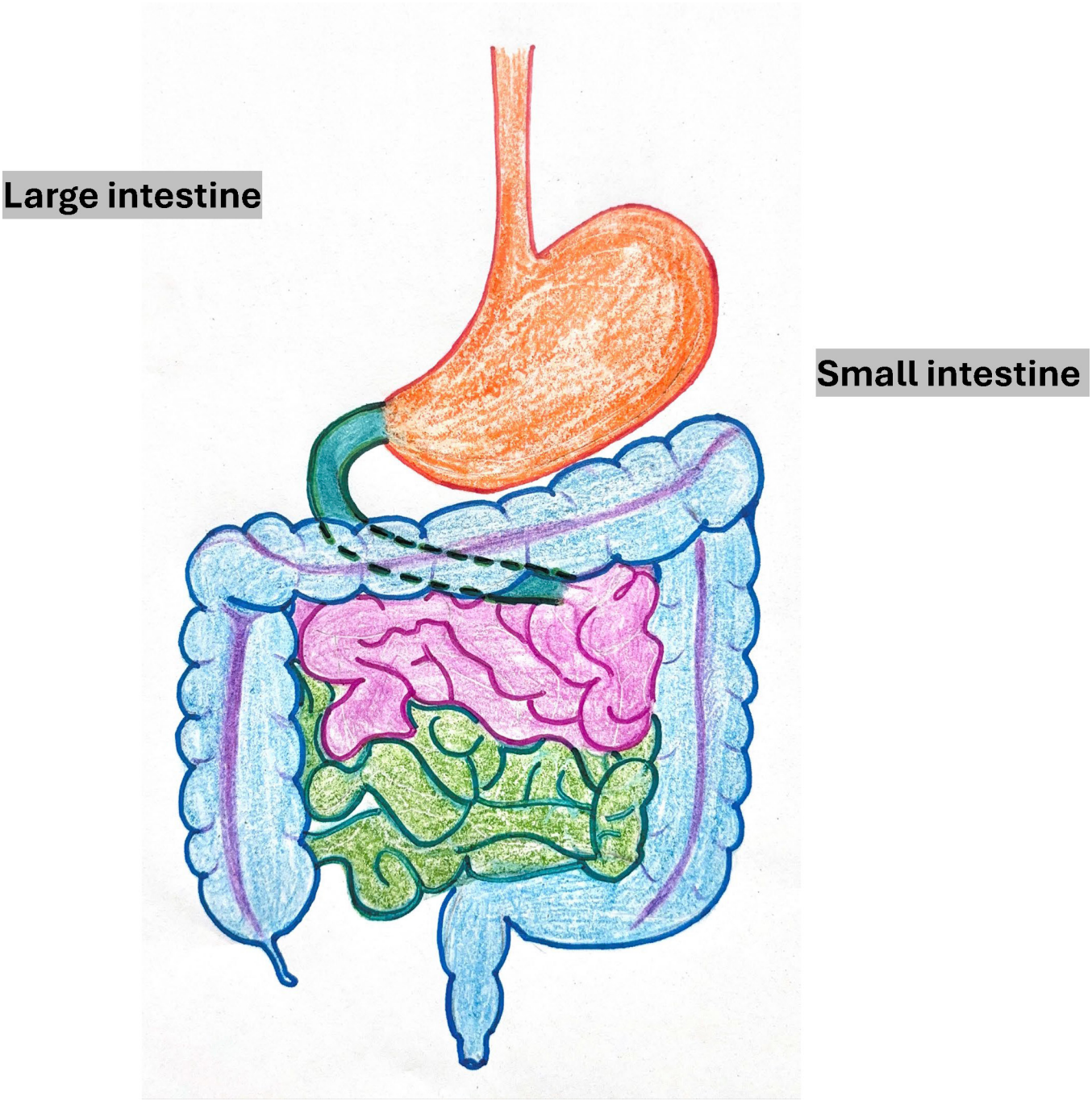

Figure 1. Digestive tract.

Part II – Blockage and Backup

At the ER, Sara, the nurse practitioner, gently placed Arin on the examination table and asked Janvi what had happened. Janvi explained and Sara noted that the pain seemed intermittent as Arin had now quieted down as she began her examination. She palpated the region that Arin mentioned hurt and discovered a lump in the abdominal region, in the right lower quadrant (RLQ). She suspected that Arin had swallowed a small object. It was common with preschoolers and would be the third case that month. Sara sent Arin for an X-ray of his abdominal area. As Arin waited to be prepped for the X-ray, Sara chatted with Arin to ease his fear and distract him from the pain.

"What daycare do you go to?"

"BrightStars," replied Arin slowly.

"Who is your favorite teacher?"

"Anthony of course!" said Arin, warming to the topic. "He's the best, not like the girls. He runs and wrestles with us."

Sarah laughed. "So, you like playing with the boys and not the girls. You know girls are super cool."

Arin wasn't convinced. "Only the girls in my family. The rest are mean!"

"So are you saying I'm mean?" asked Sarah, feigning surprise.

"No, no..., you taking care of me. You are nice. You can be part of my family."

Sarah smiled. "I'm honored. What happened at play time today?"

"I was digging a hole to China." Lowering his voice, Arin then whispered, "I saw Maya hiding marbles yesterday. I was looking for them on my way to China."

"So you're like a spy. Did you find them?" asked Sarah.

Arin gave her a big smile and nodded.

"What happened to the marbles?" she continued.

"They looked like little gumballs, all sticking together. I pulled them apart and eat them. They didn't taste so good. Yuck!"

"How many marbles?" asked Sarah.

Arin put four of his fingers up as the X-ray technician indicated he was going to start the process. Sarah googled the size of the marbles. They were about 13 mm in diameter.

From the X-ray and based on the conversation with Arin, Sarah observed that the three magnetic marbles that clung together were at the junction between the small and large intestine. The fourth had partially perforated the jejunum wall, trapped by the serosa. Arin was immediately referred to the emergency gastroenterologist, Dr. Fonseca.

Questions

1. What is the junction between the small and large intestine called? Why were the marbles likely to be stuck at this junction and not at the cardiac or pyloric sphincters? (*Hint:* what structural difference exists between these sphincters?)

2. As in Arin's case, what would occur if the ileocecal junction remained blocked for a prolonged period? Table 1 below outlines potential consequences. For each, identify the underlying cause and list some resulting outcome(s).

   Table 1. Potential consequences of prolonged blockage of the ileocecal junction.

Cause	*Consequence*	*Outcome (s)*
	Backup of intestinal contents	
	Small intestine bacterial overgrowth	
	Inflammation or infection	
	Ischemia or necrosis	

3. Given the partial perforation of Arin's jejunum, in what order did the magnetic ball pass through the intestinal tunics before becoming lodged in the serosa? If a complete perforation were to occur, what would be the pathophysiological consequences?

Once Arin's transfer to Dr. Fonseca was complete, Sarah went to the nursing station for her scheduled lunch break. As she sat outside eating, she thought back to a couple of cases she had experienced last year that were like Arin's.

The first involved a four-year-old boy, Kaden, who had received a Sky magnet kit for his fourth birthday. His older brother Shawn and Kaden had a squabble over the toy, and Kaden decided to hide it. When Shawn asked Kaden where the toy was, Kaden smiled and said, "You'll never find it!" This joy was short lived. Later that evening Kaden complained of a stomachache. It was dismissed as something that "would pass," but the pain worsened. His father, John, took Kaden to North Shore hospital. A blood test was conducted on Kaden, and the results were normal. The X-ray of his abdominal area revealed a "string of pearls" in the intestine. The magnetic beads had stuck together. Kaden had swallowed the 36 beads in the kit. 14 partial-thickness perforation was determined within the small intestine. Kaden required surgery, and a part of the small intestine was removed.

The second case involved a young girl, Kali. Two-year-old Kali had discovered the Buckyball that contained hundreds of small magnetic balls on Mom's office desk. When the abdominal pain started Kali's parents scheduled a doctor's appointment but then decided to take her to North Shore ER to rule out appendicitis. An X-ray showed a bracelet-like "string of pearls" structure in the abdominal region. Kali had swallowed 24 of the magnets that linked together in her intestine, creating partial-thickness perforation in the small intestine. "Thankfully we were at the ER, and Kali immediately got the surgery. They took out a foot of her small intestine and repaired the 'holes'," Dad stated.

A week after being discharged, both children started losing weight.

Questions

4. Why was it important to repair the "holes" in the small intestine immediately?

5. Why were the children losing weight after the surgery?

6. Assuming the major and minor duodenal papilla openings were unaffected, what nutrient absorption would be affected by a shorter small intestine?

7. What anatomical features allow the small intestine to effectively perform its function of digestion and absorption?

8. Suppose the balls had made their way into the colon, and perforation occurred in this region. Which nutrient absorptions would be affected by this perforation?

Part III – More Tests

Dr. Fonseca knew that prolonged obstruction would result in major complications. Arin was scheduled immediately for surgery to remove the marbles and repair the jejunum. Janvi waited nervously in the waiting room as Arin underwent surgery. She couldn't believe that it had come to this and that something as silly as swallowing some marbles could be so dangerous. Dr. Fonseca interrupted her thoughts, approaching her from the surgical room, "Everything went as planned and we have removed the marbles. We used a "milking technique" and did a non-surgical intervention that successfully allowed us to gently push the three marbles from the ileocecal junction into the colon and collect them. The fourth marble we collected via an assisted mini-laparoscopic technique. Minimal down time for recovery, one week at most. Arin tolerated the surgery well and we do not expect any complications at this point." Janvi breathed a sigh of relief.

Dr. Fonseca checked back in on Arin 24 hours later as she did with all her patients but noticed that Arin was not recovering the way she would expect for such a young and healthy body. Arin was nauseous, with knees drawn to his chest during episodes of pain, and when she looked at his chart, a nurse had recently noted that he had red "currant jelly" stool. Knowing this sign was not good, Dr. Fonseca immediately ordered a panel of tests for Arin indicating they were high priority. Shortly after, Dr. Fonseca received Arin's results, which were urgently sent to her from the hospital lab. The lab had flagged some abnormal results that were concerning.

Table 2. Arin's test results.

Test	*Normal*	*Arin's*
Calprotectin stool test	49 µg/g or less	122 µg/g
Occult blood, stool	less than 2 to 3 mg/gm	4.6 mg/gm
Hemoglobin	11.5–13.5g/dL	10.2 g/dL
Hematocrit	34–40%	28%

Questions

1. What is the purpose of each test in Table 2 above? Explain.

2. A nurse observed that Arin had red "currant jelly" stool. What does this finding typically indicate in a patient like Arin, given his age?

3. Based on Arin's test results, what must have occurred for his stool to appear red?

4. What may have occurred for Arin's stool to have a "jelly" consistency?

5. What cells in the large intestine are responsible for mucus secretion?

6. What additional tests would be necessary to confirm the proposed underlying condition?

Part IV – Intussusception

After reviewing the test results, Dr. Fonseca discussed her findings with Janvi. She explained that Arin's stool contained blood and elevated levels of mucus, both indicative of intestinal inflammation. During the physical examination, Dr. Fonseca palpated Arin's abdomen and detected a distinct, sausage-shaped mass, which is a classic sign of intussusception. Notably, the mass was located in the right lower quadrant (RLQ). Based on this clinical finding, she ordered an abdominal X-ray, which confirmed the diagnosis: a telescoping of the intestine consistent with intussusception.

Janvi understood how her son had eaten marbles and caused a blockage, but intussusception was another matter. "How could this have happened?" she asked.

Dr. Fonseca replied, "The cause is not known, although some studies indicate a viral infection or recent surgery can lead to intussusception."

"So it seems we fixed one problem, and another arises…," sighed Janvi.

Dr. Fonseca explained, "The small intestine has folded like a telescope, sliding into a neighboring segment. In about 80 to 90 percent of cases, this happens at the junction between the small and large intestines. The X-ray confirms that the ileum has telescoped into the cecum. As a result, just like with the marbles we talked about, the passage of food is blocked."

Janvi was feeling overwhelmed. "Does he need another surgery!?"

"Not unless the blood supply gets cut off, bowel tissue dies, or infection arises. I don't believe surgery will be necessary," reassured the doctor.

"So what happens next?" asked Janvi.

"We'll monitor and continue to keep Arin comfortable for the next few days to allow bowel healing from the first procedure, then perform a therapeutic enema. We'll give Arin IV fluids to stay hydrated and maintain electrolyte balance." Seeing Janvi's expression, she added, "He'll be playing outside in no time."

Five weeks later Arin was back home in his yard, healthy, happy, and digging a hole to China.

Questions

1. Why is a therapeutic enema often effective in treating intussusception in young children like Arin?

2. What primary risks are associated with this procedure?