

A Pain in the Gut: A Case Study in Gastric Physiology

by

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Part I – The Accident

Frank was driving home after a long day at work. It was late and he was having problems driving in the dark with so much traffic. He was forced to take a detour and felt tired, so he took another sip of soda.

“What would I do without sugar and caffeine?” he mumbled to himself.

Frank realized that he should probably stop the car as he noticed his hands begin to shake, but he continued anyway. Rounding a corner he realized that he was having trouble focusing on the road. He tried to blink away the blurriness and shook his head, but things did not change. In an instant, the car slipped off the road and hit a tree.

“What was that?” exclaimed Frank to the night air.

He quickly got out of the car and checked himself out. Other than the shock of the accident, Frank seemed to be okay. He pulled out his cell phone and called his wife, Stacey, to come pick him up. He then called to report the accident to the police and his insurance agent.

His wife arrived about an hour later and looked very concerned when she saw Frank sitting in the police car.

“Why aren’t you going to the hospital?” screamed Stacey. “Were you drinking again?”

“I’m fine, and no I wasn’t drinking. Check with Sergeant Eversman if you don’t believe me. I lost focus; it’s been a long day and my vision’s a little off. This is too much stress. Please, I just want to go home.”

They drove home, but Stacey continued to badger Frank about going to the hospital.

Questions

1. List Frank’s physical problems.
2. What do you think is causing Frank’s blurred vision?
3. With the above physical problems in mind, what do you speculate about Frank’s condition?

Part II – The Checkup

“Good morning Frank, what can I do for you today?” asked Doctor George.

“I was in a car accident last night. I’m fine, but I thought I would see you before I leave for my business trip this afternoon. I guess it’s better to be safe than sorry.”

“I’m glad you came to see me. I can always squeeze in my old college roommate even though you dropped biology for a business degree.” Both men smiled. “Your blood work should be here soon. Have you managed to cut down on your drinking and smoking?” asked the doctor.

“Old habits die hard, I’m afraid,” admitted Frank. “I still smoke occasionally, but I have really cut down on the drinking. In fact, I was drinking soda last night; the breathalyzer test was negative for alcohol, as I knew it would be. I don’t know what came over me. I was tired after a long day. I was driving home and ended up wrapped around a tree. I can’t believe this happened,” Frank sighed.

“I believe you Frank, but our blood work isn’t looking for alcohol,” the doctor responded. “Besides being tired, how did you feel while you were driving? Was there anything abnormal that you noticed?”

“Well, the thing that surprised me was my vision. I have had great vision my whole life; it runs in my family. But recently my vision has been blurry, and last night it got to the point where I couldn’t see the lanes of the road—and, well, you know the rest,” explained Frank.

“You mentioned it was a late night. Did you eat or drink anything?” asked the doctor.

“Just the typical stuff I always have when I’m tired. I stopped for a couple of candy bars and a refill of my large soda, just to stay awake. I have been really stressed lately and I am finding it very difficult to cope, so I usually stop at the convenience store on the way home from work.”

“Was it diet soda?”

“No, I can’t drink that stuff,” responded Frank.

”So, how is your vision now?”

“My vision is okay now. After the accident, I went home and went to bed. I woke up a little earlier than usual, but I feel fine now,” mentioned Frank.

The nurse came in and gave the doctor the results of the blood tests.

Table 1 – Frank’s (Fasting) Blood Test Results

	<i>Normal</i>	<i>Frank</i>
<i>Blood glucose (mg/dL)</i>	70–130	165
<i>Blood insulin (IU/mL)</i>	5–10	1

“Is there something wrong?” asked Frank.

“Your blood glucose levels are above normal. Are you sure you didn’t eat or drink before the blood test this morning?”

Frank shook his head.

“I am concerned because it’s been more than 12 hours since the accident and your blood glucose is elevated. I hate to think what it was after you ate the candy bars and drank all of that soda. Your body can convert excess glucose to sorbitol; you may have heard it referred to as sugar alcohol. Anyway, sorbitol accumulates in the lens of the eye, and this could explain your blurred vision because it draws water into the fibers of the lens and makes them swell. Since this changes the shape of the lens, it can affect your vision and in the long term it can even make the lens opaque and form a cataract.”

“But I didn’t do anything out of the ordinary. I always have those snacks and soda when I’m driving late at night, and it’s never been so bad that I had an accident!”

“That’s what worries me, Frank. How long have you been feeling this high level of stress at work?”

“For about a year. They have been laying off people from work and I feel it’s only a matter of time before it’s my turn. Stacey says that we should buy stock in companies that make candy bars and soda, and I admit that I am putting on a little weight.”

“This is not good. Both your high sugar intake plus the work related stress, which can cause excess cortisol secretion, can raise your blood glucose levels. High blood glucose levels like yours suggest diabetes mellitus and I know this problem runs in your family. At this point I usually send my patients to take a glucose tolerance test, but I know that you are going out of town on business this afternoon. How about we set you up for a glucose tolerance test after your trip and in the meantime take it easy on the sugar and try to relax.”

“I can do that.”

“Also, I think that it would be wise not to drive.”

Questions

1. What hormone is responsible for decreasing blood glucose levels?
2. Which gland secretes this hormone?
3. There are two types of diabetes mellitus: Type 1 or insulin-dependent diabetes mellitus (IDDM) and Type 2 or noninsulin-dependent diabetes mellitus (NIDDM). Fill in Table 2 below to show the difference between the two types of (untreated) diabetes in terms of high, normal, or low for both blood insulin levels and insulin receptor function.

Table 2 – Diabetes Mellitus

<i>Variable</i>	<i>Type 1</i>	<i>Type 2</i>
<i>Blood insulin level</i>		
<i>Insulin receptor function</i>		

4. If Frank is suffering from untreated diabetes mellitus, based on Tables 1 and 2 which type do you think he suffers from?
5. Is this diagnosis reasonable considering that some members of Frank’s family suffer from diabetes mellitus?

Part III – Something's Not Right

“It’s good to have you home, honey. I missed you. How was the flight?” Stacey had come to the airport to pick Frank up and she leaned over to kiss him as he climbed into the car with his luggage. “How were the meetings? You look tired,” she added.

“The past week was intense and I am exhausted. I thought I would manage some R & R during the trip, but no such luck. John and Dan were fired and we were told that there would be more layoffs in the future if business doesn’t pick up. Everyone is feeling stressed.”

“You’re one of the hardest workers they have Frank, they can’t let you go.”

“I hope you’re right. They gave us tomorrow off in lieu of making us work for 7 days straight, but I can’t help but think I should go in and get a jump on the week.”

“I know you don’t want to hear this, but you have an appointment for that glucose tolerance test first thing in the morning. We’ll need to eat soon because the instructions say you are not allowed to eat for 8 hours before the test.”

Frank felt miserable. “I’m really not hungry. Maybe it was the change in diet, but I’ve had a persistent stomach ache and I didn’t eat much when I was away.

“Well, we need to take extra special care of you until we find out what’s wrong. I am sure everything’s going to be okay.”

The next morning the alarm went off and Frank felt refreshed after a good night’s sleep.

“What’s the matter Stacey? You look like you’ve seen a ghost.”

Stacey brought him her pocket mirror so that he could see for himself. “Forget the glucose tolerance test. I think we need to go to the Emergency Room right now.”

Doctor Smithers looked into Frank’s eyes. “It’s a good thing you came in because even a first year medical student could see that you are jaundiced.”

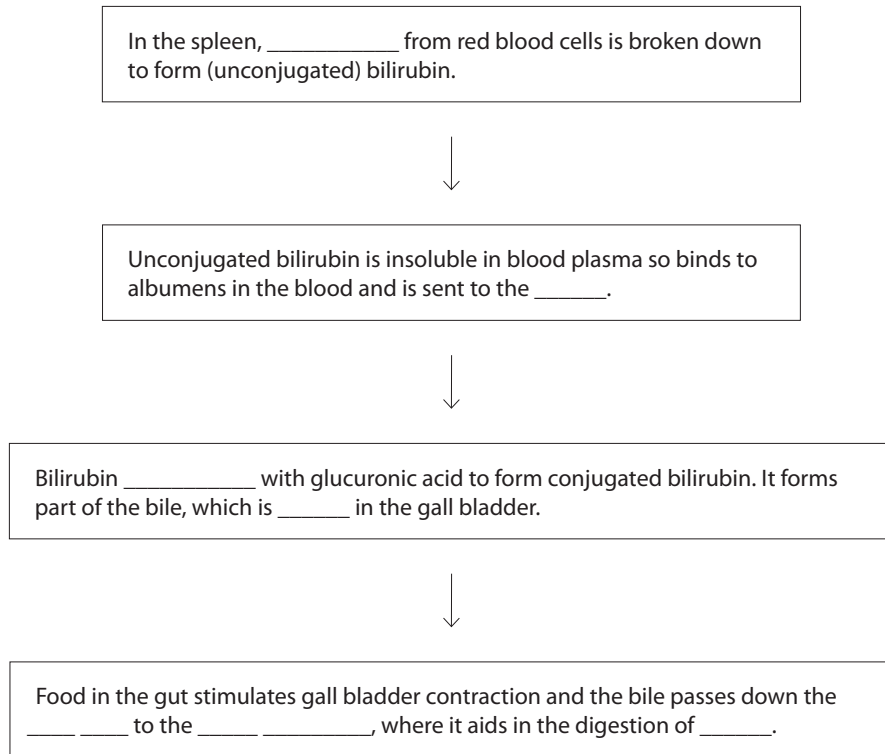
Stacey looked concerned. “What does that mean? Is he going to be okay?”

“Well it could mean a few different things,” replied the doctor, “so we are going to have to run some tests to be sure.”

Questions

1. What new physical signs or symptoms is Frank exhibiting?
2. What does the doctor see in Frank’s eyes that indicates jaundice?
3. What molecule is responsible for Frank’s jaundiced appearance?
4. On the following page, fill in Flow Chart 1 with the best choices from the provided word list.
5. Use Flow Chart 1 to suggest possible reasons for Frank’s jaundiced appearance.
6. Do you think that Frank’s jaundice is connected to the high blood glucose levels seen on the morning before his business trip? Why or why not?
7. Would you like to make a diagnosis to explain Frank’s jaundiced appearance?
8. What tests would you run to determine or confirm any of your diagnoses?

Flow Chart 1



Word List

bile duct	lipid
binds	liver
carbohydrate	pancreas
cell membrane	pancreatic duct
cytoplasm	protein
dissociates	small intestine
globin (protein)	stomach
hemoglobin	stored

Part IV – The Test Results

“What does it mean to be jaundiced, doctor? Why did the whites of my eyes turn yellow?”

“It’s usually caused by a high level of a molecule called bilirubin in your blood, Frank.”

“I was a biology major in college, but I don’t remember where bilirubin comes from.”

“Your blood has cells called erythrocytes or red blood cells; they contain hemoglobin which gives blood its red color. Cells in the spleen break down red blood cells and the products are reused by your body. The heme portion of hemoglobin is converted to bilirubin, which is the molecule that is responsible for your yellow color.”

“I remember now, isn’t bilirubin involved in digestion?”

“Yes. Bilirubin leaves the spleen in the blood and, because it’s not soluble in water, it binds with blood proteins called albumens to form *unconjugated bilirubin*. This bilirubin is taken up by the cells in the liver, where it combines with glucuronic acid to form *conjugated bilirubin*. It is one component of the bile, which travels down the bile duct to the gall bladder and the small intestine. When you eat, the gall bladder contracts and pushes the stored bile into the small intestine to aid in the digestion of fat.”

“So what do my tests show?”

“Your hematocrit and your liver enzymes are at normal levels.”

“So, my liver’s okay?”

“These enzymes are normally confined to the liver cells and would only be found in large amounts in the blood if your liver was damaged. So these results indicate that there is no liver damage; that’s good. But I am concerned that there is tenderness in the upper left quadrant of your abdomen ... sorry, around your stomach,” the doctor smiled at Frank and Stacey.

“As I explained before, a jaundiced appearance is often produced by a buildup of bilirubin in the blood and your results confirm this (Table 3).”

Table 3 – The Level of Bilirubin in Blood

<i>Bilirubin Type</i>	<i>Frank’s Blood</i>	<i>Normal Blood</i>
unconjugated	0.9 mg/dl	0.3 – 1.6 mg/dl
conjugated	0.6 mg/dl	0 – 0.3 mg/dl

“One more thing concerns me,” continued the doctor. “There is almost no urobilinogen or urobilin in your urine.”

“What are they?” asked Frank.

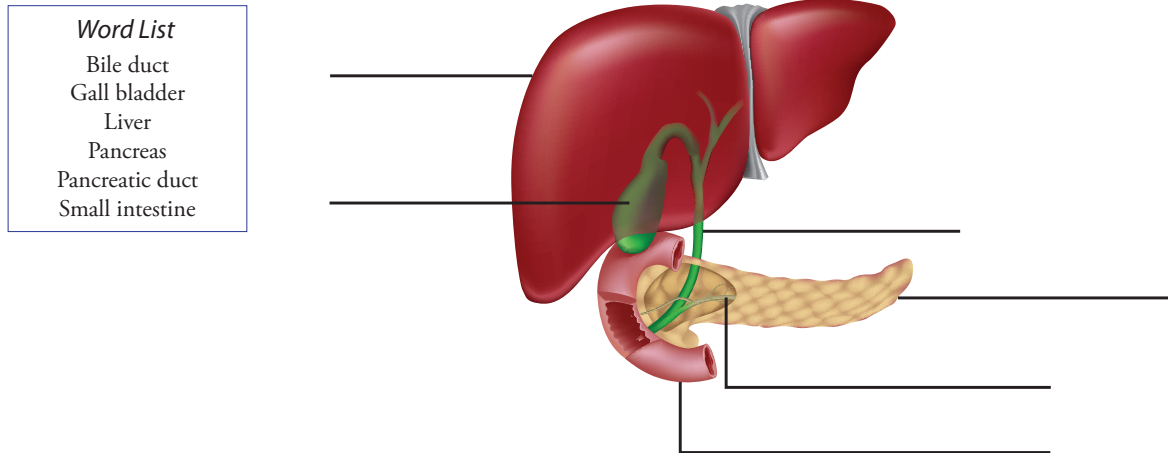
“Bacteria in your intestines change bilirubin to urobilinogen. This urobilinogen can be reabsorbed back into your body and some is converted to urobilin. These two molecules circulate in your blood and are excreted in your urine; it is the urobilin that produces the straw color of urine. The low level of these two molecules in your urine plus the high level of bilirubin in your blood and the pale color of your stools indicates to me that, for some reason, bilirubin is staying in your body instead of going into your intestines.”

Questions

1. Where is unconjugated bilirubin formed?
2. Is the level of unconjugated bilirubin in Frank’s blood within the normal range?
3. Where is conjugated bilirubin formed?
4. Is the level of conjugated bilirubin in Frank’s blood within the normal range?

- Using Flow Chart 1, outline some possible reasons for the high level of conjugated bilirubin; remember Frank's liver enzymes are normal.
- Frank experienced tenderness in the upper left quadrant of his abdomen. Use the word list in Figure 1 to label the major organs in this area.

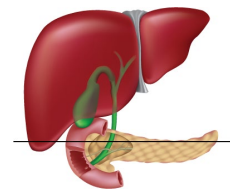
Figure 1. Diagram of the organs in the upper left quadrant of the abdomen plus a word list for labeling.



- Consider your diagnosis for Frank's high blood glucose levels. Which gland secretes insulin?
- Which organs are involved in creating Frank's jaundiced appearance?
- Look at Figure 1 and determine whether this gland and these organs (answers to Questions 7 and 8) are connected in any way.
- Can you think of a reason that would explain the high levels of glucose and conjugated bilirubin in Frank's blood?
- Would you like to make any adjustments to your diagnoses?

Part V – CT Scans

“Here is your CT scan, Frank. Just to orient you, it shows a slice across your abdomen just below your diaphragm (inset on right). This scan (Figure 2) is taken from a healthy individual; we use it in teaching and you can see labels on the various organs. Now look at your scan (Figure 3), which was taken at a similar plane. I have drawn arrows to show your pancreas,” explained the doctor.



“My pancreas looks larger; and what are those dark blobs?”

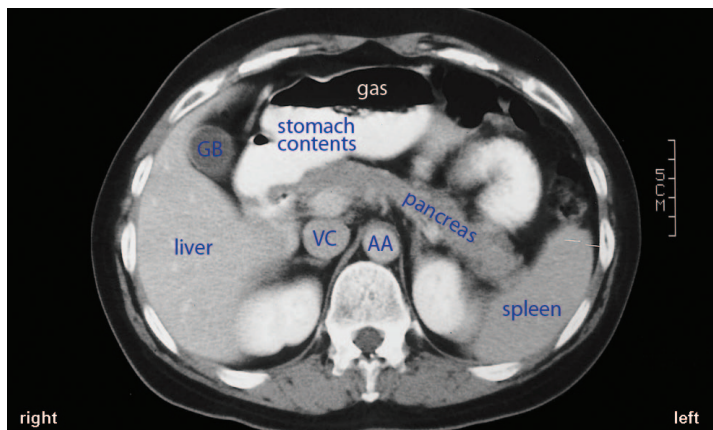


Figure 2. Healthy Patient's CT Scan

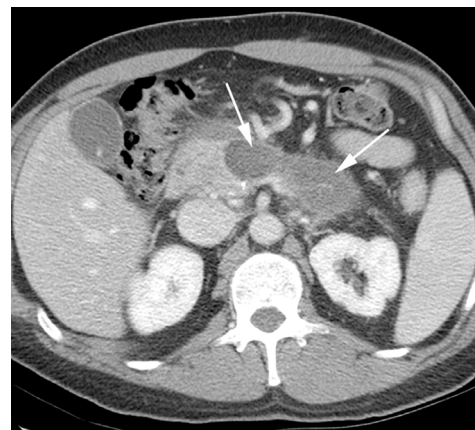


Figure 3. Frank's CT Scan

Questions

1. Speculate on the identity of the “dark blobs” Frank noticed in Figure 3.
2. Do you think these “dark blobs” could affect the secretion of insulin?
3. Do you think these “dark blobs” could inhibit the liver from producing conjugated bilirubin?
4. Frank's CT scan shows the “head” of the pancreas in the vicinity of the small intestine and the stomach. What do you think would be the effect of an enlarged pancreas on the ability of the gall bladder to send bile down the bile duct and into the small intestine?
5. Why does Frank have elevated levels of bilirubin in his blood?
6. Would you like to modify your diagnosis?

Image credits:

Figure 2: University of Leeds, <http://www.bmb.leeds.ac.uk/teaching/visible/>, used with permission.

Figure 3: Thoeni R F. The revised Atlanta classification of acute pancreatitis: Its importance for the radiologist and its effect on treatment. *Radiology* 2012;262:751–764. Used with permission.

Part VI – The Final Diagnosis

“So what’s the problem doctor?” asked Frank.

“Your CT scan shows that your pancreas contains some unusual growths, what you called ‘dark blobs,’” replied the doctor. “These growths may be interfering with your ability to secrete insulin.”

“So does that mean I do not have diabetes?”

“We’ll need to do more tests to determine that, but I am very concerned about the size of your pancreas, which seems to be so big that it’s blocking the bile and pancreatic ducts.”

“So these growths are blocking the duct that takes bile from the gall bladder into the small intestine and are the source of my pain?”

“That seems possible,” replied the doctor. “With a blocked bile duct, bilirubin cannot get into your small intestine and will build up in your gall bladder, your liver, and ultimately in your blood.”

“That would explain why I am jaundiced. Are those ‘dark blobs’ cancerous, doctor?”

“We’ll need to take a biopsy to be certain, but I am afraid they may well be. I’m sorry, Frank. Still, we’re very lucky that we discovered these growths at such an early stage. If you had waited we could be looking at more serious problems.”

“So, what’s the next step?”

“We’ll need to do more tests, but I think you’ll probably need surgery to remove the growths. I know that this may sound drastic, so I think you should see a specialist. We are fortunate because we have a very good gastroenterologist and an excellent abdominal surgeon on staff. I have scheduled an appointment for you to see them this afternoon. One advantage of having them in this hospital is that it will be easy to get your test results and CT scans to them before your meeting. They can refer you to other doctors if you wish, but I think they will advise you to get this treated as soon as possible.”



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