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SELF-STUDY TEST

Gastrointestinal Nuclear Medicine

Questions are taken from the *Nuclear Medicine Self-Study Program I*, published by The Society of Nuclear Medicine

DIRECTIONS

The following items consist of a heading followed by numbered options related to that heading. Select those options you think are true and those that you think are false. Answers may be found on page 1668.

True statements concerning the lactulose-H₂ breath test for detecting bacterial overgrowth within the small intestine include which of the following?

1. Up to 30% of patients with bacterial overgrowth do not have bacterial flora capable of producing H₂ from metabolism of the standard 10-gm lactose load.
2. H₂ may result from normal host tissue metabolism.
3. Fasting H₂ breath levels occur after cigarette smoking.
4. Fasting H₂ breath levels may result from small intestinal bacterial overgrowth.
5. Patients who have no rise in H₂ level (> 20 ppm H₂) above baseline after administration of 10 g of lactulose should be retested with 30 g of lactulose.

True statements concerning cholecystikinin (CCK) cholescintigraphy include which of the following?

6. It is an appropriate screening test for patients with upper abdominal pain of uncertain origin.
7. It can be used to identify patients with sphincter of Oddi dyskinesia.
8. Use of CCK increases the sensitivity of hepatobiliary imaging for detecting mechanical cystic duct obstruction.
9. Rapid bolus injection of CCK increases the positive predictive value of CCK cholescintigraphy for diagnosing biliary dyskinesia.

True statements concerning cholecystikinin (CCK) include which of the following?

10. It is produced by the duodenal mucosa.
11. All commercial forms of CCK retain physiologic activity by reproducing the complete 33 amino acid polypeptide chain length.
12. It decreases hepatic bile secretion.

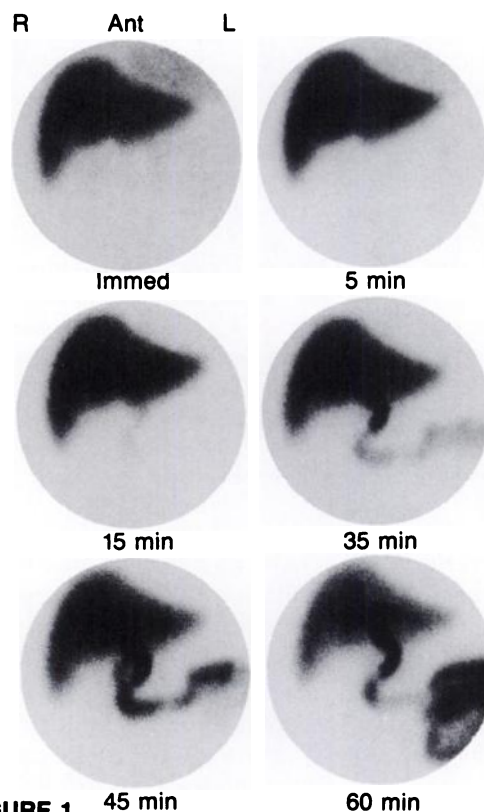


FIGURE 1. 45 min 60 min

A 51-yr-old man, five days post-coronary artery bypass surgery, develops fever, nausea, and abdominal pain. You are shown this patient's ^{99m}Tc lidofenin hepatobiliary study (Fig. 1).

Which of the following could explain the findings in these images? (continued on page 1668)

Quantitative measurement of regional pulmonary blood flow with positron emission tomography. *J Appl Physiol* 1986;60:317-326.

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to radiopharmaceutical production. *J Nucl Med* 1981;8:277-287.

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- insufficient period of fasting before the study
- acute pancreatitis
- fasting for 4 hr before the study
- acute or chronic cholecystitis

Reasonable approaches at this point to improve the diagnostic utility of the study in Figure 1 include which of the following?

- administer morphine sulfate, 0.04 mg/kg, intravenous, and continue imaging for an additional 30-45 min
- continue imaging for an additional 3 hr
- administer sincalide, 0.02 µg/kg, intravenous, administer

a second dose of ^{99m}Tc lidofenin, and image for 60 min

- administer 200 ml of water by mouth

Which of the following characteristics among the ^{99m}Tc acetanilidoiminodiacetate (IDA) derivatives favors hepatocyte uptake and concentration in the biliary tree?

- the structure should contain a nonpolar group
- the structure should be lipophilic
- high urinary excretion
- low plasma protein binding

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ANSWERS

ITEMS 1-5: Lactulose-H₂ Breath Testing

ANSWERS: 1, T; 2, F; 3, T; 4, T; 5, T

King and Toskes have reviewed carbohydrate-H₂ breath testing for detecting bacterial overgrowth and compared these tests with the ¹⁴C-xylose breath test and intestinal culture. Although H₂ breath tests are attractive because of their ease of performance and nonradioactive nature, they are both inadequately sensitive and specific. H₂ breath tests are also affected by a number of factors that make their interpretation problematic. Cigarette smoking within 1 hr before the test elevates breath H₂; diarrhea and prior treatment with antibiotics and enemas impair bacterial production of H₂. Although earlier studies suggested that only an occasional patient may lack H₂-producing bacteria, it is now appreciated that up to 30% of patients may not generate significant H₂ with the usually employed 10-g lactulose-H₂ test; in such patients, 30 g of lactulose should be administered. It also appears that as many as 30% of patients with culture-proven bacterial overgrowth may have elevated levels of breath H₂ in the fasting state.

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ITEMS 6-9: CCK Cholescintigraphy

ANSWERS: 6, F; 7, T; 8, F; 9, F

CCK cholescintigraphy should be employed to confirm a surgeon's and/or gastroenterologist's clinical impression that right upper quadrant pain and biliary colic are a manifestation of acalculous biliary disease. It should not be employed as a screening test in individuals with vague abdominal pain, because false-positive studies will occur since the maximal gallbladder ejection fraction response to CCK in this patient population has yet to be determined.

CCK cholescintigraphy can be employed as a noninvasive means of identifying patients with sphincter of Oddi dyskinesia, as some will demonstrate a CCK cholescintigraphic pattern indicative of this disorder. A delay in biliary-to-bowel transit and failure of the sphincter of Oddi to relax after CCK infusion (the dilated common duct sign) are the cardinal scintigraphic features of this dysfunctional disorder of the biliary tree.

The most accurate test for the detection of acute cholecystitis is hepatobiliary scintigraphy. Its sensitivity exceeds 95% without the use of CCK. However, pretreatment with CCK is often employed to improve the specificity of this test in patients with sludge in their gallbladders or in those who have been fasting or undergoing total parenteral feeding for prolonged periods.

False-positive CCK cholescintigrams will occur if CCK is not infused

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SELF-STUDY TEST

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ANSWERS

slowly over a 1-3 min duration. Presumably, this is due to spasm of the cystic duct, which impairs emptying of the gallbladder and falsely lowers the gallbladder ejection fraction.

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ITEMS 10-12: Properties of CCK

ANSWERS: 10, T; 11, F; 12, F

Cholecystokinin (CCK) is a 33-amino-acid polypeptide hormone produced by the duodenal mucosa in response to fat, lipolytic products, amino acids and small polypeptides in the small intestine. It causes the gallbladder to contract, the sphincter of Oddi to relax, enhances jejunal, ileal and, to a lesser extent, colonic motility, increases pyloric tone, and stimulates the secretion of pancreatic enzymes and bile. The diffuse effects of CCK on intestinal motility explain why many patients report "gurgling in the stomach" following its injection. Its active or cholecystokinetic portion resides totally in its C-terminal octapeptide fragment.

There are two commercial preparations of the 33-amino-acid polypeptide cholecystokinin: Pancreozymin™ is produced by Boots Co., Ltd., England, and Cholecystokinin™ by the Karolinska Institute in Stockholm. Both sincalide, the C-terminal octapeptide, and ceruletide diethylamine, the C-terminal decapeptide of cholecystokinin, are synthetic cholecystogogues. Sincalide (Kinevac™) is produced by Squibb & Sons, Inc., and ceruletide diethylamine (Tymtran™) by Adria Laboratories. Their effects on the gastrointestinal and hepatobiliary system are identical to that of intact cholecystokinin.

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ITEMS 13-16 and 17-20: False-Positive Scintigraphy for Acute Cholecystitis

ANSWERS: 13, T; 14, T; 15, F; 16, T; 17, T; 18, T; 19, T; 20, F

The images in Figure 1 reveal rapid uptake of the radiotracer by the liver. The intrahepatic and extrahepatic ducts are seen by 15 min. By 30 min, there is transit of the radiotracer into the duodenal sweep. However, the gallbladder is not visualized throughout the 60 min of the study. Hence, there may be complete cystic duct obstruction (acute cholecystitis). Since the study was carried out only to 60 min, one cannot ascertain whether the gallbladder may eventually visualize (e.g., only chronic cholecystitis

may be present).

Among the causes of false-positive studies (i.e., nonvisualization of the gallbladder not due to cystic duct obstruction) are an insufficient period of fasting and acute pancreatitis. As many as 50% of normal individuals who are not fasted have nonvisualization of the gallbladder. Endogenous release of cholecystokinin and contraction of the gallbladder following a meal are presumed to prevent gallbladder filling. A fast of at least 2 hr, and preferably 4 hr, is required before beginning cholescintigraphy to minimize the effect of endogenous cholecystokinin. Prolonged fasting, for several days or more, such as may be encountered in post-operative patients or those receiving total parenteral feeding, also may lead to a false-positive cholescintigraphic study, presumably because the bile within the gallbladder is very viscous or mixed with sludge. Under such circumstances, it is helpful to administer cholecystokinin 30-60 min before cholescintigraphy; this will cause contraction of a normal gallbladder, which will then be in its refilling phase during the imaging study. It is generally agreed that acute pancreatitis may be a cause of non-visualization of the gallbladder, although controversy exists as to the percentage of individuals with acute pancreatitis who will not have visualization of the gallbladder.

Since nonvisualization of the gallbladder at 60 min may be due to chronic cholecystitis as well as acute cholecystitis, several approaches have been developed to distinguish between them. Obtaining images up to 4 hr postinjection has been shown by many investigators to be useful in separating chronic cholecystitis from acute cholecystitis. The gallbladder will eventually visualize in patients with chronic cholecystitis since the cystic duct is patent, although the gallbladder may be scarred and sluggish. In patients with acute cholecystitis, the cystic duct is virtually always functionally or anatomically obstructed, and the gallbladder will not visualize.

The false-positive rate for acute cholecystitis also can be reduced significantly by medicating the patient with a cholecystokinin analogue, or by use of morphine sulfate. Cholecystokinin given intravenously (slowly over 1-3 min) empties a sludge-filled or distended gallbladder, allowing a second dose of the hepatobiliary agent to flow into the gallbladder. If the cystic duct is obstructed, the gallbladder cannot contract against the obstruction. Alternately, if the gallbladder fails to visualize by 1 hr, 0.04 mg/kg morphine sulfate diluted in 10 ml of saline may be given intravenously with further imaging over the next 30 min. Morphine increases the tone of the sphincter of Oddi at the distal common bile duct. The resultant increase in pressure within the biliary system is enough to overcome a partial obstruction of the cystic duct, or to cause filling of a fibrosed gallbladder, thus bringing about earlier visualization of the gallbladder.

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SELF-STUDY TEST

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ANSWERS

Choy, et al. have reported an increase in specificity for acute cholecystitis (from 83% to 100%), compared to the use of delayed imaging without a loss of sensitivity.

Occasionally, it is difficult to distinguish pooled activity within the proximal duodenum from the gallbladder itself, or one may mistake pooled activity within the duodenum for the gallbladder. In these instances, it is useful to administer 200-300 ml of water by mouth. This will facilitate flushing of activity from the duodenum, but has no effect on the gallbladder. Since the duodenum is clearly identified in this patient, and activity within it is seen to change over time, it should not be mistaken for the gallbladder. Hence, imaging after administering water to this patient would not provide further useful information.

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ITEMS 21-24: Factors Affecting ^{99m}Tc IDA Uptake

ANSWERS: 21, T; 22, T; 23, F; 24, F

Since the development of the original IDA derivatives, work on the molecular structure of these compounds has proceeded in the direction of producing an agent with ideal biokinetics. The ^{99m}Tc IDA agents are carried in blood nonspecifically bound to plasma proteins, particularly albumin. The lipophilicity of the compound is directly related to the level of protein binding. Substitutions of nonpolar groups on the phenyl ring of the molecule make it more lipophilic. Protein binding prevents renal excretion and promotes hepatic uptake. This is an important consideration in the jaundiced patient where these agents compete for protein binding sites with bilirubin.

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Note: For further in-depth information, please refer to the syllabus pages included at the beginning of *Nuclear Medicine Self-Study Program I: Part I*.