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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 1818.

Drugs that typically slow gastric emptying include which of the following?

1. nicotine
2. verapamil
3. isoproterenol
4. levodopa
5. metoclopramide
2. domperidone

True statements concerning Barrett's esophagus include which of the following?

7. More than half of patients with Barrett's esophagus will develop squamous cell cancer of the esophagus.
8. The radiologic appearance on upper gastrointestinal radiography is diagnostic in most patients.
9. In patients with gastroesophageal reflux, an increase in symptoms suggests development of Barrett's esophagus.
10. Sequential [^{99m}Tc] pertechnetate imaging in patients with Barrett's esophagus is helpful in determining which patients will develop malignancy.

True statements concerning scintigraphic evaluation of peritoneovenous shunt patency include which of the following?

11. Because of its low specificity, it is not helpful in most cases.
12. When ^{99m}Tc MAA is injected intraperitoneally, non-visualization of the efferent limb of the shunt indicates shunt malfunction.
13. The afferent portion of the shunt is the most frequent site of shunt malfunction.
14. Congestive heart failure occasionally causes false-positive studies.
15. Direct puncture of the efferent limb of the shunt occasionally is necessary to precisely locate the site of malfunction.

True statements concerning scintigraphy for detection of Meckel's diverticulum include which of the following?

16. Pretreatment with cimetidine increases the frequency of false-negative studies.
17. Uterine blood-pool activity occasionally causes false-positive studies.
18. Small bowel duplication is usually distinguishable from Meckel's diverticulum.
19. Technetium-99m pertechnetate is selectively concentrated in parietal cells of ectopic gastric mucosa.

True statements regarding Meckel's diverticula in adults include which of the following?

20. Most are symptomatic.
21. Two-thirds of affected elderly patients present with melena.
22. Technetium-99m pertechnetate imaging has a sensitivity of greater than 80%.

True statements concerning red blood cell labeling techniques with ^{99m}Tc include which of the following?

23. When the modified in vivo ("in vitro") method is used, heparin rather than acid citrate dextrose (ACD) is preferred as the anticoagulant.
24. Stanous pyrophosphate and ^{99m}Tc should be injected through the same indwelling catheter when either the in vivo or the modified in vivo technique is used.
25. The bladder is the organ receiving the highest radiation exposure when the in vivo method of red blood cell labeling is used.
26. Technetium-99m binds predominantly to the red blood cell membrane.

The widening interest in pretargeting technology following favorable reports such as those outlined here makes it likely that avidin-biotin will find broad application in this area of radiopharmaceutical development.

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ANSWERS

ITEMS 1-6: Effect of Drugs on Gastric Emptying

ANSWERS: 1, T; 2, T; 3, T; 4, T; 5, F; 6, F

Many drugs have been shown to slow gastric emptying, and their effects must be considered in reporting the results of gastric emptying studies. The nicotine associated with cigarette smoking has been shown to slow gastric emptying. In addition, calcium channel blockers have been shown to decrease the amplitude and duration of contractions of smooth muscle throughout the gastrointestinal tract. Calcium channel blockers either decrease the number of calcium channels (nifedipine, verapamil, diltiazem) and/or decrease the rate of calcium transport in the remaining channels (verapamil, diltiazem). Adrenergic agonists, especially beta agonists (such as isoproterenol), all tend to delay gastric emptying. Dopamine is a neural transmitter, which appears to be involved primarily in gastric relaxation. Dopamine agonists, such as levodopa, will slow gastric emptying. The D₂-receptor antagonist metoclopramide stimulates gastric contractions and, thus, increases the rate of gastric emptying. It is also felt to have a central antiemetic effect. Domperidone is another dopaminergic antagonist, which also accelerates gastric emptying and has been shown to increase gastric antral contractions.

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ITEMS 7-10: Barrett's Esophagus

ANSWERS: 7, F; 8, F; 9, F; 10, F

Much has been written about the clinical presentation and assessment of patients with Barrett's esophagus. Although Barrett's esophagus causes no symptoms per se, the clinical presentation is related to

gastroesophageal reflux and covers the spectrum of regurgitation, heartburn, chest and abdominal pain, and dysphagia. It has been suggested that patients with Barrett's esophagus have less severe symptoms than do those with reflux esophagitis without Barrett's epithelium. The five major complications of Barrett's esophagus include: esophagitis, ulceration, stricture, bleeding, and adenocarcinoma (not squamous cell cancer). The frequency of adenocarcinoma of the esophagus in patients with Barrett's esophagus is approximately 10%. The risk of esophageal cancer with Barrett's esophagus is approximately 30 to 40 times greater than that in the general population. Once the diagnosis of Barrett's esophagus has been made on biopsy, periodic endoscopy with biopsy is recommended to monitor for malignant transformation. The radiographic appearance of Barrett's esophagus is not specific and includes gastroesophageal reflux, hiatal hernia, esophageal stricture, ulceration, irregular mucosal folds, granulating reticular mucosal pattern, and intramural pseudodiverticulosis. The findings of a benign-appearing stricture in the proximal esophagus or a deep esophageal ulceration should suggest the diagnosis and prompt endoscopic evaluation.

The scintigraphic assessment of Barrett's esophagus has not been widely explored or utilized. The accumulation of ^{99m}Tc pertechnetate in the lower esophagus after intravenous injection of this tracer is considered a positive examination and is related to mucous-secreting cells of Barrett's mucosa. The swallowing of free ^{99m}Tc in saliva and reflux of gastric activity can cause significant problems in scan interpretation, however.

Scintigraphy can identify possible areas of Barrett's esophagus, but plays no role in assessment for possible malignancy. Currently, scintigraphy plays no definitive role in the evaluation of patients with suspected Barrett's esophagus. A large prospective study with adequate controls will be necessary to define if any future role for scintigraphy exists.

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ITEMS 11-15: Peritoneovenous Shunt Imaging

ANSWERS: 11, F; 12, F; 13, T; 14, T; 15, T

Scintigraphic techniques for assessing patency of peritoneovenous shunts utilize tracers injected into the peritoneal cavity and/or directly into the efferent limb of the shunt. These imaging techniques monitor the transit

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ANSWERS

of tracer from the peritoneal cavity through the shunt into the target organs (lung or liver/spleen) of the tracer employed (^{99m}Tc macroaggregated albumin [MAA] or ^{99m}Tc sulfur colloid). The most frequent cause of shunt malfunction is obstruction by fibrin deposits of the afferent limb of the shunt. Less frequently, thrombus formation occurs in the efferent portion of the tubing. When ^{99m}Tc MAA is the tracer utilized at high and low flow rates, there may be nonvisualization of the efferent shunt tubing. Hence, direct target organ visualization (i.e., tracer accumulation in the lungs) should be utilized as the criterion of shunt patency. Disease states that cause elevated right heart pressure, such as congestive heart failure, can cause false-positive studies. Thus, when only the afferent portion of the shunt is visualized, direct puncture of the efferent limb is generally necessary to locate the site of malfunction more precisely.

Both the sensitivity and specificity of peritoneovenous shunt scintigraphy appear to be high. In a study of 40 patients, six of whom were evaluated when their shunts appeared to be malfunctioning, no false-positive or false-negative studies were encountered.

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ITEMS 16-19: Scintigraphy for Meckel's Diverticula

ANSWERS: 16, F; 17, T; 18, F; 19, F

The histamine-2 receptor antagonist, cimetidine, enhances imaging of Meckel's diverticulum by causing continued accumulation of [^{99m}Tc] pertechnetate in ectopic gastric mucosa and by reducing secretion of ^{99m}Tc activity into the bowel. By decreasing the amount of pertechnetate entering the small bowel, cimetidine helps to reduce the frequency of false-positive studies.

Up to 73% of menstruating women have been shown to demonstrate a uterine "blush" following [^{99m}Tc] pertechnetate administration during the menstrual or secretory phase of their menstrual cycle. This may lead to a false-positive interpretation. In general, premenarchal, postmenopausal, and menstruating patients in the proliferative phase do not show this uterine "blush."

Small bowel duplications occasionally contain ectopic gastric mucosa and may simulate Meckel's diverticulum on scintigraphy with [^{99m}Tc] pertechnetate. Because the position within the abdomen of a small bowel duplication can mimic that of Meckel's diverticulum and because both anomalies contain ectopic gastric mucosa, it usually is not possible to distinguish Meckel's diverticulum from a small bowel duplication by [^{99m}Tc] pertechnetate imaging.

Autoradiographic studies have shown that, after intravenous administration, [^{99m}Tc]pertechnetate is selectively concentrated by the mucous-producing cells of gastric mucosa, rather than by parietal cells or chief cells. Experimental animal studies have demonstrated that at least 2 cm² of functioning ectopic gastric mucosa is necessary for visualization.

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ITEMS 20-22: Meckel's Diverticula in Adults

ANSWERS: 20, F; 21, F; 22, F

Although Meckel's diverticulum is the most common congenital anomaly of the gastrointestinal tract, with a prevalence of approximately 1%, most are not symptomatic. Additionally, those that cause symptoms usually do so in the first 2 yr of life. Ectopic gastric mucosa is more frequently encountered in symptomatic Meckel's diverticula, but may also be present in asymptomatic Meckel's diverticula. Lower gastrointestinal bleeding is the most frequent presentation of symptomatic Meckel's diverticulum in the pediatric population. In adults, the most common presentation is acute inflammation (Meckel's diverticulitis). Obstruction is seen less often, and gastrointestinal bleeding occurs rarely. Several studies have clearly shown that the sensitivity of [^{99m}Tc] pertechnetate scintigraphy for Meckel's diverticulum is greater than 80% in the pediatric population. In adults, however, the sensitivity of Meckel's scintigraphy is approximately 60%. The precise reasons for this are unclear.

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ITEMS 23-26: Red Blood Cell Labeling with ^{99m}Tc

ANSWERS: 23, F; 24, F; 25, T; 26, F

In vivo red blood cell labeling is the most frequently utilized method because it is the simplest approach. It is not the most satisfactory method, however, for gastrointestinal bleeding scintigraphy. Because of the variability in labeling efficiency, significant amounts of unbound, free ^{99m}Tc can be secreted into the stomach and bowel, causing false-positive studies. Additionally, much of the activity not bound to red blood cells is excreted by the kidney as labeled small proteins and reduced technetium complexes. This urinary activity may cause problems in interpretation (e.g., a rectal bleeding site may be obscured) and renders the bladder as the critical organ with this labeling method (approximately 2.4 rads/20 mCi). When in vivo techniques are used, the "cold" stannous pyrophosphate should be injected directly into a vein. The precise reason for this is unclear, but if the cold pyrophosphate is injected via an indwelling catheter, poor red blood cell labeling can occur, and this may result in a nondiagnostic examination.

The basic theory underlying red blood cell labeling with ^{99m}Tc is as follows. The stannous ion complex freely diffuses into the red blood cell and binds to cellular components. Pertechnetate ion also freely diffuses into and out of red cells. Once the pertechnetate ion is inside the red

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blood cell, the stannous ion (Sn^{2+}) reduces it, and the reduced technetium species binds to hemoglobin. Once bound, it remains intracellular. If any stannous ion is present outside the red blood cell, any free extracellular pertechnetate will be reduced. This free reduced technetium will degrade the images (increased background activity and increased urinary excretion).

The in vitro method provides the optimal red blood cell labeling, because of its uniformly high labeling efficiency. The most recent modification of the in vitro method uses whole blood and does not require centrifugation or the removal of blood into multiple sterile containers. The Brookhaven-modified red blood cell labeling kit achieves high labeling efficiency by stopping the premature extracellular reduction of ^{99m}Tc pertechnetate. By the addition of an oxidizing agent (sodium hypochlorite), which cannot pass through the red blood cell membrane, extracellular stannous ion is oxidized to stannic ion (Sn^{4+}). This prevents extracellular reduction of pertechnetate ion.

The modified in vivo ("in vitro") technique of red blood cell labeling has been developed as a compromise between the in vivo method and the original in vitro method (which required a long incubation period, multiple handling steps, and written patient consent, because of its investigational status). When the "in vitro" technique is used, heparin is often used as the anticoagulant. Unfortunately, ^{99m}Tc heparin complexes can be excreted in the urine and accumulated in the bladder. For this reason, some investigators recommend that ACD solution be used as the anticoagulant, which yields a slightly higher labeling efficiency and reduced urinary activity.

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For further in-depth information, refer to the syllabus pages in Nuclear Medicine Self-Study I.