Detection of Ectopic Gastric Mucosa in Meckel's Diverticulum and in Other Aberrations by Scintigraphy: II. Indications and Methods—A 10-Year Experience

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Ten years' experience with pertechnetate (Tc-99m) abdominal scintigraphy has shown that the method is specifically indicated for the diagnosis and location of ectopic gastric mucosa in a Meckel's diverticulum, in enteric or gastric duplications and cysts, and in Barrett's esophagus. Careful patient preparation is essential, and sequential gamma camera imaging for 1 hr in the anterior projection is advisable, with complementary lateral, upright, and postvoiding views. Nonspecific accumulations of the tracer within tumors, intestinal obstructions, arteriovenous malformations, and the urinary tract can be recognized with the help of the clinical history and can be investigated by other tests. This approach has raised the accuracy of the method above 90%.

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Ten years' experience with pertechnetate scintigraphy for the diagnosis of ectopic gastric mucosa in bleeding Meckel's diverticulum and other congenital anomalies has proven the validity of this method (*1*). In 1967, Harden et al. (*2*) proposed the use of this tracer for the noninvasive diagnosis of Meckel's diverticulum containing ectopic gastric mucosa. In 1970, the method was introduced into clinical practice by Jewett, Allen, Duszynski, and Anthone (*3–5*). Many reports followed about this method or its clinical significance, experimental studies were performed in animals, and the method was utilized to diagnose Barrett's esophagus.

Abdominal imaging with pertechnetate has become an established procedure in children and adults. Careful patient preparation and a standardized technique based on sequential gamma camera imaging has resulted in an overall sensitivity of 85%. Experience in differentiating "nonspecific" accumulations of pertechnetate from true ectopic gastric mucosa has increased the specificity to 95%. In view of all the studies reported (954) with a surgical or clinical diagnosis, the accuracy of the method is calculated at 98%. When only surgically proven cases are analyzed, the calculated accuracy is 90% (*1*).

Since the clinical introduction of the pertechnetate anion ($^{99m}TcO_4^-$) (*6*), it has been known to be concentrated by the gastric mucosa (*2, 6*), and its accumulation by the mucoid cells is the basis of this test. The effects of drugs and hormones on the test have been studied in animals and in patients. There is evidence suggesting that an improvement can be achieved by the use of cimetidine, pentagastrin, or glucagon.

The current knowledge on the pathophysiologic mechanisms involved and the past clinical experience with pertechnetate abdominal imaging have been the subject of a previous publication (*1*). The present paper describes the clinical indications, the most effective methods, including patient preparation and techniques of imaging, principles of interpretation, and the radiation exposure of the patient from radiopertechnetate.

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INDICATIONS

The most frequent indication for pertechnetate abdominal imaging has been hematochezia (fresh blood

in the stool), less frequently melena, occult blood in the stool, anemia, or abdominal pain. The study is performed to reveal the existence of certain congenital aberrations containing ectopic gastric mucosa, complicated or manifested by gastrointestinal bleeding or abdominal pain. The most common of these is a bleeding Meckel's diverticulum.

Meckel's diverticulum is a congenital outpouching usually located in the distal 100 cm of the ileum, a remnant of the omphalomesenteric duct of the embryo (*1*). It occurs in 1-3% (*7*) of the general population, but only 25-40% produce symptoms (*8*). Of the symptomatic Meckel's diverticula, 57% contain ectopic gastric mucosa. Significant acid-peptic secretion may lead to complications because of severe bleeding due to ulceration of the unprotected adjacent intestinal mucosa (*9*), less commonly, perforation (*10*) and obstruction, and occasionally pain (*9*). Bleeding as well as other complications from a Meckel's diverticulum are much more common in the young, and more than 50% occur by the age of 2 yr (*9*). Diverticulitis, enteroliths (*11,12*), and intestinal obstruction complicating Meckel's diverticulum are usually unrelated to ectopic gastric mucosa, although it may be present incidentally (*9*).

Ectopic gastric mucosa can also be found in gastrogenic cysts (*13*), enteric duplications (*14-17*), duplication cysts (*18,19*), in an otherwise normal small bowel (*20,21*), or in Barrett's esophagus (*22*). Similar complications may occur through acid-peptic secretion of the ectopic tissue.

Obstructed loops of bowel (*23*), intussusception (*3,4,23*), inflammatory lesions (*16,23-25*), arteriovenous malformations (*20,26,27*), ulcers (*16*), and some tumors of the bowel (*28,29*), along with urinary-tract abnormalities, have been related to pertechnetate abdominal imaging because of nonspecific accumulation of the pertechnetate.

Of all the above, the clinical suspicion of bleeding ectopic gastric mucosa in a Meckel's diverticulum is the principal indication for pertechnetate abdominal imaging, since this condition is nearly always missed by radiographic methods, including angiography (*30-32*).

METHODS

Patient preparation. Fasting for several hours is necessary (*33*). Barium studies (*21,30*), proctoscopy, and drugs with an effect on the gastrointestinal tract (*23*) should be deferred, if possible, for 2-3 days before the study, although some investigators find this to be unnecessary (*14,21*). Perchlorate should not be given before the test (*34,35*). Pentagastrin (6 μg/kg subcutaneously before injection) (*36*) may be used to stimulate uptake in gastric mucosa, and cimetidine (300 mg/day for 2 days before the study) (*37*) or glucagon (50 μg/kg i.v. 10 min after injection of the tracer) (*38,39*), to prevent peristaltic removal of pertechnetate from the region of the lesion. The patient is instructed to empty the bowel and the bladder (*21*) if possible. Gastric suction after intubation is recommended by some authors (*40-42*), but it is not generally needed for the 60-min protocol (*14,21*). A marker may be placed on the symphysis pubis for original positioning but is unnecessary once the bladder is visualized.

Technique. A rectilinear scanner can be used, and as many scans as possible should be acquired over a 1-hr period. Serial imaging with a gamma camera with high-resolution collimation is more advantageous (*30,43,44*). The patient is placed supine under the detector, with restraint if needed for an infant or young child. Some investigators prefer the prone or the left decubitus position (*45*). The lower chest and the entire abdomen are monitored in the anterior projection. An intravenous injection of 30-100 μCi/kg of pertechnetate (Tc-99m) is given, followed by a dynamic study of the abdomen at 1- to 5-sec intervals for 30-60 sec to examine blood flow and blood-pool patterns. Static images of the abdomen are then taken at 5- to 10-min intervals for 60 min. Accumulate 350,000-500,000 counts for the first image with appropriate film intensity setting, and use the same time and intensity for subsequent images.

Lateral images are routinely recorded at 30 min and 1 hr, or as needed to define renal activity (*30,43*). Upright anterior and oblique images can assist in differentiating duodenal (immobile) from ectopic gastric mucosa activity (responsive to gravity). Postvoiding images (anterior, lateral, or oblique) are needed to define accumulations of activity in the vicinity of the ureters and particularly the bladder (*41*). A vertical posture between images helps to empty the renal pelvis and the ureters.

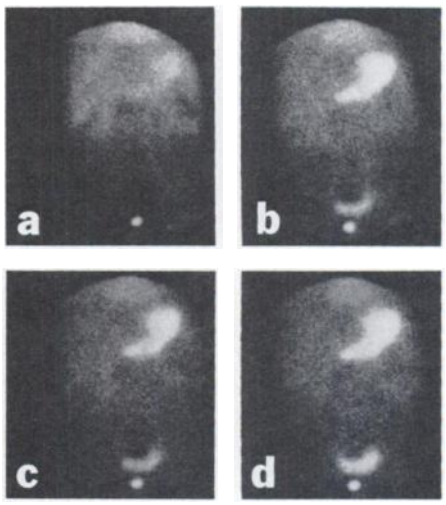

FIG. 1. Negative pertechnetate scintigrams in a 5-year-old boy at 10 min (a), 20 min (b), 40 min (c), and 60 min (d) after injection of pertechnetate.

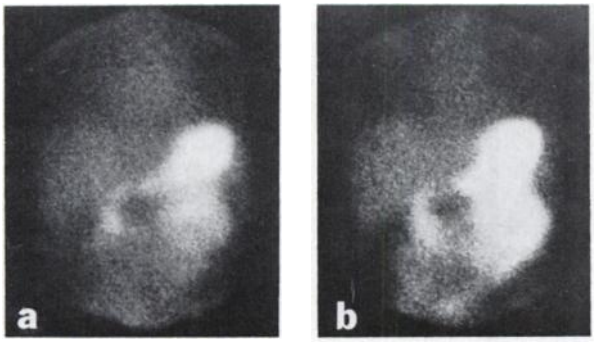

FIG. 2. Negative scintigrams in a 4-year-old girl showing duodenal and jejunal activity at 20 min (a) and 50 min (b) after pertechnetate injection.

Interpretation. *The negative image* (Fig. 1). With a gamma camera and high-resolution collimator, the anatomy of the different organs in the field of view can be recognized. The blood pools of the heart, liver, spleen, kidneys, and large vessels are visualized and become less evident with time. Photon-deficient areas from air within the stomach or bowel can be appreciated. The urinary bladder, if full, appears originally as a photon-deficient region and gradually becomes radioactive due to excretion of pertechnetate. The kidneys and ureters may become distinctly active when obstructed. The most prominent accumulation of radioactivity occurs in the stomach; it begins to appear usually during the first 10 min and increases in intensity, whereas the rest of the abdominal activity declines. The duodenum usually becomes visible slightly later and should not be confused with ectopic mucosa (*46*); this is commonly followed by visualization of the jejunum and occasionally the ileum (Fig. 2). Unusually early, prominent accumulation of activity in the ileum or the colon may occur as a result of normal digestion if the patient has eaten recently, or as a result of an intestinal inflammatory process (Fig. 3).

The positive image. Any accumulation of radioactivity that cannot be attributed to an organ (normal or abnormal) should characterize the study as abnormal; it may be attributed to the presence of ectopic gastric mucosa or to a "nonspecific" accumulation due to other intra-abdominal disease.

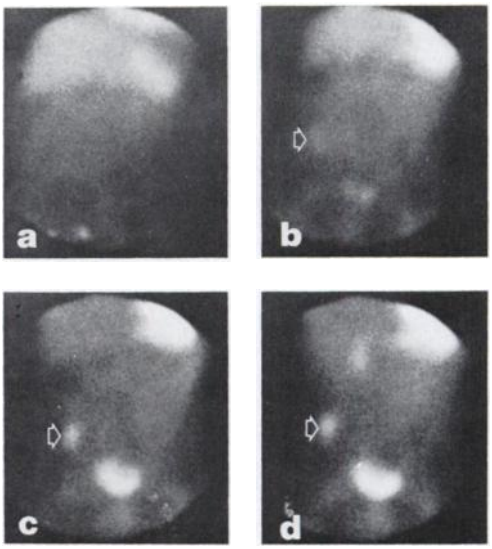

FIG. 4. Typical positive scintigrams in a child with a bleeding Meckel's diverticulum that contained ectopic gastric mucosa; 10 min (a), 20 min (b), 30 min (c), and 50 min (d) after pertechnetate injection. Arrows indicate lesion.

Ectopic gastric mucosa in a Meckel's diverticulum. There are characteristics that may strongly support this diagnosis:

1. Usually the hyperactivity is prominent, rounded, and of small size (Fig. 4).

2. It appears simultaneously with that in the stomach, usually between 10 and 20 min after injection, and persists throughout the study, increasing in intensity parallel to the intensity of the stomach (Fig. 4). Occasionally the activity fluctuates, probably because of a "washaway" effect of the intestinal secretion or hemorrhage.

3. It may be located anywhere in the abdomen but more commonly is in the right lower quadrant.

4. It may change position in the abdomen (*37*,*47*) after the patient is raised or turned (Fig. 5), or has voided (Fig. 6). We recommend that upright anterior and oblique views be obtained to differentiate ectopic mucosa

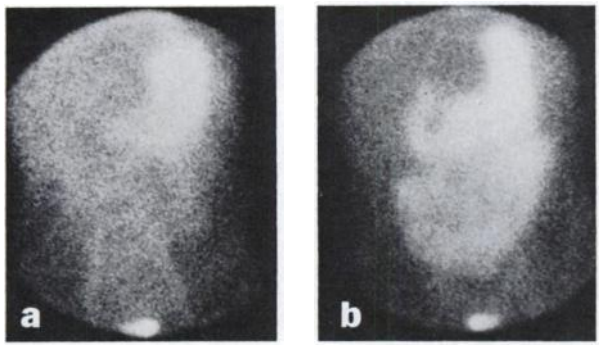

FIG. 3. Scintigrams from a child with enteritis, showing small-intestinal activity at 20 min (a) and 60 min (b) after pertechnetate injection.

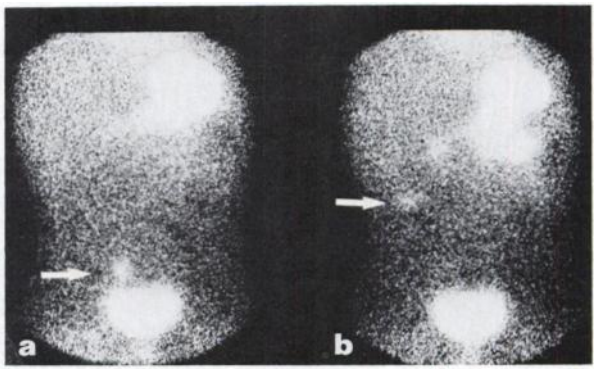

FIG. 5. Positive scintigrams showing a Meckel's diverticulum (arrow) that changes position in the abdomen, (a) at 30 min; (b) at 45 min.

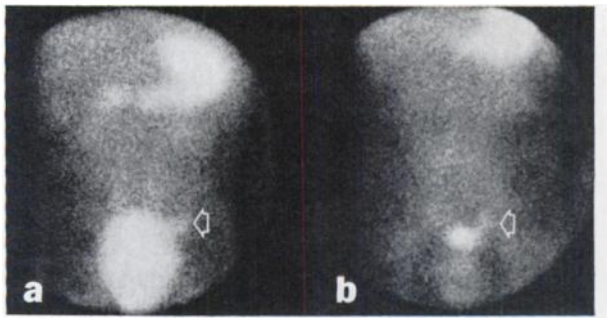

FIG. 6. Positive scintigrams with focus of activity associated with the left upper margin of urinary bladder (a). Lesion follows bladder after voiding (b). Intravenous pyelogram and cystograms were normal; ectopic gastric mucosa was present in excised Meckel's diverticulum.

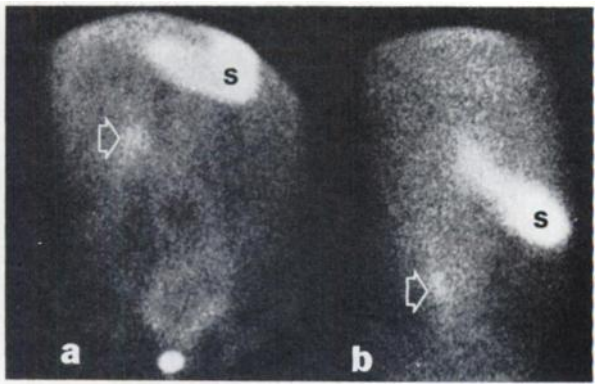

FIG. 8. Anterior (a) and right lateral (b) images showing renal pelvic activity (open arrow) to be retroperitoneal. S = stomach.

from the activity of the duodenum. The former drops, as the free intestine follows gravity unless adhesions are present, whereas the latter maintains its position (Fig. 7).

5. The diverticulum is intra-abdominal; if visible on a lateral view, it will be located anteriorly, in contrast to the retroperitoneal urinary-tract structures (Figs. 7 and 8).

6. The lesion is single, although more than one area of ectopic mucosa in different parts of the bowel is possible (*21*). Gastric mucosa may exceed the limits of the Meckel's diverticulum and spread in the adjacent bowel, producing a large, low-intensity lesion on the scan (Fig. 9).

Ectopic gastric mucosa in other than Meckel's diverticulum. Islands of ectopic gastric mucosa in otherwise normal bowel also produce abnormal scintigrams (*21*). A few cases of abnormal scintigrams from ectopic gastric mucosa in enteric duplication and duplication cysts have been described (*14-17,19,48*). The hyperactivity was small and focal (*14,19,48*) or large (*15,17*) depending on the size of the abnormality. Gastrogenic cysts may show mediastinal accumulation of activity on pertechnetate imaging (*13*). Surgery will be likely in all these cases.

Barrett's esophagus. In this abnormality, the mucosa of the esophagus is lined with columnar epithelium of the gastric type instead of the normal stratified squamous epithelium. Dysphagia, "heartburn," regurgitation, and bleeding may occur. Carcinomatous transformation of the columnar epithelium has been reported (*49*).

Although rare in children, Barrett's esophagus can be detected by pertechnetate imaging (Fig. 10) when cells of the gastric mucoid type are present (*50*). The technique is different in that continuous suction of the radioactive saliva from the patient's mouth is indicated, if the patient cannot avoid swallowing his saliva. Activity cephalad of the stomach indicates the existence of esophageal gastric-type mucosa (*13,51-53*) involving the lower segment, and frequently extending to the middle, and occasionally to the upper segment (*22*). It must be differentiated from hiatal hernia and gastroesophageal reflux (*13,51*). Scintigraphy detects true ectopic gastric mucosa containing mucus-producing cells, which, if not abundant, may result in normal images (*54*). Parietal cells are not necessary for an abnormal image (*53*). Metaplasia of the esophageal epithelium

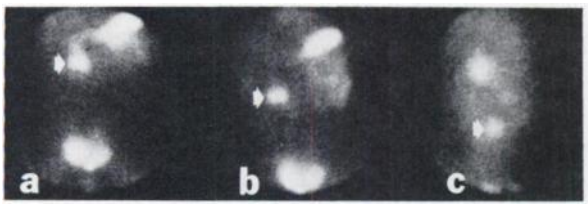

FIG. 7. Positive scintigram showing a focus of activity (arrow) in duodenum (a). Upright anterior image (b) shows normal activity to have moved caudally (distance from stomach increased); lateral image (c) shows lesion to be intraperitoneal. Child had a Meckel's diverticulum with ectopic gastric mucosa.

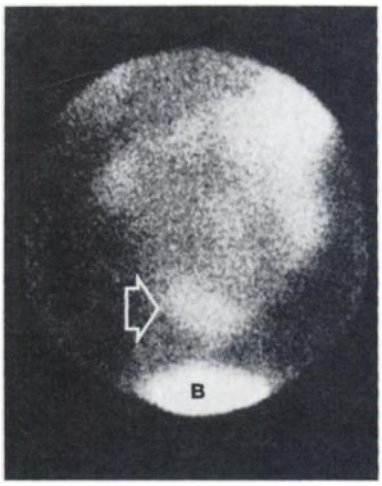

FIG. 9. Abdominal scintigram at 60 min after pertechnetate injection, showing prominent midline activity in lower abdomen (arrow). Ectopic gastric mucosa was found to exceed the limits of a Meckel's diverticulum, spreading into the adjacent bowel wall. B = urinary bladder.

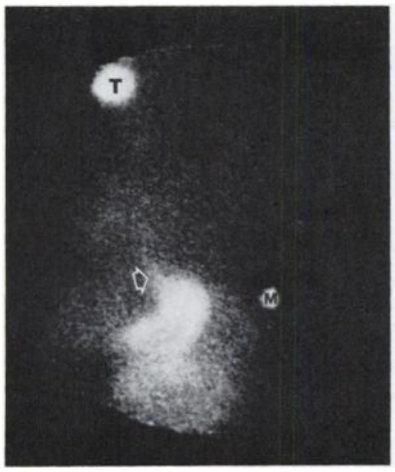

FIG. 10. Barrett's esophagus (arrow) visualizing on pertechnetate scintigram. T = thyroid gland; M = marker at level of xiphoid.

does not produce an abnormal scan, as we have found in two cases.

False-positive pertechnetate studies. "Nonspecific" positive images may occur, although they are uncommon (*21*) and they do not consistently result in positive findings (*55*).

1. Peptic ulceration (*14*) may show up most probably due to hyperemia or active bleeding (*16,25*). We have no personal experience, but we would expect that the image would be prominent early and would fade between 20 and 30 min. Other tests are more specific for this diagnosis.

2. Intussusception (*3,4,23,56*), intestinal obstruction (*5,23,57*), regional enteritis (*24,25*), and localized inflammation (*16,23*) have been reported to produce positive pertechnetate scans. The cause should be attributed to hyperemia and hypersecretion of the bowel. The clinical picture is usually different, however, and radiological studies may provide a more specific diagnosis. When visualized, the lesions on scintigraphy are much larger than the typical Meckel's diverticulum (*21*) and assume the configuration of the segment of the bowel involved.

3. Arteriovenous malformations (*20,27*), hemangiomata, and some tumors (*28,29*) can cause positive images. Again, increased blood flow or blood pool is the most likely cause, and the dynamic early appearance at the beginning of the pertechnetate study may help in differentiation.

4. Urinary tract abnormalities (*25*), such as hydronephrosis, extrarenal pelvis, ectopic kidney, hydroureters, vesicoureteral reflux, and bladder diverticula may produce positive scans that are very confusing in the anterior projection. The dynamic study and lateral, postvoiding, and upright images can lead to a correct diagnosis. Occasionally, excretory urograms, renal scintigrams, or retrograde studies may be needed to confirm the scintigraphic findings.

Authors of large series have found "nonspecific" positive images to be uncommon and a minor problem in interpretation of the scans (*21,55*). The above compilation of nonspecific lesions comes from individual case reports. Certainly pertechnetate imaging is not a method for the diagnosis of these abnormalities (*21,41*).

False-negative studies and increased reliability with drugs. With the best technique, the sensitivity of the method is approximately 85% (*1*). False-negative studies occur because:

1. Ulceration and hemorrhage may occur without gastric mucosa (erosion from stones) (*10*).

2. The ectopic gastric mucosa may be insufficient in mass (inherently (*58*), or after necrosis) or function (impaired blood supply) to be visualized.

3. Dilution and "wash-away" of the activity by hemorrhage or bowel hypersecretion diminish localization.

4. Suboptimal techniques or overlapping organs (bladder, duodenum) obscure the picture.

The clinical use of pentagastrin (*36*) and/or glucagon may reduce the number of false positives; cimetidine may also be effective, but reportedly (*37*) requires 1-2 days of pretreatment; injectable cimetidine may prove clinically more useful. Further experience is necessary to establish indications for their routine use.

DOSIMETRY

Technetium-99m has a half-life of 6 hr and decays by gamma emission (140 keV). An internal conversion close to 10% adds to the overall radiation exposure from this radionuclide.

It is calculated that the radiation dosimetry for the total body is in the range of 13 mrads per mCi in the standard man. The target organs—thyroid gland, gastric mucosa, and large-intestinal mucosa—receive, respectively, 270, 100, and 150 mrads per mCi (*6,59*).

The thyroid gland can be protected by use of potassium perchlorate after the examination. Considering the specificity and the sensitivity of the method, the exposure, equivalent to approximately 20 sec of x-ray fluoroscopy (*60*), is acceptable, particularly because no other method is as accurate (*30-32,61*). The study is acceptable to the Nuclear Regulatory Commission and the Food and Drug Administration and does not require a special informed consent (*60*).

CONCLUSION

Pertechnetate abdominal imaging has become a routine test in nuclear medicine practice. The overall accuracy of 98%, experienced in all series and cases reported, and in 90% when surgically proven cases were analyzed, has proven the validity of this method (*1*). A sensitivity of 85% (surgically proven cases) calls for further work to improve the technique. The clinical use of gut hormones (glucagon or pentagastrin and gluca-

gon) or H_2 blockade by cimetidine will probably improve the sensitivity, as indicated by experimental work in animals and a few tests in patients.

The test should be performed after careful patient preparation, sequential 1-hr imaging with multiple scintigrams in different views, and informed interpretation, as described above. It is the only specific test to diagnose ectopic gastric mucosa, the surgical removal of which will cure patients suffering from serious and life-threatening hemorrhage. Clinical experience, however, has indicated that false-positive studies can result from technical errors or from interpretation of the images without knowledge of the patient's clinical condition and without the help of the information from the adjunctive radiologic examination needed in some cases.

REFERENCES

1. SFAKIANAKIS GN, CONWAY JJ: Detection of ectopic gastric mucosa in Meckel's diverticulum and in other aberrations by scintigraphy: 1. Pathophysiology and 10-year clinical experience. *J Nucl Med* 21: 647-654, 1981
2. HARDEN RMcG, ALEXANDER WD, KENNEDY I: Isotope uptake and scanning of stomach in man with ^{99m}Tc-pertechnetate. *Lancet* 1:1305-1307, 1967
3. DUSZYNSKI DO, JEWETT TC, ALLEN JE: Potentialities of abdominal scanning with ^{99m}Tc-sodium pertechnetate. *J Nucl Med* 11: 628, 1970 (abst)
4. DUSZYNSKI DO, ANTHONE R: Jejunal intussusception demonstrated by Tc^{99m} pertechnetate and abdominal scanning. *Am J Roentgenol* 109: 729-732, 1970
5. JEWETT TC JR, DUSZYNSKI DO, ALLEN JE: The visualization of Meckel's diverticulum with 99m Tc-pertechnetate. *Surgery* 68:567-570, 1970
6. MCAFEE JG, FUEGER CF, STERN HS, et al: Tc^{99m} pertechnetate for brain scanning. *J Nucl Med* 5:811-827, 1964
7. BERQUIST TH, NOLAN NG, ADSON MA, SCHUTT AJ: Diagnosis of Meckel's diverticulum by radioisotope scanning. *Mayo Clin Proc* 48:98-102, 1973
8. KILPATRICK JM: Scanning in diagnosis of Meckel's diverticulum. *Hosp Pract* 9:131-138, 1974
9. RUTHERFORD RB, AKERS DR: Meckel's diverticulum: A review of 148 pediatric patients, with special reference to the pattern of bleeding and to mesodiverticular vascular bands. *Surgery* 59:618-626, 1966
10. CANTY T, MEGUID MM, ERAKLIS AJ: Perforation of Meckel's diverticulum in infancy. *J Pediatr Surg* 10:189-193, 1975
11. HIRSCHY JC, THORPE JJ, CORTESE AF: Meckel's stones. A case report. *Radiology* 119:19-20, 1976
12. GERSHATER R: Enterolith causing bleeding in a patient with Meckel's diverticulum. Angiographic demonstration. *Radiology* 120:327-328, 1976
13. MARK R, YOUNG L, FERGUSON C, et al: Diagnosis of an intrathoracic gastrogenic cyst using ^{99m}Tc-pertechnetate. *Radiology* 109:137-138, 1973
14. HO JE, KONIECZNY KM: The sodium pertechnetate Tc 99m scan: An aid in the evaluation of gastrointestinal bleeding. *Pediatrics* 56:34-40, 1975
15. WILSON JP, WENZEL WW, CAMPBELL JB: Technetium scans in the detection of gastrointestinal hemorrhage. Preoperative diagnosis of enteric duplication in an infant. *JAMA* 237:265-266, 1977
16. HO JE, GLEASON WA, THOMPSON JS: The expanding spectrum of disease demonstrable by Tc-99m pertechnetate abdominal imaging. *J Nucl Med* 19:691, 1978 (abst)
17. Case Records of the Massachusetts General Hospital (Case 16-1980: Duplication of ileum with ectopic gastric mucosa and peptic ulceration with perforation). *N Engl J Med* 302: 958-962, 1980
18. RODGERS BM, YOUSSEF S: "False positive" scan for Meckel diverticulum. *J Pediatr* 87:239-240, 1975
19. WINTER PF: Sodium pertechnetate Tc 99m scanning of the abdomen. Diagnosis of an ileal duplication cyst. *JAMA* 237:1352-1353, 1977
20. MONOD BROCA P, BACH C, DESGREZ A: Hémorragies intestinales: Contribution à la détection des hétérotopies de muqueuse gastrique et du diverticule de Meckel: Intérêt de scintigramme gastrique. *Chirurgie* 98:649-652, 1972
21. BERQUIST TH, NOLAN NG, STEPHENS DH, et al: Specificity of ^{99m}Tc-pertechnetate in scintigraphic diagnosis of Meckel's diverticulum: Review of 100 cases. *J Nucl Med* 17:465-469, 1976
22. SAILER JF, JANEWAY CM: Pertechnetate demonstration of a Barrett's esophagus involving the length of the esophagus. *J Nucl Med* 19:1366-1367, 1978 (Letter to the editor)
23. DUSZYNSKI DO, JEWETT TC, ALLEN JE: Tc^{99m}Na pertechnetate scanning of the abdomen with particular reference to small bowel pathology. *Am J Roentgenol* 113:258-262, 1971
24. GELFAND MJ, SILBERSTEIN EB, COX J: Diagnosis of Meckel's diverticulum by scintigraphy: Clinical and pathological correlation. *J Nucl Med* 17:553, 1976 (abst)
25. LUNIA S, LUNIA C, CHANDRAMOULY B, et al: Radionuclide meckelogram with particular reference to false-positive results. *Clin Nucl Med* 4:285-288, 1979
26. CHAUDHURI TK, CHAUDHURI TK, CHRISTIE JH: False positive Meckel's diverticulum scan. *Surgery* 71:313, 1972 (Letter to the editors)
27. SIDDIQUI A, RYO UY, PINSKY SM: Arteriovenous malformation simulating Meckel's diverticulum on ^{99m}Tc-pertechnetate abdominal scintigraphy. *Radiology* 122:173-174, 1977
28. POLGA JP, SARGENT J, DICKINSON P: Positive intestinal scan caused by carcinoid tumor. *J Nucl Med* 15:365-366, 1974
29. TAUSCHER JW, BRYANT DR, GRUENTHER RC: False positive scan for Meckel diverticulum. *J Pediatr* 92:1022-1023, 1978
30. MEQUID MM, WILKINSON RH, CANTY T, et al: Futility of barium sulfate in diagnosis of bleeding Meckel diverticulum. *Arch Surg* 108:361-362, 1974
31. FARIS JC, WHITLEY JE: Angiographic demonstration of Meckel's diverticulum. *Radiology* 108:285-286, 1973
32. DALINKA MK, WUNDER JF: Meckel's diverticulum and its complications with emphasis on roentgenologic demonstration. *Radiology* 106:295-298, 1973
33. PRIEBE CJ, MARSDEN DS, LAZAREVIC B: The use of ^{99m}technetium pertechnetate to detect transplanted gastric mucosa in the dog. *J Pediatr Surg* 9:605-613, 1974
34. WINE CR, NAHRWOLD DL, WALDHAUSEN JA: Role of the technetium scan in the diagnosis of Meckel's diverticulum. *J Pediatr Surg* 9:885-888, 1974
35. SELTZER MH, CONTE PJ JR, RICKERT RR, et al: Diagnosis of a bleeding Meckel's diverticulum using radiopertechnetate. *Am J Gastroenterol* 67:235-239, 1977
36. TREVES S, GRAND RJ, ERAKLIS AJ: Pentagastrin stimulation of technetium 99m. Uptake by ectopic gastric mucosa in a Meckel's diverticulum. *Radiology* 128:711-712, 1978

37. PETROKUBI RJ, BAUM S, ROHRER GV: Cimetidine administration resulting in improved pertechnetate imaging of Meckel's diverticulum. *Clin Nucl Med* 3:385-388, 1978
38. SFAKIANAKIS GN, ANDERSON GF, KING DR, et al: The effect of intestinal hormones on the Tc-99m pertechnetate (TcO_4) imaging of ectopic gastric mucosa in experimental Meckel's diverticulum. *J Nucl Med* 22:678-683, 1981
39. ANDERSON GF, SFAKIANAKIS GN, KING DR, et al: Hormonal enhancement of technetium-99m pertechnetate uptake in experimental Meckel's diverticulum. *J Pediatr Surg* 15: 900-905, 1980
40. POLGA JP: Nasogastric suction to improve gastrointestinal scanning. *J Nucl Med* 15:374, 1974
41. SINGH PR, RUSSELL CD, DUBOVSKY EV, et al: Technique of scanning for Meckel's diverticulum. *Clin Nucl Med* 3: 188-192, 1978
42. FEGGI LM, BIGHI SM: Technical notes for scintigraphy of Meckel's diverticulum. *J Nucl Med* 20:888-889, 1979
43. KILBURN E, GILDAY DL, ASH J: Meckel's diverticula—Serial multiple view imaging. *J Nucl Med* 17:553, 1976 (abst)
44. SFAKIANAKIS GN, HAASE GM, ORTIZ VN, MORSE TM: Abdominal imaging for ectopic gastric mucosa: A reevaluation. *J Nucl Med* 19:691, 1978 (abst)
45. GELFAND MJ, SILBERSTEIN EB, COX J: Radionuclide imaging of Meckel's diverticulum in children. *Clin Nucl Med* 3:4-8, 1978
46. COLBERT PM: Problems with radioisotope scan for Meckel's diverticulum (letter to the editor). Kilpatrick ZM: Reply. *N Engl J Med* 291:530-531, 1974
47. HEGGE FN: Prominent motion of a Meckel's diverticulum. *J Nucl Med* 19:1087, 1978 (Letter to the editor)
48. RODGERS BM, YOUSSEF S: "False positive" scan for Meckel diverticulum. *J Pediatr* 87:239-240, 1975
49. BRAND DL, YLVISAKER JT, GELFAND H, et al: Regression of columnar esophageal (Barrett's) epithelium after antireflux surgery. *N Engl J Med* 302:844-848, 1980
50. PAULL A, TRIER JS, DALTON MD, et al: The histologic spectrum of Barrett's esophagus. *N Engl J Med* 295:476-480, 1976
51. BERQUIST TH, NOLAN NG, CARLSON HC, et al: Diagnosis of Barrett's esophagus by pertechnetate scintigraphy. *Mayo Clin Proc* 48:276-279, 1973
52. GORDON F, RAMIREZ-DEGOLLADO J, MUNOZ R, et al: Diagnosis of Barrett's esophagus with radioisotopes. *Am J Roentgenol* 121:716-719, 1974
53. BERQUIST TH, NOLAN NG, STEPHENS DH, et al: Radioisotope scintigraphy in diagnosis of Barrett's esophagus. *Am J Roentgenol* 123:401-411, 1975
54. CHAUDHURI TK, POLAK JJ: Autoradiographic studies of distribution in the stomach of ^{99m}Tc-pertechnetate. *Radiology* 123:223-224, 1977
55. ROSENTHALL L, HENRY JN, MURPHY DA, et al: Radiopertechnetate imaging of the Meckel's diverticulum. *Radiology* 105:371-373, 1972
56. JAMES AE JR, STRECKER E-P, MILLER FJ, et al: An experimental study of ^{99m}Tc pertechnetate abdominal scans in jejunal intussusception: Preliminary results. *J Surg Res* 19: 71-76, 1975
57. DUSZYNSKI DO: Radionuclide imaging studies of gastrointestinal disorders. *Semin Nucl Med* 2:383-386, 1972
58. CONWAY JJ and the Pediatric Nuclear Club of the Society of Nuclear Medicine: The sensitivity, specificity and accuracy of radionuclide imaging of Meckel's diverticulum. *J Nucl Med* 17:553, 1976 (abst)
59. SMITH EM: Internal dose calculation for ^{99m}Tc. *J Nucl Med* 6:231-251, 1965
60. CONWAY JJ: Radionuclide diagnosis of Meckel's diverticulum. *Gastrointest Radiol* 5:209-213, 1980
61. BREE RL, REUTER SR: Angiographic demonstration of a bleeding Meckel's diverticulum. *Radiology* 108:287-288, 1973