Intestinal Concentration of ^{99m}Tc-Pertechnetate Into Isolated Loops of Rat Bowel

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In scanning patients for Meckel's diverticulum, the colon occasionally visualizes more rapidly than would be expected simply from gastric secretion and intestinal transit. To gain a better understanding of the intestinal physiology of pertechnetate and thereby to make a more intelligent interpretation of abdominal scans, segments of the gastrointestinal tract of Sprague–Dawley rats were isolated by transection between double ligations. After abdominal closure, the animals received an intravenous injection of $^{99m}TcO_4$ and were killed at 30, 45, or 150 min after injection. Technetium concentrations in the stomach, colon, and appendiceal contents increased significantly with time after dosing, and after 30 min technetium could be clearly imaged in the stomach, upper small intestine, appendix, and colon. These results suggest that technetium is actively secreted by the intestinal mucosa. Additionally, the results indicate caution in the interpretation of scans in patients with suspected Meckel's diverticulum since, in the rat and probably in the human, significant amounts of technetium can accumulate in the gut apart from gastric secretion and intestinal transit.

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Pertechnetate, administered subcutaneously or intravenously, is actively secreted by the gastric mucosa (*1–3*) and this fact provides the basis for its use in scanning to detect Meckel's diverticulum (*4–6*). During such use, however, we have observed that the intestine occasionally appears more rapidly than would be expected simply by gastric secretion and intestinal transit. Others have made similar observations and postulated active secretion by the bowel mucosa (*5,7*). The recent autoradiographic findings indicating that pertechnetate is concentrated and secreted by the epithelial cells rather than the parietal cells of the stomach (*8,9*) also strengthen the possibility that pertechnetate may be secreted by epithelial cells of the bowel mucosa.

If intestinal secretion of pertechnetate does occur, then the possibility of a physiologic false-positive scan in patients suspected of having Meckel's diverticulum must be considered, especially since the scan findings may be used as an indication for surgery. Apart from the importance of this practical problem, documentation of pertechnetate transfer between physiologic compartments is fundamental in clarifying the mechanism of enteric concentration of technetium compounds and the subsequent radiation dose to the bowel. These considerations led us to study the dynamics of technetium concentration in isolated loops of rat intestine.

MATERIALS AND METHODS

Ten Sprague–Dawley rats, 230–270 gm in weight, were anesthetized with ether. The abdomens were opened and double ligations were placed at the following sites: the pylorus; 10 cm proximal to the appendix; 0.5 cm proximal to the appendix; and

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0.5 cm distal to the appendix. To ensure that no contents passed from one isolated segment to the next, the bowel was severed between each of the double ligations. Ligation of the upper small-bowel segment at its distal end was not performed due to its greater technical difficulty. Care was taken to preserve the mesenteric blood supply. The abdomen was then closed and 100 μCi of ^{99m}Tc-pertechnetate in 0.1 cm^3 of normal saline was injected into the tail vein of each rat. Five rats were killed by intracardiac puncture and exsanguination 45 min after injection; the remaining five rats were similarly killed 150 min after injection. The contents of the stomach, colon, appendix, distal small-bowel segment, and an 8-cm segment of proximal small bowel were collected and placed in counting vials. The organ segments were then washed and the washings added to the appropriate vials. The segments were blotted dry and weighed. In addition, the tail, blood, liver, and kidney samples were also obtained. All samples were counted using the 140-keV photopeak of ^{99m}Tc in an automated Searle Radiographics well counter.

To avoid any errors due to subcutaneous extravasation of injected technetium in the tail, with incomplete absorption, the injected dose was calculated by subtracting the activity remaining in the tail from the total injected dose. The results are expressed as % dose/gram tissue/100 gm rat (Table 1). The data describing activity in the organ contents are similarly expressed; for example, activity in the stomach contents is presented as % dose/gram stomach tissue/100 gm rat. The means at 45 and 150 min were compared by Student's t-test.

A similar experiment was conducted in four additional Sprague–Dawley rats, weighing 208–227 gm. At 30 min after dosing, two rats were killed by ether overdose and imaged with a Searle Radiographics HP scintillation camera with a pinhole collimator. The remaining two rats were killed and imaged at 2 hr. Immediately after imaging, the abdomens were opened and the isolated segments removed from the body, arranged as indicated in Fig. 1A, and reimaged. When the imaging was completed, the organ segments and their contents were weighed and counted as previously described.

TABLE 1. ^{99m}Tc ACCUMULATIONS IN TISSUE AND TISSUE CONTENTS (% DOSE/GM TISSUE/100 GM RAT)*

	45 min	150 min	p value‡
Blood	1.36 ± 0.09	0.92 ± 0.12	≤ 0.01
Stomach	1.37 ± 0.54	1.81 ± 0.81	NS
Upper small intestine (USI)	0.52 ± 0.22	0.48 ± 0.16	NS
Liver	1.45 ± 0.42	1.66 ± 0.21	NS
Kidney	0.62 ± 0.18	1.04 ± 0.41	NS
Lower small intestine (LSI)	0.20 ± 0.05	0.16 ± 0.06	NS
Colon	0.21 ± 0.06	0.26 ± 0.10	NS
Appendix	0.24 ± 0.05	0.23 ± 0.03	NS
Stomach contents†	2.26 ± 0.98	8.99 ± 1.51	≤ 0.005
USI contents†	0.68 ± 0.30	1.10 ± 0.78	NS
LSI contents†	0.22 ± 0.12	0.15 ± 0.03	NS
Colon contents†	0.35 ± 0.08	1.28 ± 0.23	≤ 0.0025
Appendix contents†	0.16 ± 0.05	1.16 ± 0.23	≤ 0.0025

* Mean of five animals in each group ± 1 s.d.
† % dose in the lumen of the organ segment/gram segment tissue/100 gm rat.
‡ Significance of the difference between the mean uptakes at 45 and 150 min by Student's t-test. NS indicates "not significant."

RESULTS

The results are shown in Table 1. As expected, Tc concentration in the blood decreased significantly from 45 min to 150 min. Technetium concentration in the stomach wall probably did not change during the study, but its accumulation in the stomach contents increased significantly. Concentration of technetium was higher in the wall of the upper small intestine than in the wall of the lower small intestine, but in neither case did the concentration significantly change during the study period. Some technetium appeared in the contents of the lower small intestine, but there was no increase during the period of observation. Technetium accumulation in the contents of the upper small intestine was greater than in the contents of the lower small intestine and it seemed to be increased at 150 min compared to 45, although the difference was not considered significant. The failure to detect a significant difference may have occurred because the upper small-intestinal segment was not ligated at its distal end.

Technetium concentrations in the wall of the appendix and colon were similar and did not significantly increase. In contrast, technetium accumulation in the contents of both the appendix and colon increased significantly during the study period.

A scintillation camera image (using a pinhole collimator) of one of the rats killed at 30 min after dosing was obtained (Fig. 1B). Diffuse abdominal Tc accumulation is observed. After imaging, the stomach, gut, and both kidneys were removed from the rat, arranged as indicated in Fig. 1A, and reimaged (Fig. 1C). The stomach, kidneys, midportion of the small intestine, appendix, and colon can be seen easily. It should be kept in mind that the proximal portion of the upper small intestine was sampled for inclusion in Table 1, while most of the scan activity occurred in the lower portion of this

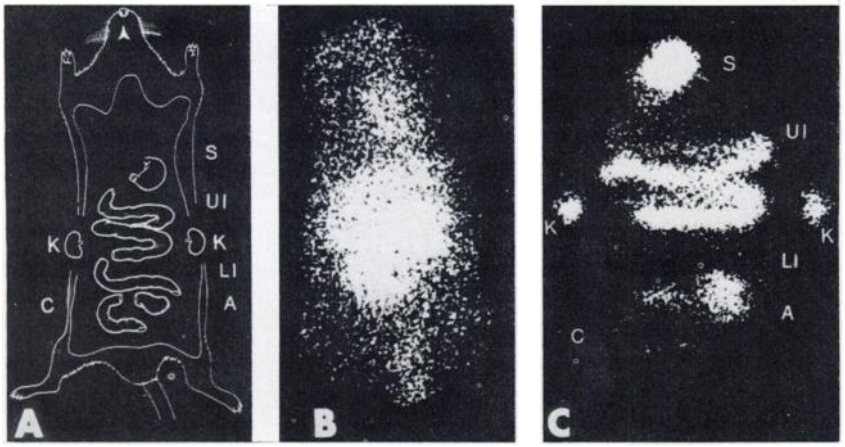

FIG. 1. (A) Rat intestine is ligated and severed at pylorus, 10 cm proximal to appendix, 0.5 cm proximal to appendix, and 0.5 cm distal to appendix. (B) Scintillation camera image of rat killed 30 min after injection of pertechnetate. (C) Isolated loops from same rat have been removed from body, arranged as indicated ing Fig. 1A, and re-imaged. (S) Stomach; (UI) upper small intestine; (K) kidney; (LI) lower small intestine; (A) appendix; (C) colon.

segment, which was not sampled. Undoubtedly, some of the Tc secreted passed out of the upper segment by peristalsis. Consequently, the total activity entering the contents of the upper small bowel was almost certainly greater than the activity actually tabulated.

DISCUSSION

In the rat, at least, technetium appears rapidly in the bowel lumen without help from the stomach. Assuming that the human gastrointestinal system handles pertechnetate similarly, normal accumulation in the gut lumen might result in localized areas of radionuclide concentration. In the human, this occurrence could result in a false-positive scan for Meckel's diverticulum and at least one such case, where surgery revealed no satisfactory explanation for the area of increased uptake, has been reported (*10*).

Note that technetium did not accumulate significantly in the lumen of the distal small intestine during the study period (Fig. 1C). Perhaps the distal ileum in the human, which is located primarily in the right lower quadrant and is the most common location for Meckel's diverticulum, does not significantly accumulate technetium or does so to a much lesser degree than the remainder of the bowel. In this situation, a Meckel's diverticulum secreting technetium could be more easily detected since it would stand out against the relatively cold background of the ileum in the right lower quadrant. These considerations might help explain why abdominal scanning with pertechnetate for Meckel's diverticulum has been reported to be of value (*4,6*). The clinician should keep in mind, however, the possibility of a false-positive scan, particularly if the area of increased technetium accumulation is located outside the right lower quadrant.

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