RECTAL ABSORPTION OF ^{99m}Tc-PERTECHNETATE IN THE DOG

Vicente J. Caride

Yale University School of Medicine, New Haven, Connecticut

As a prerequisite of the utilization of $^{99m}TcO_4^-$ as a tracer to study the rectal-to-hepatic vascular pathways, we analyzed the dynamics of its rectal absorption in dogs. Activity was recorded over the rectal area and over the heart with a dual-probe system. Pertechnetate was absorbed from the rectal lumen with a $t_{1/2} = 1.41 \pm 0.57$ for its first component. The second component did not show any appreciable slope. Results obtained for rectal absorption of ^{131}INa were $t_{1/2} = 2.2 \pm 0.72$, 40 $\pm$ 22 and 360 $\pm$ 253 min for each of the components of the curve.

Paper chromatography did not show any variation in the chemical state of the TcO_4^- in the rectal content or blood. We suppose that this different handling of pertechnetate compared with that of iodine was due to a further concentration of technetium in the colonic wall. This in turn may be responsible for the existence of a significant amount of radioactivity remaining in the abdominal area.

Several authors have reported on the absorption of pertechnetate from the uppergastrointestinal tract (*1,2*). Following oral ingestion, the peak of blood radioactivity could be noted at about 30 min. Information on absorption of pertechnetate from the lower regions of the gut is less complete. In one report, following introduction of the material through a colostomy, the highest activity in the blood was reached at only 5 min (*2*). We have therefore studied the dynamics of pertechnetate absorption from the rectum—both to quantify the event and as a necessary prerequisite in studying the details of rectal to hepatic transport of radionuclides.

MATERIALS AND METHODS

Mongrel dogs (9–15 kg) were anesthetized with intravenous sodium pentobarbital and studied under the dual-probe system (3-in. NaI (Tl) crystals, scales, and spectrometers). This was coupled to a high-speed Franklin printer. The ^{99m}Tc (as $^{99m}TcO_4^-$, from a generator) was administered through a polyethylene catheter (i.d. = 0.04 in.) that was placed 8-cm in from the rectal margin (residual radionuclide expressed from the tube by a drop of air). Approximately 50 μCi of ^{99m}Tc were used. The volume of pertechnetate-saline solution introduced through the catheter into the rectal lumen was 0.1 ml up to 6 ml (no differences were observed in results obtained with the different volumes). The dogs were on their backs and one probe was placed over the abdominal wall (above the rectal area). The second probe was positioned over the heart. Activity in each area was followed for 1 hr. The resultant activity compared with time plots was corrected for physical decay of ^{99m}Tc. In three dogs, ^{99m}Tc was injected through the gut wall into an exteriorized loop of the left colon, which had both its ends ligated.

In four dogs the intrarectal experiments were performed with approximately 100 μCi of ^{131}INa in place of sodium pertechnetate. The monitoring was identical, and the gamma-ray spectrometer was set to the energy of ^{131}I.

The data on rectal activity were then plotted on a logarithmic scale compared with time on a linear scale. When two components to the resultant line were observed, the magnitude and half-time of each was calculated. Data on activity detected over the heart were analyzed on the assumption of an approach to equilibrium, i.e.,

$$A = A_\infty (1 - e^{-\lambda t})$$

plots were made of

$$\mathrm{Ln}\left(1 - \frac{A}{A_\infty}\right) \text{ vs time.}$$

Ascending paper chromatography of standards,

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For reprints contact Vicente J. Caride, Yale University School of Medicine, Dept. of Radiology, 333 Cedar St., New Haven, Conn. 06510.

rectal contents, and blood was performed using Whatman No. 3 paper and 100% methanol (*3*).

RESULTS

Rectal disappearance of ^{99m}Tc activity showed a two-component curve. The first component had a mean half-time of 1.41 ± 0.57 min in nine trials (Table 1). About 14% of the pertechnetate was handled in this manner. The second component had an indefinitely long half-time (Fig. 1).

In the three dogs who had the ^{99m}Tc introduced into the exteriorized colon, the first component of the curves had a mean half-time of 3.0 min (Table 2). As with the rectal experiments, there was no appreciable second component.

The buildup of radioactivity over the heart following rectal introduction of pertechnetate showed a rapid initial slope and then a prolonged plateau (Fig. 2). Also shown on the figure is a plot of $(1 - A/A_\infty)$ on a logarithmic scale. The accumulation half-time by this plot was 0.8 min in the case illustrated. Shown in Table 2 are the $T_{1/2}$ values for cardiac activity following introduction of pertechnetate into the exteriorized colon. Table 3 shows comparable data for cardiac activity after pertechnetate introduction into the rectum. Blood samples were taken in three dogs at 10 min after intrarectal administration of TcO_4^-. Samples of the rectal contents were obtained at the same time to obtain evidence on the chemical state of the technetium. On chromatography studies it was found that the principal peak was at $R_f = 0.41$ for both rectal contents and blood, the same as TcO_4^-.

The rectal disappearance of ^{131}I (introduced as sodium iodide) differed from that of pertechnetate. Shown in Table 4 are the data that show three different disappearance components.

TABLE 1. DATA ON THE RECTAL ABSORPTION OF ^{99m}Tc-PERTECHNETATE

Dog No.	$t_{1/2}$ (min)	%*	Vol (cc)
8	2.5	22	1
10	1.5	26	1
11	1.0	14	1
12	1.1	13	0.25
12†	1.3	10	1
13	1.71	8	0.1
14	0.85	13	0.2
29	0.75	10	6
33	2.0	13	6
Mean 1.41 s.d. ± 0.57		14.3	

* % is percent of ^{99m}Tc disappearing by this mechanism.
† Repeat study on same dog.

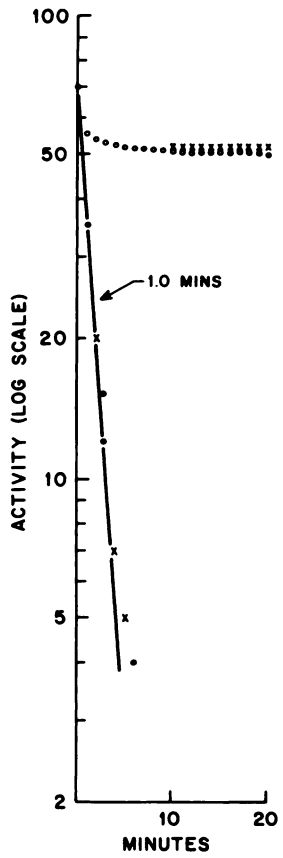

FIG. 1. Rectal disappearance of ^{99m}Tc [(Dog #11) data are corrected for decay of ^{99m}Tc].

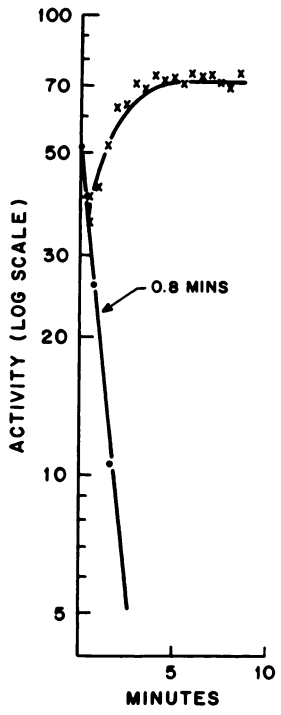

FIG. 2. Increase of radioactivity over heart following intrarectal introduction of pertechnetate. Straight line portion of curve was calculated on assumption of exponential approach to equilibrium.

TABLE 2. DISAPPEARANCE OF PERTECHNETATE FROM EXTERIORIZED COLON OF DOG

Dog II	Colon $t_{1/2}$	Colon %	Heart activity $t_{1/2}$
26	2.6	14.0	0.8 min
37	2.0	11.7	2.0 min
38	4.5	27.5	1.5 min
Mean:	3.0	17.7	1.4

TABLE 3. RADIOACTIVITY DETECTED OVER HEART AFTER INTRARECTAL INTRODUCTION OF PERTECHNETATE

No.	$t_{1/2}$ (min)
8	2.0
10	1.0
11	0.4
12	0.5
13	0.5
13*	0.7
14	0.4
14*	0.3
28	1.4
35	0.8
35*	1.8
Mean 0.89	
s.d. ± 0.59	

* Repeat study on same dog.

TABLE 4. RECTAL DISAPPEARANCE OF ^{131}I (AS SODIUM IODIDE)

Dog No.	$t_{1/2}$ (min) C_1	$t_{1/2}$ (min) C_2	$t_{1/2}$ (min) C_3	% * C_1	% * C_2	% * C_3	Volume introduced (cc)
1	2.0	56	650	40	27	33	3
2	2.0	62	—	13	17	70	1
3	1.5	17	182	13	23	64	1
4	3.2	25	250	15	33	52	3
Mean	2.2	40	360	20	25	55	
s.d.	±0.72	±22	±253	±13.2	±6.7	±16.3	

* % is percent of ^{131}I disappearing by this mechanism for each component (C_1, C_2, C_3).

DISCUSSION

The present data point out the kinetics of pertechnetate absorption from the rectum and its difference from absorption of iodide.

We have found that 14% of the initial activity of $^{99m}TcO_4^-$ was rapidly absorbed from the colon. During the following hour, however, there was little decreased activity. Coincidentally, radioactivity detected over the heart reflecting circulating pertechnetate in the blood showed a pattern of rapid initial slope followed by a prolonged plateau.

These facts lead us to hypothesize that $^{99m}TcO_4^-$ is undergoing some continuous absorption to maintain the blood level of activity, but at the same time there is concentration into the colon leading to an approximate equilibrium. Several different mechanisms could explain the data: Secretion into the lumen, concentration of circulating ^{99m}Tc in the colonic wall, or formation of poorly absorbable compounds in the intestinal lumen ($^{99m}TcO_4^-$ combining with secretion and feces).

Evidence that all of the mechanisms can occur has been reported (*4–7*). However, secretion of pertechnetate into the lumen occurs as a late event (*6*), and no change in the chemical state of $^{99m}TcO_4^-$ was disclosed by paper chromatography.

Iodide was handled differently by the colon. Forty-five percent of the initial activity was absorbed during the first hour, and the remaining iodide was continuously absorbed at a slower rate ($t_{1/2} = 360$ min). Similar results have been noted by Cohn (*8*) (in dogs 48.4 ± 4.6% of KI absorbed in the first 2 hr by the colon), and by Levitan (*9*) who found that in humans, at 24 hr after intrarectal administration of iodide, 72.7 ± 9% was absorbed by the colon. The main difference found in our experiment between technetium and iodide might be due to the further concentration of technetium in the colonic wall.

To choose the appropriate tracer to study portal circulation, using rectal entry, we need to know its behavior in the lumen. Delayed absorption due to formation of unabsorbable compounds, secretion into the lumen, etc., could account for longer circulation times leading to erroneous interpretations. Rectal entry has been used by others to determine "portal circulation time," the existence of portal hypertension, the patency of portal shunts, or the presence of metastases. This has been done by introducing ether (*10,11*) or radioactive tracers such as ^{24}Na (*12*), ^{131}I-Na (*13–15*), and recently, ^{133}Xe (*16*).

However, few studies have been made of the rectal absorption of each of the tracers. From our present data we conclude that $^{99m}TcO_4^-$ is not the ideal tracer to study portal circulation, using rectal entry, because a significant amount of radioactivity remains in the abdominal area following administration. This introduces considerable error.

An ideal tracer for such studies has to be rapidly absorbed, chemically as well as biologically inactive, and preferably without recirculation. On this basis, radioxenon might be a more advisable tracer (*16*).

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