Use of ^{99m}Tc-Labeled Triethylenetetramine–Polystyrene Resin for Measuring the Gastric Emptying Rate in Humans

Keyphrases □ Technetium Tc 99m—as radiolabel on triethylenetetramine–polystyrene resin, scintigraphic determination of gastric emptying rate, humans □ Scintigraphy, external—determination of gastric emptying rate using ^{99m}Tc-labeled triethylenetetramine–polystyrene resin □ Triethylenetetramine–polystyrene resin—^{99m}Tc-labeled, use in scintigraphic determination of gastric emptying rate, humans □ Gastric emptying rate—scintigraphic determination using ^{99m}Tc-labeled triethylenetetramine–polystyrene resin, humans □ Radiopharmaceuticals—^{99m}Tc-labeled triethylenetetramine–polystyrene resin, scintigraphic determination of gastric emptying rate, humans

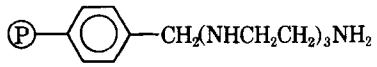
To the Editor:

The introduction of γ-emitting short-lived radionuclides provides the opportunity for the determination of gastric emptying time using external scintigraphy. Quantitative dynamic data can be obtained with these radionuclides without physical or physiological influences on the GI tract (1). Futhermore, excellent scintigraphic images of the stomach, intestines, and colon can be obtained with a low target organ and total body radiation dose.

Several radiopharmaceutical preparations have been introduced for measuring gastric motility and emptying: ^{51}Cr-sodium chromate (2, 3), ^{113m}In- or ^{99m}Tc-labeled diethylenetriaminepentaacetic acid (3, 4), ^{113m}In-microcolloid (5), an insoluble colloid of ^{99m}Tc-antimony sulfide (6), ^{99m}Tc-labeled human albumin microspheres (7), and their combinations (3, 8).

After a meal, the liquid phase of gastric contents is discharged through the pylorus more rapidly than the solid phase. Therefore, radiopharmaceutical preparations dispensed as liquids give lower values for the half-time of gastric emptying (4), and minor deviations in time would provide opportunity for greater error. Comparison of emptying rates using ^{113m}In-diethylenetriaminepentaacetic acid and ^{51}Cr-sodium chromate showed that significantly slower rates were obtained with chromate. Subsequent *in vitro* studies demonstrated adsorption of chromate on the solid component of the meal (3). Thus, difficulties may be encountered with radiopharmaceuticals that appear to interact with the solid particles in a meal and the stomach wall. Colloidal preparations are difficult to prepare, and their physicochemical properties offer disadvantages such as the formation of micelles and coagulation.

Additional criteria in selecting a radiopharmaceutical preparation for gastric emptying are that it should: (*a*) not influence the osmolality of the stomach content (9), (*b*) be nonabsorbable and nonadsorbable (10), (*c*) bind the radionuclide tenaciously and provide no opportunity for physical or chemical interaction with food particles or the stomach wall, (*d*) possess ideal food mixing characteristics and have a particle size comparable to that of food, and (*e*) be nontoxic and inert and give reproducible and noninvasive estimates of the gastric emptying time without exposing the patient to a high radiation dose. The last prerequisite becomes exceedingly important in gastric emptying determinations involving pediatric patients (5).



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Polystyrene beads (40–100 mesh) bearing triethylenetetramine (I) functions (11) (2 mEq/g) efficiently and quantitatively chelated pertechnetate[1] ($^{99m}TcO_4^-$) from aqueous solutions (12). The ^{99m}Tc-labeled resin is stable in simulated gastric juice USP, releasing only 2.0% of the radioactivity in 25 hr at 37°. When the ^{99m}Tc-complex with I was administered to dogs and humans with a standardized meal, it satisfied all of the previously mentioned criteria for the determination of gastric emptying times. The release of radioactivity from the resin was monitored by collecting blood and urine samples from dogs and human volunteers. Less than 0.2% of the radioactivity was released during the passage of the resin throughout the entire GI tract.

In a typical experiment, 0.25 g of I in 20 ml of water was stirred with the $^{99m}TcO_4^-$ solution[1] (20 μCi) for 10 min. The resin was recovered by filtration, washed with water, and subsequently added to the test meal. This meal consisted of 33.3 g of cream of wheat and 2.4 g of sodium chloride in 235 ml of water. After the subject ingested the labeled test meal, the time was recorded and the subject was placed in a supine position under the collimated detector of a multicrystal scintillation γ-camera[2]. The positions of the γ-camera and of the patient were adjusted so that the entire stomach appeared in the center of the monitoring oscilloscope.

Several scintiphotos of the stomach were obtained at certain time intervals. In each time interval, a series of seven or eight points was collected. Each point represented the integrated relative radioactivity per minute of the desired flagged area of the stomach. The data were stored on a magnetic tape for future reference. The logarithm of the relative radioactivity of the stomach was plotted against time. The half-time of the gastric emptying of the test meal and the ^{99m}Tc-labeled I resin beads was determined from the slope of the line. A whole body survey at the end of each study failed to show any detectable activity outside of the GI tract.

By utilizing the described technique, gastric emptying times ranging from 45 to 60 min were obtained for 10 healthy volunteers (Fig. 1). These times agree with results obtained with other radiopharmaceuticals (6). In all normal subjects studied, monoexponential kinetics were obtained for gastric emptying. Similar kinetic profiles were obtained with patients with pyloric stenosis, although

[1] Technetium Tc 99m, obtained from a ^{99}Mo-generator (E. R. Squibb and Sons, Princeton, NJ 08540) in its pertechnetate form ($^{99m}TcO_4^-$), is a γ-emitting radionuclide with a half-life of 6 hr and an energy of 140 Kev.

[2] Baird Atomic System 77 (Baird Atomic Nuclear Division, Bedford, MA 01730) equipped with a computer and magnetic tape and possessing storage and replay capability.

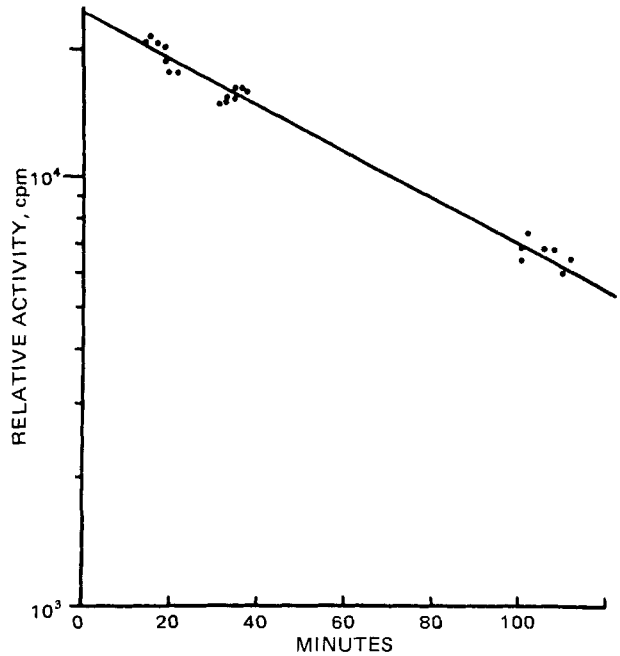

Figure 1—*Rate of clearance of ^{99m}Tc-labeled polystyrene beads bearing triethylenetetramine functions from the stomach of a normal human male subject (half-time of gastric emptying = 51 min).*

these subjects exhibited longer gastric emptying times (115 min) (Fig. 2).

Measurement of gastric emptying is an important aid to the clinician studying gastroduodenal disease, dumping syndrome, and postvagotomy disturbances. Gastric emptying is delayed in malignant disease of the stomach, gastric ulcers, and pyloric stenosis. On the other hand, hastened emptying has been associated with duodenal ulcers. Symptoms of dumping syndrome and diarrhea following gastrectomy and vagotomy are due to altered gastric emptying (10). A simple, accurate, and noninvasive technique for measuring gastric emptying is needed. ^{99m}Tc-Labeled I has a great potential for becoming a popular radiodiagnostic agent for routine clinical determinations of gastric emptying times.

Gastric emptying has been suggested to be a major determinant in the absorption rate of drugs. Individual variations in the rate of drug absorption from any one dosage form may be due largely to differences in the rate of gastric emptying (13, 14). Experiments are now in progress to assess ^{99m}Tc-labeled I in studying the effects of drugs on the gastric emptying rate as well as the gastric emptying influence on drug bioavailability.

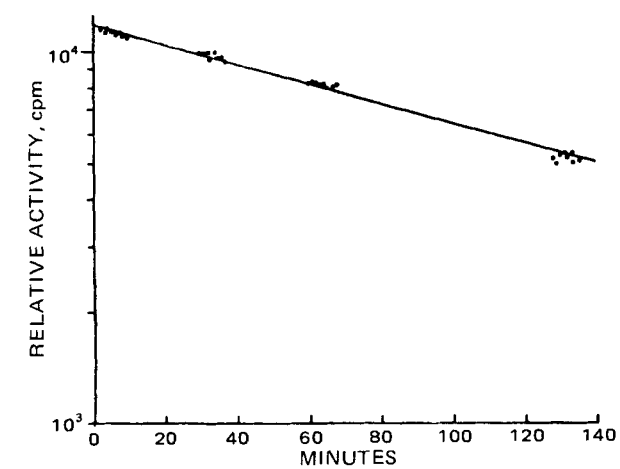

Figure 2—*Rate of clearance of ^{99m}Tc-labeled polystyrene beads bearing triethylenetetramine functions from the stomach of a female patient with pyloric stenosis (half-time of gastric emptying = 115 min).*

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Received March 16, 1976.
Accepted for publication December 9, 1976.
We thank Ms. S. Yonts for assistance and Dr. F. DeLand for guidance and encouragement.
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Identification of an Impurity in Illicit Amphetamine Tablets

Keyphrases □ Amphetamine—illicit tablets, impurity identified as α-benzylphenethylamine ■ α-Benzylphenethylamine—identified as impurity in illicit amphetamine tablets ■ Contaminants—α-benzylphenethylamine identified in illicit amphetamine tablets

To the Editor:

An impurity detected in exhibits of illicit amphetamine tablets has been identified as α-benzylphenethylamine (I). The tablets, of a type known as "mini-bennies," were found to contain caffeine as well as *dl*-amphetamine (II), the latter as a sulfate salt. TLC examination on silica gel plates[1] revealed an additional spot, R_f 0.7, which, upon

[1] Mobile phase consisted of ammonia-saturated chloroform–methanol (18:1); visualization was by shortwave UV.