

# Colonic Transit Time: Current Methodology and its Clinical Implications.

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**Abstract:** An abnormality in transit is commonly considered to account for unexplained gastrointestinal (GI) symptoms. This review describes the most commonly used methods for the measurement of GI transit including small bowel transit test for dyspeptic symptoms and diarrhea, colonic transit test for constipation. Colonic transit times can help uncover causative diagnoses by stratifying motility disorders into two main patterns: colonic inertia and outlet obstruction. Several factors, including diet, physical activity, and psychological and hormonal factors may affect digestive transit-time results; therefore, some variation is expected. Noninvasive tests of GI transit help in the evaluation to guide therapy.

## MEASUREMENT OF COLONIC TRANSIT

Colonic dysmotility (abdominal pain, constipation, and diarrhea) are first evaluated by careful review of medical history, physical examination and laboratory studies to identify disorders that may produce chronic constipation symptoms. Endoscopy, colonoscopy, enteroscopy and barium meal follow through may be performed to assess organic causes. Recently, GI transit studies have become an important part of the evaluation of patients with constipation without any organic cause of obstruction.

## PHYSIOLOGY OF COLONIC MOTILITY

Purpose of colonic movement is to slow down the movement of intestinal contents and to facilitate absorption of water and allow growth of microorganisms. At the same time the colonic contents need to be propelled forward for passage of feces. Studying colonic motility is difficult due to lack of good animal model and irregular colonic activity.

There are two different patterns of colonic motility

**Ring contractions** - Ring contractions are further of two types: tonic and rhythmic. Tonic ring contractions are responsible for haustrae formation and mixing of contents and they disappear during peristalsis. Rhythmic ring contractions are lumen occlusive and migrate caudally. They are responsible for mass movements.

**Sleeve contractions:** Sleeve contractions are responsible for basic tone of colon.

## PURPOSE OF MEASUREMENT OF COLONIC TRANSIT TIME

Measurement of colonic transit time helps in understanding the pathophysiology of constipation. On basis of colonic transit time constipation can be subdivided in two types

1. Normal transit constipation
2. Delayed Transit Constipation

In normal transit constipation there is a segmental delay of colonic transit and is seen in anorectal sensory defect and psychiatric patients.

## DELAYED TRANSIT CONSTIPATION CAN BE FURTHER SUBDIVIDED INTO TWO TYPES

- a. Colonic inertia
- b. Outlet dysfunction

Colonic inertia is due to uncoordinated motility, it is associated with abnormalities in other parts of gastrointestinal tract and urinary

abnormalities.

These studies addition to demonstrating that the patient's colonic transit is slow, these tests may be used to determine whether the patient's slow transit constipation is caused by too little movement (colonic inertia) or too much, uncoordinated movement. These tests may also help in understanding the effect of medical or surgical treatment for constipation. It can also determine if normal transit is present in the setting of the patient's perception of constipation

## METHODS TO MEASURE COLONIC TRANSIT TIME

The main limitation in measuring colonic transit is due to physiological variability in colonic movement.

There are two basic techniques described to assess colonic transit time (CTT).

1. Radio-opaque Markers
2. Scintigraphy based methods.

## CTT USING RADIO-OPAQUE MARKERS

Radiopaque markers can be obtained commercially from many companies. Markers can also be made by cutting circular (2 × 6-mm) or semicylindrical (6 × 6-mm) shapes from 16 F radiopaque Levine tubes. These markers can be placed in a gelatin capsule coated with a pH-sensitive material so that the markers are released after arrival in the colon.

## PROTOCOL FOR SOLID MARKER COLONIC TRANSIT STUDIES

A screening colonic transit test is usually performed without any special preparation of the patient. This procedure allows for the evaluation of baseline colonic transit. No other study should be scheduled for the duration of the marker study. Patients are instructed to continue their usual diet and activities including their usual medications. Colonic transit should be measured with patients off their usual laxatives, enemas, or other medications known to affect GI motility. In a study investigating the effect of clearing the bowel of feces prior to the marker study, 17 of 21 adults with slow colonic transit in the first study had slow transit in the second study. The four patients with outlet obstruction in the first transit study showed no evidence of delayed transit in the second study after a cleanout. Thus, in the setting of a patient with a large amount of stool in the colon, magnesium citrate can be administered for 1–2 days prior to marker testing to clear the colon.

The earliest method was proposed by Hinton, 1969.<sup>2</sup> In a study by

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Arhan et al., 20 radiopaque markers were ingested in the morning and abdominal x-rays were taken at 24-hr intervals until all markers had been passed.<sup>3</sup> Most healthy, symptom-free subjects passed all markers out of the colon within 4 to 5 days.

A simplified version of the radiopaque marker total colonic transit test involves one abdominal x-ray on the sixth day or 120 hr after marker ingestion.<sup>4</sup>

Another approach for total and segmental colonic transit, described by Metcalf et al.<sup>5</sup> and Chaussade et al.<sup>6</sup>, involves the ingestion of radiopaque markers each day at the same time for 3 sequential days. An abdominal x-ray is taken at the same time on the fourth day of the study and then at 3-day intervals (7th day, 10<sup>th</sup> day, etc) until all markers have been passed.

## ASSESSMENT AND INTERPRETATION OF COLONIC TRANSIT USING SOLID MARKERS.

Various approaches are reported to evaluate the progress of radiopaque markers through the gut<sup>2,3,4</sup>. The rate of disappearance of the 20 markers is exponential, with the mean number of markers retained in the healthy colon reported as 16 (1 day after ingestion), 8 (2 days after), 4 (3 days after), 2 (4 days after), and 1 (5 days after)<sup>3</sup>. Marker studies have been used to calculate segmental colonic transit where markers are counted in the right colon, left colon, and rectosigmoid. In this method, the radiograph is separated into segments, markers counted, and a simple mathematical formula used to calculate transit time. For example, if 8 markers were counted in the right colon after 24 hr, 3 markers after 48 hr, 1 marker after 72 hr, and 0 marker after 96 hr, the right colonic transit time =  $(8 + 3 + 1) \times 1.2 = 14.4 \text{ hr}^3$ . For the simplified version of the radiopaque marker total colonic transit test, which involves one abdominal x-ray 120 hr after marker ingestion<sup>4</sup>, colonic transit is normal in adults if <20% of the markers can be seen on the x-ray<sup>4</sup>. Less than 20% marker retention on the fifth-day x-ray would be normal for children<sup>7</sup>. Patients may be found with abnormal transit time for one segment of the colon but not the whole colon. Delay in one segment is only important if total colonic transit is abnormally delayed. However, studies validating the ability of this approach to accurately select patients who would benefit from resection of just one segment of the colon are lacking. Accordingly, segmental colonic transit times (Figure 1) are not often used. Instead, the result is used to simply document slow colonic transit and outlet obstruction.

Fig 1



Abdominal x-ray on day 7 of the transit study. Twenty of the 60 markers are retained, most of them in the rectosigmoid, but some also in the left colon. The mean colonic transit time in hours is  $1.2 \times$  the number of markers retained in each x-ray (Figures 7 and 8). The total number of markers in each segment is used and multiplied by 1.2 regardless of the type of marker,  $60 + 20 = 80 \times 1.2 = 96 \text{ hr}$ .

## SCINTIGRAPHIC COLONIC TRANSIT TEST

This uses radio-isotopes such as Indium 111, Iodine cellulose, Gallium citrate colonic transit scintigraphy is a safe and noninvasive method for the quantitative evaluation of overall and regional colonic transit. It is applicable for patients with slow and fast transit alike and there is no increase of radiation exposure with multiple scans. Disadvantages are related to the handling of the radioisotope, high

costs, and need for specialized equipment (i.e., a gamma camera). The isotope can be given orally in a nonabsorbable form together with a test meal (radiolabeled mixed meal)<sup>7</sup> in a capsule coated with a pH-sensitive material that dissolves in the colon or terminal ileum (coated capsule)<sup>8</sup> or encapsulated in nondigestive capsules<sup>9</sup>. Anterior and posterior gamma camera images are obtained at specified time points.

## EQUIPMENT DESCRIPTION AND SPECIFICATIONS FOR SCINTIGRAPHIC COLONIC TRANSIT STUDY.

The equipment used for colonic scintigraphy is similar to that used for gastric emptying study. Specifically, in order to include the entire colon within the region of interest, a gamma camera with a large field of view is required. Since 111In is the preferred radioisotope for colonic transit studies, the gamma camera should be equipped with a medium-energy collimator. Anterior and posterior images are captured and analyzed according to hand-drawn region of interest on a dedicated nuclear medicine computer.

## PROTOCOL FOR SCINTIGRAPHIC COLONIC TRANSIT STUDIES.

**Radiolabeled Mixed Meal.** A conventional dual-labeled test meal, consisting of a sandwich of two 99mTc-sulfur colloid-labeled scrambled eggs and 300 ml of water labeled with 111In-DTPA, is consumed by the patient to start the study<sup>7</sup>. Dual isotope imaging begins immediately after ingestion of the meal. For 2 hr, to measure gastric emptying of solids and liquids, an image is acquired every 30 min in the upright position. After 2 hr, the subjects are imaged in the supine position every 30 min for the measurement of small bowel transit. This part of the study is continued until all of the tracer has entered the colon. For colonic transit, images are taken at 24, 48, and 72 hr (Figures 2 and 3). The rationale for utilizing radiolabeled liquid for the small intestine and colonic transit portions of this technique is that this reduces the variability in small intestine and colonic transit results that might be caused by delayed gastric emptying for solids. In general the liquid component of a test meal empties from the stomach much more rapidly than the solid component.

Fig 2

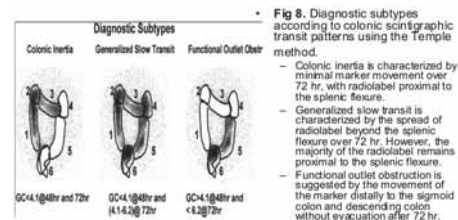
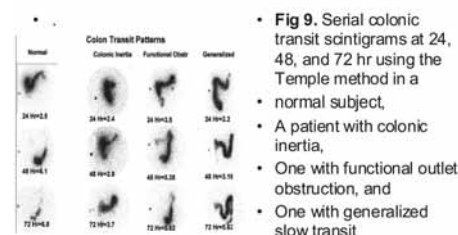


Fig 3



**Fig 8.** Diagnostic subtypes according to colonic scintigraphic transit patterns using the Temple method.

- Colonic inertia is characterized by minimal marker movement over 72 hr, with radiolabel proximal to the splenic flexure.
- Generalized slow transit is characterized by the spread of radiolabel beyond the splenic flexure over 72 hr. However, the majority of the radiolabel remains proximal to the splenic flexure.
- Functional outlet obstruction is suggested by the movement of the marker distally to the sigmoid colon and descending colon without evacuation after 72 hr.

**Fig 9.** Serial colonic transit scintigrams at 24, 48, and 72 hr using the Temple method in a

- normal subject,
- A patient with colonic inertia,
- One with functional outlet obstruction, and
- One with generalized slow transit

**Coated Capsule.**  $^{111}\text{InCl}_3$  (0.10 mCi) is mixed with a slurry of 5 mg activated charcoal. The slurry is evaporated to dryness on a hotplate at 90°C, and the dried charcoal is placed into a size 1 gelatin capsule (Eli Lilly, Indianapolis, IN) and coated with pH-sensitive methacrylate (Eudragit S100)<sup>8,10</sup>. The capsule is administered with 3 oz of water. This capsule opens to release its contents in the area of the terminal ileum or cecum. After the capsule has been emptied from the stomach or after a maximal wait of 2 hr, 2 scrambled eggs labeled with  $^{99m}\text{Tc}$  are consumed. The technetium-labeled meal is used for the measurement of gastric emptying. Images are taken at 0, 2, 4, 6, and 24 hr. A standardized lunch consisting of 500 kcal is consumed 4 hr after the start of the study.

In contrast to these studies based on limited images, continuous capture of marker movement within the colon must be used to discriminate between patients with colonic inertia (hypomotility) and those with normal or hypermotility whose transit abnormality is on the basis of poor coordination of pressure activity in different parts of the colon<sup>11</sup>.

## ASSESSMENT AND INTERPRETATION OF COLONIC TRANSIT USING SCINTIGRAPHY

The geometric center is a weighted average of the radioactivity counted over specific parts of the bowel, i.e., the ascending, transverse, and descending colon as well as the rectosigmoid. The method practiced at the Mayo Clinic designates numbers from 1 to 5 for counts in these regions as well as the activity in defecated stools, respectively, as a weighted factor (Figure 3). The method practiced at Temple University designates numbers from 1 to 7 for counts in ascending colon, hepatic flexure, transverse colon, splenic flexure, descending colon, rectosigmoid, and evacuated stools, respectively, as a weighted factor (Figures 2 and 3). The geometric center is calculated as the sum of the fraction represented by the counts in each region divided by the total counts with the sum multiplied by the region number<sup>12</sup>. Thus, a low geometric center implies that most of the radiolabeled material is close to the cecum, whereas a high geometric center indicates that most of the radiolabeled material is in the rectosigmoid or the stools.

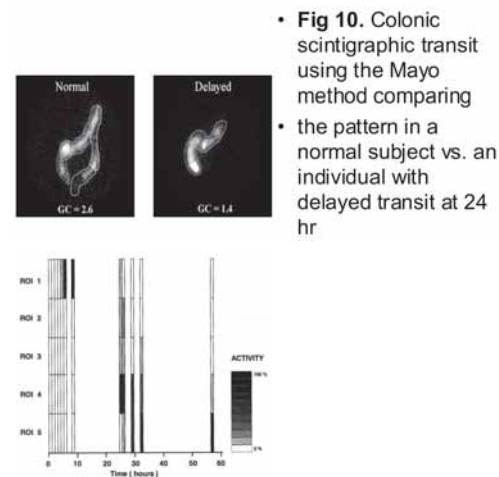
**Radiolabeled Mixed Meal.** For colonic transit following a radiolabeled meal, scintigraphic images are taken at 24, 48, and 72 hr. The normal values for the geometric center range from 2.0 to 7.0 for 24 hr, 4.6 to 7.0 for 48 hr, and 6.2 to 7.0 for 72 hr. The diagnosis of colonic inertia is made when the geometric center is less than 4.6 at 48 hr. Although the ranges of normal colonic transit times reported by several investigators are similar<sup>10</sup>, these ranges are not directly comparable because of significant differences in the study protocols. The timing of meals, their caloric and fiber content, and their carbohydrate, fat, and protein content remain to be standardized<sup>13</sup>.

**Coated Capsule.** Luminal pH increases crossing the ileocecal valve area. By using a gelatin capsule coated with pH-sensitive methacrylate, this method permits delayed release of radioisotope and accurate calculation of transit across the colon from a single starting location and time. A marker, to be used to map the location of the capsule, is placed on the patient's anterior superior iliac spine. The geometric center at 4, 24, and, occasionally, 48 hr is estimated using the geometric mean of counts in the ascending, transverse, descending, and rectosigmoid colon and stool (weighted by factors of 1 to 5, respectively).

The primary variable of interest is the geometric center at 24 hr (normal range, 1.6–3.8) (Figure 9). The normal values for the geometric center according to the Mayo method are  $\leq 1.4$  for 4 hr and 1.7–4.0 for 24 hr<sup>14</sup> (Fig. 4). Slow colonic transit is defined as a

geometric center less than these normal values at 24 hr<sup>14</sup>. Compared to the radioopaque marker technique, scintigraphic assessment of colonic transit takes less time and can identify not only slow, but also rapid colonic transit. This approach provides >90% sensitivity for distinguishing between normal and delayed or accelerated transit<sup>10,15,16</sup>.

Fig 4



- Fig 10. Colonic scintigraphic transit using the Mayo method comparing
- the pattern in a normal subject vs. an individual with delayed transit at 24 hr

## CONCLUSIONS

Radio opaque marker studies are simple and can clearly measure prolonged transit, but segmental transit is unreliable unless methods to outline the bowel are used. Radioisotope studies require a specialist centre and several days to perform but give detailed information on transit through the stomach, small and large bowel. GI transit studies are important to study the motility disorders and thus guide the treatment.

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