Colonic Transit Study by Radio-Opaque Markers

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Abstract

Assessment of colon transit time is the most useful tool to evaluate disorders of colonic motility. It is especially helpful in making a pathologic diagnosis and for planning management in patients with complaints of constipation. Currently, several techniques for assessing colon transit time are available. Assessment of colon transit by radio-opaque markers has been most widely used. This study is simple and inexpensive, as well as reliable. However, it requires good compliance on the part of the patient, produces radiation exposure, and does not measure the transit of a true meal [1–3].

Keywords

Colon transit time • Constipation • Motility • Colonic motility disorders • Radio-opaque markers

Introduction and General Considerations

Colon transit study is indicated to measure total and segmental colonic transit times in patients with complaints of constipation, and may help in evaluating the results of medical or surgical treatment for colonic motility disorders. This study is contraindicated in pregnancy and bowel obstruction.

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Radio-Opaque Markers

Radio-opaque markers can be obtained commercially or can be made by cutting Levine tubes. Commercially prepared markers are plastic beads or rings that are usually ingested in a capsule. Two kinds of radio-opaque markers, Kolomark™ (M.I.Tech., Pyongtaik, Korea) [4] and Sitzmarks® (Konsyl Pharmaceuticals, Fort Worth, TX, USA) [5] are commonly used in Korea. Each single capsule contains 20 or 24 radio-opaque markers, respectively (Fig. 3.1).

Patient preparation

Any special preparation of patients is not required prior to the colon transit study by radio-opaque markers. All contrast material, if any, should be cleared from the colon, and no other study should be scheduled for the duration of the study. Patients should be instructed to continue their usual diet and activities, including their usual medications. Colon transit study, however, should be performed with patients off their usual laxatives, enemas, or other medications known to affect gastrointestinal motility [6].

Methods

After Hinton et al. [7] first described the measurement of gut transit through ingestion of radio-opaque markers in 1961, there have been many methods to assess colon transit time using these markers. The techniques can be divided into two categories: (1) single-capsule technique and (2) multiple-capsule technique.

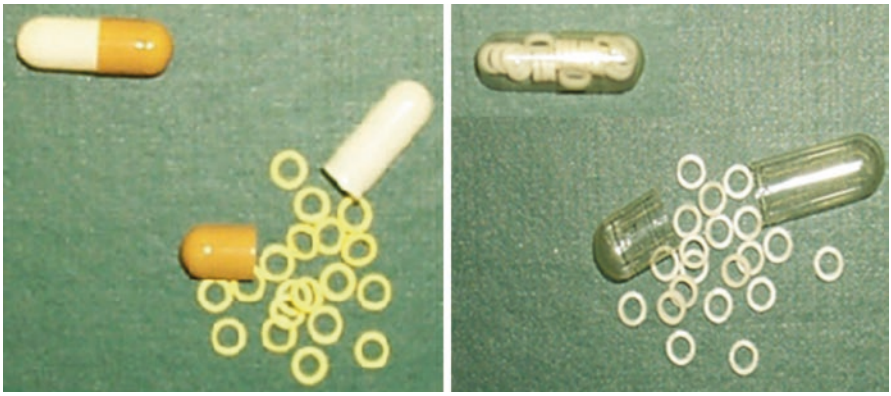

Fig. 3.1 Kolomark™ and Sitzmarks® capsules: 20 or 24 radio-opaque o-ring markers of same size and weight are in the gelatin capsule

Single-Capsule Technique

Subjects are asked to ingest 20 (or 24) radio-opaque markers in a single capsule at a specific time (usually 8 or 9 a.m.). Abdominal X-rays are then taken in supine position at 24-h intervals until all markers are defecated [8]. This method, however, is time-consuming, inconvenient, and produces greater radiation exposure. A simplified method of single-capsule technique involves one abdominal X-ray on day 6, or 120 h after marker ingestion (Fig. 3.2) [9].

Multiple-Capsule Technique

Subjects are asked to ingest capsules containing 20 (or 24) radio-opaque markers daily at a specific time (usually 8 or 9 a.m.) for three sequential days. Abdominal X-rays are taken on day 4 (four-day method) [10], or on days 4 and 7 (seven-day method) [11]. The four-day method is useful in selecting constipated patients with delayed colon transit but it does not give relevant information on severity of delayed transit. The seven-day method can be used in selecting patients with severely delayed transit [12]. An additional abdominal X-ray can be taken on day 10 in those patients with markers still present on day 7 (Fig. 3.3a, b) [13].

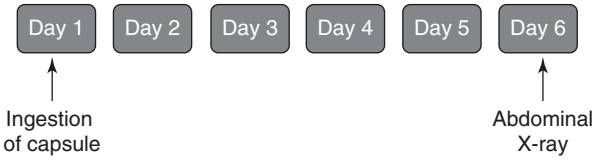

Fig. 3.2 Single-capsule technique

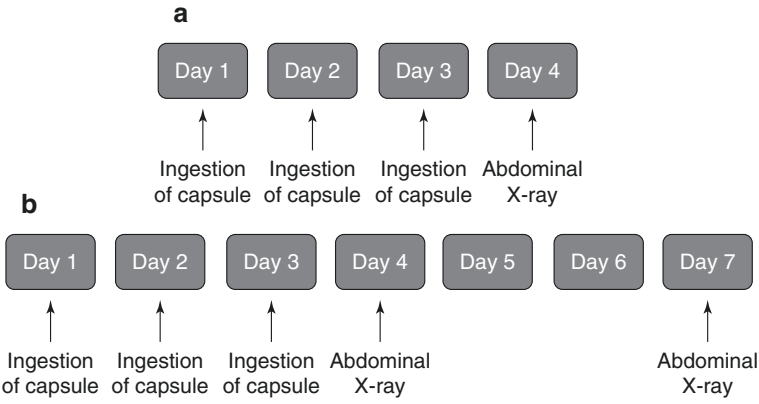

Fig. 3.3 Multiple-capsule technique: (**a**) four-day method; (**b**) seven-day method

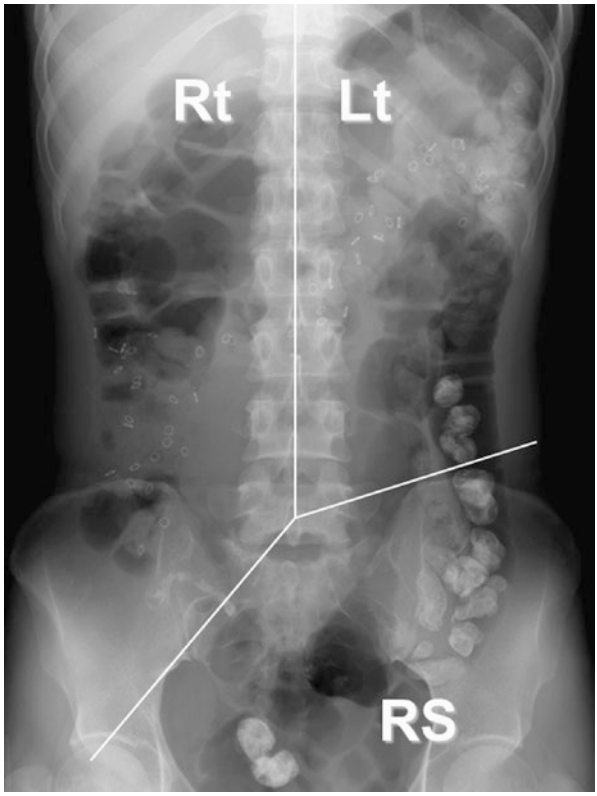

Fig. 3.4 Colonic segments determined by bony landmarks in abdominal X-ray: *Rt* right colon, *Lt* left colon, *RS* rectosigmoid colon

Interpretation

Interpretation is based on the number of markers present in three colonic segments on the abdominal X-ray: right colon, left colon, and rectosigmoid colon. Markers located to the right of the vertebral spinous processes above a line from the fifth lumbar vertebrae to the pelvic outlet are assigned to the right colon. Markers to the left of the vertebral spinous processes and above an imaginary line from the fifth lumbar vertebrae to the anterior superior iliac crest are assigned to the left colon. Markers inferior to a line from the pelvic outlet on the right and the superior iliac crest on the left are assigned to the rectosigmoid colon [8]. Abdominal X-rays should include the diaphragms and the pubis to ensure that all markers in the colon are visualized (Fig. 3.4).

Calculations

Mean transit time of the markers in a single-capsule technique is calculated in the following way [8]:

$$\text{Mean transit time}(\text{hr}) = \frac{1}{N}\sum_{i=1}^{j} n_i \left[\frac{t(i+1)-t(i-1)}{2}\right]$$

where N is the number of given markers, n_i is the number of markers present on abdominal X-ray obtained at time t_i, t is the time elapsed from ingestion of markers to time where abdominal X-ray is taken and $t_0 = 0$, $\left[\frac{t(i+1)-t(i-1)}{2}\right]$ is the time interval between successive abdominal X-rays, and j is the number of abdominal X-rays obtained.

When the single-capsule technique using 20 (or 24) markers in a capsule is performed and successive abdominal X-rays are taken at 24-h intervals, the above formula can be simplified into:

$$\text{Mean transit time}(\text{hr}) = 1.2(\text{or } 1.0) \times (n_1 + n_2 + n_3 \ldots n_j)$$

where n is the number of markers present on each abdominal X-ray, and j is the number of abdominal X-rays obtained.

When the multiple-capsule technique using 20 (or 24) markers in a capsule is performed, the same simplified formula can be used if markers are given at 24-h intervals.

Single-Capsule Technique

Delayed transit is defined when more than 20 % of markers retained on day 6 abdominal X-ray (Table 3.1) [9].

Multiple-Capsule Technique

Mean transit times in each colonic segment and through the entire colon are calculated by multiplying the number of markers by 1.2 (or 1.0 when using a capsule containing 24 markers) (Tables 3.2 and 3.3).

Considerations in Interpretation

The stool pattern and frequency during the study period need to be as usual to show representative colon transit. If not, repeating the study should be considered.

Patients may be found with abnormal transit time for any one colonic segment, but not the total colon. There can be a variation of transit times from day to day in

Table 3.1 The abdominal X-ray five days after ingestion of a single capsule containing 20 radio-opaque markers shows retaining 5 markers (≥ 20 % of markers given) indicating delayed colonic transit

	Number of markers present			
Film	Right colon	Left colon	Rectosigmoid colon	Total colon
Day 6	1	2	2	5

Table 3.2 Calculation of mean transit time by multiple capsules technique (four-day method using a capsule containing 20 radio-opaque markers)

	Number of markers present			
Film	Right colon	Left colon	Rectosigmoid colon	Total colon
Day 4	11	11	12	34

Right colon transit = 1.2 × 11 = 13.2 h
Left colon transit = 1.2 × 11 = 13.2 h
Rectosigmoid colon transit = 1.2 × 12 = 14.4 h
Total colon transit = 1.2 × 34 = 40.8 h

Table 3.3 Calculation of mean transit time by multiple-capsule technique (seven-day method using a capsule containing 20 radio-opaque markers)

	Number of markers present			
Film	Right colon	Left colon	Rectosigmoid colon	Total colon
Day 4	11	11	12	34
Day 7	0	0	2	2
Sum	11	11	14	36

Right colon transit = 1.2 × 11 = 13.2 h
Left colon transit = 1.2 × 11 = 13.2 h
Rectosigmoid colon transit = 1.2 × 14 = 16.8 h
Total colon transit = 1.2 × 36 = 43.2 h

colonic segments and, therefore, delayed transit in one colonic segment can only be considered abnormal if the total colon transit is also delayed [6].

Colon transit appears to be different for different populations, depending upon race, ethnicity, and dietary habit. The method and normative data of one population, therefore, may not be applicable to another population. Colon transit should be standardized and validated for an individual population [14].

Method to Study Colonic Transit in Populations with Faster Colon Transit

In some populations with faster colonic transit, such as among Indian, a conventional method of ingesting a marker every 24 h and then obtaining abdominal radiograph on the fourth day may not be appropriate. Hence, a modified method has been standardized for populations with rapid gut transit. In this method, 20 radio-opaque markers have to be ingested each time at 0 h, 12 h and 24 h. Subsequently, abdominal radiographs are obtained once at 36 h and once at 60 h. Using receiver operative characteristic (ROC) curves, the best cut-off values that differentiated healthy subjects from patients with transit disorders at 36 and 60 h was 30 and 14 markers, respectively. The sensitivity, specificity, positive and negative predictive values, diagnostic accuracy, and area under the ROC curve at 36 h were 90 %, 82 %, 90 %,

82 %, 87 % and 0.9 %, respectively; the corresponding values at 60 h were 95 %, 100 %, 100 %, 92 %, 97 % and 0.99 %, respectively.

Conclusion

Slow colonic transit is an important cause of chronic constipation. Colon transit study by radio-opaque markers is a simple and popular technique to evaluate colon transit time. It not only gives an assessment of transit across the whole colon, but also gives an idea about segmental colon transit. The popular method of assessing colon transit involves administration of multiple radio-opaque markers (typically 20 each time) three times (at 0, 24 and 48 h) and obtaining an abdominal radiograph on the 4th and 7th day. However, in some populations with rapid gut transit time, this protocol may have to be modified to reduce the interval between ingestion of the markers and time of abdominal radiograph.

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