Normative Data of Liquid Gastric Emptying and Small-bowel Transit: A Prospective Cross-sectional Study

Abstract

Purpose of the Study: The primary objective was to establish the reference values for liquid gastric emptying and small bowel. The secondary objectives encompassed comparing the anterior view and geometric mean methods, assessing gender differences, and exploring potential correlations with age. **Materials and Methods:** Thirty-five consecutive healthy participants (28 females and 7 males) with a mean age of 42 ± 11 years (median, 42; range, 23–65) underwent liquid gastric emptying scintigraphy at five intervals (0, 0.5, 1, 2, and 4 h), with optional additional imaging at 24 h. Liquid gastric emptying was evaluated using percent retention and half-time (T1/2). Small-bowel transit was assessed using the index of small-bowel transit (ISBT), calculated as the ratio of terminal ileal reservoir counts to total abdominal counts at 4 h. Reference values were established based on percentiles or mean and standard deviation (SD). Rapid small-bowel transit was determined through visual inspection. Statistical analysis involved paired Samples t-test or Wilcoxon signed-rank test for comparing imaging methods, independent Samples t-test or Mann–Whitney U-test for gender comparison, and Spearman's rank correlation for assessing age-related associations. A 2-tailed $P < 0.05$ indicated significance. **Results:** Rapid liquid gastric emptying based on the geometric mean method was defined as percent retention <8% at 30 min, while delayed emptying as percent retention >33%, >20%, and >4% at 1, 2, and 4 h, respectively. The reference range of T1/2 of gastric emptying was 10–60 min. The reference value for small-bowel transit using the geometric mean method was established as ISBT >30% at 4 h, while rapid small-bowel transit was defined as the first visualization of activity in the cecum-ascending colon within 1 h. Parameters for liquid gastric emptying and small-bowel transit were notably higher in the anterior view method compared to the geometric mean method ($P \leq 0.019$), except for percent retention at 2 h ($P = 0.510$). Nevertheless, the obtained reference values, whether based on percentiles or mean and SD, showed no notable variance between the two methods to warrant clinical significance. Gender did not display an impact on liquid gastric emptying or small-bowel transit in either method ($P \geq 0.173$), and age demonstrated no significant moderate or strong correlations (Spearman's $\rho \leq 0.397$). **Conclusion:** The study determined reference values for liquid gastric emptying and small-bowel transit through a standard gastric emptying scintigraphy protocol, avoiding additional complex procedures or extended imaging sessions. The established normative data can apply to individuals of both genders aged ≥18 years. While advocating the geometric mean method as the primary choice, the study acknowledges that in busy centers handling multiple studies with limited resources and a single-head gamma camera catering to multiple studies, the anterior view method remains a feasible alternative.

Keywords: *Gastric emptying scintigraphy, index of small-bowel transit, liquid gastric emptying, normal range, normative data, reference values, small-bowel transit scintigraphy, small-bowel transit*

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Introduction

Disorders affecting the motility and function of the upper and lower gastrointestinal tract commonly exhibit a wide spectrum of symptoms. The considerable overlap in symptoms poses a challenge when differentiating between these disorders based solely on symptomatic presentation.[1] To aid in the thorough assessment of such cases, the American and European Neurogastroenterology and Motility Societies endorse the use of particular scintigraphic techniques. Gastric emptying scintigraphy serves as a recommended method for evaluating conditions such as gastroparesis and dumping syndrome, while small-bowel transit scintigraphy offers valuable insights into diffuse gastrointestinal motility disorders.[2]

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For bowel transit scintigraphy, a conventional approach involves a dual-tracer solid-liquid meal, typically employing Tc-99 m sulfur colloid for the solid part and In-111 diethylenetriamine pentaacetate (DTPA) water for the liquid component. An alternate suggestion involves using delayed-release capsules containing In-111 DTPA charcoal particles.[1] Previous studies have primarily examined bowel transit using the dual solid-liquid method.[3-10] However, the potential impact of the solid meal on the derived measurements of bowel transit for liquid meals remains uncertain. Furthermore, the availability of In-111 is restricted, and its utilization leads to higher radiation exposure for patients compared to Tc-99 m.

Scant literature data hint at potential abnormalities in liquid gastric emptying among patients experiencing symptoms of gastroparesis despite having normal solid gastric emptying.[11,12] In addition, examining bowel transit in a subgroup of patients with gastrointestinal symptoms but normal solid gastric emptying holds clinical relevance. Utilizing a liquid meal – either as part of a dual solid-liquid meal or as a pure liquid meal – for bowel transit assessment is proposed due to the rarity of substantially delayed liquid gastric emptying that could affect bowel transit measurement.[1] However, there are limited normative data available for liquid gastric emptying and bowel transit, and variations in methodologies persist due to a lack of standardization.

This study aimed to evaluate liquid gastric emptying and small-bowel transit in a cohort of healthy volunteers. The primary objective was to establish reference values for liquid gastric emptying and small-bowel transit. The secondary objectives included a comparative analysis of liquid gastric emptying and small-bowel transit using the anterior view and geometric mean methods, examining gender-based disparities, and exploring potential correlations with age.

Materials and Methods

This prospective, observational cross-sectional study spanned a 1-year duration, commencing in March 2022 after the approval received from the Institute Ethics Committee (IECPG-143/24.02.22, RT-24/March 24, 2022). The study recruited individuals aged ≥18 years, who voluntarily provided written consent. Subjects with diabetes or any other conditions recognized to influence gastrointestinal motility, including gastrointestinal disorders or surgeries, along with neurological ailments, were excluded. In addition, pregnant or breastfeeding women, those using medications (opiate analgesics, anticholinergic drugs, and prokinetic agents) affecting gastrointestinal motility, premenopausal women >10 days of their menstrual cycle, individuals unwilling to provide informed written consent, noncompliance with the scintigraphy protocol, and participants with known allergic reactions to Tc-99 m sulfur colloid were excluded from participation.

Scintigraphy protocol

All healthy volunteers adhered to a fasting period of at least 6 h preceding the procedure. Scintigraphy was performed on the healthy volunteers following the ingestion of 300 mL of potable water mixed with 1 mCi of Tc-99 m sulfur colloid within 5 min. In addition, immediately after the radioactive meal, another 50 mL of potable water (nonradiolabeled) was consumed to cleanse any residual activity adhering to the oropharyngeal region and esophagus. One-minute static images encompassing the abdominal region were acquired using a dual-head gamma camera (GE Discovery NM/CT 670) equipped with parallel hole, low-energy high-resolution collimators, and photopeak set at 140 keV and 20% energy window; a zoom factor of 1 and a matrix size of 128 × 128. The images were acquired with the subjects lying supine, and the data were recorded at various time points: immediate (0 h image), 30 min, 1 h, 2 h, and 4 h. During the imaging session lasting until the 4 h mark, participants refrained from consuming any food or liquids. When uncertainty arose regarding the localization of the terminal ileal reservoir (as detailed below), participants returned on the subsequent day for an additional set of static imaging sessions at the 24 h mark, each lasting 4 min. Both the anterior and posterior detectors were simultaneously employed for image acquisition at each specified time point, ensuring comprehensive coverage of the radioactivity distribution within the field of view.

Image analysis

The acquired images were processed and analyzed on a dedicated Xeleris 4 DR workstation with a vendor-specified gastric emptying scintigraphy protocol. All the images of each time point were visually inspected to ensure adequate image quality and assess the temporal movement of activity within the gastrointestinal tract. Regions of interest (ROIs) were meticulously delineated to encompass the gastric activity in both the anterior and posterior images for each time point [Figure 1]. The counts derived from these ROIs were used to compute the percent retentions at 30 min, 1 h, 2 h, and 4 h, as well as the half-time (T1/2) of gastric emptying after decay correction with the total gastric counts normalized to 100% at time $t = 0$ (the first image acquired immediately after meal ingestion). The T1/2 of gastric emptying represented the duration required for gastric counts to decrease to 50% of its initial value.

To analyze small-bowel transit, a large rectangular ROI was delineated, encompassing the entire abdomen in both the anterior and posterior images at each time point [Figure 2a]. The decay-corrected total abdominal counts at the 4 h image (TAC 4 h) served as the input value for filling the small bowel. In cases where any remaining gastric activity was visually observed in the 4 h image, its counts were subtracted from the TAC to obtain the corrected input value for filling the small bowel. Another ROI was meticulously drawn, encompassing the terminal

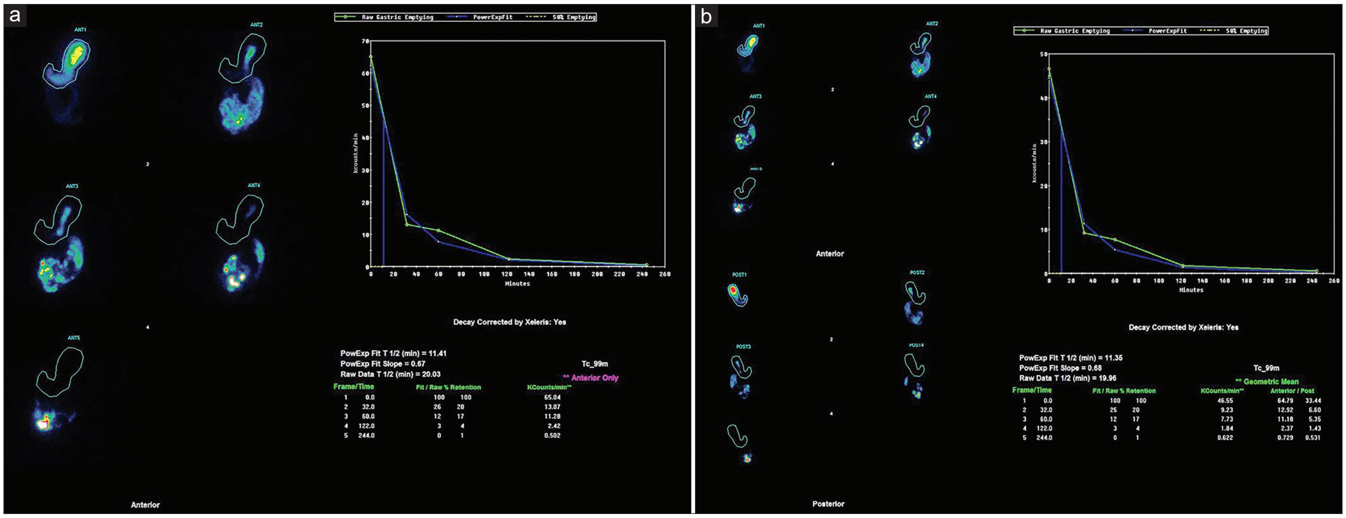

Figure 1: Assessment of liquid gastric emptying in a 43-year-old healthy female in the anterior view (a) and geometric mean (b) methods. Regions of Interest were drawn, encompassing the gastric activity on the static images of each time point (0, 0.5, 1, 2, and 4 h)

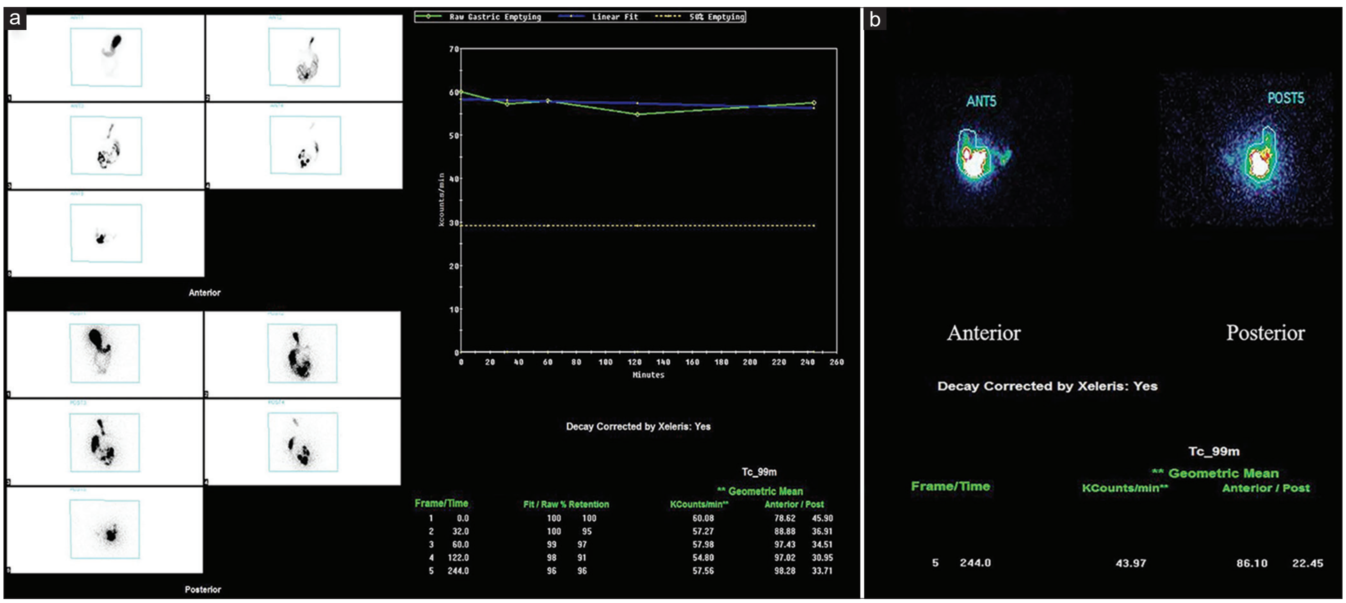

Figure 2: Assessment of small-bowel transit in a 43-year-old healthy female. Total abdominal counts were derived at time points (0, 0.5, 1, 2, and 4 h, respectively) using a large rectangular regions of interest (ROI) on the static images of each time point (a). Derivation of terminal ileal reservoir counts at 4 h using ROIs on the anterior and posterior images (b). In this subject, the index of small-bowel transit was calculated to be 88% and 76% in the anterior view and geometric mean methods, respectively

ileal reservoir region, including the cecum-ascending colon if radioactivity had passed through the terminal ileum and ileocecal junction, in both the anterior and posterior images of the 4 h scan [Figure 2b]. The resulting decay-corrected counts in the terminal ileal reservoir, termed as the terminal ileal reservoir counts (TIRC), represented the activity arrived at the terminal ileum at 4 h. The value TIRC/TAC4 h × 100 reflected the percent arrival of the TAC at the terminal ileum at 4 h and was used as the index of small-bowel transit (ISBT).

Statistical analysis

Categorical variables were described as frequency (percentage). Continuous variables were described with mean ± standard deviation (SD), median (minimum–maximum), and percentiles (2.5th, 5th, 95th, and 97.5th percentiles). Continuous variables were tested for normality with Shapiro–Wilk test. Comparison of continuous variables between different camera view methods was done with paired Samples *t*-test or Wilcoxon signed-rank test as applicable. Spearman's rank correlation was performed between age and ISBT. Comparison of continuous variables between females and males was done with independent Samples *t*-test or Mann–Whitney *U*-test as applicable. The reference value of gastric emptying at 30 min was derived using mean–1.645 × SD of the percent retention values (assuming 95% of the population had values above this cutoff value) while those at 1, 2, and 4 h were derived using the 95th percentile values (assuming 95% of the population had values within these respective cutoff values). The reference range of T1/2 of gastric emptying was derived using the 2.5th and 97.5th percentile values (assuming 95% of the population had values within this range), while that of the ISBT was derived using the Fifth percentile values, respectively (assuming that 95% of the population had values above this cutoff value). Rapid small-bowel transit was assessed by visually inspecting the static images at multiple time points to identify the first visualization of activity in the cecum-ascending colon. A two-tailed $P < 0.05$ was considered statistically significant. Statistical packages IBM SPSS 26.0.0.0 (IBM Corp., Somers, New York, USA) and MedCalc 19.6.4 (MedCalc Software, Ostend, Belgium) were used for the statistical analyses.

Results

A total of 35 consecutive healthy subjects (28 females, seven males) with a mean age of 42 ± 11 years (median, 42; range, 23–65) were enrolled in the study. Six patients underwent additional static imaging at 24 h.

Assessment of gastric emptying

In the anterior view method, the mean percent retention (%) at 30 min, 1 h, 2 h, and 4 h was found to be 39 ± 18, 15 ± 16, 5 ± 10, and 1 ± 1, respectively, while the corresponding median values were 40 (2–85), 9 (1–77), 1 (0–58), and 1 (0–4), respectively. The mean T1/2 of gastric emptying was 29 ± 19 min with a median value of 28 min (11–122). The mean percent retention (%) at 30 min, 1 h, 2 h, and 4 h was found to be 34 ± 16, 13 ± 12, 5 ± 8, and 1 ± 1, respectively, while the corresponding median percent retention values were 37 (2–72), 9 (1–52), 2 (1–45), and 1 (1–4), respectively, by geometric mean method. The mean T1/2 of gastric emptying was 24 ± 11 min with a median value of 24 min (10–67). Summary statistics of gastric emptying parameters of the enrolled subjects are depicted in Table 1.

On comparing the percent retention between the anterior view and geometric mean methods, there was a statistically significant difference for the 30 min, 1 h, and 4 h values ($P \leq 0.019$). Furthermore, there was a statistically significant difference in the T1/2 of gastric emptying derived by these two methods ($P < 0.001$). Details of the comparison are given in Table 2. There was no statistically significant correlation between age and gastric emptying parameters in both the anterior view and geometric mean methods, except for the percent retention at 4 h on geometric mean method, which showed weak positive correlation (Spearman's ρ =0.340; P = 0.046) [Table 3]. There was no statistically significant difference in the percent retention and T1/2 of gastric emptying between females and males ($P \geq 0.445$) [Table 4].

Assessment of small-bowel transit

In this study, the ISBT calculated at the 4 h mark served as the indicative parameter for small-bowel transit. The mean and median values of ISBT (%) on the anterior view method were 75 ± 21 and 84 (2–94), respectively, while the corresponding values in the geometric mean method were 70 ± 19 and 77 (3–92), respectively [Table 1]. This difference was found to be statistically significant ($P < 0.001$) [Table 2]. Age and ISBT showed a weak negative correlation in the anterior view method (Spearman's $\rho = -0.397$, $P = 0.018$), while the correlation in the geometric mean method was not statistically significant (Spearman's $\rho = -0.149$; $P = 0.432$) [Table 3]. There was no gender disparity in the ISBT on both the anterior view and geometric mean methods ($P \geq 0.173$) [Table 4].

Reference values of liquid gastric emptying and small-bowel transit

In the present study, we proposed reference values of whole gut transit parameters based on geometric mean method. We use geometric mean method as it provides attenuation and depth correction. Rapid gastric emptying was defined as percent retention <8% at 30 min. Delayed gastric emptying was established as percent retention >33%, >20%, and >4% at 1 h, 2 h, and 4 h, respectively. The reference range for half-time (T1/2) of gastric emptying was established as 10–60 min. The Fifth percentile value for ISBT calculated at 4 h was 30%; hence, the reference value of ISBT at 4 h was established as >30% in geometric mean method. Based on visual inspection of the multiple static images of different time points, it was observed that in two subjects, the first visualization of cecum-ascending colon occurred at 1 h, while in two other subjects, it occurred at 2 h. In 20 subjects, the first visualization of cecum-ascending colon occurred at 4 h, while in the remaining 11 subjects, cecum-ascending colon activity was not visualized even up to the 4 h mark. This indicates that the first visualization of activity in the cecum-ascending colon at 1 h was noted in only 5.7% (2/35) of the subjects. Considering that 94.3% (33/35) of the subjects exhibited the first visualization of activity in the cecum-ascending colon by ≥2 h, it was proposed to define the presence of rapid small-bowel transit as the first visualization of activity in the cecum-ascending colon at ≤1 h. The proposed normative data of liquid gastric emptying and small-bowel transit are depicted in Table 5.

Discussion

The study established the normative data regarding liquid gastric emptying and small-bowel transit in a group of healthy individuals, aligning with the multitime point static imaging methodology advocated by consensus guidelines and recommendations for solid gastric emptying.[13,14] This approach ensured a consistent, patient-friendly methodology

Table 1: Summary statistics of liquid gastric emptying and small bowel transit

Parameter	Mean±SD	Median (range)	Skewness	Kurtosis	Probability of normality	2.5th percentile	5th percentile	95th percentile	97.5th percentile
Liquid gastric emptying									
Anterior view method									
Percent retention (%)									
30 min	39±18	40 (2 – 85)	-0.01679	0.3036	0.3302	4	7	69	80
1 h	15±16	9 (1 – 77)	1.8277	4.8699	<0.0001	1	1	36	62
2 h	5±10	1 (0 – 58)	4.1982	19.6317	<0.0001	0	1	23	46
4 h	1±1	1 (0 – 4)	1.8368	5.1696	<0.0001	0	0	3	4
T1/2 (min)	29±19	28 (11–122)	3.8544	18.4373	<0.0001	11	11	46	103
Geometric mean method									
Percent retention (%)									
30 min	34±16	37 (2 – 72)	-0.09666	0.07101	0.3458	3	6	59	68
1 h	13±12	9 (1 – 52)	1.1540	1.1268	0.0003	1	2	33	45
2 h	5±8	2 (1 – 45)	3.8082	16.4945	<0.0001	1	1	20	37
4 h	1±1	1 (1 – 4)	1.6983	1.9904	<0.0001	1	1	4	4
T1/2 (min)	24±11	24 (10 – 67)	2.0630	7.6095	0.0002	10	10	40	60
Small bowel transit									
ISBT (%)									
Anterior view method	75±21	84 (2 – 94)	-2.0347	4.0466	<0.0001	11	28	91	93
Geometric mean method	70±19	77 (3 – 92)	-1.8495	3.6440	<0.0001	12	30	86	90

min, minutes; T1/2, half-time of gastric emptying; SD, standard deviation; ISBT, index of small bowel transit

Table 2: Comparison of liquid gastric emptying and small-bowel transit between anterior view and geometric mean methods

Data	Anterior view method		Geometric mean method		*P*
	Mean±SD	Median (range)	Mean±SD	Median (range)	
Percent retention (%)					
30 min	39±18	40 (2–85)	34±16	37 (2–72)	<0.001*
1 h	15±16	9 (1–77)	13±12	9 (1–52)	0.019#
2 h	5±10	1 (0–58)	5±8	2 (1–45)	0.510#
4 h	1±1	1 (0–4)	1±1	1 (1–4)	0.012#
T1/2 (min)	29±19	28 (11–122)	24±11	24 (10–67)	<0.001#
ISBT (%)	75±21	84 (2–94)	70±19	77 (3–92)	<0.001#

**P* value based on paired samples *t*-test, #*P* value based on Wilcoxon signed ranks test. T1/2: Half-time of gastric emptying, SD: Standard deviation, ISBT: Index of small-bowel transit

Table 3: Correlation analysis

Parameter	Spearman's rho (*P*)	
	Anterior view method	Geometric mean method
Percent retention (%)		
30 min	−0.096 (0.583)	−0.130 (0.458)
1 h	−0.062 (0.723)	−0.058 (0.740)
2 h	0.181 (0.298)	0.237 (0.170)
4 h	0.326 (0.056)	0.340 (0.046*)
T1/2 (min)	−0.207 (0.273)	−0.149 (0.432)
ISBT (%)	−0.397 (0.018*)	−0.266 (0.123)

**P* value significant at <0.05. T1/2: Half-time of gastric emptying, SD: Standard deviation, ISBT: Index of small-bowel transit

for both liquid and solid gastric emptying, as opposed to continuous dynamic imaging sessions spanning extended periods. However, due to the anticipated faster rate of liquid gastric emptying, an extra early static imaging time point (30 min) was included alongside the typical 4 time points utilized for solid gastric emptying assessments (0, 1, 2, and 4 h).

Delayed liquid gastric emptying in the presence of solid meals was characterized by a percent retention exceeding 50% at 1 h.[15,16] In a recent study by Antoniou *et al*., employing a dual solid-liquid meal, the defined cutoff values for delayed liquid gastric emptying were found to be percent retentions of >60% at 1 h and >22% at 2 h.[7] Conversely, in the current study, using a nonnutrient liquid meal (water), the established cutoff values for delayed liquid gastric emptying were percent retentions of >33% at 1 h and >20% at 2 h. This discrepancy might stem from the divergence in meal composition between our study and the aforementioned ones. Notably, our derived cutoff value for percent retention at 2 h (>20%) aligned closely with Antoniou *et al.*'s previously established value (>22%).

Table 4: Comparative analysis of liquid gastric emptying and small bowel transit based on gender

Parameter	Females		Males		P
	Mean±SD	Median (range)	Mean±SD	Median (range)	
Anterior view method					
Percent retention (%)					
30 min	38±20	40 ± (2 – 85)	44±11	44 (25 – 55)	0.445*
1 h	15±17	8 (1 – 77)	18±15	20 (1 – 36)	0.484#
2 h	6±12	1 (0 – 58)	2±1	2 (1 – 4)	0.856#
4 h	1±1	1 (0 – 4)	1±0	1 (1 – 2)	0.681#
T1/2 (min)	30±22	28 (11 – 122)	27±8	27 (12 – 36)	0.954#
ISBT (%)	80±14	85 (36 – 94)	59±34	64 (2 – 91)	0.173#
Geometric mean method					
Percent retention (%)					
30 min	33±17	36 (2 – 72)	35±11	37 (20 – 47)	0.773*
1 h	13±13	8 (1 – 52)	15±11	18 (2 – 28)	0.606#
2 h	5±9	2 (1 – 45)	3±1	3 (1 – 4)	0.706#
4 h	1±1	1 (1 – 4)	2±1	1 (1 – 3)	0.502#
T1/2 (min)	25±12	24 (10 – 67)	21±7	23 (10 – 29)	0.471#
ISBT (%)	73±13	78 (40 – 92)	55±31	58 (3 – 84)	0.267#

min, minutes; T1/2, half-time of gastric emptying; SD, standard deviation; ISBT, index of small bowel transit. *P based on Independent Samples *t*-test. #*P* based on Mann-Whitney *U* Test

Table 5. Proposed reference values of liquid gastric emptying and small bowel transit

Time	Liquid gastric emptying		Small bowel transit
	Rapid emptying	Delayed emptying	
Percent retention			ISBT
30 min	<8%	-	>30% (with no visualization of caecum-ascending colon activity within 1 h; if present, small bowel transit is considered rapid)
1 h	-	>33%	
2 h	-	>20%	
4 h	-	>4%	
Half-time of emptying			
	<10 min	>60 min	

min, minutes; ISBT, index of small bowel transit

Furthermore, our study introduced an additional criterion for delayed liquid gastric emptying at 4 h (percent retention >4%). Criteria for rapid liquid gastric emptying had not been previously defined.[5] Our study derived a cutoff value designating rapid liquid gastric emptying as percent retention <8% at 30 min.

Another often-discussed parameter for liquid gastric emptying was the T1/2 of gastric emptying. The reported normal values for T1/2 of liquid gastric emptying exhibited considerable variance in the literature, primarily stemming from reports between the early 1970s and the early 1990s, where methodologies for count measurements and gamma camera performance characteristics were significantly diverse.[12] Ziessman *et al*. established the reference threshold for T1/2 of liquid gastric emptying as <19 min (mean ± 2 SD) and <22 min (mean ± 3 SD); values exceeding these benchmarks signify delayed liquid gastric emptying.[11] Meanwhile, Antoniou *et al*. recently delineated the cutoff value for T1/2 of liquid gastric emptying as <25 min, while in the presence of a solid meal, it was determined as <74 min.[7] In the present study, a reference range of T1/2 of liquid gastric emptying was established using percentiles, spanning from 10 to 60 min. This incorporation encompasses the previously unexplored aspect of rapid liquid gastric emptying, denoted by T1/2 <10 min. Conversely, a T1/2 exceeding 60 min indicates delayed liquid gastric emptying. It is noteworthy that the assessments of T1/2 of liquid gastric emptying based on nonnutrient liquid-only meals (such as water) in studies by Ziessman *et al*. and Antoniou *et al*. relied on continuous dynamic imaging for 30 min. In contrast, the corresponding values derived in our study were based on multiple static imaging sessions at different time intervals rather than continuous dynamic imaging. In accordance with consensus guidelines and recommendations endorsing multitime point imaging protocols for solid gastric emptying studies,[13,14] we propose utilizing T1/2 of liquid gastric emptying as a complementary parameter when maintaining the percent retention as the primary metric for assessing liquid gastric emptying. In addition, despite establishing criteria for rapid liquid gastric emptying based on percent retention at 30 min and T1/2 of gastric emptying, the clinical significance of rapid liquid gastric emptying warrants further investigation in future studies.

In our study, we established the ISBT at 4 h as the representative measure for small-bowel transit. To achieve this, we employed TAC 4 h as the input activity available to fill the small bowel. While current guidelines propose deriving this activity from the average of TAC across multiple time points (e.g., 2, 3, 4, and 5 h), Maurer *et al*. found minimal variability in TAC during the initial 6 h of bowel transit studies. They suggested that employing TAC from a single time point could be a practical simplification.[1,17] Hence, our study opted for using TAC 4 h as the input value for filling the small bowel. This method not only simplified the analysis but also reduced the overall assessment time.

In our study, we established the reference cutoff value for small-bowel transit, denoted by ISBT, as >30% at the 4 h mark. Notably, Bonapace *et al*. proposed a reference cutoff of >40% at 6 h, also emphasized in the practice guideline for bowel transit studies.[1,4] Yet, it is crucial to acknowledge the methodological variations between our study and Bonapace *et al*.'s research. They employed a dual solid-liquid meal technique and determined the ISBT at 6 h, whereas we utilized a nonnutrient liquid meal (water) and derived the ISBT at 4 h. Our study considered the first appearance of activity in the cecum-ascending colon within 1 h on visual inspection of static images as indicative of rapid small-bowel transit. Bonapace *et al*. recommended a threshold of <90 min for the same.[4] Their study involved frequent imaging every 30 min, while we assessed small-bowel transit using standard imaging time points (0, 1, 2, and 4 h), as recommended for solid gastric emptying studies.[13] Despite discrepancies in methodology and meal types used, the outcomes show relatively similar results.

In our study, we examined two approaches for evaluating liquid gastric emptying and small-bowel transit: the anterior view method and the geometric mean method. It was evident that the percent retention (except at 2 h), T1/2 of liquid gastric emptying, and ISBT were significantly higher in the anterior view method as compared to that of the geometric mean method [Table 2]. However, a closer look at the distributions of these parameters revealed that the derived reference values of these parameters based on percentiles or mean and SD did not differ significantly except for the T1/2 (11–103 min in anterior view method vs. 10–60 min in geometric mean method) [Table 1]. Considering these results, our suggestion favors the geometric mean method as the primary approach due to its incorporation of attenuation and depth correction. Nonetheless, we acknowledge that in facilities dealing with a high volume of patients and constrained resources, particularly where a single-head gamma camera serves multiple studies, the anterior view method could be deemed a viable alternative.

In terms of gender disparities, our study did not uncover any statistically noteworthy differences in either liquid gastric emptying or small-bowel transit. In addition, we observed no significant moderate or strong correlation between age and liquid gastric emptying or small-bowel transit. Thus, the determined parameters for liquid gastric emptying and small-bowel transit might be applicable across both genders and various age brackets for individuals aged 18 years and above. However, it is important to note that Table 3 indicates a weak positive correlation between age and percent retention at 4 h using the geometric mean method, whereas ISBT exhibited a weak negative correlation with age in the anterior view method. Our study lacks sufficient power to confirm this correlation, necessitating larger prospective studies to adequately address this observation.

The present study exhibits several noteworthy aspects. It introduced a more patient-friendly method for evaluating liquid gastric emptying and small-bowel transit compared to the lengthy and frequent imaging protocols commonly described in the literature. Evaluating small-bowel transit at 4 h instead of 6 h enhances patient comfort by reducing the procedure duration by 2 h. In addition, this study established criteria for rapid liquid gastric emptying, a previously unestablished parameter. However, the clinical implications of rapid liquid gastric emptying necessitate assessment in subsequent studies. Furthermore, employing a liquid-only meal approach allowed for the utilization of a single radioisotope, in contrast to the dual solid-liquid meal approach that required two radioisotopes, Tc-99 m for the solid meal and In-111 for the liquid meal. By employing Tc-99 m, a widely accessible radioisotope with enhanced radiation profile and imaging characteristics, this approach effectively addresses the constraints associated with the limited availability of In-111, particularly within the Indian context.

Nevertheless, despite its strengths, the study has limitations, primarily attributed to the small sample size. Another potential constraint within the study arises from the subjective nature of identifying the terminal ileal reservoir, which could present potential difficulties. Strategies to mitigate this concern might include additional imaging at 24 h, the placement of a radioactive marker in the right iliac crest during static image acquisitions, or the utilization of single photon emission tomography–computed tomography/computed tomography acquisition at 4 h for structural corroboration.

Conclusion

The study established the reference values for liquid gastric emptying and small-bowel transit using a standard gastric emptying scintigraphy protocol, without requiring any supplementary intricate procedures or prolonged imaging sessions. These outcomes hold potential applicability, underscoring the significance of evaluating liquid gastric emptying and small-bowel transit among individuals exhibiting normal solid gastric emptying. The established normative data can apply to individuals of both genders aged 18 years and above. While endorsing the geometric mean method as the preferred approach, the study recognizes that in centers with high patient throughput with resource constraints where a single-head gamma camera caters to multiple studies, the anterior view method remains a viable alternative

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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Conflicts of interest

Suman Dhukia, Asem Rangita Chanu, Sambit Sagar, Jasim Jaleel, Priyanka Gupta, Dikhra Khan, Sivasankar Kanankulam Velliangiri, Bangkim Chandra Khangembam, Chetan Patel, and Rakesh Kumar declare that they have no conflicts of interest.

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