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Validation of a Single Time Point Measurement of Total Abdominal Counts to Simplify Small Bowel and Colon Transit Analyses

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Abstract

The SNMMI EANM Procedure Guide on Gastrointestinal Transit currently indicates that the mean of total abdominal counts of seven time points (0-360 min) are used to define the total abdominal counts for bowel transit studies. The purpose of this study was to investigate the variability of total abdominal counts during the initial six hours of bowel transit and to determine if a simplified, single time point measurement can be used. METHODS: Thirty consecutive bowel transit studies were retrospectively analyzed. Patients received an oral dose of 4.6 MBq(125 μCi) ^{111}In-DTPA in 300 cc of water together with a standard egg white solid-phase, gastric emptying meal to measure small bowel and colon transit. ^{111}In-DTPA geometric mean and decay corrected total abdominal counts obtained at 0, 30, 60, 120, 180, 240, 300, and 360 minutes post meal ingestion were analyzed. The coefficient of variation (CV) was used to determine the variability of the mean total abdominal counts. Slope of the regression line, Student's t-test and a Pearson Product-Moment Correlation Coefficient (PCC) were also calculated to determine the correlation of total abdominal counts at each time point compared to the mean of all time points. RESULTS: The mean CV of total abdominal counts of each patient was 3.3% with a range of 1.1% to 6.3%. The mean of the slope of the regression line of the total abdominal counts of the patients was -0.001±0.003. There was no significant difference between the measured slope of the regression line compared to a line with a slope of 0 ($p>0.05$). Comparing the counts at each time to the mean counts, there was no significant difference ($p>0.05$). The PCC of each of the counts showed a significant and strong correlation between each interval and the mean total abdominal counts ($p<0.01$).

CONCLUSION: There is no significant variability in geometric mean In-111 DTPA total abdominal counts during the initial 6 hours of bowel transit studies. This can permit a more simplified analysis using the total abdominal counts from only a single time point.

Key Words: Gastrointestinal transit scintigraphy, gastric emptying, small bowel transit, colon transit

Introduction:

Gastric emptying scintigraphy continues to evolve with more standardization of imaging protocols (*1*). Currently solid-meal, gastric emptying scintigraphy is most commonly ordered to assess patient symptoms of upper gastrointestinal dyspepsia when gastroparesis is suspected as a cause of a patient's symptoms. Scintigraphic gastrointestinal transit studies have been expanded to involve the ingestion of a radiolabeled solid, liquid or combined solid and liquid meal. The liquid phase is used to measure both liquid gastric empting as well as small bowel and colon transit. A recent practice guidelines has been adopted by the Society of Nuclear Medicine and Molecular Imaging(SNMMI) together with the European Association of Nuclear Medicine(EANM) which expands gastric emptying scintigraphy to include measurement of both small bowel and colon transit (*2*,*3*).

Effective, January 1, 2016, two new Current Procedural Teminology (CPT) codes 78265 and 78266 became available to report gastric emptying scintigraphy with small bowel and colon transit studies. Therefore studies of the motility of the entire gastrointestinal tract (stomach, small bowel and colon) can now be performed where the small-bowel alone or small bowel and colon transit are continuations of the gastric emptying scintigraphy study.

The current SNMMI EANM Practice Guideline on Gastrointestinal Transit indicates that the mean of total abdominal counts from seven individual time points from 0

minutes up to 360 min should be used to define the total abdominal counts available to fill the terminal ileum and colon when quantifying small bowel and colon transit studies (*3*). This recommendation was based on early studies using older gamma cameras where there was concern for potential non uniform count rates from the photomultiplier tubes and that there could be significant variability in the measurement of total abdominal counts due to variable bowel geometry and depth related attenuation of counts over the multiple imaging time points.

We have observed in many small bowel and colon transit studies however that there is little variation in the measurement of the total abdominal counts that is used to calculate the percentage of activity in the terminal small bowel at 6 hours post meal ingestion and the geometric centers of colon activity at 24, 48, and 72 hours. The purpose of this study therefore was to investigate the variability of geometric mean total abdominal counts during the initial six hours of small bowel transit imaging and to determine if a single time point measurement could be used to simplify the analysis.

Methods:

This was a retrospective review of prior patient imaging studies and data. Our institutional review board approved this retrospective study and the requirement to obtain informed consent was waived. Thirty consecutive patient studies from a 3 month time period that were performed to measure combined small bowel and colon transit as part of a dual-isotope mixed solid and liquid meal were

retrospectively analyzed. The study population included 35 females and 5 males. They aged from 20 to 69 years of age. The mean body surface area of the patients was 1.76 sqm (Du Bois Method) with a range of 1.37 to 2.33 sq m (Table 1).

All acquisition parameters followed the SNNMI EANM Practice Guideline utilizing a combined liquid water and egg white, solid-phase meal to record gastric emptying as well as small bowel and colon transit (*3*). Patients received an oral dose of 4.6 MBq(125 μCi) ^{111}In-DTPA in 300 cc of water combined with 37 MBq (1.0 mCi)of ^{99m}Tc-sulfur colloid in 120 gm cooked liquid egg white in a meal including 2 slices white bread and 30 gm strawberry jam.

A large field of view gamma camera, General Electric Millenium MPR (GE Healthcare), was used for imaging. All images were obtained in a 128 x128 pixel matrix using a medium-energy collimator. The photopeak setting for ^{99m}Tc is 15% at 140 keV. Both the 172-keV and the 247-keV peaks for ^{111}In with 15% windows were used.

To obtain the ^{111}In -DTPA total abdominal counts, large rectangular manual regions of interest where drawn to encompass the entire abdomen and to obtain the ^{111}In-DTPA geometric mean and decay corrected counts at times (t) = 0, 30, 60, 120, 180, 240, 300, and 360 minutes post meal ingestion (Figures 1, 2 and 3). We obtain an additional set of images at t = 30 minutes . While this is not required by the SNNMI EANM Practice Guideline on Gastrointestinal Transit, this is added at our institution to help in evaluation of gastric accommodation and potential rapid gastric emptying.

The coefficient of variation (CV) was used to determine the variability of the mean of the total abdominal counts for each patient. Slope of the regression line, Student's t-test and a Pearson Product-Moment Correlation Coefficient (PCC) were also calculated to determine the correlation of the TAC at each time point compared to the mean of all time points.

Results:

The mean CV of TAC of each patient was 3.3% with a range of 1.1% to 6.3%. The mean of the slope of the regression line of the measured counts of the patients was 0.001±0.003. There was no significant difference between the measured slope of the regression line compared to a line with a slope of 0 ($p>0.05$). Comparing the counts at each time to the mean counts, there was no significant difference($p>0.05$). The PCC of each of the counts showed a significant and strong correlation between each interval and the mean counts ($p<0.01$).

Discussion:

Indications for gastric emptying scintigraphy with small-bowel and colon transit imaging include, but are not limited to: evaluation of gastrointestinal tract transit abnormalities as a cause of symptoms in patients with known or suspected gastroparesis, dyspepsia, irritable bowel syndrome, chronic constipation, chronic diarrhea, chronic idiopathic intestinal pseudoobstruction, scleroderma, celiac disease, and malabsorption syndromes. In the evaluation of patients with constipation, gastrointestinal transit measurements may

demonstrate a motility disorder or slow colon transit or may provide evidence to support a diagnosis of defecation disorder or functional rectosigmoid obstruction.

The American Neurogastroenterology and Gastrointestinal Motility Society and the European Society of Neurogastroenterology and Motility have stated in a position paper that whole-gut transit scintigraphy(combined gastric emptying with small bowel and colon transit) is recommended for “detection of altered small-intestine transit in subjects with suspected diffuse gastrointestinal motility disorder” and that colon transit scintigraphy “ offers reproducible and accurate performance,” to measure regional colon transit in patients with suspected colonic motility disorders or more diffuse disorders involving the stomach or small intestine “ (*4*). The recent approval of new CPT codes to perform both small bowel and colon transit studies will likely result in an increase volume of these studies being performed. The results of this study show that there can be considerable time savings in processing of these studies using a single time point for total abdominal counts rather than measuring the mean total abdominal counts of the current recommended seven time points. Based on the results of this study, use of a single time point measurement for total abdominal counts will result in only a small change in the values calculated for small bowel transit(percentage of activity in the terminal ileum) and geometric centers of colon transit (mean variation of 3.3% with a range of 1.1% to 6.3%).

There was consistency and lack of significant variability in measured total abdominal counts found in this study over the eight time points measured in a diverse group of

patients whose body surface areas ranged from small to large body habitus. This likely relates to the low administered oral ^{111}In-DTPA activity and therefore no significant dead-time losses or loss of counting efficiency especially with modern photomultiple tubes resulting in low counting losses (*5*). The geometric mean correction utilizing both anterior and posterior views has also been previously documented to provide good depth attenuation count correction (*6,7*).

Conclusions: There is no significant variability in the measured geometric mean of In-111 DTPA total abdominal counts during imaging of the initial 6 hours of small bowel and colon transit studies. This can permit a decrease in the time required for image analysis by potentially obtaining total abdominal counts only from a single time point. Because it is diagnostically necessary to still visually analyze the small bowel and colon transit patterns imaging at all the recommended seven time points however will still need to be performed.

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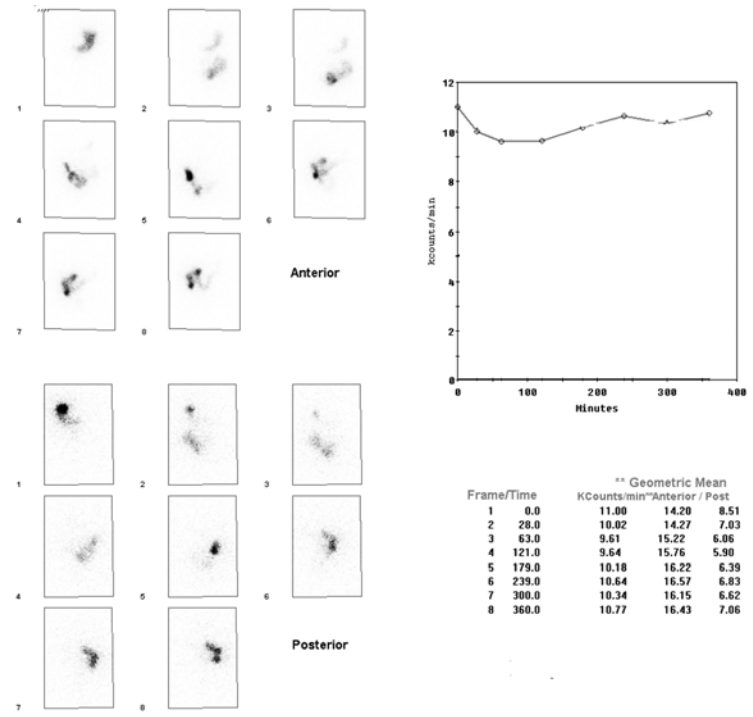
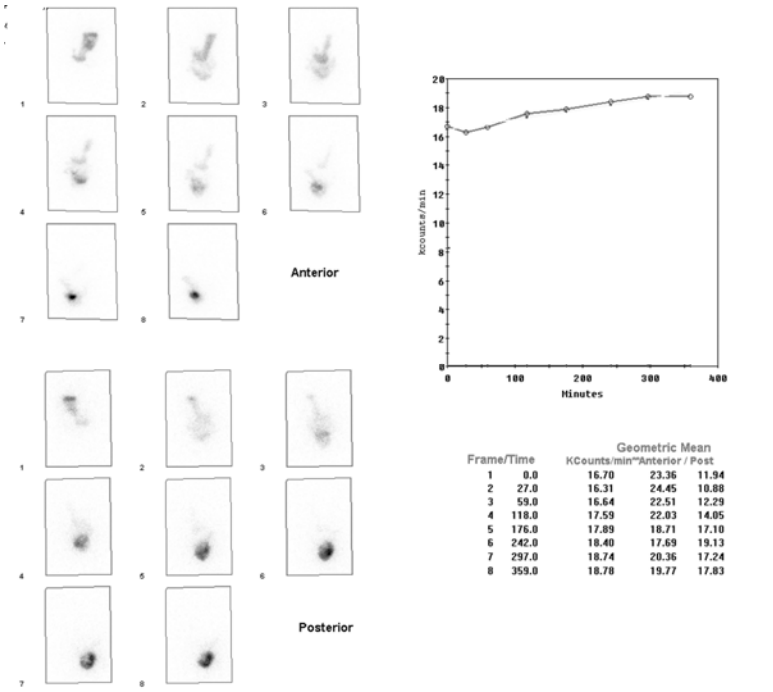


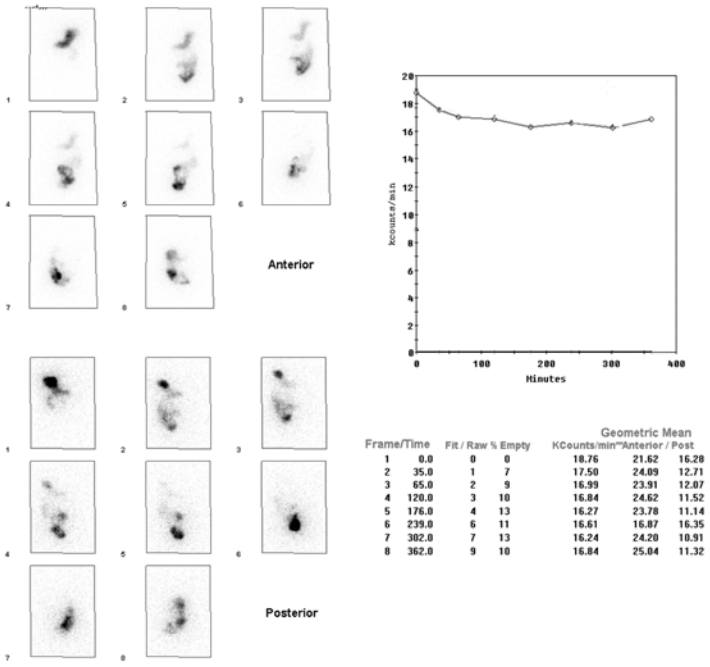
Frame/Time		** Geometric Mean KCounts/min** Anterior	Post
1	0.0	11.00	14.20	8.51
2	28.0	10.02	14.27	7.03
3	63.0	9.61	15.22	6.06
4	121.0	9.64	15.76	5.90
5	179.0	10.18	16.22	6.39
6	239.0	10.64	16.57	6.83
7	300.0	10.34	16.15	6.62
8	360.0	10.77	16.43	7.06

Figure 1 : Anterior and posterior ^{111}In-DTPA images of the abdomen are shown with examples of the large rectangular ROIs used to obtain total abdominal counts for calculation of the geometric mean and decay corrected total abdominal counts for all time points. There is small time point to time point variation in total abdominal counts however the variation from the mean is always less than 10%. (Table 1)



Frame/Time		Geometric Mean KCounts/min**Anterior	Post	
1	0.0	16.70	23.36	11.94
2	27.0	16.31	24.45	10.88
3	59.0	16.64	22.51	12.29
4	118.0	17.59	22.03	14.05
5	176.0	17.89	18.71	17.10
6	242.0	18.40	17.69	19.13
7	297.0	18.74	20.36	17.24
8	359.0	18.78	19.77	17.83

Figure 2: Orientation and regions shown are the same as Figure 1 however this shows an example of a patient where there is a mild increase in total abdominal counts over the course of the 6 hours of imaging.



Frame/Time		Fit / Raw %	Empty	Geometric Mean KCounts/min**	Anterior	Post
1	0.0	0	0	18.76	21.62	16.28
2	35.0	1	7	17.50	24.09	12.71
3	65.0	2	9	16.99	23.91	12.07
4	120.0	3	10	16.84	24.62	11.52
5	176.0	4	13	16.27	23.78	11.14
6	239.0	6	11	16.61	16.87	16.35
7	302.0	7	13	16.24	24.20	10.91
8	362.0	9	10	16.84	25.04	11.32

Figure 3: Orientation and regions shown are the same as Figure 1 but in this case there is a mild decrease in total abdominal counts over the course of 6 hours imaging.

Table 1 – Patient demographics

Age	Sex	Weight (lbs)	Height (inches)	BSA(sqm) - Du Bois Method
37	F	285	66	2.33
50	M	195	72	2.11
51	F	117	60	1.49
68	F	143	62	1.66
57	F	146	61	1.65
24	F	103	67	1.53
67	F	245	68	2.23
33	F	146	65	1.73
59	F	215	66	1.75
30	F	113	66	1.57
35	F	190	67	1.98
52	M	145	66	1.74
28	F	127	61	1.56
52	F	146	64	1.71
37	F	145	64	1.71
52	F	128	65	1.64
52	F	128	64	1.62
51	F	138	65	1.69
40	F	245	62	2.08
46	F	176	68	1.94
45	F	200	65	1.98
35	F	110	65	1.53
68	F	174	70	1.97
28	F	143	63	1.68
51	M	119	72	1.71
20	M	123	65	1.61
68	F	104	64	1.59
40	F	110	62	1.48
69	M	183	70	2.01
40	F	92	62	1.37

Table 2 – Summary of measured total abdominal counts(Kcounts/min) for all patients and all time points.

Patient #	t=0	t=60	t=120	t=180	t=240	t=300	t=360	Mean	STDev	CV		Slope of Regression Line
1	21.81	21.53	21.98	21.57	21.76	21.76	23.03	21.92	0.51	2.34%		0.002
2	24.67	22.93	21.20	20.90	21.37	23.28	23.49	22.55	1.41	6.27%		-0.002
3	34.42	32.06	31.58	31.13	30.75	30.78	33.81	32.08	1.48	4.60%		-0.003
4	17.77	16.85	16.65	16.84	16.34	16.66	16.28	16.77	0.49	2.94%		-0.003
5	25.37	25.08	26.25	25.74	25.91	25.89	26.07	25.76	0.41	1.58%		0.002
6	25.02	24.59	23.89	24.46	24.19	25.36	24.94	24.64	0.51	2.06%		0.001
7	22.71	20.89	20.86	20.03	19.10	21.54	21.96	21.01	1.21	5.74%		-0.002
8	22.55	22.13	22.32	22.34	22.88	23.85	23.07	22.73	0.59	2.61%		0.003
9	27.13	26.55	26.82	26.38	25.73	26.17	26.01	26.40	0.48	1.82%		-0.003
10	17.06	16.30	16.49	16.09	15.19	15.16	15.24	15.93	0.75	4.70%		-0.005
11	24.07	24.88	23.75	24.51	24.61	23.94	24.30	24.29	0.40	1.65%		0.000
12	19.65	20.07	19.42	19.63	19.59	19.14	19.56	19.58	0.28	1.43%		-0.001
13	16.46	16.99	17.19	17.17	17.24	18.05	18.19	17.33	0.60	3.48%		0.004
14	23.20	22.31	21.88	22.76	22.34	23.34	22.41	22.61	0.52	2.31%		0.000
15	22.06	20.55	20.04	19.80	20.14	19.78	20.10	20.35	0.80	3.91%		-0.004
16	21.90	22.31	22.36	22.70	23.11	22.24	23.38	22.57	0.52	2.31%		0.003
17	23.31	21.92	23.10	23.05	23.92	23.82	23.68	23.26	0.68	2.93%		0.003
18	18.89	18.83	18.37	18.57	19.40	20.02	19.16	19.03	0.55	2.91%		0.003
19	18.91	19.60	18.96	19.29	18.82	19.14	19.21	19.13	0.27	1.39%		0.000
20	16.15	15.82	14.76	14.32	13.92	13.90	14.43	14.76	0.89	6.06%		-0.006
21	25.39	24.34	23.50	23.82	22.70	22.95	23.54	23.75	0.90	3.80%		-0.005
22	23.81	22.57	21.69	21.69	20.89	21.00	21.01	21.81	1.06	4.86%		-0.007
23	14.88	15.44	14.40	14.71	14.05	15.13	14.87	14.78	0.46	3.10%		-0.001
24	17.76	18.66	18.72	18.97	18.94	18.82	19.59	18.78	0.54	2.90%		0.004
25	19.94	20.50	20.25	20.35	20.45	19.97	20.15	20.23	0.22	1.09%		0.000
26	20.80	18.74	18.23	18.04	18.13	17.85	17.74	18.50	1.06	5.74%		-0.007
27	10.37	10.11	9.75	9.74	10.39	9.52	9.91	9.97	0.33	3.34%		-0.001
28	14.08	13.17	12.99	12.36	12.94	13.67	13.35	13.22	0.55	4.18%		-0.001
29	22.94	21.84	21.80	21.65	21.62	21.74	22.82	22.06	0.57	2.57%		0.000
30	22.38	21.10	20.55	20.89	21.31	20.53	19.75	20.93	0.81	3.89%		-0.005
Mean	21.18	20.62	20.33	20.32	20.26	20.50	20.70	20.56	0.66	3.28%		-0.001
p-value	0.593	0.954	0.837	0.832	0.790	0.959	0.902			p-value		0.095
PPC	0.978	0.994	0.996	0.995	0.990	0.990	0.991			StDev		0.003