

Colonic Transit Time—What Is Normal?

By S. Wagener, K.R. Shankar, R.R. Turnock, G.L. Lamont, and C.T. Baillie
Liverpool, England

Background: Constipation is a common problem in childhood, and various radiologic methods have been advocated for investigation. Colonic transit time (CTT) has been used in adults to investigate colonic motility, but few studies evaluate this method in children. Data on CTT in the normal paediatric population are scarce.

Methods: The colonic transit time was measured in 22 healthy children (median age, 10 years; range, 4 to 15 years) by Abrahamsson's method. Children took bolus ingestions of radiopaque markers on 6 consecutive days, and on day 7 a single abdominal x-ray was performed. This was evaluated for total and segmental colonic transit time.

Results: The mean total CTT was 40 hours, and the upper limit of normal (95th percentile) was 84 hours. The upper

limit of normal for segmental transit time was as follows: 14 hours for the ascending, 33 hours for the transverse, 21 hours for the descending, and 41 hours for the rectosigmoid colon.

Conclusions: CTT provides an objective measure to assess childhood constipation. To date, 6 studies using 5 different methods have been published reporting values for healthy children. Comparing these, Abrahamsson's method has low radiation exposure and is well tolerated. This study contributes additional normal values in children.

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INDEX WORDS: Colonic transit time, childhood constipation.

CONSTIPATION IS COMMONLY described by frequency, consistency and size of stools, and difficulty in passing a bowel motion.^{1,2} After clinical assessment by history and physical examination, various radiologic methods have been used to investigate constipation in children. These include the plain abdominal radiograph,^{3,4} contrast enema, defaecating proctogram, and the measurement of colonic transit time.^{5,6} Additionally, colonic and anorectal manometry have been used to investigate colonic motility,⁶⁻⁸ rectometrography has been used to assess rectal compliance⁸ and electromyography has been used to evaluate muscular coordination during defecation. Few of these investigations have any proven value in the investigation of severe constipation, and only a rectal biopsy will identify an underlying pathology in the minority of patients with Hirschsprung's disease.⁹

Evaluation of the colonic transit time, allows the clinician both to confirm clinical suspicion of constipation and quantify its severity. Analysis of segmental colonic motility usually distinguishes 2 types of delayed

transit (pancolonic and rectosigmoid hypomotility). Few studies have evaluated colonic motility in children, and normal data are limited. We present the results of a study measuring total and segmental colonic transit time in 22 children without symptoms of constipation. The literature is reviewed.

MATERIALS AND METHODS

Twenty-two healthy children (median age, 10 years; range, 4 to 15 years) who were admitted for routine day case surgery other than gastrointestinal surgery took part in this study. None had any symptoms of constipation as assessed by a questionnaire.¹⁰ The study was approved by the Royal Liverpool Children's Hospital Ethics Committee. Informed written consent was taken from parents and children.

The colonic transit time (CTT) was measured using the saturation method described by Abrahamsson et al.¹¹ Radiopaque polythene granules (2 mm³, specific gravity of 1.2; Portex, SIMS Portex Ltd, UK) were used as markers. Several weeks after their day case surgery, the children swallowed 10 radiopaque markers at the same time daily for 6 days. A single abdominal radiograph was performed on the seventh day, 24 hours after ingestion of the last dose of markers. During this time, the children were asked to keep to their usual diet. By the seventh day, a steady state is reached in which the number of swallowed and excreted markers are equal.¹¹ Total CTT (in hours) is the number of retained markers divided by the daily ingested dose and multiplied by 24. Segmental transit times were calculated by counting the number of retained markers in 4 colonic segments (ascending, transverse, descending, and rectosigmoid) as a fraction of the total retained. Markers observed at the junction of colonic segments were proportioned equally between adjoining segments. The product of each fraction and the total CTT was the segmental colonic transit time.¹¹ Statistical analysis was performed using SPSS software (SPSS 10.0, SPSS Inc, Chicago, IL).

RESULTS

Total and segmental CTT were evaluated in 22 healthy children. The mean total CTT was 39.6 hours (standard

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Address reprint requests to C.T. Baillie, Consultant Paediatric Surgeon, Department of Paediatric Surgery, The Royal Liverpool Children's Hospital (Alder Hey), Eaton Rd, Liverpool L12 2AP England.

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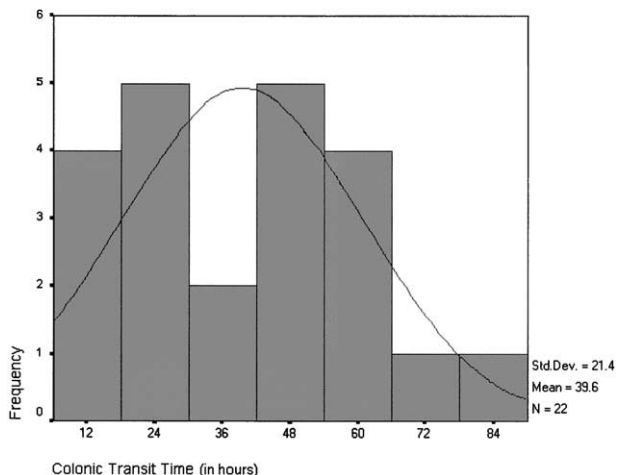


Fig 1. Histogram shows the results for total CTT (hours) with Superimposed Gaussian distribution.

deviation [SD], 21.4 hours; range, 7.2 to 86.4 hours). Because transit times were not normally distributed but skewed, the upper limit of normal could not be expressed in terms of 2 SD above the mean (Fig 1). Therefore, the 95th percentile was used as the upper limit of normal CTT,¹¹ giving a time of 84 hours. A comparison with previously reported normal values for total CTT in children¹²⁻¹⁷ is detailed in Table 1.

Mean segmental transit times were as follows: ascending colon, 5.5 hours (range, 0 to 14.4 hours); transverse colon, 10.9 hours (range, 0 to 33.6 hours); descending colon, 6.1 hours (range, 0 to 21.6 hours), and rectosigmoid colon, 18.2 hours (range, 0 to 40.8 hours). Upper limits of normal segmental transit times were expressed as 95th percentile values (Table 2). Previously published values for segmental CTT in children are summarised in Table 3.

DISCUSSION

A variety of methods have been used to measure colonic transit time. Hinton et al¹⁸ described a method using serial radiographs of collected faeces. After this, variations of 2 methods, either using a single bolus of

Table 2. Segmental CTT, the Upper Limit of Normal is Expressed as 95th Percentile

	Mean Segmental CTT, SD	Upper Limit of Normal (95th Percentile)
Ascending colon	5.5, SD 4.4	14.2
Transverse colon	10.9, SD 9.6	33.1
Descending colon	6.1, SD 5.4	20.6
Rectosigmoid colon	18.2, SD 13.3	40.8

NOTE. All values are given in hours.

markers and serial radiographs¹² or repeated ingestion of markers and a single abdominal radiograph have been described.^{11,17,19} Some reports suggest the use of colonic scintigraphy.^{16,20} This requires repeated attendance for scintigraphy, and mean radiation doses¹⁶ compare unfavourably with the radiation dose for a single abdominal x-ray (1.4 mSv).

The first study to measure the CTT in healthy children was performed by Arhan et al.¹² A single bolus of markers was ingested, and daily radiographs were performed until all markers were excreted. Two studies^{14,15} used a simplified method, first described by Metcalf et al.¹⁹ On 3 consecutive days, markers were ingested, using a different shape each day, and a single radiograph was taken on the fourth day. This method underestimates CTT in patients with a transit time longer than 72 hours.^{14,20} The latest study by Gutierrez et al¹⁷ used ingestion of differently shaped markers for 6 days and a single radiograph on the seventh day.

Abrahamsson et al¹¹ adapted Metcalf's method in adults, giving daily bolus marker ingestions of the same shape for 6 days with a single radiograph on the seventh day. Evaluation is simplified by using markers of one shape only. Radiation exposure is low, and the method is therefore suitable for repeated assessment of constipated children.

Six studies have been published reporting values for CTT in healthy children (Tables 1 and 3). In most, the number of children studied is between 10 and 30. Our study falls within this range analysing data from 22 children. The series by Corazziari et al¹³ is significantly larger but is based on Hinton's method in which markers

Table 1. Total CTT in Healthy Children Expressed as Mean and SD, the Upper Limit of Normal Expressed as Mean + 2 SD

Study	No. of Children	Age (yr)	Total CTT (h)	Upper Limit of Normal (h)	Method Used
Arhan et al (France, 1981) ¹²	23	<15	29, SE 4	62.0	Arhan et al ¹²
Corraziari et al (Italy, 1985) ¹³	78	2 mo to 12 yr	25, SD 3.7	32.4	Hinton et al ¹⁸
Bautista Casanovas et al (Spain, 1991) ¹⁴	10	6-14	37.8, SD 6.2	50.2	Metcalf et al ¹⁹
Zaslavsky et al (Brazil, 1998) ¹⁵	13	12-18	30.2, SD 13.2	56.6	Metcalf et al ¹⁹
Tota et al (Italy, 1998) ¹⁶	15	3-14	22.3, SD 4.8	25*	Vattimo et al ²⁰ (radionuclides)
Gutierrez et al (Spain, 2002) ¹⁷	30	2-14	29.08, SD 8.3	45.68	Adapted Metcalf et al ¹⁹
Current study (UK)	22	4-15	39.6, SD 21.4	84†	Abrahamsson et al ¹¹

Abbreviation: SE, Standard error.

*Value used in study.

†95th percentile.

Table 3. Previous Reported Segmental CTT in Healthy Children Expressed as Mean and SD and the Upper Limit of Normal Expressed as Mean + 2 SD

Study	Right Colon		Left Colon		Rectosigmoid Colon	
	Segmental CTT	Upper Limit of Normal	Segmental CTT	Upper Limit of Normal	Segmental CTT	Upper Limit of Normal
Arhan et al, ⁶ 1981	7.7*	18.0	8.7*	20.0	12.4*	34.0
Bautista Casanovas et al, ¹⁴ 1991	10.8, SD 3.5	17.8	12.2, SD 2.7	17.6	14.7, SD 2.1	19.1
Zaslavsky et al, ¹⁵ 1998	6.7, SD 3.9	14.5	7.9, SD 7.8	23.5	15.6, SD 10.7	37.0
Tota et al, ¹⁶ 1998	5.4, SD 3.0	7†	7.1, SD 3.4	8†	9.8, SD 3.2	10†
Gutierrez et al, ¹⁷ 2002	7.25, SD 5.75	19.02	6.6, SD 6.2	19.0	14.96, SD 8.7	32.36

NOTE. All values are given in hours.

*Mean only.

†Value used in study.

are recorded by faecal x-ray.¹⁸ It has not been repeated for obvious logistic reasons, and measurement of segmental transit is impossible by this method.

The upper limit of normal for total CTT based on the mean plus 2 SD varies significantly between different studies. Two Italian studies^{13,16} have reported short values (25 and 32 hours). Regional factors and study methodologies might have a role in explaining these. Our data showed that transit times were not distributed normally being skewed towards longer values (Fig 1). This finding was most likely the case in all studies reported, with the exception of Corazziari et al¹³ who had sufficient numbers to ensure a normal distribution. We therefore used the 95th percentile as the upper limit of normal and would question the validity of values using the mean and 2 SDs. The upper limit of normal from our data was 84 hours, which is longer than previously reported.

To measure the segmental CTT, most investigators have divided the abdominal radiograph into 3 regions using bony landmarks according to the method proposed by Arhan et al.¹² In practice it is easy to differentiate

between colonic segments on a transit abdominal x-ray, and our preference was to count markers in 4 anatomic segments corresponding to ascending, transverse, descending, and rectosigmoid colonic segments. Direct comparison of normal segmental values from other studies with our data is therefore not possible, with the exception of the most important data (namely total colonic and rectosigmoid transit times). Segmental transit time was found to be longest in the rectosigmoid region, which corresponds with previous studies.

Studies in children with functional constipation have shown a good correlation between CTT and clinical symptoms.^{5,20} It has been suggested that children with different subgroups of constipation (pancolonic transit delay, rectosigmoid transit delay) might benefit from different treatment approaches.^{5,15,16} These arguments provide the rationale for assessing total and segmental CTT in constipated children.

This study adds a series of normal values to the limited data available. The method used is well tolerated, non-invasive, and has low radiation exposure.

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Discussion

A. De Caluwe, London, England: Could you tell why if you have already done the study 6 times? You need to do it a seventh time to come to the same conclusion.

S. Wagener (response): One reason is that there is a large variation in normal values in the literature. The normal values used in most studies of constipated children are those of Arhan with an upper normal limit of 62 hours. In view of the large variations between studies, one is forced to conclude that it might be better to have local values. Another reason is that different study methodologies have been used and, apart from the 2002 study, all have used more than one abdominal x-ray or colonic scintigraphy. In view of the higher radiation exposure, we wished to use a method combining low radiation exposure and the ability to study segmental and total colonic transit time using one abdominal x-ray.

A. Martins, Lisbon, Portugal: If normal is so variable, how does it help in terms of managing patients in the future?

S. Wagener (response): In choosing which normal values to use, our preference has been to favour our local

data in case of regional differences. If you use a method which enables measurement of segmental transit times, it is possible to distinguish between pan-colonic transit delay and rectosigmoid transit delay. It has been found in different studies that these children seem to respond to different management strategies. The less severe are usually the ones with the rectosigmoid transit delay. These children often have good results with laxatives and dietary measures. In pan-colonic transit delay many of these children, at least in the Liverpool experience, seem to progress to surgical management.

A. Martins: Can we compare what is normal in children with normal for a particular child?

S. Wagener (response): This is a difficult question. I think that you would probably need studies with a larger number of children to get very definite normal values. This is why we have used the 95th percentile as our results were not normally distributed. As our upper limit of normal transit was longer than in previous studies, we have possibly underestimated the number of children with transit delay.