How common is colonic elongation in children with slow-transit constipation or anorectal retention?

Yee Ian Yik\textsuperscript{a,b,c}, David J. Cook\textsuperscript{d}, Duncan M. Veysey\textsuperscript{d}, Coral F. Tudball\textsuperscript{d}, Timothy M. Cain\textsuperscript{d}, Bridget R. Southwell\textsuperscript{a}, John M. Hutson\textsuperscript{a,b,e,*}

\textsuperscript{a}F Douglas Stephens Surgical Research and Gut Motility Laboratories, Murdoch Children’s Research Institute, Melbourne, Australia
\textsuperscript{b}Department of Paediatrics, University of Melbourne, Melbourne, Australia
\textsuperscript{c}Department of General Surgery, Faculty of Medicine, University of Malaya, Kuala Lumpur, Malaysia
\textsuperscript{d}Department of Biomedical Imaging, Royal Children’s Hospital, Melbourne, Australia
\textsuperscript{e}Department of Urology, Royal Children’s Hospital, Melbourne, Australia

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Abstract

\textbf{Purpose:} Colonic elongation is reported as a possible cause for slow colonic transit, as it is observed in patients with slow-transit constipation (STC). This study aimed to determine the frequency of colonic elongation in children with STC or anorectal retention using radioimaging. We hypothesized that transverse colon elongation may occur in patients with STC, whereas sigmoid colon elongates in patients with anorectal retention.

\textbf{Methods:} Nuclear transit scintigraphy performed for chronic constipation (1999-2011) was analyzed qualitatively for elongated transverse colon or sigmoid colon. Three major colonic transit patterns were identified: slow transit in the proximal colon (STC), normal proximal colonic transit with anorectal retention (NT-AR), and rapid proximal transit ± anorectal retention (RT). \(\chi^2\) Test was used for statistical analysis (\(P < .05\) significant).

\textbf{Results:} From 1999 to 2011, 626 children had nuclear transit scintigraphy. Transverse colon elongation occurred more frequently in STC (73/322, or 23\%) compared with NT-AR (9/127, or 7\%) and RT (5/177, or 3\%; \(P < .0001\)). Sigmoid colon elongation was equally common in NT-AR (8/127, or 6\%) compared with RT (10/177, or 6\%) and STC (14/322, or 4\%; \(P < .9\)).

\textbf{Conclusion:} Transverse colon elongation is more common in STC (23\%), whereas sigmoid colon elongation is not more common in anorectal retention. Colonic elongation may be the cause or the result of the underlying slow colonic transit.

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Chronic constipation is a major health condition affecting both adults and children. Various investigations have been used to study this condition in attempts to identify the underlying pathophysiology. Radioimaging has been used extensively to study the gastrointestinal tract to optimize treatment in clinical practice. Standard imaging...
techniques like an abdominal radiograph or contrast enema have been used to investigate children with chronic constipation. These investigations provide information on fecal contents ( abdominal radiographs and ultrasonography) and also identify obvious structural abnormalities as the underlying cause of chronic constipation, for example, Hirschsprung disease ( contrast enema). Ultrasonography has been used to evaluate the size and volume of the rectum in children with chronic constipation [1-4]. Several scoring systems have been developed to assess the degree of fecal loading and its localization in different colon segments, that is, Barr, Blethyn, or Leech score [5-8]. Furthermore, a barium enema will also show if an elongated colon is present in a child (Fig. 1), and this was previously reported as the presence of redundancies in different parts of the colon, described as “dolichocolon” or “ptosis of transverse colon” [9,10]. More recently, special imaging techniques like radio-opaque marker studies and nuclear transit scintigraphy (NTS) have been introduced to study colonic motility. With this radioimaging technique, colonic elongation has been observed anecdotally, but the significance of this is still unclear.

Nuclear transit scintigraphy has emerged as a valuable diagnostic tool providing useful information on gastrointestinal motility to guide therapy and also to monitor the response to treatment. It also provides additional information on the anatomical structure of the colon, revealing the presence of colonic elongation in some patients. Colonic elongation has been reported in animal studies as a possible underlying cause for slow colonic transit as observed with experimental stretching of the colon [11]. Anecdotally, colonic elongation is observed in some patients with slow-transit constipation (STC) [12].

At our institute, we have used NTS to study children with chronic constipation since 1997. We have been able to identify 3 subgroups of children based on the characteristics of their colonic transit, namely, normal, slow, and rapid proximal colonic transit [13-15]. In the same study, we are able to recognize the presence of colonic elongation. This study aimed to determine the frequency of colonic elongation in children with STC or anorectal retention using radioimaging. Slow-transit constipation is defined as intractable chronic constipation (symptoms >2 years not responding to standard medical treatments) with a characteristic colonic transit pattern as described previously, where the radiotracer is retained mainly in the transverse colon [13,14,16], with more than 40% retained in the transverse colon at 24 hours and/or more than 30% at 48 hours. For anorectal retention, the colonic transit pattern is normal with more than 60% of radiotracer retained in the rectosigmoid colon at the end of NTS, at 48 hours. We hypothesized that elongation of the transverse colon would occur in patients with STC, and elongation of sigmoid colon would be found in patients with anorectal retention.

1. Methods

Nuclear transit scintigraphies were used at our institute to investigate children with intractable chronic constipation (defined as chronic constipation not responding to maximal laxative therapy, behavioral therapy, and toilet training program with duration of symptoms of >2years). After cessation of laxative treatment for 5 to 7 days beforehand, children drank milk containing either 99m-technetium colloid (pre-2000) or gallium-67 citrate (post-2000) at a dose calculated as previously described [13,16]. Nuclear transit scintigraphy is a non-invasive radionuclear imaging technique that simply involves the ingestion of a radiotracer and serial images captured using a γ-camera. Six regions of interest were identified: 1, small bowel; 2, ascending colon; 3, transverse colon; 4, descending colon; 5, rectosigmoid colon; and 6, evacuation into toilet. Images were taken between 0 and 2 hours (at 0, 0.5, 1, and 2 hours) and then at 6, 24, 30, and 48 hours. Three major groups were identified according to colonic transit patterns:

1. normal transit in the proximal colon with anorectal retention (NT-AR; Fig. 2A);
2. rapid transit in the proximal colon ± anorectal retention (RT; Fig. 2B) [15]; and
3. slow transit in the proximal colon (slow-transit constipation, STC)
   a. STC with elongated colon (Fig. 2C),
   b. STC with focal holdup (Fig. 2D),
   c. STC with anorectal retention (Fig. 2E), and
   d. STC with delayed gastric emptying and/or slow small bowel transit (Fig. 2F) [17].

Fig. 1 Barium enema of a child with elongated transverse colon (the colon was traced from the cecum to the rectum) included for comparison with the images acquired by NTS. The finding of elongated colon was consistent with the results of the child’s NTS. HF indicates hepatic flexure; SF, splenic flexure.
All the NTSs performed for children investigated for intractable chronic constipation from 1999 to 2011 were retrieved and stored in a separate database with ethics approval (30059A) by Y.I.Y.

This is a retrospective review of radioimaging with available data collected from the images captured during NTS for children with chronic constipation.

Colonic elongation was considered present qualitatively when the transverse colon or sigmoid colon was unusually long and tortuous, with a more than 30% increase in length, compared with the usual anatomical contour as described above (Fig. 3). All the images were looked at with particular focus on the transverse colon and sigmoid colon for evidence of elongation by YIY. Elongated colon

![Fig. 2](image)

**Fig. 2** Colonic transit patterns on NTS. A-E, Images captured at 6, 24, 30, and 48 hours. A, NT-AR, B, RT (defined as >25% of radiotracer beyond hepatic flexure at 6 hours and/or >25% of radiotracer beyond the end of descending colon) [15]. C, STC with elongated colon. D, STC with focal holdup at hepatic flexure (HF). E, STC with anorectal retention. F, Images at 2 and 6 hours for gastric emptying and SB transit—delayed gastric emptying (DGE; defined as >15% radiotracer at 2 hours in the stomach and gastric half-emptying time, $T_{1/2} > 50$ minutes) and slow SB transit (SSBT; defined as >25% of radiotracer at 6 hours in the SB) [17], in addition to STC. SB indicates small bowel; S, stomach.
was later analyzed according to the 3 major colonic transit patterns identified.

A barium enema of a child with elongated colon was also included for comparison with the images acquired by NTS, and the finding of elongated colon was consistent (Fig. 1). $\chi^2$ test was used for statistical analysis, and $P < .05$ was considered significant.

### 2. Results

From 1999 to 2011, 626 (mean, 8.3 years; range, 4 months to 23 years; 338 boys) children had NTS performed to investigate intractable chronic constipation, with 322 diagnosed as having STC; 127, normal colonic transit; and 177, rapid proximal colonic transit. Transverse colon elongation was observed in 73 (23%) of 322 children with STC, 9 (7%) of 127 children with NT-AR, and 5 (3%) of 177 children with RT. The difference was statistically significant ($P < .0001$) comparing STC with NT-AR or RT groups (Table 1). Sigmoid colon elongation was less common, occurring almost equally in 14 (4%) of 322 patients with STC, 8 (6%) of 127 patients with NT-AR, and 10 (6%) of 177 patients with RT, with no significant difference between NT-AR and STC or RT groups ($P < .9$; Table 1).

Further analysis of these children according to age group found that the older the child, the higher the incidence of colonic elongation in children with STC but not in children with normal and rapid colonic transits (Table 2 and Fig. 4).

Only a few children had had a contrast enema performed as part of the investigations of their underlying chronic constipation. No patients in the current study had associated spinal abnormalities. We were not able to appreciate the presence of elongated colon in some children because the holdup was much more proximal, with the distal part of the colon not delineated. Interestingly, in children where elongated colon was observed, there was no evidence of a dilated segment proximal to the elongated segment of the colon.

### 3. Discussion

We have used NTS to investigate children with intractable chronic constipation since 1997 and were able to identify

### Table 1

<table>
<thead>
<tr>
<th>NTS diagnosis</th>
<th>Total no. of patients</th>
<th>No. of patient with transverse colon elongation (%)</th>
<th>No. of patient with sigmoid colon elongation (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>STC</td>
<td>322</td>
<td>73 (23%)*</td>
<td>14 (4%)**</td>
</tr>
<tr>
<td>NT-AR</td>
<td>127</td>
<td>9 (7%)*</td>
<td>8 (6%)***</td>
</tr>
<tr>
<td>RT</td>
<td>177</td>
<td>5 (3%)*</td>
<td>10 (6%)***</td>
</tr>
</tbody>
</table>

* $P < .0001$.
** $P = .4$.
*** $P = .8$.  

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**Fig. 3** Qualitative analysis of colonic elongation based on NTS. *Elongated colon* was defined as the presence of long and tortuous transverse colon (TC) and/or rectosigmoid colon (RSC). A, NT with normal length colon. B, STC with normal length colon. C, NT with elongated SC. D, STC with elongated TC. E, STC with elongated SC. F, STC with both elongated TC and SC. NT indicates normal transit; ASC, ascending colon; DSC, descending colon; SC, sigmoid colon.
children with 3 major colonic transit patterns. In this study, we observed a significantly higher occurrence of transverse colon elongation in children with STC as compared with the subgroups of children with NT-AR and RT \((P < .0001; \text{Table 1})\). For sigmoid colon elongation, the occurrence was not significantly higher in the NT-AR group when compared with the STC and RT groups. In our study, not all patients had a contrast enema performed. However, NTS images if acquired properly could provide adequate information on colonic length and structure as we have demonstrated in the current study. It is less invasive compared with contrast enema and also contributed to less discomfort. Moreover, the colon was not distended as occurred in the contrast enema, and the effect observed may be more physiological. In addition, NTS is much less invasive than colonic manometry as a test for colonic dysmotility, with the avoidance of general anaesthesia and colonoscopy if there is no preexisting appendix stoma in the patient. Nuclear transit scintigraphy is not a replacement for colonic manometry but a simpler alternative with additional information on gastric emptying and small bowel transit.

Slow-transit constipation is considered a more severe spectrum/form of chronic constipation because this group is usually more resistant to treatments. Because great variations in the length of the colon have been observed in fetuses, children, and adults \([18]\), the presence of an elongated colon might be the cause for prolonged colonic transit in some children with STC. On the other hand, the colon has been shown to undergo substantial changes in length (in guinea pigs) as it fills with fecal matter \([11]\), suggesting that

### Table 2

<table>
<thead>
<tr>
<th>Age group (y)</th>
<th>Normal colonic transit</th>
<th>Rapid colonic transit</th>
<th>Slow colonic transit</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ETC</td>
<td>ESC</td>
<td>Normal colonic length</td>
</tr>
<tr>
<td>&lt;2</td>
<td>0</td>
<td>0</td>
<td>4 (100)</td>
</tr>
<tr>
<td>2-4</td>
<td>0</td>
<td>0</td>
<td>24 (100)</td>
</tr>
<tr>
<td>5-7</td>
<td>2 (6)</td>
<td>2 (6)</td>
<td>27 (88)</td>
</tr>
<tr>
<td>8-11</td>
<td>5 (10)</td>
<td>4 (8)</td>
<td>42 (82)</td>
</tr>
<tr>
<td>12-17</td>
<td>2 (12)</td>
<td>2 (12)</td>
<td>13 (76)</td>
</tr>
<tr>
<td>≥18</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Total (all age groups)</td>
<td>9 (7)</td>
<td>8 (6)</td>
<td>110 (87)</td>
</tr>
</tbody>
</table>

Percentage (%) indicates the number of patients with different colonic length within each colonic transit pattern.

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![Elongated Transverse Colon (ETC)](image)

**Fig. 4** Percentage of children with elongated transverse colon based on colonic transit patterns according to age groups (the number within each column of the bar represents the real number of patient in each age group).
Colonic elongation in children with STC

elongation could be the long-term effect of chronic constipation. Interestingly, we found that, in our series, children with STC had a higher prevalence of transverse colon elongation compared with children with normal and rapid colonic transit patterns. However, with regard to children and chronic constipation, it remains an open question of which came first. Colonic elongation may also be related to the fact that constipation in children often continues through adolescence into adulthood. As for chronic constipation with outlet obstruction/anorectal retention (NT-AR), sigmoid colon elongation may be the secondary effect of a long-standing outlet obstruction.

An animal study by Heredia et al [11] showed that elongation of colonic longitudinal muscles was associated with slow colonic transit with reduced colonic migrating motor complexes. This association also may be applicable in humans because high-amplitude propagating contractions were observed to be reduced in children with STC [19]. This may well explain the association of elongated colon and its poor motility, contributing to slow colonic transit in some children with STC, as suggested recently by Southwell [20]. Elongated colon (called redundant) is also notable during colonoscopy because it is very hard to perform a full colonoscopy in the presence of a redundant colon [21]. Raahave et al [22] reported in an adult study that both the colonic transit time and constipation symptoms increase with the degree of redundancy and that these are the patients who are least likely to respond to treatment. In children with STC, they usually do not respond to medical therapies [23-25], and the presence of elongated colon may well be the reason why some of these children are even more resistant to treatment. At our institute, we are studying the use of NTS to predict or monitor the response of children with STC to electrical stimulation, and this might also serve as a tool to identify a segment of bowel to be resected later on if required. We have shown that elongation can resolve after electrical stimulation, suggesting that nonsurgical treatment could overcome it (unpublished data). Also, our most recent data showed that patients with reduced interstitial cells of Cajal have focal holdup in the proximal colon or colonic elongation (unpublished data). The loss of interstitial cells of Cajal may result in the elongated colon or vice versa. Slow-transit constipation can be associated with abnormal rectosigmoid function (outlet obstruction/anorectal retention) or can occur with normal rectosigmoid function [14].

There is a lot of discussion about whether the defect is primarily at the outlet (anorectum) producing slowing of motility upstream as a secondary effect or if a defect can occur in the proximal colon without an outlet defect. The study of Heredia et al [11] shows that the effects of elongation are different in the proximal and distal colon and provides evidence that the proximal colon can inhibit motility in the distal colon. Thus, it is possible that elongation can inhibit motility in the proximal colon primarily, and this can then affect the distal colon.

So far, there is no literature to suggest that colonic elongation is a common occurrence in the normal population without chronic constipation using scintigraphy. One limitation of this study is that it is based on the observation of the presence of colonic elongation in children with chronic constipation, without a control population from children with normal defecation. Also, in the presence of focal holdup, we were not able to appreciate elongation of colon beyond the point of holdup. However, in other children where elongated colon was observed, there was no evidence of a dilated segment proximal to the elongated segment of colon suggesting distal obstruction. The elongated colon might be stretched by the contents within that were moving slowly.

In conclusion, transverse colon elongation occurred in 23% of children with STC diagnosed by NTS. By contrast, elongation of the sigmoid colon was equally common in patients with anorectal retention (6%) compared with STC (4%). Colonic elongation may be the cause or the result of the underlying slow colonic transit. There is strong evidence from animal studies to suggest that colonic elongation can cause STC. Colonic elongation may be a marker for a subgroup of children with STC that are more difficult to treat.

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