

ORIGINAL ARTICLE

Do gastrointestinal transit times and colonic dimensions change with time since spinal cord injury?

PM Faaborg^{1,2}, P Christensen^{1,2}, M Rosenkilde³, S Laurberg¹ and K Krogh²

¹Surgical Research Unit, Department of Surgery P, Aarhus University Hospital, Aarhus, Denmark; ²Neurogastroenterology Unit, Department of Hepatology and Gastroenterology V, Aarhus University Hospital, Aarhus, Denmark and ³Department of Radiology, Aarhus University Hospital, Aarhus, Denmark

Study design: Long-term follow-up study.

Objectives: To determine whether gastrointestinal transit times (GITTs) and colonic dimensions change during the first or subsequent decades after spinal cord injury (SCI).

Setting: Aarhus University Hospital, Denmark.

Methods: GITT and colonic dimensions were evaluated by means of radio-opaque markers. Group A ($n = 12$) was investigated 1 year after SCI and again 13 (range 11–14) years later. Group B ($n = 10$) was studied 19 (range 9–36) years after injury and again 12 (range 11–12) years later. All had been treated with conservative bowel management.

Results: In group A, the median GITT 1 year after injury was 4.3 (range 1.1–6.5) days and 13 years later, it was 3.2 (range 1.3–6.5) days, $P = 0.96$. In group B, the median GITT 19 year after injury was 3.4 (range 0.6–5.9) days and 12 years later, it was 3.2 (range 1.9–5.5) days, $P = 0.77$. None of the two groups experienced a significant change in the diameter of the caecum/ascending colon, transverse colon, descending colon or the sigmoid during long-term follow-up. Megacolon was present in four patients at baseline and in five at follow-up.

Conclusion: GITTs and colonic dimensions did not change, neither during the first decade nor long after SCI.

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Keywords: neurogenic bowel dysfunction; constipation; total gastrointestinal transit time; megacolon and colonic dimensions

Introduction

Constipation, fecal incontinence and abdominal pain are common symptoms after spinal cord injury (SCI).^{1–6} Unfortunately, constipation-related symptoms and their impact on the quality of life increase with time since injury,^{1,5} and abdominal pain is especially common in subjects who are at least 5 years after injury.⁶

Constipation is usually evaluated by symptom scores or, objectively, by radio-opaque markers or scintigraphy. Colonic or gastrointestinal transit times (GITTs) after SCI have previously been described in cross-sectional studies^{7–11} and in a single follow-up study within the first year after injury.¹² However, long-term results are not available. Also, it has been suggested that megacolon is a common condition in subjects with long-standing spinal cord injuries¹³ but, again, long-term prospective evaluations are lacking. Accordingly,

the aims of the present study were to evaluate the long-term effects of SCI on GITTs and colonic dimensions.

Materials and methods

In order to assess changes in GITTs and colonic dimension during the first decade after cord injury and in the long-term, we studied two groups of individuals: Group A was studied at a median 1.0 (range 0.5–1.2) years after injury and again 12.8 (range 10.9–13.6) years later. Group B was studied at a median 18.7 (range 8.9–35.8) years after injury and again 12.2 (11.0–12.3) years later. Both groups were recruited among participants from two previous studies performed at our unit:

Group A: GITTs, segmental colonic transit times, colonic diameters, gastrointestinal symptoms and use of medication were registered 1 year after SCI in 18 subjects¹² during the period 1 January 1996 to 31 December 1997. In 2009, 16 were still alive and 12 accepted to participate in follow-up (Figure 1).

Correspondence: Dr PM Faaborg, Surgical Research Unit, Department of Surgery P, Aarhus University Hospital, Aarhus Sygehus, Tage-Hansensgade 2, Aarhus C DK-8000, Denmark.
E-mail: pmfaaborg@gmail.com
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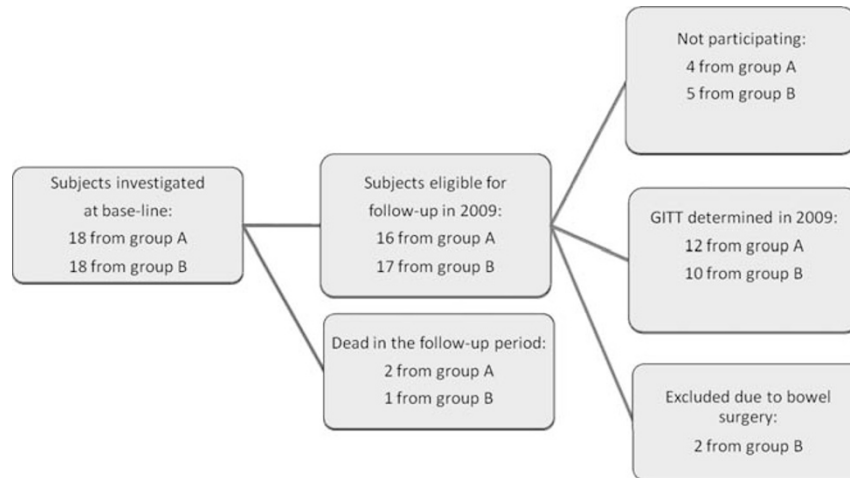


Figure 1 Participants' selection for the present study. Group A¹² represents follow-up of GITT ~ 1 year and a decade after cord injury. Group B¹⁴ represents follow-up of gastrointestinal transit time approximately one and two decades after cord injury. GITT, gastrointestinal transit times.

Table 1 Background demographics. Age and time since injury are at follow-up

	Group A	Group B
Number of persons	12 (8 male, 67%)	10 (7 male, 70%)
Age (median with range)	49.5 (37.7–67.2) years	48.0 (29.7–71.9) years
Time since injury (median with range)	12.8 (10.9–13.6) years	29.7 (21.1–48.0) years
Age at injury (median with range)	36.5 (24.1–55.2) years	18.6 (0.0–24.3) years
Complete lesions	4 (33%)	8 (80%)
Supraconal lesions	6 (50%)	6(60%)
Conal/cauda equine lesions	6 (50%)	4 (40%)

Group B: in 1997, 18 subjects with SCI participated in the short-term (four weeks) evaluation of a new prokinetic drug (Prucalopride, Janssen-Cilag, Birkerød, Denmark).¹⁴ All were 9–36 years after injury. Before inclusion, the same parameters as described for group A were determined. In 2009, 17 were still alive and 10 accepted to participate in the present study (Figure 1).

Background data on participants are shown in Table 1. Level and completeness of injury were classified according to international guidelines.¹⁵ None of the subjects included for follow-up had undergone colorectal surgery or developed other conditions that could affect their bowel function. Medication used at baseline and at follow-up in 2009 was compared. Patients were instructed to use exactly the same laxative and dose during the follow-up investigation as was listed in their file during baseline studies.

The study was performed according to the Helsinki II declaration and approved by the local Ethics Committee. Informed consent was obtained before inclusion.

Gastrointestinal and segmental transit times

Gastrointestinal and segmental colonic transit times were determined by the method described by Abrahamson *et al.*¹⁶ Participants took one gelatine capsule (P & A Mauch, Münchenstein, Switzerland) every day for 6 consecutive days. Each capsule contained 10 radio-opaque polyurethane

markers containing 40% barium sulfate. On day 7, a single anterior–posterior plain abdominal X-ray picture was taken. The method for calculation of GITTs and segmental colonic transit times has previously been described in detail.^{12,16} The upper limit of GITTs that can be determined by this method is 6.5 days. A consultant colonic radiologist and the first author independently evaluated all X-rays. In case of discrepancy between results, a conclusion was reached after joint discussion.

Colonic dimensions

We defined megacolon as a segmental colonic diameter >mean + 2 s.d. for healthy controls investigated with double-contrast barium enema.¹⁷ This corresponds to diameters of the ascending colon >8.7 cm, transverse colon >8.0 cm, descending colon >5.6 cm and the sigmoid >6 cm. The height of the first lumbar vertebra and the diameter of the femoral head were used to correct for differences in radiographic magnification. During analysis, the investigator did not know whether the X-ray picture had been taken at baseline or at follow-up. For the examination of the abdominal X-ray pictures, we attempted to blind the investigators as to the time of investigation. This was, however, not possible as old and new radiographs differ from a technical point of view.

Statistical analysis

Calculation of sample size was based on data from a previous study,¹² with median GITTs at baseline of 3.6 days and an s.d. of 1.8 days. A target difference of 2 days (between baseline and follow-up), a power of the test of 90% and a significant level (alpha) of 5% gave a sample size of nine in each group.

Analysis of all the data was performed with the program STATA/IC 10 for Windows (StataCorp, College Station, TX, USA). As data for gastrointestinal and segmental colonic transit times, as well as colonic diameters deviated from the normal distribution (normal probability plots), the non-parametric Wilcoxon's matched-pairs signed-rank test was used for comparisons. Descriptive statistics were performed on background data and bowel function; data are presented as proportions or for quantitative variables, as median with range. $P < 0.05$ was considered statistically significant.

Results

Gastrointestinal transit times and segmental colonic transit times are presented in Table 2. Apart from a decrease in rectosigmoid transit time from 1 to 13 years after SCI, no statistically significant changes were found. Likewise, no

statistically significant changes in colonic dimensions were observed (Table 3). Two group A and three group B participants had a single mega-colon segment at baseline and at follow-up. Additional two group B participants had a single megacolon segment at follow-up.

Bowel symptoms and use of laxatives are shown in Table 4. There was a trend toward more use of digital stimulation or evacuation of the rectum. Otherwise, there were no major changes in bowel function or use of laxatives. Dividing subjects into those with complete ($n = 12$) and those with incomplete lesions ($n = 10$) did not change the overall pattern; likewise, no change of the overall pattern resulted from dividing the subjects into those with supraconal lesions ($n = 14$) and those with conal/cauda equine lesions ($n = 6$) (data not shown).

Discussion

Long-term follow-up on colorectal function has shown that symptoms of constipation and abdominal pain increase with time after SCI.^{5,6} We therefore speculated that GITTs would also become more severely prolonged in the long-term. The present study is the first to provide long-term follow-up on colorectal transit times and colonic dimensions. Compared

Table 2 Total gastrointestinal and segmental colonic transit times determined a) 1 and 13 years after spinal cord injury ($n = 12$) (top) and b) 19 and 30 years after spinal cord injury ($n = 10$) (bottom)

Segment	Group A (1 year after SCI)	Group A (13 years after SCI)	
Cecum/ascending colon	0.5 (0–1.6)	0.9 (0.1–3.0)	$P = 0.40$
Transverse colon	0.6 (0–1.1)	0.7 (0–1.7)	$P = 0.20$
Descending colon	1.3 (0.1–2.8)	0.6 (0–3.2)	$P = 0.56$
Rectosigmoid	1.3 (0.1–2.0)	0.5 (0–2.0)	$P = 0.026$
Total gastrointestinal	4.3 (1.1–6.5)	3.2 (1.3–6.5)	$P = 0.96$
	Group B (19 years after SCI)	Group B (30 years after SCI)	
Cecum/ascending colon	0.6 (0–2.3)	0.8 (0–2.1)	$P = 0.90$
Transverse colon	0.1 (0–0.8)	0.1 (0–1.1)	$P = 0.59$
Descending colon	0.3 (0–2.3)	1.2 (0–2.3)	$P = 0.29$
Rectosigmoid	0.9 (0–1.5)	0.9 (0–2.0)	$P = 0.77$
Total gastrointestinal	3.4 (0.6–5.9)	3.2 (1.9–5.5)	$P = 0.77$

Abbreviation: SCI, spinal cord injury.

Results are given in days and shown as median (range).

Table 3 Maximum colonic diameters in centimeters (shown as median (range))

	Group A (1 year after SCI)	Group A (13 years after SCI)	
Cecum/ascending colon	6.0 (3.5–12.0) [7]	6.8 (4.0–9.5) [12]	$P = 0.27$
Transverse colon	5.5 (4.0–6.5) [7]	4.5 (3.5–6.5) [12]	$P = 0.15$
Descending colon	4.0 (3.0–6.0) [7]	4.0 (2.0–7.0) [12]	$P = 0.55$
Sigmoid colon	4.5 (4.0–5.0) [4]	4.3 (3.0–6.0) [10]	$P = 0.45$
	Group B (19 years after SCI)	Group B (30 years after SCI)	
Cecum/ascending colon	6.5 (5.0–10.0) [9]	7.0 (4.0–9.5) [9]	$P = 0.17$
Transverse colon	5.0 (4.0–7.0) [5]	5.5 (4.5–9.0) [10]	$P = 0.35$
Descending colon	4.0 (3.0–5.0) [9]	4.3 (3.0–6.0) [10]	$P = 0.54$
Sigmoid	5.5 (4.0–8.0) [4]	4.0 (3.5–7.0) [7]	$P = 0.11$

Abbreviation: SCI, spinal cord injury.

As it was not always possible to determine every diameter, the number of subjects in whom it was possible is shown in [].

Table 4 Bowel function and use of laxatives in all the 22 participants

	Baseline data	Follow-up data
Normal desire to defecate	6	7
No desire to defecate	8	9
Altered desire to defecate	8	6
Defecation less than every second day	3	4
General or abdominal discomfort at defecation	14	10
Fecal incontinence at least once per month	2	3
<i>Laxative use</i>		
Oral laxatives	4	5
Mini enema or suppositories	7	8
Digital stimulation or evacuation of stools	9	13
Transanal colonic irrigation	0	0

Abbreviation: SCI, spinal cord injury.

Follow-up is either 13 or 30 (range 10.9–48.0) years after SCI.

with healthy subjects and in accordance with previous studies, most spinal cord injured subjects had prolonged gastrointestinal and segmental colonic transit times. Baseline GITT in group A was 1 year after injury and in group B, the median was 19 years after injury. Compared with baseline values, no major changes occurred during the first or later decades after injury. Furthermore, our results indicate that those subjects with most severely prolonged colonic transit continued to have so 10 years later.

Megacolon after long-term SCI has been a concern to many. Harari *et al.*¹³ defined megacolon as a segmental colonic diameter of >6 cm or a rectal diameter of >4.5 cm, and reported it to be present in 73% of the chronic spinal cord injured patients studied. A generally accepted definition of megacolon is not available,¹⁸ but from our clinical experience as colorectal surgeons and gastroenterologists, we find that the diameters previously reported are too small. Therefore, we applied a definition inspired by double-contrast barium enema radiograph evaluations, thereby accepting somewhat larger diameters. Whether this is valid is, of course, debatable. However, no major changes in colonic dimensions appeared during the follow-up periods. Accordingly, our results suggest that, in the majority of patients, a prolonged colonic transit time after SCI does not cause megacolon.

Altered use of laxatives is a potential source of error in long-term studies of bowel function after SCI. Most subjects used the same laxative in almost the same dose at baseline and at follow-up 12–13 years later. GITTs in subjects using stimulant laxatives ($n=4$) were comparable with the rest of the group. As we had very thorough data on their use of laxatives at baseline, we were able to have patients use the same drug and dose during the assessment of GITTs at follow-up.

Selection bias may have influenced our results. The 12 subjects in group A were recruited from the 18 subjects completing a study 13 years earlier.¹² Those 18 were recruited among the 26 consecutive, newly spinal cord injured patients in our uptake area. Subjects in group A were comparable with the general SCI population in terms of age at injury and completeness of lesion. However, there was a

tendency toward longer baseline GITTs in those participating at follow-up (median 4.3 days) as compared with those who did not (median 2.8 days). Subjects in group B had volunteered for a clinical trial on prokinetics and they generally included a larger proportion with complete lesions than expected from the entire Danish spinal cord injured population. This could lead to selection of those with the most severe symptoms. On the other hand, some subjects with very severe bowel dysfunction would have been offered surgery and would therefore not be available for the group B study at baseline.

As constipation-related symptoms become more severe as time since injury passes,⁵ we expected median total gastrointestinal transit to follow. Sample size calculated ahead of study start overshoot this effect, and as a consequence, the study is underpowered to show a transit time difference of less than 1 day. Others found poor correlation between total GITT and symptoms as well.¹⁹

The methodological strength of this study lies in its prospective long-term follow-up design. It overcomes some of the limitations of cross-sectional studies. Furthermore, baseline data, bowel function, medical and surgical history are all accounted for. Other methodological challenges have to be discussed. For the examination of the radiographs, blinding the time of investigation was not possible because of technical differences in old and modern radiographs. However, this is unlikely to have influenced results significantly, as there was no trend toward larger or smaller measurements associated with old or new radiographs. When measuring the diameters of the various sections of the colon, we experienced problems. Typically, a redundant sigmoid was overlying another segment, making the transverse colonic and sigmoid diameters difficult to measure.

In a large prospective follow-up of neurogenic bowel dysfunction in Danish spinal cord injured⁵ patients, we found that symptoms of constipation became more severe with time since injury, but this did not lead to a change in pharmacological treatment of bowel function. In the present study, numbers are too small to draw any firm conclusions about colorectal functional change over time. However, in support of the external validity of our results, there was a tendency toward more use of anorectal digitations during defecation at long-term follow-up. Also, selection of symptomatically stable patients may explain unaltered treatment over time.

In conclusion, the study demonstrated that GITT and colonic proportions did not become more abnormal, neither during the first decade nor later after injury.

Conflict of interest

The authors declare no conflict of interest.

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