Gut, 1970, **11**, 668-672

The transport of colonic contents in the irritable colon syndrome

J. A. RITCHIE

From the Nuffield Department of Clinical Medicine, The Radcliffe Infirmary, and the Nuffield Institute for Medical Research, Oxford

SUMMARY The mean distance of travel and hourly incidence of propulsive and retropulsive movements of colonic contents have been assessed by means of time-lapse cinefluorography and compared in 98 patients with the irritable colon syndrome and in 90 control subjects.

Net propulsion in patients with the irritable colon syndrome was less than in the controls at rest, similar to the controls after feeding, and greater than in the controls after an injection of carbachol.

In both clinical groups, food and carbachol increased the incidence of propulsive and retropulsive movements but did not alter the average distance over which they travelled.

The figures suggest that at least two-thirds of all net propulsion of colonic contents in the irritable colon syndrome takes place under circumstances not reproduced in the present study.

The irritable colon syndrome has been recognized in one form or another for about 100 years; as the name implies, it has been studied almost exclusively from a clinical viewpoint.

The early descriptions emphasized the tendency to secrete an excess of mucus (da Costa, 1871; Hale White, 1905). Later observers concentrated on the close association with psychological factors (Bockus, Bank, and Wilkinson, 1928; White and Jones, 1940) or on the tendency to muscular spasm (Ryle, 1928). Chaudhary and Truelove (1962) examined the symptoms, associations, aetiology, and prognosis of the condition in 130 patients, whom they divided into two clinical groups. Those with colonic pain were classified as having a spastic colon and the others as having painless diarrhoea; the only significant difference between the two groups was that in the group with painless diarrhoea the prognosis was more favourable. Ritchie and Tuckey (1969) found a pattern of motor activity throughout the pelvic colon in patients with painless diarrhoea, which differed from that of patients with a spastic colon, but there was a marked similarity of activity amongst those with pain, whether their bowel function was diarrhoeic, normal, or constipated.

Received for publication 24 June 1969.

Recordings of intracolonic pressure by Chaudhary and Truelove (1961) showed differences between the two clinical groups under resting conditions, but their motor responses to emotional stimulation and to injections of prostigmin were virtually identical. In a radiological study, Lumsden, Chaudhary, and Truelove (1963) could seldom distinguish a diarrhoeic patient from one with spastic colon on the appearances of a barium enema alone.

The present series of observations was designed to measure the distance travelled by colonic contents and to record the frequency of the movements involved in patients with the irritable colon syndrome. The results obtained by means of time-lapse cinefluorography under resting conditions and after feeding and cholinergic stimulation have been compared with data from normal controls to see what light this may shed on the underlying colonic dysfunction.

Diagnostic Criteria

The diagnosis of the irritable colon syndrome is based on a variable symptomatology that may

include abdominal or low-back pain, colonic tenderness on pressure, and some upset of bowel function, either constipation or diarrhoea, with or without the passage of excessive mucus. It must be established in each case primarily by exclusion, for many of the clinical conditions that are seen in a gastroenterological outpatient department may present a superficially similar picture. In each of the patients studied, the symptoms were severe enough to have brought them to hospital for investigation.

Although the irritable colon syndrome may well represent the outcome of a number of different physical processes, it will be treated in the present study as if it were a specific motor abnormality.

Materials and Methods

The 90 subjects acting as controls for this study were all convalescent ward patients of the Radcliffe Infirmary, who were considered to be free of any disease likely to affect their gastrointestinal motility. Sixteen (18%) of them had two or more bowel actions per day, but these regarded themselves as normal and the increased frequency of motions gave rise to no complaints. This represents approximately the normal distribution of different frequencies of bowel action as recorded by Connell, Hilton, Irvine, Lennard-Jones, and Misiewicz (1965) in patients without gastrointestinal symptoms.

The 98 patients diagnosed as suffering from the irritable colon syndrome, who were accepted for inclusion, had all been previously examined by barium enema and sigmoidoscopy to exclude organic disease; in doubtful cases a biopsy was taken. In each of them a general physical examination had indicated no other condition to explain their symptoms, and their sedimentation rates were normal. Fifty-two (53%) had two or more bowel actions per day, which is three times as many as in the control group. The average age was 49 years.

Each person investigated had swallowed 100 ml of lactose-free Micropaque barium sulphate suspension at bedtime, about 13 hours before the study began; this provided the contrast medium for cinefluorography. The technique employed for the time-lapse studies was the same as that previously described (Ritchie, 1968a), and all subjects were observed for a period of 45 to 60 minutes under resting conditions. Many of them were then given lunch and the observations continued. Some were given an injection of 0·25 mg of carbachol, either immediately following the rest period or after the effects of their lunch had passed off. As the duration of observations varied from one subject to another, the frequency with which propulsive movements occurred under any one set of conditions was related to the number of hours' observation it represented in the course of the study rather than to the number of subjects making up the group.

Length of Propulsive Movements

Measurements of length in the colon, and so of the rate of propulsion of its contents, being derived in the present study from radiographic data, are bound to be approximations. However, over a large number of observations involving the whole colon, the extent of this inaccuracy is less than might be expected.

The antero-posterior looping of the bowel that occurs at the hepatic, splenic, and pelvic flexures, and may be found elsewhere as well, must result in sections of unknown length being observed at oblique angles. This means that the colon is always longer than it appears to be from measurements of its shadow. Studying the layout of different types of colon, and measuring the shadows cast by three-dimensional representations of them fashioned from wire, indicates that the apparent length of the bowel in silhouette is between 75 and 85% of its true length. The average shortfall in the length and therefore in the rate of colonic propulsion over a substantial number of different subjects is thus approximately 25%.

Another source of inaccuracy is the optical magnification of the colonic shadow as it reaches the image intensifier. This varies also for different parts of the colon with the depth from the surface and the thickness of the individual patient's abdomen. Measurements of the area of irradiation on the anterior abdominal wall in a large number of instances and of its position in relation to the 32-cm phosphor of the image intensifier indicate that the average diameter of the field in the middle of the abdominal cavity was about 25 cm. This is equivalent to a magnification of 25%.

The magnification provides no means of correcting the apparent rate of individual movements of colonic contents seen in oblique view. It even introduces additional errors by seeming to accelerate movements that occur in a horizontal plane. However, the net effects of magnification and oblique projection on measurements over the whole length of the colon tend to cancel one another out. Moreover, for purposes of comparison in the present study any residual mean error must be present equally in the patients with the irritable colon syndrome and in the normal controls.

The average length of the colon, estimated radiographically in this way, appeared to be about 150 cm, which is the lesser of the two figures 150-180 cm quoted by Cunningham (1964). This may have been because there was a tendency to prefer the smaller patients for study to enhance

the quality of cinefluorography with a minimum of radiation.

The length of each propulsive and retropulsive movement was taken as the total distance over which the bowel contents were seen to have moved during a series of cinefluorograms. If two or more unrelated movements occurred in different parts of the colon during one period of observation, their lengths were recorded separately.

By multiplying together the mean length and hourly incidence of propulsive movements, it was possible to calculate the average rates of transport for each group. When similar calculations were made for the retropulsion of colonic contents, the difference between the two figures represented the net colonic propulsion per hour.

Results

PROPULSION UNDER RESTING CONDITIONS

The 90 control subjects observed over a total of 71 hours at rest gave rise to 32 colonic propulsive movements of all kinds. This represents an hourly incidence of 0·46 movements over an average distance of 18 cm, and the mean rate of colonic propulsion over the whole group was therefore $18 \times 0{\cdot}46 = 8$ cm/hr (Table I). During the same period, 32 retropulsive movements also occurred, which is almost the same incidence. These averaged 7 cm in length and provided a mean rate of retropulsion of 3 cm/hour. Each normal colon's notional net hourly propulsion under resting conditions thus amounted to about $8 - 3 = 5$ cm.

	At Rest	*After Food*	*After Carbachol*
Number of subjects	90	37	20
Time of observation (hr)	71	31	20
Number of propulsive movements	32	35	25
Hourly incidence	0·46	1·13	1·25
Mean length (cm)	18	14	18
Propulsion per hour (cm)	8	16	73
Number of retropulsive movements	32	27	9
Hourly incidence	0·45	0·87	0·45
Mean length (cm)	7	7	7
Retropulsion per hour (cm)	3	6	3
Net propulsion (cm)	5	10	20

Table I *Movement of colonic contents per hour in normal subjects*

Ninety-eight patients with the irritable colon syndrome produced only 15 propulsive movements in the course of 73 hours of observation at rest, which is equivalent to 0·20 movements per hour (Table II). Although the average distance covered was about 29 cm, the mean hourly resting rate of colonic propulsion was less than 6 cm. Retropulsive movements under resting conditions were twice as common at 0·41/hr, and their mean length was 12 cm. This gave rise to a mean rate of retropulsion of approximately 5 cm/hr, so the net aboral transportation among these patients was less than 1 cm/hr. Movement of colonic contents in the two groups at rest is compared in Figure 1.

	At Rest	*After Food*	*After Carbachol*
Number of patients	98	78	67
Time of observation (hr)	73	101	60
Number of propulsive movements	15	51	64
Hourly incidence	0·20	0·50	1·08
Mean length (cm)	29	33	32
Propulsion per hour (cm)	6	16	35
Number of retropulsive movements	30	38	40
Hourly incidence	0·41	0·38	0·68
Mean length (cm)	12	13	11
Retropulsion per hour (cm)	5	5	7
Net propulsion (cm)	1	11	28

Table II *Movement of colonic contents per hour in patients with the irritable colon syndrome*

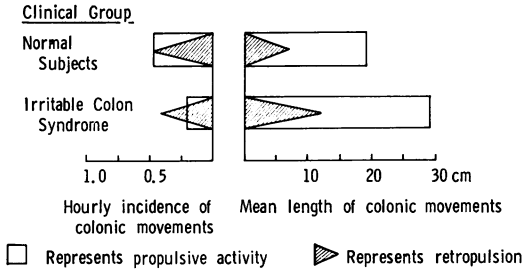

Fig. 1 *Movement of colonic contents under resting conditions.*

PROPULSION AFTER FEEDING

Thirty-seven control subjects were observed for an average period of 51 minutes each from the beginning of lunch. They showed 35 propulsive movements in the 31 hours, with an incidence of 1·13/hr and a mean length of only 14 cm. This gave an average of 16 cm each for propulsion during the hour after food, double the resting figure. The incidence of retropulsive movements after food was also doubled, though their length was unaffected, so net propulsion rose to 10 cm/hr.

The 78 patients with the irritable colon syndrome who were given lunch were observed for a total of 101 hours and during this time they produced 51 propulsive movements, an incidence of 0·50/hr. The movements averaged 33 cm in length, giving almost the same hourly rate of propulsion, 16 cm, as that of the controls. In the same period there were 38 retropulsive movements 13 cm in length, so retropulsion amounted to 5 cm/hour and net propulsion was 11 cm/hr. These figures are expressed graphically in Figure 2

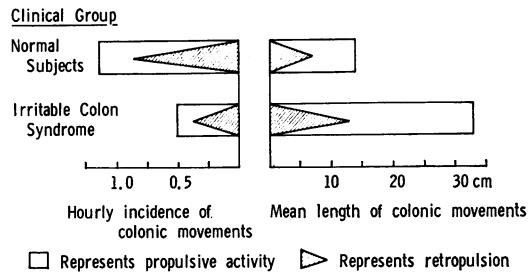

Fig. 2 *Movement of colonic contents after feeding*

PROPULSION AFTER CARBACHOL

Twenty control subjects who were each given an intramuscular injection of 0·25 mg of carbachol and observed for one hour produced 25 propulsive movements. This represents an increase in their incidence to 1·25/hr, and, even though the length of the movements was still only 18 cm as it was under resting conditions, the hourly rate of propulsion rose to 23 cm. Retropulsion was exactly the same as that found at rest, totalling 3 cm/hr, so net propulsion was increased to 20 cm/hr.

Sixty-seven patients with the irritable colon syndrome were studied after carbachol injection for a total of 60 hours, during which they produced 64 propulsive movements, an incidence of 1·1/hr. The movements averaged 32 cm in length, raising the propulsion rate to 35 cm/hr. The corresponding incidence of retropulsion was increased to 0·68 movements per hour, but with their mean length only 11 cm, the hourly rate was no more than 7 cm and net propulsion rose to 28 cm/hr. Propulsion and retropulsion in the two groups after carbachol are compared in Figure 3.

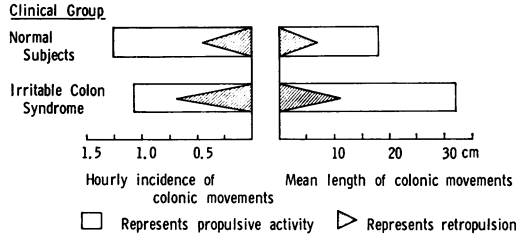

Fig. 3 *Movement of colonic contents after injection of carbachol.*

Discussion

HOURLY RATES OF PROPULSION

The propulsion of colonic contents in patients with the irritable colon syndrome was effected with a much lower incidence of propulsive movements than in the control group. However, each movement extended on average over a greater length of bowel. This is because the normal short-distance movements of colonic contents in either direction are much less common in the irritable colon syndrome (Ritchie, 1969).

Under resting conditions, the mean rate of propulsion in the irritable colon syndrome was less than that of the controls, and the rate of retropulsion was increased; as a result, the net propulsion for the group was only about 20% of the normal figure. The significance of this observation is discussed in the next section.

After eating lunch there were twice as many movements of colonic contents in both directions among members of the control group as there had been under resting conditions; in patients with the irritable colon syndrome this increase was limited to propulsive movements as feeding had no effect on retropulsion, and the figure for net propulsion rose to the same level as that of the controls. Amongst normal subjects, eating a meal has been found only to increase colonic propulsion in those who had two or more bowel actions per day (Ritchie, 1968b); in the present study, propulsive activity in patients with the irritable colon syndrome was increased after lunch, even when their daily frequency of bowel function was normal.

Carbachol had little effect on retropulsion in either group. However, it raised the incidence of propulsive movements in both; the effect was twice as powerful among patients with the irritable colon syndrome, in whom it produced a fivefold increase compared with the resting figure. It was remarkable that neither feeding nor the injection of carbachol had any significant effect on the mean distance covered by the movement of contents in either direction.

DAILY DISTANCES OF PROPULSION

Assuming that each member of both clinical groups had three meals per day, the distance covered by the net aboral movement of colonic contents during the three hours that followed them would have amounted to about 30 cm/day. During the other 21 hours, net propulsion in the control group would have been $21 \times 5{\cdot}2 = 110$ cm. The total daily advance of contents, 140 cm, is thus within 7% of the mean figure for the observed length of the colon.

Net propulsion of colonic contents in the irritable colon group over the same period was $21 \times 0{\cdot}9 = 19$ cm, giving a total for the 24 hours of only 52 cm. Although this might at first sight suggest that propulsive activity is severly curtailed in the irritable colon syndrome, with a colonic transit time of up to three days, there is no other evidence to support any such interpretation. Measurements of gastrointestinal transit time in the irritable colon syndrome by Manousos, Lumsden, and Truelove (1967) show it to be somewhat faster than that of normal

controls. In the present study, barium had reached the rectum by the start of the observation period in 65% of the control subjects and in 68% of patients with the irritable colon syndrome.

It is therefore likely that more than two-thirds of each day's propulsive activity in the irritable colon syndrome takes place under some limited set of conditions which were not explored in the present study. For example, it may tend to occur during the night, while the patient is asleep, or immediately on waking; that would explain the sudden urge to stool that about 45% of these patients experience as soon as they get out of bed. In others, propulsion may be stimulated by the first food or drink taken after a 12-hour fast; 35% of patients with the irritable colon syndrome get some degree of urge to defaecate after eating. Muscular exertion, which represents the other major variation of physical circumstances whose effects have not been directly examined, does not appear clinically to influence their bowel function to any comparable degree.

My thanks are due to Dr G. M. Ardran, Mr M. S. Tuckey, and Dr S. C. Truelove for their help. The work has been supported by a grant from the Medical Research Council.

References

Bockus, H. L., Bank, J., and Wilkinson, S. A. (1928). Neurogenic mucous colitis. *Amer. J. med. Sci.*, **176**, 813-829.

Chaudhary, N. A., and Truelove, S. C. (1961). Human colonic motility. *Gastroenterology*, **40**, 1-36.

Chaudhary, N. A., and Truelove, S. C. (1962). The irritable colon syndrome. *Quart. J. Med.*, **31**, 307-322.

Connell, A. M., Hilton, C., Irvine, G., Lennard-Jones, J. E., and Misiewicz, J. J. (1965). Variation of bowel habit in two population samples. *Brit. med. J.*, **2**, 1095-1099.

Cunningham, D. J. (1964). *Textbook of Anatomy*, 10th ed., edited by G. J. Romanes. Oxford Medical Publications, London.

Da Costa, J. M. (1871). Membranous enteritis. *Amer. J. med. Sci.*, **62**, 321-338.

Lumsden, K., Chaudhary, N. A., and Truelove, S. C. (1963). The irritable colon syndrome. *Clin. Radiol.*, **14**, 54-63.

Manousos, O. N., Lumsden, K., and Truelove, S. C. (1967). Transit times of food in patients with diverticulosis or the irritable colon syndrome and normal subjects. *Brit. med. J.*, **3**, 760-762.

Ritchie, J. A. (1968a). Colonic motor activity and bowel function: Part 1. Normal movement of contents. *Gut*, **9**, 442-456.

Ritchie, J. A. (1968b). Colonic motor activity and bowel function: Part 2. Distribution and incidence of motor activity at rest and after food and carbachol. *Gut*, **9**, 502-511.

Ritchie, J. A. (1969). Colonic transport in the irritable colon syndrome. In *Proceedings of International Symposium on Motility of Gastrointestinal Tract.*

Ritchie, J. A., and Tuckey, M. S. (1969). Intraluminal pressure studies at different distances from the anus in normal subjects and in patients with the irritable colon syndrome. *Amer. J. dig. Dis.*, **14**, 96-106.

Ryle, J. A. (1928). Address on chronic spasmodic affections of the colon and the diseases which they simulate. *Lancet*, **2**, 1115-1119.

White, B. V., and Jones, C. M. (1940). Mucous colitis. *Ann. intern. Med.*, **14**, 854-872.

White, W. H. (1905). A study of 60 cases of membranous colitis. *Lancet*, **2**, 1229-1235.