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Measurement of intestinal progression of a meal and its residues in normal subjects and patients with functional diarrhoea by a dual isotope technique

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SUMMARY A new double isotopic method was used to measure the gastrointestinal progression of a meal in nine healthy subjects and seven patients with functional diarrhoea. 51Chromium chloride (colonic marker) was ingested eight hours before the beginning of the scintigraphic study so that it was by then located in the colon at that time. A second marker, 99mTechnetium sulphur colloid labelled the meal. Scintigraphic images were taken before and after the meal for two hours, detecting simultaneously the two isotopes. In the 51Cr window right colon was localised and intracolonic propulsion was studied; and in the 99mTc window gastric emptying and colon filling of the meal marker was quantified. A propulsive gastrocolic reflex was evidenced in five of the seven patients with functional diarrhoea but in none of the normal subjects. Unabsorbed residues of the meal are propelled rapidly in the ileocaecal region. Small intestinal transit of the meal marker was twice as rapid in patients with functional diarrhoea as in normal subjects.

There is no accurate method to measure the transit of a meal through the gut in man. Barium studies give non-quantitative and unphysiological results. The mouth to anus transit time of non-digestible markers or pellets[1 2] reflects essentially intracolonic propulsion and not the more rapid small bowel transit. Intestinal progression of a telemetric or an isotopically labelled capsule[3] is not necessarily related to that of a normally ingested food. The technique using slow infusion of a non-absorbable marker allows measurement of intraluminal outputs at any point of the gut and thus intraluminal propulsion;[4] however, such a technique is complex and small intestinal intubation could alter motility.[5] The detection of breath hydrogen excretion[6–8] is a very simple method but gives the transit time of the head and not of the bulk of the meal; and its results depend also on the capacity of colonic bacteria fermentation.

Scintigraphic studies of intestinal transit were first used to detect movements of colonic contents[9] or the arrival of a meal into the caecum.[10] We described in 1978 a method to quantify the intraluminal progression of a non-absorbable marker of a meal from stomach to caecum;[11] more recently Read and colleagues[8] described and validated a scintigraphic method to measure transit time of a meal and the residues of its absorption through the small intestine. In these two studies, the validity of the results is limited by an approximative localisation of the caecum. We describe here a technique that gives an accurate localisation of the right colon and allows simultaneously measurement of gastric emptying of a meal, its progression through the small intestine and the propulsion of colonic contents.

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Methods

SUBJECTS

Studies were carried in nine healthy subjects (eight men, one woman, mean age 38 years) who gave informed consent, and in seven patients (four men, three women, mean age 39 years) with functional diarrhoea in whom morphological and functional investigations ruled out any organic disease.

Meal and markers

The same solid-liquid meal was eaten by each subject; it was prepared with 90 g steak, 40 g bread,

10 g butter, 10 g sucrose, one egg white, 200 ml skimmed milk and 150 ml of water (total caloric value 1839 J [438 cal]; 38% carbohydrate, 36% fat, 26% protein). Two gamma emitting markers were detected simultaneously: 51 chromium chloride (51Cr) was used as a colonic marker; it was ingested eight hours before the beginning of the study, and had therefore reached the right colon at that time; 99m Technetium sulphur colloid (99mTc) was used as a non-absorbable meal marker; it was added to the water of the meal. We have previously shown that this marker is partly absorbed on solids so that it labels both solids and liquids.[12]

Procedure

Eight hours before ingesting the meal, the subject drank 150 ml water with 600 μCi of 51Cr and then fasted overnight. At 9 am he was placed upright against the 360-KeV large field parallel collimator of a gamma-camera. A one minute image was taken, and the marked meal was then eaten (within 10 minutes) and immediately after images were taken for one minute periods at 30 minute intervals for two hours. An external 99mTc point source was taped on the upper right abdomen to allow accurate repositioning of the subject. On all images, 51Cr (colonic marker) and 99mTc (meal marker) were detected simultaneously using specific windows of the camera. All data were stored on disks and processed by a digital computer (Informatek, France) which was used for the following operations: the stomach was identified by the location of the activity of the meal marker (99mTc) on the image taken immediately after ingestion of the test meal; the right colon was identified on each image by the location of the colonic marker (51Cr) (Fig. 1). All counts were corrected for background activity, scatter of 51Cr into the 99mTc window and for physical decay of isotopes; they were expressed as a fraction of the ingested activity (activity counted in the whole abdominal field). All results are given as mean ± SEM. The Mann-Whitney U test was used to compare the normal subjects and the patients.

Results

The colonic marker was located in the right and the transverse colon at the beginning of the study in six of the nine healthy subjects and in six of the seven patients (Fig. 1); in the other four subjects it was located in the right colon. The colonic marker was located more distally than the right colon and thus failed to give the localisation of the caecum in two patients and one healthy subject who were thus not included in the present study. An aboral propulsion of intracolonic content was observed in only one of the nine normal subjects during the hour after the ingestion of the meal, whereas in five of the seven patients an aboral colonic propulsion was evidenced (Fig. 2).

The progression of the front of the meal from the stomach to the ileum was very fast in normal subjects and in patients: the meal marker was located in, or close to the caecal area as soon as 30 minutes after the end of the meal. The percentages of the meal marker (^{99}Tc) reaching the caecal area in normal subjects and in patients are given in the Table. The amounts of meal marker leaving the small bowel were markedly higher in patients than in normal subjects (the differences being significant from 30 minutes to 120 minutes after the ingestion of

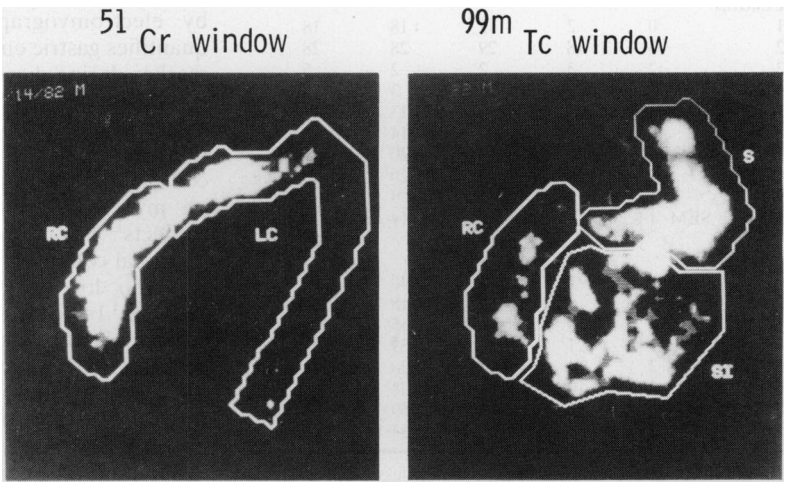

Fig. 1 *Scintigraphy of a normal subject two hours after ingestion of meal. In ^{51}Cr window colonic marker allows localisation of colon (RC=right colon, LC=left colon). In ^{99m}Tc window progression of meal marker is evident (S=stomach, SI=small intestine). RC area delineated with ^{51}Cr is reported on the ^{99m}Tc image to quantify right colonic filling.*

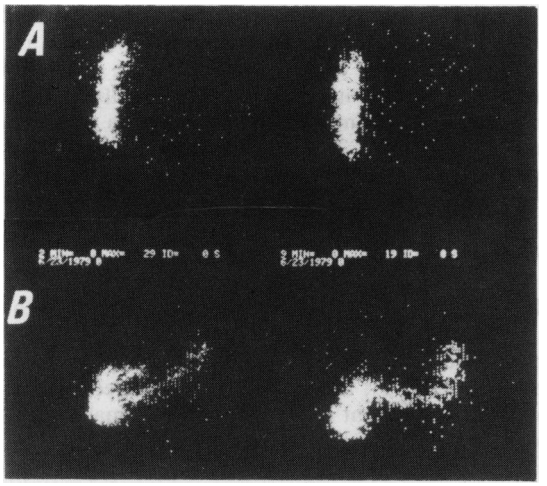

Fig. 2 *Colonic scintigraphies (51Cr window) taken before (left) and 30 minutes after the meal (right) in normal subject without intracolonic propulsion (A) and in diarrhoeal patient with intracolonic propulsion (B).*

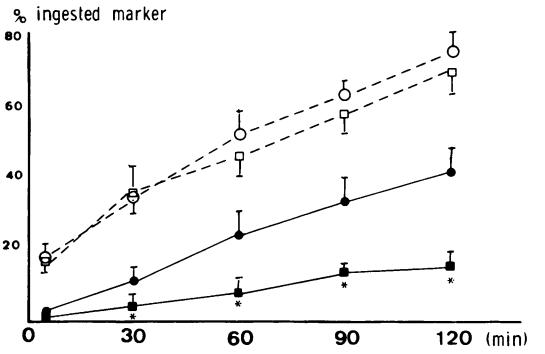

Fig. 3 *Percentage of meal marker that leaves stomach (dotted line) and that reaches colon (plain line). Squares depict normal subjects (n=9) and circles depict diarrhoeal patients (n=7); statistical evaluation of difference between controls and patients: *p<0·05.*

the meal), whereas no significant difference was found between patients and controls for the gastric emptying rate of the meal marker (Fig. 3).

Discussion

Abnormalities of intestinal motility are thought to be implicated in the pathogenesis of many gastrointestinal disorders, but their true pathogenic role will remain putative until a simple and reliable technique to determine the transit time of ingested food is available.

Table *Percentages of the meal marker reaching colon*

Subject (No.)	*5 min*	*30 min*	*60 min*	*90 min*	*120 min*
Controls					
1	0	2	2	18	18
2	3	18	29	28	28
3	2	3	2	2	5
4	2	3	2	3	3
5	1	3	8	13	11
6	0	5	9	14	17
7	1	6	6	20	32
8	1	6	12	20	23
9	1	2	6	9	9
Mean ± SEM	1·2±0·3	5·3±1·7	8·4±2·8	14·1±2·8	16·2±3·4
Patients					
1	0	7	34	40	52
2	1	6	12	18	24
3	3	10	10	15	27
4	2	21	32	39	41
5	2	4	4	20	—
6	2	10	31	38	—
7	9	21	55	69	71
Mean ± SEM	2·7±1·1	11·3±2·6*	25·4±6·7*	34·1±7·1*	43±8·6*

* Statistically significant difference (p<0·05 or less) from controls.

The non-invasive isotopic method described in this work has several advantages: (a) it gives an accurate localisation of the caecum: in previous scintigraphic studies, the caecum was localised arbitrarily in the right iliac fossa[8] or on the latest images of the study, at a time when the marker has progressed and accumulated in the caecum;[11] the double isotope technique we propose, allows a direct and accurate localisation of the caecum and its content even before the ingestion of the meal and throughout its digestion; (b) it visualises the propulsion of intracolonic contents as soon as the meal is ingested, thus allowing the detection of the propulsive effect of the gastrocolic reflex described by electromyography and manometry;[13] (c) it quantifies gastric emptying and caecal filling of meal marker during digestion.

No propulsion of colonic contents was observed after the ingestion of the meal in eight of the nine normal subjects; this absence of gastrocolic reflex could either mean that this phenomenon described on myoelectric and pressure grounds in normal subjects[13] has no propulsive correspondence in the proximal colon, or that the caloric load of our meal was too low to enhance this reflex in normal subjects. In contrast, in five of the seven patients with functional diarrhoea, we have observed a propulsion of colonic contents during the hour after the meal; this could account for the fact that in these patients diarrhoeal stools often occurred postprandially.

Small bowel progression of the front of the meal

from stomach to ileocaecum was found to be extremely rapid; this has already been shown by intubation and isotopic studies[11 14] in which the time needed by the front of the meal to reach distal ileum was between 20 and 40 minutes. Read and colleagues[8] using simultaneously a scintigraphic and a breath test technique found a much slower transit of the front of the meal from mouth to caecum (four hours). This discrepancy can be explained by differences in the nature of the meal tested, or by differences in the techniques used: the sensitivity of the breath test technique and that of the scintigraphic detection using a single crystal scintillation without anatomic control of its position[8] were probably low and thus could have overestimated the transit time; on the other hand, in the present study diffusion of ileal activity into the caecal area or overlap of ileal loops with caecum could have underestimated mouth to colon transit time. Nevertheless, this discussion only concerns the transit time of the front of the meal; it is more physiologically relevant to obtain information on the progression of the bulk of the meal, as given in the present work by the percentages of ingested marker reaching the colon at different times of the digestion. The two fold increase of the rate of arrival of the meal marker in the caecal area observed in patients with functional diarrhoea, agrees with previous dynamic studies[7] and with work showing myoelectrical abnormalities of small intestine in such patients.[5] The absence of significant difference of gastric emptying between normal subjects and patients rules out a participation of the stomach in this disturbance. All these results support the conclusion that this form of irritable bowel syndrome affects not only the colon but also the small intestine.

Some progress is still needed in the technique described here, such as the use of more specific markers for the various components of the meal, the use of a double anterior and posterior detection to minimise errors linked to geometric variation of the activity detected, the quantification of intracolonic propulsion using areas of interest placed on the projection of several successive segments of the colon. We think, however, that such a technique provides an interesting tool for further studies on gastrointestinal transit, particularly to shed light on the relationship between motility and absorption in health and diseases, and to test therapeutic action of intestinal kinetic acting drugs.

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