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Abnormal gastrocolonic response in patients with ulcerative colitis*

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SUMMARY The purpose of these studies is to determine the colonic myoelectrical and contractile response after eating a 1000 calorie meal in patients with active ulcerative colitis. During fasting, slow waves are identifiable significantly more in patients with ulcerative colitis than in normal subjects ($P < 0.01$). The predominant slow wave frequency is 6.1 ± 0.2 cycles/min, which is similar to the normal subjects. The slow waves are not altered by eating in either group. Minimal spike or contractile activity occurs during the fasting period both in patients with ulcerative colitis and in normal subjects. In patients with ulcerative colitis, spike activity increases rapidly after eating the 1000 calorie meal ($P < 0.01$), but the maximal response is decreased and shorter in duration than in normal subjects. There is no simultaneous increase in colonic contractility above fasting levels after the meal in patients with ulcerative colitis. This is strikingly different from the simultaneous increase in contractile and spike activity ($P < 0.01$) that occurs after eating in normal subjects. These studies suggest that in ulcerative colitis (1) the colonic smooth muscle slow wave activity is intact; and (2) a disturbance in the normal colonic contractile response to eating is present despite an adequate spike response. This lack of colonic contractility may contribute to the increase in diarrhoea that occurs in these patients after eating.

Idiopathic ulcerative colitis is an inflammatory disorder of the colonic mucosa that is characterised by diarrhoea and haematochezia. Previous studies have described decreased colonic contractility in patients with ulcerative colitis.[1 2] Decreased motility is associated with diarrhoea, and increased colonic contractility is associated with constipation due to slower flow of colonic contents through the colon.[3] Therefore, the decrease in colonic motor function in ulcerative colitis may contribute to the diarrhoea.

Eating is a known stimulant of colonic motility.[4–7] Disorders in the normal colonic motor response to eating can also contribute to symptoms of diarrhoea or constipation.[3 8 9] An increase in sustained postprandial colonic motility is associated with slower flow of luminal contents and constipation.[8] However, some patients with diarrhoea may have a short-lived increase in postprandial colonic motility.[9] In these patients, colonic motility quickly returns to hypoactive basal levels, permitting diarrhoea to occur. The purpose of this study is to determine the possible mechanisms of the disordered motility in patients with ulcerative colitis during fasting and after ingestion of a meal.

Methods

Studies were performed on 17 normal subjects of both sexes who ranged in age from 20 to 35 years and on 12 patients with ulcerative colitis of both sexes who ranged in age from 22 to 51 years. All subjects fasted at least 12 hours before the studies. Informed consent was obtained from each subject. Studies were approved by the Committee on Studies Involving Human Beings at the University of Pennsylvania.

All patients had the characteristic clinical history of acute ulcerative colitis including bloody diarrhoea, with mucosal erythema, oedema, friability, and erosions in the rectum and rectosigmoid observed on proctoscopy. All patients had disease proximal to the descending colon as documented by barium enema. Mucosal ulcerations and loss of haustral folds were observed in involved areas on the barium

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enema. Ova, parasites, and enteric pathogens were absent from the stool of all patients. Ulcerative colitis was present for at least one year and all patients were symptomatic at the time of the study. No patient had fever, clinical signs of shock, or severe abdominal pain at the time of the study.

All subjects or patients underwent sigmoidoscopy without air insufflation, enemas, or cathartics. Two biopolar silver-silver chloride wire electrodes were attached to the colonic mucosa 5 to 25 cm from the anus under direct vision through the sigmoidoscope.[10] Each bipolar electrode was connected to a junction box containing a $\frac{1}{16}$ ampere fuse. The junction box was in turn connected to a rectilinear recorder (Beckman R411, Beckman Instruments, Inc., Fullerton Calif) through an AC coupler (9806A) with a time constant of 1·0 s (0·16 Hz) and a 22 Hz filter. All subjects were grounded through an ECG surface electrode attached to the right leg.

Intraluminal pressure was measured at the same level as the recording electrode. Pressure was measured using polyvinyl catheters which were continuously perfused with distilled water using an infusion pump.[10] Pressure was transmitted to transducers (Statham P321A) and recorded simultaneously with the myoelectrical activity. Respirations were monitored by a pneumograph belt placed around the chest and connected to a transducer. Myoelectrical and intraluminal pressure recording were begun 30 minutes after the removal of the sigmoidoscope.

Thirty minutes after the removal of the sigmoidoscope, a 30 minute basal recording period was begun. After the basal period the subjects were fed a 1000 calorie meal.[5] The meal consisted of a roast-beef sandwich (132 g), with white bread (46 g) and mayonnaise (22 g), and a milkshake (150 g) with vanilla ice cream (132 g).[5] Each subject ate the meal in five minutes or less without difficulty.

Myoelectrical activity and intraluminal pressure were recorded for 50 minutes after the consumption of each meal. Each myoelectrical recording was evaluated for slow waves and spike potentials by at least two investigators. Slow waves were regular cyclical changes in electrical potential that were greater than 0·02 mV in amplitude.

Slow wave frequency was calculated from the number of slow wave cycles during recording periods greater than 90 seconds. The results were expressed as cycles/minute. Spike potentials were counted over each 10 minute period. Only one spike potential was counted in a slow wave cycle regardless of the number of rapid deflections during that period. Intraluminal pressure was expressed as a motility index—that is, product of the mean amplitude of the pressure waves multiplied by the sum of the durations of each pressure wave—for each 10 minute period. Only pressure waves greater than 3 mmHg were analysed. Statistical analysis was made using the paired and unpaired Student's *t* test.

Results

Figure 1a shows a recording of myoelectrical and motor activity in a normal subject after a 1000 calorie meal. Slow waves are regular and continuously present at a frequency of 6·1 cycles/min. Spike bursts are superimposed on the slow waves. Phasic increases in intraluminal pressure occur simultaneously with the slow wave and spike activity. The frequency of the contractile response is similar to the slow wave frequency (6·0 cycles/min). Figure 1b is a similar recording from a patient with ulcerative colitis who had eaten the 1000 calorie meal. The slow wave activity is irregular, but the overall slow wave frequency is 5·0 cycles/min. Spike potentials are superimposed on the slow wave as in normal subjects. However, there is no simultaneous increase in intraluminal pressure.

Table *Parameters of slow wave activity*

	Normal subjects		*Ulcerative colitis*	
	Fasting	*Post-prandial*	*Fasting*	*Post-prandial*
Recordable slow wave activity (%)	66·3±4·2	67·4±4·5	89·1±3·1*	92·5±2·2*
Slow wave frequency (cycles/min)				
a†	6·3±0·1	6·8±0·3	6·1±0·2	6·4±0·1
b‡	3·4±0·2	3·1±0·1	3·8±0·3	3·1±0·1
Slow wave activity with frequency 6cycles/min(%)	91·3±3·4	90·8±3·8	89·7±5·2	87·2±7·5

*P<0·01

†Slow wave population with a frequency of approximately 6 cycles/min.

‡Slow wave population with a frequency of approximately 3 cycles/min.

The Table shows the parameters of slow wave activity in normal subjects and in patients with ulcerative colitis. Slow wave activity is not identifiable continuously in our recordings, but is present during a greater percentage of the recording period in patients with ulcerative colitis, basally (P<0·01) and post-prandially (P<0·01). The predominant frequency of the slow waves is approximately 6 cycles/min. The predominant slow wave frequency is similar in normal subjects and in patients with ulcerative colitis. A small amount of slow wave activity has a frequency of approximately 3 cycles/min in both groups. After eating, 6 cycles/min slow wave activity remains the predominant frequency in

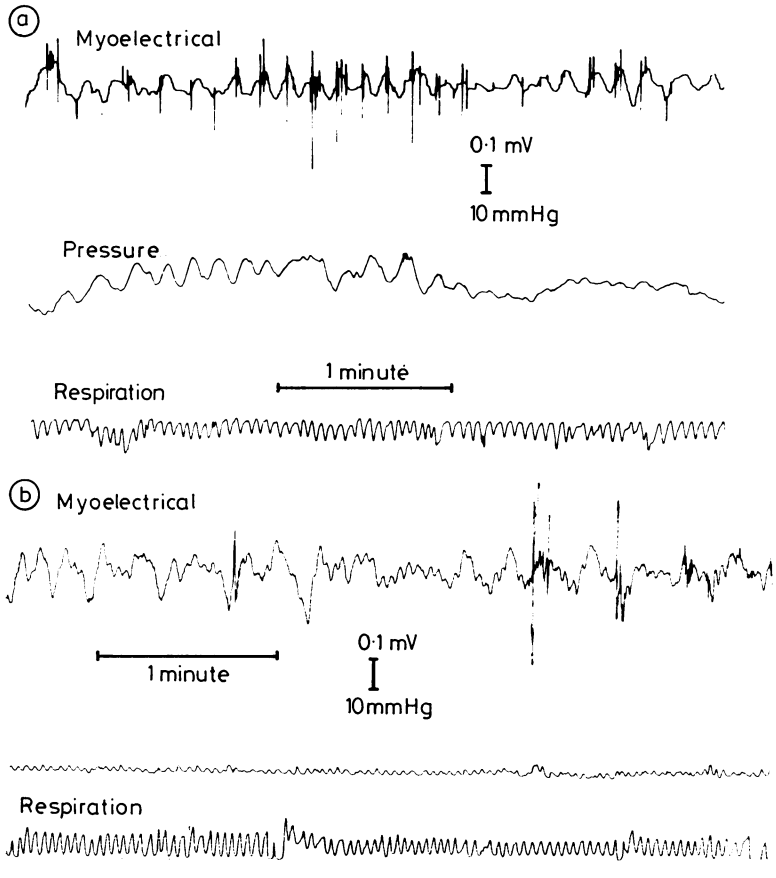
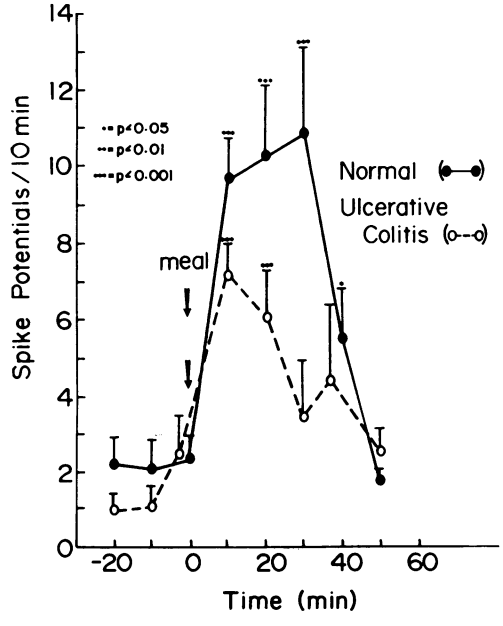


Fig. 1 *Recording of myoelectrical activity, intraluminal pressure, and respirations in a normal subject (a) 25 minutes after a meal and in a patient with ulcerative colitis (b) 15 minutes after a meal. (a) In the normal subject the slow waves have a frequency of 6·1 cycles/min and spike potentials are superimposed on the slow waves. A simultaneous increase in intraluminal pressure is present also. (b) In the patient with ulcerative colitis the slow waves are irregular with a frequency of 5·0 cycles/min. Spike activity is present, but there is no simultaneous increase in colonic intraluminal pressure.*



both groups. Thus, patients with ulcerative colitis have more idenitifiable slow wave activity than do normal subjects, but the frequency of the slow waves does not differ from that in normal subjects.

Figure 2 shows the colonic spike response before and after a 1000 calorie meal both in normal subjects and in patients with ulcerative colitis. The patients with ulcerative colitis have $1{\cdot}5 \pm 0{\cdot}2$ spike potentials/10 min for the 30 minute fasting period. This fasting level of spike activity is similar to the spike activity in normal subjects during the 30 minute fasting period ($P > 0{\cdot}05$). In patients with ulcerative colitis, there is a rapid increase in spike activity after eating. Spike potentials increase to $7{\cdot}1 \pm 0{\cdot}9$ spike potentials/10 min within the first 10 minutes ($P < 0{\cdot}001$). Colonic spike activity remains increased for 20 minutes after eating ($P < 0{\cdot}001$) before re-

Fig. 2 *The colonic spike response in normal subjects and in patients with ulcerative colitis, measured for three 10 minute periods before and for 50 minutes after a 1 000 calorie meal. All values are shown as mean ± SEM.*

turning to fasting levels. In normal subjects spike activity also increases rapidly after eating. Although the spike response is greater in normal subjects compared with patients with ulcerative colitis throughout the entire postprandial period, a significant increase in spike activity occurs only in the 10-minute period 20–30 minutes after the meal ($P<0.05$). Thus, patients with ulcerative colitis show an increase in spike activity after eating, but the magnitude and the duration of the response are less than in normal subjects.

Figure 3 shows the effect of eating on colonic intraluminal pressure in patients with ulcerative colitis and in normal subjects. The motility index during fasting in patients with ulcerative colitis is 477 ± 139/10 minute and is similar to that in normal subjects ($P>0.05$). After eating there is no increase in the colonic motility index in patients with ulcerative colitis ($P>0.05$). In normal subjects the motility index increases to 2350 ± 720/10 min ($P<0.01$) within the first 10 minutes after the meal. The motor response in normal subjects remains raised for 30 minutes after the meal. Thus, patients with ulcerative colitis fail to show an increase in colonic intraluminal pressure after a meal, although spike activity does increase significantly.

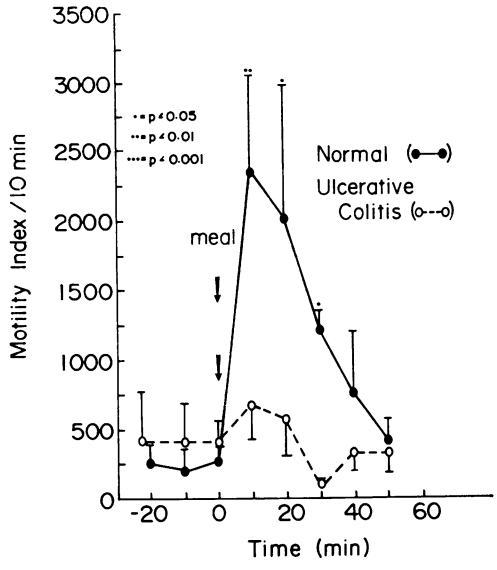


Fig. 3 *The colonic contractile response, expressed as motility index, in normal subjects and patients with ulcerative colitis, measured for three 10 minute periods before and for 50 minutes after a 1 000 calorie meal. All values are shown as mean±SEM.*

Discussion

In patients with ulcerative colitis, diarrhoea and urgency may be precipitated by eating. These studies were undertaken to enhance our understanding of the alterations in colonic myoelectrical and contractile activity that may be associated with eating in patients with ulcerative colitis. The results of these studies indicate that abnormalities in these parameters of colonic motor function may contribute to the diarrhoea in this disease.

Patients with ulcerative colitis showed three basic differences as compared with normal subjects: (1) total recordable slow wave activity was increased; (2) the myoelectrical response to feeding was diminished in amplitude and duration; and (3) there was a marked dissociation between motor activity and spike activity in the colon. These results suggest that the diminished motility seen in ulcerative colitis may be due to this dissociation in myoelectrical and mechanical activity.

In normal subjects and in patients with ulcerative colitis, the predominant slow wave frequency was similar at 6 cycles/min. These findings differ from the slow wave frequency observed in patients with the irritable bowel syndrome where a significant increase in 3 cycles/min activity was noted.[11 12] Thus, different diseases leading to colonic symptoms and diarrhoea show dissimilar patterns of slow wave frequencies.

The increased duration of time occupied by slow waves in ulcerative colitis is difficult to explain. It is possible that the increase in slow wave activity is due to the myogenic response to inflammation. There is no firm evidence to support this hypothesis. The other possible explanation may simply be a technical one. The clip electrode may maintain closer muscular contract in the inflamed and ulcerated colon because of thinning of both the mucosa and submucosa and, because muscular contact is closer, slow wave activity may be better monitored. The exact explanation for the increased amount of slow wave activity remains unexplained.

The major observation in these studies is that the post-prandial colonic motor activity in patients with ulcerative colitis is significantly reduced compared with normal subjects. This reduction in motor activity was present despite only moderate alterations in the magnitude and duration of the colonic spike response. A spike response of the magnitude seen in these patients with ulcerative colitis is adequate to initiate contractile activity.[5] As smooth muscle spike potentials initiate the contractile activity, the absence of a contractile response may indicate a defect in electromechanical coupling or an inability of colonic muscle to fully contract.[13 14] Limited *in vitro* studies (personal observation) show

that colonic muscle in ulcerative colitis cannot generate normal active tension in response to neurohumoral agents.

Colonic motility is diminished in most patients with active colitis, although some patients may have increased contractility.[1 2 15] Prolonged large amplitude contractions (type IV waves) have been described in previous studies which used balloons to measure colonic motility.[1 2] Type IV waves were not observed in this study. The presence of type IV waves may be an artefact due to the use of balloons. Davidson *et al.*[16] observed type IV waves in patients with ulcerative colitis only if a balloon were inflated in the rectum.

The possible role of these motility changes in the diarrhoea of ulcerative colitis is not clear. It is probable that distal colonic and rectal motor activity impede faecal flow.[3] Therefore, the diminution in colonic motility could increase the symptoms of diarrhoea.

The present study confirms the previous observation of diminished colonic contractile activity and possibly provides a mechanism for these changes. This study suggests that the electrical controls of myogenic function (slow waves and spike potentials) are preserved, but the contractile apparatus is impaired. The mechanism of this impairment requires further study.

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References

[1]Kern F Jr, Almy TP, Abbot FK, Bogdonoff MD. The motility of the distal colon in non-specific ulcerative colitis. *Gastroenterology* 1951; **19:** 492–503.

[2]Spriggs EA, Code CF, Bargen JA, Curtiss RK, Hightower NC Jr. Motility of the pelvic colon and rectum of normal persons and patients with ulcerative colitis. *Gastroenterology* 1951; **19:** 480–91.

[3]Connell AM. The motility of the pelvic colon. Part II, Paradoxical motility in diarrhoea and constipation. *Gut* 1962; **3:** 342–8.

[4]Holdstock DJ, Misiewicz JJ. Factors controlling colonic motility: colonic pressures and transit after meals in patients with total gastrectomy, pernicious anemia or duodenal ulcer. *Gut* 1970; **11:** 100–10.

[5]Snape WJ Jr, Matarazzo SA, Cohen S. Effect of eating and gastrointestinal hormones on human colonic myoelectrical and motor activity. *Gastroenterology* 1978; **75:** 373–8.

[6]Tansy MF, Kendall FM. Experimental and clinical aspects of gastrocolic reflexes. *Am J Dig Dis* 1973; **18:** 521–31.

[7]Wangel AG, Deller DJ. Intestinal motility in man. III. Mechanisms of constipation and diarrhea with particular reference to the irritable colon syndrome. *Gastroenterology* 1965; **48:** 69–84.

[8]Connell AM, Jones FA, Rowlands EN. Motility of the pelvic colon. Part IV—Abdominal pain associated with colonic hypermotility after meals. *Gut* 1965; **6:** 105–12.

[9]Waller SL, Misiewicz JJ, Kiley N. Effect of eating on motility of the pelvic colon in constipation or diarrhoea. *Gut* 1972; **13:** 805–11.

[10]Snape WJ Jr, Carlson GM, Cohen S. Human colonic myoelectric activity in response to prostigmin and the gastrointestinal hormones. *Am J Dig Dis* 1977; **22:** 881–7.

[11]Snape WJ Jr, Carlson GM, Cohen S. Colonic myoelectric activity in the irritable bowel syndrome. *Gastroenterology* 1976; **70:** 326–30.

[12]Taylor I, Darby C, Hammond P, Basu P. Is there a myoelectrical abnormality in the irritable colon syndrome? *Gut* 1978; **19:** 391–5.

[13]Daniel EE, Chapman KM. Electrical activity of the gastrointestinal tract as an indication of mechanical activity. *Am J Dig Dis* 1963; **8:** 54–102.

[14]Holman ME. Introduction of electrophysiology of visceral smooth muscle. In: Code CF, ed. *Handbook of physiology:* Section 6, *Alimentary canal,* Vol. 4, *Motility.* Washington DC: American Physiological Society, 1968: 1165–208.

[15]Chaudhary NA, Truelove SC. Human colonic motility: a comparative study of normal subjects, patients with ulcerative colitis, and patients with the irritable colon syndrome. I—Resting patterns of motility. *Gastroenterology* 1961; **40:** 1–17.

[16]Davidson M, Sleisenger MH, Almy TP, Levine SZ. Studies of distal colonic motility in children. II—Propulsive activity in diarrheal states. *Pediatrics* 1956; **17:** 820–32.