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# Colonic motility

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Colonic motor activity may be divided into two modes: propulsive contractions or mass movements and non-propulsive contractions or segmental activity. Although it seems that the two modes of activity appear to have different functions, are effected by different types of muscle contraction, and may be mediated through separate pathways, the division should be regarded as convenient for descriptive purposes, rather than resting on sound experimental foundations. Despite considerable progress in electrophysiology and pharmacology of the colon (see reviews by Daniel and Bennett, this symposium), the regulation of human colonic motor function in health and disease is still not well understood. It is not known precisely how either mode of colonic contraction is initiated, although both mass movements and segmental contractions can be experimentally stimulated or inhibited by many pharmacological or physiological stimuli. Nor is it certain how either type of activity is altered in disease. The interplay of the effects of the various biogenic substances and the relationship between absorptive (see Cummings, this symposium) and the motor functions of the large bowel, remain to be worked out.

## Mass Movements

Colonic mass movements are difficult to record, and have not been extensively studied. They were initially observed radiologically, but the now known hazards of ionizing radiation limit radiological observation, even with sophisticated time-lapse cinefluorography (Ritchie, Ardran, and Truelove, 1962). Some information on the distribution of faeces before and after a mass movement can be collected by using radioopaque markers (Hinton,

Lennard-Jones, and Young, 1969) and judiciously spaced plain abdominal films: the surprisingly localized extent of colonic evacuation after defaecation and the existence of retropulsion have been documented in this way (Halls, 1965).

Specialized techniques employing detailed monitoring of radioopaque or radioactive markers have provided most experimental data available on this important component of colonic activity. Thus mass movements tend to be stimulated by ingestion of food and by somatic activity; they are diminished by sleep (Holdstock, Misiewicz, Smith, and Rowlands, 1970). Mass movements are more frequent in diarrhoea than in constipation and treatment with antidiarrhoeal or laxative drugs tends respectively to decrease or increase their occurrence. Colonic propulsion of a marker may be accelerated in a variety of diarrhoeas, whereas small intestinal propulsion of the same marker appears unaltered (Waller, 1973). The length of colon rapidly traversed by a marker may be extensive in diarrhoea due to pathological or pharmacological causes (Misiewicz, Waller, Kiley, and Horton, 1969; Waller, 1973). More data and a better understanding of the pharmacological control of mass movement are badly needed.

## Segmental Activity in Health

Pressure waves recorded from the colonic lumen by indwelling sensors represent segmental non-propulsive, non-peristaltic contractions of colonic muscle (Connell, 1961). The raised pressure is an index of the forces exerted by the colonic muscle on the bowel contents. Muscle contractions elevate intraluminal pressures when the lumen is obliterated by mucosal folds with the formation of a closed chamber, or when there is resistance to displacement of faeces because of areas of contraction elsewhere in the bowel, or because of the high viscosity of colonic contents. Pressure activity of the large bowel has been intensively studied, but because of problems of colonic intubation most of the data relate to the rectum and the distal sigmoid. There are only relatively few studies of the proximal colon, often with specialized techniques (Misiewicz, Connell, and Pontes, 1966; Torsoli, Arullani, and Casale, 1967). Perhaps not surprisingly, studies in normal subjects are scanty (Connell, 1961), and because of this and the unpredictable nature of colonic segmental contractions, the range of normal has not yet been established. Moreover, the configuration of the recorded waves depends to some extent on the type of pressure sensor employed, making comparisons between various workers difficult.

The recorded pressure waves appear to be similar in amplitude and duration over the whole colon, with the exception of the caecum and the rectum (Misiewicz *et al*, 1966; Kock, Hultén, and Leander, 1968). In the colon, the amplitude lies commonly between 10 and 60 mmHg, the frequency being approximately 2·5-3 waves $min^{-1}$. The caecum contracts at a slightly higher frequency with waves of a shorter duration, whilst rectal pressures are mostly of lower amplitude ($\simeq$10 mmHg) and are present more continuously than those in the sigmoid. The functional significance of these differences is not clear. None of these contractions are consciously perceived by the normal subject. Bursts of segmental activity of variable duration occur apparently at random in the basal state. In the animal small intestine the apparently random segmentation has been shown by Christensen, Glover, Macagno, Singerman, and Weisbrodt (1971) to depend in fact upon the frequency plateaux of the basal electrical rhythm (BER), but this kind of correlation has not yet been worked out for the human colon.

The presence and amplitude of the non-propulsive segmental contractions are affected by many factors. Colonic segmentation increases in response to meals and diminishes during sleep. Cholinergic drugs, eg, prostigmine, augment whilst atropine-like or anticholinergic drugs inhibit segmental activity: it is also inhibited by 5-hydroxytryptamine (Misiewicz, Waller, and Eisner, 1966) and by bradykinin (Murrell and Deller, 1967). Of the alimentary polypeptide hormones only gastrin and CCK have been studied in any detail. Exogenous gastrin or pentagastrin do not appear to affect colonic segmentation, but the actions of the several molecular species of this hormone have not been investigated (Misiewicz, Holdstock, and Waller, 1967; Bennett, Misiewicz, and Waller, 1967; Misiewicz, Waller, and Holdstock, 1969). Injections of exogenous CCK (Harvey and Read, 1973c) or intraluminal administration of $MgSO_4$ (which is said to release CCK) are followed by augmented segmental activity (Harvey and Read, 1973 a and b). The increased colonic motor activity after meals (preferably *not* termed the gastrocolic reflex) is therefore unlikely to be due to gastrin, especially as the effect is present in patients with total gastrectomy and thus seems dependent upon the entry of food into the small intestine (Holdstock and Misiewicz, 1970). Cholecystokinin is therefore the more likely candidate for the humoral mediator, but correlations of circulating immunoreactive CCK levels with the colonic response are still awaited. These correlations may on occasion prove disillusioning, as has been the case with comparisons between cardiac sphincter pressures and gastrin levels after meals (Morris, Schoen,

Brooks, and Cohen, 1974). Moreover, the colonic response occurs in anacidic patients. It is very likely that other pathways—such as the ileo-colic reflex—also take part in stimulating colonic segmentation after meals.

The effects of prostaglandins (PGs) on isolated human colonic muscle are reviewed by Bennett (this symposium). These substances are of great interest because they may be involved in the local control of intestinal tone (Ferreira, Herman, and Vane, 1972) and may be produced in abnormal amounts in disease. *In vivo*, $PGF_{2\alpha}$ infused intravenously is without effect, but $PGE_2$ inhibits segmental activity (Hunt, Dilawari, and Misiewicz, 1975).

However produced, the changes in levels of colonic segmentation should not be equated with changes in propulsion or transit of colonic contents, unless these latter variables are measured independently. It is generally accepted that the segmental contractions mix and ensure good contact of the faecal stream with the mucosa; they act to delay, rather than to accelerate transit. Although these ideas are probably correct, there is little direct experimental evidence to refute or confirm them.

## Segmental Activity in Disease

Abnormalities of colonic segmental activity have been described in several pathological conditions. Colonic diverticular disease is characterized by marked thickening of the bowel muscle in the sigmoid (Morson, 1963); it is not clear whether this is due to shortening, hyperplasia, or hypertrophy. Whatever the mechanism, the increased muscle thickness is accompanied by gross infolding of colonic mucosa which is thrown into numerous, crescentic, interdigitating folds, with the formation of many closed chambers in the lumen when the colon contracts. It is not certain whether this anatomical abnormality alone, or in combination with increased force of muscle contraction, produces the increased amplitudes of segmental pressure waves that have been reported in this condition, and which presumably generate the forces that extrude the diverticula. This hypothesis rests mainly on results of two studies, in one of which considerable overlap with pressures in normals was recorded (Arfwidsson, 1964; Painter and Truelove, 1964; Painter, Truelove, Ardran, and Tuckey, 1965). Perhaps there are other factors that influence the appearance of diverticula, but the muscle abnormality seems to be the primary event: intraluminal pressures diminish after sigmoid myotomy. Whether the thickened muscle can be ascribed to the allegedly diminished consumption of dietary fibre in western society remains to be settled (Painter and Burkitt, 1971) but there is some supporting experimental evidence from studies on laboratory animals (Hodgson, 1972).

Segmental activity tends to be low in diarrhoea and high in constipation: abnormalities of colonic segmental response during and after meals have also been described (Waller, Misiewicz, and Kiley, 1972). This apparent paradox is resolved, if the hypothesis regarding the delay in transit produced by segmental contractions is true. The absence of segmental contractions allows mass movements to drive colonic contents along unobstructed lengths of the bowel, with resultant fast transit rates. The tubular colon of chronic ulcerative colitis may be an extreme example of this situation. In a proportion of patients who abuse laxatives the colon may present a featureless appearance (Plum, Weber, and Sauer, 1960), whilst some purgatives, eg, oxyphenisatin, stimulate progressive—and therefore presumably propulsive—colonic contractions (Hardcastle and Mann, 1968). It is not known whether low segmental activity results from, or may be the cause of, excessive colonic fluid loss.

Abdominal pain is clinically important in a variety of disorders and colonic segmental pressures have been much studied in conditions like the irritable bowel syndrome or postprandial abdominal discomfort in an effort to elucidate the mechanism of this symptom. Excessive segmental pressures have been described after psychological, pharmacological, or physiological stimuli (Chaudhary and Truelove, 1961; Connell, Jones, and Rowlands, 1965), and good correlations between pain and pressure waves have been observed in some patients (Holdstock, Misiewicz, and Waller, 1969). Some important discrepancies do exist, however. Psychological stress may result in similar colonic responses in patients and in normal subjects (Almy and Tulin, 1947; Almy, Kern, and Tulin, 1949). Some patients experience abdominal pain, but the pressures are unremarkable, whilst in others very high pressures ($\simeq$ systolic blood pressure) are present, but the patient remains free of symptoms. There are a number of possible explanations for this. The hypersegmentation may be focal in distribution and out of reach of pressure sensing devices, or it may affect the small intestine: there is evidence from *x*-ray and other studies for this. Moreover, the threshold to pain may vary between patients. An important study by Ritchie (1973) has shown colonic hyperalgesia to distension in patients with the irritable bowel syndrome. It is likely that distension is the stimulus responsible for the pain, the area of intense segmentation producing a form of functional obstruction, with gas and faeces accumulating proximally.

Although ulcerative colitis is primarily a mucosal disease, it is associated with marked abnormalities

of colonic motor function which contribute to the symptoms. Colonic haustral folds may diminish or disappear and colonic transit may be disturbed, with proximal constipation and distal diarrhoea (Lennard-Jones, Langman, and Jones, 1962). Toxic megacolon is associated with profound loss of muscle tone, whilst pseudostrictures are produced by abnormal muscularis mucosae (Goulston and McGovern, 1969). The defaecation reflex may be abnormal, with urgency and tenesmus. The colonic pressure response to opiates is abnormal. The mechanism of all these changes is not known and any explanation must remain hypothetical. However, PG synthesis increases in inflammation and PGs of the E group have been shown to relax the circular, whilst contracting the longitudinal colonic muscle (Bennett, this symposium), effects which could be responsible for some of the changes. Sulphasalazine, which is effective in ulcerative colitis, is a prostaglandin synthetase inhibitor (Collier, 1974). It is possible therefore that excessive local release of PGs may be important in ulcerative colitis.

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