

THE NORMAL MOVEMENTS OF THE COLON IN
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THE researches carried out during the last few years by means of the X-rays on the stomach and small intestines have led to a clear understanding of their motor functions. The nature of the normal movements of the colon has, however, until recently remained a complete mystery. Whenever the shadow of the colon was examined after a bismuth meal, it was found to be completely immobile, so that it was assumed that the progress of its contents along the colon depended upon peristaltic waves, which were too slow to be observed. There were, however, two exceptions. Early in 1907 Hertz and Schlesinger¹ watched the process of defæcation and saw the contents of the cæcum and ascending colon move bodily into the transverse colon, whilst everything beyond the splenic flexure was carried through the pelvic colon and rectum and evacuated. In April, 1908, one of us² had an opportunity of watching for several minutes the movements of the contents of the colon of a woman during an attack of severe colic, due to obstruction produced by cancer of the pelvi-rectal flexure. At one moment the cæcum and the transverse colon were seen and the ascending colon was invisible; then the shadow suddenly rushed towards the obstruction at the pelvi-rectal flexure, leaving the cæcum and transverse colon empty; the next moment the bismuth had rushed back to the cæcum again. Whilst this was going on, different parts of the colon were felt to rise up and contract into hard cords, the phenomenon being what Nothnagel described as intestinal stiffening. Not more than a second or two was occupied in the passage of the fæces from one end of the colon to the other, and no definite peristaltic or antiperistaltic waves were seen. The explanation then offered was that the obstruction

¹ See *Guy's Hosp. Rep.* lxi. p. 423. 1907.

² Hertz. *Arch. of the Roentgen Ray*, June, 1908.

gave rise to violent spasmodic contractions of various lengths of the intestine above it, which caused their contents to be squeezed partly forward and partly backwards, the preponderating direction depending upon the distance of the contracting segment from the obstruction: this would explain the sudden disappearance of part of the colon shadow and the simultaneous appearance of other parts.

In November, 1909, Holzknacht¹ published a paper, in which he stated that in the course of more than a thousand examinations of the human colon with the X-rays he had on two occasions seen the contents of one section pass onwards into a more distal section by a rapid movement lasting a few seconds. The movement was preceded by the sudden disappearance of the normal haustral segmentation, which returned after it was complete. He suggested that what he had observed represented the normal movements of the colon, which took place three or four times a day, the colon remaining completely inactive during the rest of the time.

Holzknacht's observations remained unconfirmed for more than two years, and it was generally believed that his conclusions could not be correct, as otherwise the movements would have been seen more frequently. In April, 1912, however, Barclay² recorded his observations on the colon of a patient suffering from carcinoma of the stomach. Twenty-four hours after his first examination, when all the bismuth had accumulated in the cæcum, ascending colon and first part of the transverse colon, he saw a movement similar to that described by Holzknacht occur immediately after the patient had swallowed a few mouthfuls of food. In less than three seconds, as he judged, some of the fæces had passed along some twelve inches of the colon; there was no break in the shadow of the colon from the cæcum to a point nearly six inches beyond the splenic flexure. So far as he could make out the haustral segmentation disappeared during the movements, but he could not be certain about this, as the movement was so rapid that he could hardly follow it. Dr Barclay tells us that at the end of 1912 he again saw a similar movement of the intestinal contents; the shadow extended to just beyond the hepatic flexure before its occurrence, and after it was over there was no break in the continuity of the shadow from the cæcum to the splenic flexure. In the paper describing his first observation, he reproduced three radiograms, which afforded evidence of the occurrence of a sudden movement of the contents of the colon in an additional case.

¹ *Münch. med. Wochensch.* LVI. p. 2401. 1909.

² *Arch. of the Roentgen Ray*, April, 1912.

Shortly after the appearance of Barclay's paper, one of us (A. F. H.) saw for the first time a similar movement of the contents of the colon in a woman suffering from muco-membranous colitis. She felt nothing at the time and the movements corresponded exactly with what Holzknrecht and Barclay described.

On referring to the tracings of the colon taken at hourly intervals in our earlier researches on the passage of food along the intestines, it occurred to us that large movements of the colon, as described by Holzknrecht, must often take place during or immediately after a meal, as we were struck at that time with the fact that though as a rule little or no appreciable change could be observed in the shadow

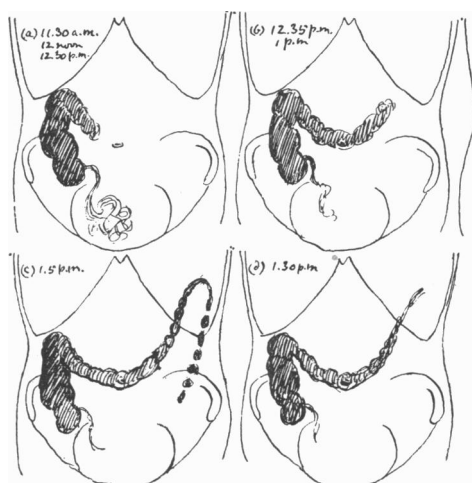


Fig. 1.

of the colon after a whole hour, a great advance occurred during the hours in which meals were taken. We therefore made an X-ray examination of six normal individuals whilst they were eating an ordinary dinner between five and seven hours after a bismuth or barium breakfast; on two occasions we were successful in seeing a large movement of the colon¹.

¹ Recently I have also sometimes allowed patients to eat during the examination I habitually make six hours after a barium meal in order to determine whether any gastric stasis is present; in this way I have twice seen a similar movement. Quite recently I accidentally observed mass peristalsis in a man half an hour after he had opened his bowels; he had felt the desire to do so immediately after having tea. (A. F. H.) Since this paper was written, J. T. Case of the Battle Creek Sanatorium has recorded numerous observations on manifestations before the Radiological Section of the International Medical Congress in August, 1913.

The following are descriptions of the second, third and fourth of our six observations; the first was seen so unexpectedly that there was no time to take tracings, and the last two were almost identical in character with the fourth. (1) A man of thirty-five, suffering from no gastric or intestinal symptoms, took two ounces of bismuth oxychloride at 7 a.m. with porridge, after which he ate bacon and eggs, bread and butter and tea (Fig. 1). The first trace of bismuth reached his cæcum at 10.30 a.m. and at 11 a.m. the shadow was practically unaltered. He then walked for half an hour, after which the shadow of the ascending colon and first two inches of the transverse colon became visible (*a*). At 12 noon and 12.30 p.m. there was no change in the shadow. He began his dinner at 12.30 p.m. and when examined immediately after he had finished there was still no change, but five minutes later the shadow was found to extend to within two inches of the splenic flexure (*b*). Apparently a large movement of the colon had taken place, which we had missed. At 1 p.m. the shadow was unaltered. Five minutes later the patient said that he felt a very slight desire to defæcate; we therefore looked at him again and were fortunate enough to see a movement taking place. The shadow of the cæcum and ascending colon did not seem to alter, but that of the transverse colon became narrow and its most distal end rapidly passed round the splenic flexure down the descending colon to the middle of the iliac colon. The movement occupied a few seconds only, and whilst it occurred the shadow was of uniform width. A few seconds afterwards the shadow of the transverse colon became split up and showed the usual haustral segmentation. The shadow of the whole bowel from the cæcum to the iliac colon was continuous (*c*). The patient then defæcated and at 1.30 p.m. the shadow was practically unaltered, except that everything beyond the splenic flexure had disappeared in accordance with our old observations on defæcation (*d*). The patient had nothing more to eat until 6 p.m. and no further change in the shadow occurred.

(2) A normal man had an ordinary breakfast with two ounces of barium sulphate at 7 a.m. At 12 noon the shadow of the end of the ileum, the cæcum and ascending colon was visible (Fig. 2 (*a*)). He then had an ordinary luncheon, consisting of meat, vegetables and pudding. During the meal the cæcum and ascending colon became more filled owing to the rapid emptying of the end of the ileum, and towards the end of the meal a large rounded mass at the hepatic flexure became cut off from the rest of the ascending colon (*b*). Immediately after the meal was finished some of this was seen to move slowly round the

hepatic flexure (*c*); the diameter of the separated portion then became suddenly much smaller, the large round shadow being replaced by a long narrow one, which extended from the hepatic flexure almost to the splenic flexure (*d*). The shadow was at first uniform, but in a few seconds haustral segmentation developed (*e*). About five minutes later the shadow suddenly became still more prolonged and passed round the splenic flexure (*f*), down the descending colon and iliac colon (*g*) to the beginning of the pelvic colon. When the movement ceased a gap was present between the most distal shadow in the transverse colon and a shadow three inches in length in the first part of the pelvic colon (*h*). A similar appearance to this (*h*) is very frequently seen in the routine examination of patients after a bismuth meal; the presence of the distinct shadows separated entirely from each other or connected

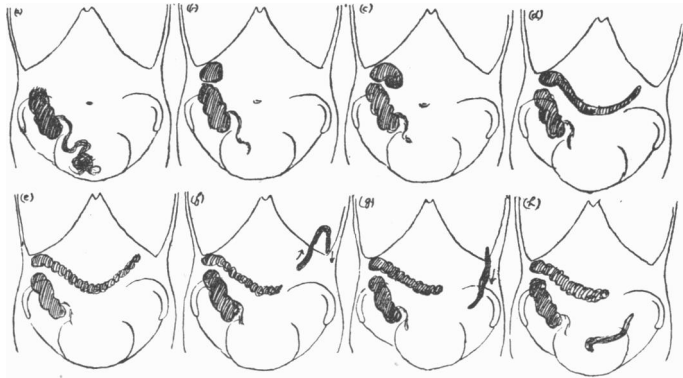


Fig. 2.

together by a faint streak is almost certainly due to the occurrence of a movement similar to that just described. The patient experienced no sensation of any sort during either movement.

(3) A woman, seen seven hours after a barium meal, was found to have no barium left in her stomach, but some was present in the cæcum and also in both limbs of the splenic flexure (Fig. 3 (*a*)). Nothing was seen in the ascending colon and transverse colon, so that it seemed probable that a large movement had taken place and carried the contents of the ascending colon to the splenic flexure. As the patient said that she felt faint with hunger a glass of milk and some bread and butter was brought into the room. Before she had time to eat anything the shadow of the splenic flexure was seen to become greatly narrowed, and the peripheral part passed in the course of about ten seconds down the descending and iliac colon to the pelvic colon (*b*). It left a faint

interrupted streak behind it; at the end of the movement the shadow of the cæcum was unaltered, a small shadow was seen in the position of the most proximal part of the original splenic flexure shadow, and a narrow interrupted streak extended down the descending and iliac colon to the pelvic colon, which had previously been invisible, but was now seen to contain a moderate quantity of barium (*c*).

We believe that the movement of the contents of the colon in defæcation and that seen by Holzknrecht, Barclay and ourselves in normal individuals apart from defæcation are examples of the same phenomenon. Under natural conditions the passage of fæces along the colon is mainly due, as Holzknrecht suggested, to a rapid movement along a considerable length of bowel repeated three or four times a day. We are still uncertain as to the nature of the movement. It is most

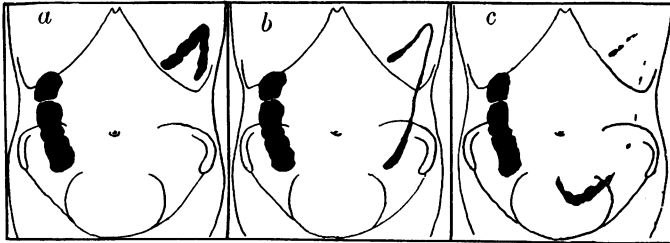


Fig. 3. (*a*) Cæcum, ascending colon and splenic flexure visible. (*b*) Shadow of splenic flexure suddenly narrowed and extending distally down descending colon and iliac colon. (*c*) End of movement: shadow of cæcum and ascending colon unaltered; traces left in descending colon; commencement of pelvic colon visible.

probably due to a powerful peristaltic wave, but it appears to be associated with an increase in the tonic contraction of the circular coat of the whole of that part of the colon through which the wave has passed. It would be difficult to explain the change from (*c*) to (*d*) in Fig. 2 in any other way.

The chief stimulus to this movement is the entry of food into the empty stomach, as the gastro-colic reflex, which Hertz described four years ago¹, seems to result in this type of action. In most individuals it only results in defæcation after breakfast, as the pelvic colon is then full and the sudden passage of fæces from it into the rectum gives rise to the call to defæcation. After other meals the desire to defæcate is not often felt, as—if the first attempt to defæcate has been successful—the colon contains comparatively little fæces, and none is present beyond

¹ Hertz. *Constipation and allied Intestinal Disorders*, p. 18. Oxford. 1909.

the splenic flexure until the later part of the afternoon, nor in the end of the pelvic colon until the evening. In spite of this, some individuals with an abnormally excitable nervous system experience the desire to open their bowels after each meal, as their gastro-colic reflex is exceptionally active and the large movements through the colon are apparently so great that a further quantity of fæces reaches the rectum after each meal. The movements occurred in one of our subjects when she felt faint with hunger, and food was brought into the room. This is a remarkable example of the influence of the mind on the motor functions of the intestines, corresponding to what has been so well studied by Pavlov in connection with the secretion of the digestive juices. In connection with this it is interesting to note that some patients, who suffer from diarrhœa after meals, also have diarrhœa when they are faint with hunger as a result of the unusual postponement of the hour of a meal.

When the colon is distended by means of an enema, active contractions often take place in it, as first described by Bergmann and Lenz¹. One of us (A. F. H.) has frequently observed them with the X-rays by running a suspension of barium sulphate into the colon through a tube introduced into the rectum. The fluid runs passively by hydrostatic pressure as far as the cæcum in normal individuals. When the amount injected is greater than about a pint and a half or when the pressure is more than about a foot and a half, and less frequently when the quantity and pressure are below these limits, the distension of the colon stimulates it to contract, and the fluid can be seen to pass rapidly in each direction from the contracted segment. Movements may continue without interruption, but more commonly they take place at intervals of some minutes, when they are often associated with a desire to empty the bowels. It has been suggested that the passage of some of the fluid towards the cæcum is due to anti-peristalsis, but the appearance is not at all suggestive of this. The sudden contraction of a segment of the bowel squeezes all the fluid out of it; that in the proximal part passes towards the cæcum while that in the distal part passes towards the rectum. The phenomenon is thus identical with what I have already described as occurring in the colon behind an organic obstruction; it is probably distinct from the movement occurring normally in the colon during defæcation and at other times, especially during and after meals. It is certainly nothing in the nature of peristalsis; it appears to be due to the contraction of the circular

¹ *Deutsche med. Wochens.* xxvii. p. 1425. 1911.

coat of the whole of a segment of the colon at the same moment. The stimulus to the movement is distension, to which may probably be added the chemical stimulation by an unknown substance, which Roger has shown forms in the fluid fæces, which accumulate above an organic obstruction of the colon. Bergmann and Lenz were also able to observe the movement more constantly if they added phenolphthalein to the fluid they injected into the bowel.

Passive filling of the colon. The cæcum and ascending colon become gradually filled by the passage of chyme from the end of the ileum into the cæcum each time a peristaltic wave reaches the ileo-cæcal sphincter, the sphincter relaxing at the same moment. The peristaltic waves are so strong that the intestinal lumen is completely obliterated and the chyme is consequently squirted with considerable force into the cæcum. In the erect position, if the cæcum is empty, as it normally is until

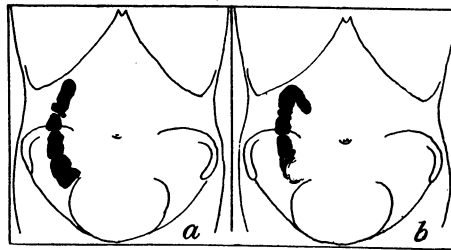


Fig. 4. (a) Before tea: cæcum and ascending colon filled with barium-containing chyme. (b) After tea: barium-containing chyme in cæcum partly replaced by barium-free chyme from ileum: first part of transverse colon visible.

about five hours after breakfast, the semi-fluid chyme collects in the lowest part of the cæcum. As more and more chyme enters, its upper surface gradually rises until perhaps the whole cæcum and ascending colon may be filled. The cæcum and ascending colon play an entirely passive rôle, the filling being due entirely to the activity of the ileum, the pressure at the end of which, as a peristaltic wave passes towards the sphincter, is considerably higher than that in the cæcum; the latter is the same as the general intra-abdominal pressure or possibly slightly higher owing to the tonic contraction of its muscular coat. We have repeatedly watched this passive filling of the proximal part of the colon with the X-rays, and it has previously been observed by Hertz in conjunction with Messrs E. G. Schlesinger, A. H. Todd, F. Cook and H. L. Gardiner by means of auscultation, palpation and percussion. Our recent observations have shown that the passive filling of the colon

occurs very slowly except during and immediately after meals, this being the period in which peristalsis at the end of the ileum is most active as a result of the gastro-iliac reflex, which is consequently as important for the colon as the gastro-colic reflex¹. When the ileum no longer contains any bismuth, all of which has collected in the cæcum and ascending colon, the entrance of chyme into the cæcum during a meal can still be observed by the appearance of a clear area in the cæcum, when the bismuth-free chyme replaces that containing bismuth (Fig. 4).

Local contractions of single sacculi. Elliott and Cannon have seen local contractions occur in single sacculi of the exposed colon of animals. These movements are similar to the segmentation, which occurs in the small intestine, and result in churning of the contents. Though they are very rarely observed in the human colon, one of us (A. F. H.) has once seen quite definite segmentation with the X-rays in the transverse colon of a woman, in whom the irritability of the mucous membrane was increased as a result of chronic infection of her colon with a pathogenic streptococcus. We have also observed small rapid movements in the haustra of the cæcum and ascending colon in several of the normal individuals whose intestinal movements we recently investigated, especially during and immediately after meals. Schwarz², by tracing the outline of the shadow of a part of the colon after a bismuth meal at short intervals, found that very slow contractions are constantly occurring in all parts of the large intestine, but most powerfully and most rapidly in the proximal parts. The contractions are either completely stationary or move very slightly backwards and forwards; they lead to mixing of the contents at the colon, but do not propel them in either direction.

¹ Cf. Hertz. "The Ileo-cæcal Sphincter." *This Journal*, XLVII. p. 54. 1913.

² *Munch. med. Wochensh.* LVIII. p. 1489. 1911.