Functional Problems Associated with Colonic Dysfunction: The Irritable Bowel Syndrome

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This issue of Pediatric Annals focuses on common functional gastrointestinal problems. Many physicians have difficulty dealing with these conditions because they cannot empathize with complaints that they consider psychological rather than somatic. Other practitioners are receptive to the concept of mind-gut interactions but are uncomfortable because they cannot visualize the precise mechanisms by which emotional problems induce intestinal reactions that result in malfunction and symptomatology. Attempts to develop some uniformity in this important area have resulted in disparate reports. This may reflect actual differences among patients or variations in measurement techniques with imprecise laboratory and clinical parameters.

Symptoms may vary from regurgitation and heartburn, which presumably arise high in the intestinal tract, to periumbilical and lower abdominal pain or disturbances of elimination with severe constipation or diarrhea, which develop at distal sites. Since the entire tract is interrelated, the pathophysiology of functional abnormalities is probably generalized and not confined to discrete areas. We have chosen to restrict the discussions in this issue to problems of the colon which are usually classed under the rubric, irritable bowel syndrome (IBS).

Some authors suggest that, in adults, symptoms of IBS occur in an unselected population as a result of an autonomic reaction induced by prolonged unresolved conscious or unconscious emotional conflict. Others believe that appearance of the symptoms as a response to stress is restricted to individuals with vulnerable colons. Freud and Zilboorg advocate that this vul-

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In children, early difficulties are more likely to be hereditary than conditioned or emotional.
nerability is induced by familial and hereditary tendencies, while others champion the cause of conditioning by early traumatic experiences as the predisposing factor.

Pediatricians are afforded a cleaner clinical model than are physicians who treat adult patients. Prior conditioning cannot be an important influence in neonatal colic or constipation. Similarly, a toddler with onset of the diarrheal IBS pattern has hardly developed the type of superego necessary to dwell on prolonged unresolved emotional conflicts. Even in the case of the older school-age child with severe abdominal pain, parents frequently insist that the child is well adjusted and that the severity and persistence of the pain is out of proportion to any apparent upsetting emotional input. The evidence in children therefore indicates that early difficulties are more likely to be related to hereditary and familial predispositions than to postnatal conditioning or to overwhelming emotional influences. Other observations in children support that body of adult literature which has found it impossible to identify specific personality types associated with IBS or to relate the onset of symptomatology to specific kinds of emotional stress.

The major hereditary aberration in colonic function that appears to be related to IBS concerns disturbances in the fluid resorbing activity and the pressure motility patterns of the distal colon. We demonstrated that colonic pressure waves, previously classified by Code et al into a numerical or alphabetic system (types 1 to 4, or A to D) consisted of three basic groups:

1. segmental or mixing waves which tend to churn the contents in one area,
2. tonus contractions of longer duration which act to squeeze bowel contents and aid in fluid extraction from the bolus, and
3. propulsive waves.

In these studies, simultaneous recordings obtained from various distal colonic sites were examined and individual wave forms were tabulated (Figure 1). Amplitudes were separated by 3 cm water pressure increments, and durations were measured by 10 second intervals. The frequency distributions were tabulated by these increments as shown in the lower portion of Figure 1. Waves up to 10.5 cm water pressure amplitude

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**Figure 1.** Distribution of wave forms in the rectosigmoid and sigmoid among 40 normal children (total 3117).
and above 25 second duration were classified as tonic waves. Those above 4.5 cm water pressure amplitude and up to 25 second duration were included as mixing waves. There were no sharp demarcations in the distribution of these short duration wave types, suggesting that their previous separation by amplitude into type I or A and type 2 or B was artificial. Careful counts did not bear out the distinction. Thus, our proposal that these be combined into one group, called segmental or mixing waves.

The waves clustered around the origins of the table in Figure 1, while often the most numerous, were omitted from the counts and classifications because they were difficult to assign to any specific group. Their exclusion explains how compilations of percentage wave activity by type under various study conditions would often total much less than 100%. (This will help clarify information presented later in this article in Tables 1 and 2.)

The tabular portion in Figure 2 is taken from a compilation of wave forms in the lower colons of six children with acute diarrhea and illustrates the frequency with which propulsive waves are encountered in infectious or inflammatory diarrhea (Figure 2). These wave forms occur much less frequently in tracings from individuals who are not experiencing diarrhea. Unlike the segmental waves of fixed short durations with varying amplitudes or tonic waves of low amplitudes but varying longer durations, propulsive waves uniquely demonstrate a fixed relationship between amplitudes and durations.

Intestinal contents are in a relatively fluid state as they travel through the tract, thereby precluding impaction. Even the inspissated material in a patient with Hirschsprung's disease remains fairly liquid throughout retention at any level proximal to the sigmoid. Ileostomies regularly discharge unformed stool and patients with anal ileostomies, resulting from pull-through operations in which ileum is brought into a surrounding lower rectal muscular cuff, defecate material which remains rather soft to liquid.

The demonstration by Hardcastle and Mann that propulsive waves are not propagated beyond approximately 20 cm from the anal margin fits our own hypothesis that, although this fluid material is regularly moved along from the mouth toward the anus by intrinsic intestinal activity, the primary function of the sigmoid and rectal area does not include propulsion. Our 30 years of laboratory and clinical observations indicate that the most efficient area of the gastrointestinal tract for fluid resorption is the distal colon. The main role of the rectum is to dry stool in preparation for its voluntarily controlled passage from the

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Figure 2. Distribution of wave forms in the rectosigmoid and sigmoid of six children with acute diarrhea (total 232).

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body. We have shown that tonus activity, which is associated with water absorption, is most active in the distal bowel.6

The terminal colon is normally the primary area for tonus activity and drying of stool, but this wave pattern and greater stool desiccation may develop in more proximal portions of the large bowel when necessary. One study of a patient with Hirschsprung's disease conducted only two weeks after excisional surgery that extended from the anal verge to the sigmoid showed that the area which was pulled down to form the "new rectum" had previously demonstrated mostly segmental mixing activity. Even within the brief postoperative period it had developed a predominate pattern of the type of tonus activity associated with drying of stool6 (Figure 3). Patients with colostomies also gradually develop an automatic pattern with more formed stools and a tonus motility pattern similar to that demonstrated postoperatively in the patient with Hirschsprung's disease. The ability for tonus activity to predominate in any area that becomes the terminus of the intestine is apparently restricted to the large bowel and does not seem to extend to the small intestine.

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Figure 3. Comparison of motility in segments of the lower colon before and after Swenson pull through.

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Individuals with tendencies to constipation do not have a better or more efficient electrolyte and water membrane transport mechanism. The drier stools result rather from stronger distal colonic muscle squeezing mechanisms and the longer periods that stool remains in contact with the rectal mucosa.\textsuperscript{9,10} As reported by Ziskind and Gellis, increased ability to squeeze and to absorb fluid from this area is associated with constipation in children.\textsuperscript{11} We have also observed exaggerated tonus in recordings taken from children with constipation. Exaggerated tonus has been demonstrated by Hiatt in the aganglonic “spastic” segment of patients with Hirschspring’s disease,\textsuperscript{12} and has been shown in adults with constipation by Connell,\textsuperscript{13} Wangel and Deller,\textsuperscript{14} and Chowdhury.\textsuperscript{15} Simple constipation is therefore the result of more effective and prolonged squeezing which improves water extraction. Such patients often have “tight” rectums on physical examination and are said to have spastic constipation. Clinical studies have demonstrated that this pattern is hereditary. In one study Bakwin and I showed six times greater concordance for constipation among monozygotic than among dizygotic twins.\textsuperscript{16}

Not all investigators agree that constipation is correlated with an exaggerated tonus pattern. Their research usually does not differentiate among wave types but concentrates on the percent of time over which records show activity. They interpret any increase of wave activity as representative of a greater tendency toward propulsive movements of intestinal contents. This condition is contrasted with relative inactivity, which they view as atony. They conclude, therefore, that a greater amount of rectal motility correlates with diarrhea and lack of activity with constipation. However, in 1951 Kern and Almy demonstrated via balloon studies an apparently paradoxical decrease in segmental and tonus activity in the rectums of adults with diarrhea.\textsuperscript{17} Our findings with children corroborate those of Kern. Working with open tipped catheters we showed that infants and children with acute infectious or chronic inflammatory diarrhea demonstrated decreased segmental and tonus activity, probably neurologically coordinated in preparation for an increase in integrated propulsive activity.\textsuperscript{7} We were able to induce disappearance of segmental waves with appearance of propulsive activity in normal children following oral administration of magnesium sulfate and parenteral injection of parasympathomimetic agents such as Urecholine\textsuperscript{8} (Figure 4).\textsuperscript{7} These findings have been confirmed by others in infectious diarrhea of children and adults.\textsuperscript{18}

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Figure 4. Effect of oral magnesium sulfate on the motility of the distal colon.

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Attempts to document correlation between pressure wave patterns with absorptive activity and other physiologic functions were made in a series of studies of normal youngsters. These studies were to be preliminary to planned investigations of these relationships in children with IBS. We interrupted these studies in the early 1960s after deciding that, despite informed consent by parents, their invasive nature rendered them unjustified. No completed report of this phase of our studies was ever published, but some of the original data from those observations are presented here to help explain our concepts on IBS.

An instrument was designed with eight polyethylene catheters bound together and interrupted at 8 inch intervals with devices that permitted isolation of the segments by balloon inflation to occlude the lumen. With this device records could be obtained from the rectum and from the sigmoid in association with fluid introduction into either of these segments (Figure 5). The numbers of segmental, tonus, and peristaltic waves counted during a baseline recording period were compared with those counted following infusion of 250 mL of normal saline into either the lower rectal or the upper sigmoid portion over a 45 minute period. Counts of wave activity were made during the 45 minute period following fluid introduction during which the child retained the fluid. The remaining fluid was then suctioned from the segment and analyzed for electrolytes and dilution or concentration effects via nonabsorbable markers.

During saline introduction into the rectum the children tended to remain comfortable, and there was no increase of segmental or tonus wave activity. After cessation of fluid introduction the percent of both mixing and tonus activity at the rectum showed significant increase associated with disappearance of more than half of the infused fluid from the lumen (Table 1). There was also an increase in the concentration of the infused fluid together with an increase in potassium content and concomitant decrease of sodium ions. No remarkable effects were observed on the sigmoid wave activity recorded.

Introductions of fluid into the upper isolated sig-
miod segment in 20 children produced a less uniform set of findings. The results divided the patients into three distinct groups (Table 2). In one group of seven there was a marked increase in the number of sigmoid mixing and tonus contractions that appeared immediately with the start of the saline instillation and continued during the subsequent waiting period. There was considerably greater absorption than had occurred following rectal saline. The appearance of increased mixing and tonus wave activity with the start of saline instillation was accompanied by mild discomfort in this group of children. In another group of eight children mixing wave activity also increased in response to the fluid introduction and was sustained during the waiting period. However, there was no appreciable increase in tonus waves in this group. Absorption was poorer than it had been in the rectum and the fluid recovered at the end of the study was not as concentrated. A third group of five children developed severe abdominal pain during the period of fluid introduction into the sigmoid. Forceful expulsion of the catheter system and of the infused saline occurred in each child during the period of fluid introduction or immediately thereafter, with an impressive increase in all types of activity, especially of propulsive waves.

In addition to sigmoid wave activity changes in this third group, there was a concomitant remarkable increase in tonus waves to 15.6% in their empty rectums, even though nothing was being instilled into these segments. The increase in rectal tonus was similar to that observed during the waiting periods of children following rectal saline introduction.

The combined observations from the studies summarized in Tables 1 and 2 suggest that under normal circumstances material introduced into the sigmoid induces a prompt reaction. Considerable mixing of contents usually takes place with variable fluid resorption. However, despite its capacity to dry stool, the sigmoid is generally less important than is the rectum as the segment for final effective desiccation of the bolus. In contrast, materials introduced into the rectum generally do not induce contractions and wave activity; instead the response is muscular relaxation and accommodation to the increasing volume. During the subsequent stable period when there is no further increase in contents, the rectum performs its usual major function, ie, squeezing and desiccating the bolus. However, the expected relaxation and accommodation of the rectum to introduction of material into this segment is not only poor, but there may even be an increase in muscle tonus in the empty rectums of certain individuals in response to propulsion of intestinal contents into the adjacent sigmoid area. Such spastic rectal activity would tend to obstruct analward movement of the sigmoid contents and could result in proximal distension, leading to pain and tenesmus. This obstruction may result in the inability to pass flatus, as in very colicky newborn infants or in older individuals with recurrent lower abdominal pain. Jorup, as early as 1950, demonstrated that high amplitude rectal tonus activity was associated with symptoms of colicky infants. 19

The rectal spasm and proximal distension may also result in forceful expulsion of fluid stool from the sigmoid as occurred in five of the children we studied. The pattern of diarrhea in these children results from

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*Figure 5. Device for measuring introduced fluid in rectum and sigmoid segments individually.*

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spasm of the rectal segment leading to difficulty with stool reaching the final area of desiccation. This supports the clinical postulate that in contrast to patients with infectious or inflammatory diarrhea in whom there is a relaxation of rectal segmental activity, all patients with IBS experience increased rectal tonus motility.20

When stool is forcefully discharged through the spastic rectum in a somewhat unformed state it could contain the colonic mucus which normally becomes dried and disappears in the rectum prior to bowel movement. As we showed in an earlier study, the appearance of starch and vegetable fibers in the stool is normally inversely related to the length of time the stool remains in contact with rectal bacteria.21 The increased rectal spasm of IBS affords less opportunity for contact between rectal bacteria and stool before its explosive discharge. Thus, the diarrheal pattern of both toddlers and adults with IBS is associated with tenesmus, urgency, difficulty with stool passage, and elimination of colonic mucus and excessive amounts of undigested vegetable material. These are consequences of the increased rectal spasm rather than other pathologic processes. It has been confirmed in adults with IBS that whether clinical complaints are predominantly those of diarrhea or constipation, stimulation, either with food intake or by artificial distention of the rectum to simulate a fecal bolus, induces an increase in segmental activity.22

Studies also suggest how various influences may induce exaggeration of the spasm in patients with IBS to the point of simulating partial obstruction. Almy and his associate demonstrated that emotionally charged situations could be accompanied by increases in tone of the distal colon.1,23 Prolonged painful physical states could also produce this condition.24,25 Mind-gut interactions resulting from pain may produce an ongoing cycle of pain in predisposed individuals. Symptoms may perpetuate themselves by causing increased excitation of the nervous system, which becomes translated into gastrointestinal dysfunction and distal spasm. For example, the pain of colic in the neonate may cause an increase in afferent-efferent impulse activity. This central reaction to gut pain leads to exaggeration of the distal colonic spasm which would then perpetuate the pain by increasing proximal distension. Such mind-gut interactions may predate any truly conscious awareness of emotional problems and their influences. At all ages IBS symptomatology in genetically predisposed individuals is more easily explained if a mechanism is postulated by which per-
sistent unrelenting physical discomfort interacts with prolonged unresolved conscious and subconscious emotional conflicts.

There is one important clinical difference that we have observed between children and adults with IBS. Although adults may primarily experience one clinical pattern it is more common for their symptoms to vary, eg, to alternate between constipation and diarrhea. However, one particular clinical pattern appears to predominate in each specific age group among children. The articles that follow each address one clinical manifestation of the common underlying IBS pathophysiology. These conditions may be difficult for the primary physician to manage easily even though they constitute an appreciable portion of day to day pediatric practice. I hope this introductory article has made the interrelationships of the clinical patterns more understandable.

REFERENCES


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