THE PATHOLOGIC PHYSIOLOGY OF CONGENITAL MEGACOLON*

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CONGENITAL MEGACOLON was known as a clinical entity many years before its classical description by Hirschsprung in 1888.[1] Hirschsprung's description reveals much thought and effort and contains complete clinical as well as postmortem findings on two cases. In fact, his emphasis on the theory that the hypertrophied and dilated portion of the colon is the primary site of the disease and that this hypertrophy and dilatation is congenital set the pattern of thinking about the disease for the next 57 years.

Since that time, scores of observations on isolated cases have been published concerning the disease. Many contain theories that are very close to what is believed today but were not adequately proved, probably due to the rarity of the disease. Any extensive review of the literature at this time would be redundant, since there are excellent reviews already in existence, the most complete of which is that of Theodor Ehrenpreis found in *Acta Chirurgica*.[2] This author, from extensive clinical and roentgenologic evidence, indicates that the disease is mainly a dysfunction of evacuation in which the rectum and lower sigmoid is the actual site of the disease, the proximal hypertrophy and dilatation being a secondary phenomenon to overcome the dysfunction. No theory is advanced as to the exact nature of the recto-sigmoidal dysfunction.

In spite of many such observations in the literature which were at variance with Hirschsprung's original theme, the belief most popularly held by physicians until 1945 was that the hypertrophied and dilated segment is the primary site of the disease.

Our faith in this concept was shaken in 1946 by observations made on two patients with congenital megacolon on whom a colostomy had been performed in the hypertrophied and dilated portion. This procedure resulted in the prompt disappearance of the hypertrophy and dilatation in the presence of a normally functioning colostomy. Any attempt at closure of the colostomy resulted in the reappearance of the megacolon. Further radiologic observations made by Caffey[3] of a persistently narrowed lower rectal and sigmoidal segment drew our attention to this area as the fundamental source of the disease.

We found in reviewing the literature that Neuhauser had previously drawn attention to the persistent recto-sigmoid spasm in congenital megacolon as seen by barium enema, and more recently motility studies by Swenson *et al.*[8, 9] demonstrated the normal capacity of the proximal hypertrophied and dilated colon for progressive peristalsis and again emphasized the spastic recto-sigmoid which was incapable of progressive peristalsis. This was done by inserting balloons into the left colon through a transverse colostomy and recording the changes in intraluminal pressure. In these defunctionalized colons the recto-sigmoid area apparently remained quiescent in the spastic state.

Our first approach was to do motility studies of this lower, narrowed segment in megacolon patients with intact colons, which was accomplished by inserting three balloons into the rectum. One of these was placed in the recto-sigmoid, another in the mid-rectum, and a third in the lower rectum. Each balloon was attached to a tambour, and the intraluminal pressures were

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recorded on a kymograph. To our surprise, we found the segment capable of rhythmic motion. Repeating these studies on several patients resulted in the more fundamental observation that the motion was a mass contraction of the entire segment. In all cases, the entire rectum and lower sigmoid contracted as a unit without any propulsive characteristics. Prostigmine given intramuscularly augmented this motion in amplitude and frequency but did not alter its characteristics. These observations led us to believe that congenital megacolon depends primarily on a lack of propulsive capacity of the terminal large gut and rectum, the megacolon itself being a compensatory hypertrophy and dilatation attempting to overcome the resulting high degree of functional obstruction.

Since proof of the nonpropulsive character of the rectal and lower sigmoidal segments was well established by motility studies, as well as by clinical observations, the next step was to identify the defect histologically.

In order to localize the pathologic defect, one need only remember that the colon retains its capacity for progressive peristalsis even when the extrinsic autonomic supply is completely removed. Peristalsis in the bowel depends upon an intramural reflex which is only altered in quantity and quality by the extrinsic innervation. It is logical, then, to suppose that the underlying congenital defect is in this reflex mechanism. With interesting variations, this assumption proved to be true. In the classical cases of congenital megacolon where there is an abrupt transition between a markedly hypertrophied and dilated proximal segment and the distal small collapsed segment, the autonomic ganglion cells of Auerbach's plexuses are either completely absent or greatly reduced in number. In looking through the literature, we found this observation to have been made many times before.[4, 5, 6] This absence or reduction of ganglion cells involves the entire rectum and extends upward into the hypertrophied segment for a variable distance.

When the transition between the hypertrophied and dilated segment and the distal normal-looking bowel is more gradual, one gets the impression that the ganglion cells are reduced, though in some cases not to the point where it is obvious. But, what is more important, this reduction in ganglion cells extends proximally into the hypertrophied segment for a considerable distance. This is the most treacherous form of congenital megacolon to cure surgically, because a much larger segment of bowel is involved, and it is impossible to tell accurately how much should be resected. This type of congenital megacolon bears further investigation, as it is the type in which surgical failure is possible.

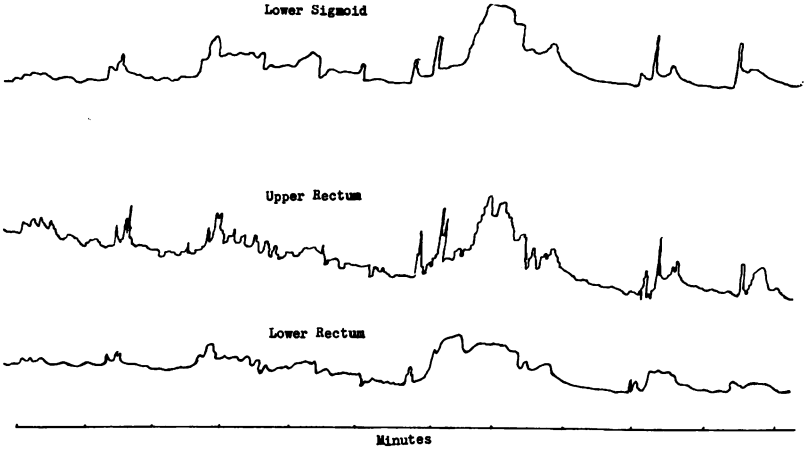
There is also another type of congenital megacolon with megarectum in which the hypertrophy and dilatation extend to the anus. This was a puzzling form of the disease until it was found that the intramural ganglion cells were absent in the distal one-half to one-third of the rectum. In most instances, it produced only mild persistent obstipation which can be controlled by enemata, but it can be a severe and disabling form of the disease requiring surgical intervention. Also, we have seen impactions in patients with megarectum produce urinary retention and sciatic pain.

The pathologic findings described were determined on 20 cases by serial sections of the operative specimens, and were done under the supervision of Dr. Raffaele Lattes.

It must be pointed out that the sphincter mechanism is involved in the achalasic process in congenital megacolon. Observation of postoperative patients during the act of defecation reveals the sphincter mechanism unable to relax in the normal fashion. In one patient of the megarectum

type, there was also a tremendous hypertrophy of the external sphincter. The inability of the external sphincter to relax is a permanent phenomenon, but it is not of sufficient intensity to alter the evacuative tions in this disease, one must remember that the underlying defect is a loss of the fundamental gut reflex of progressive peristalsis. This reflex is governed by the autonomic ganglion cells in the gut wall, which

FIG. 1



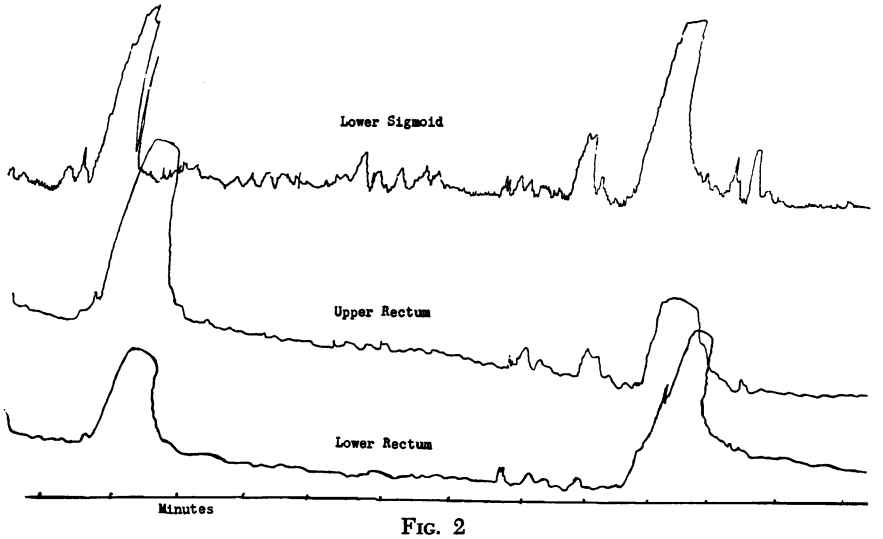


FIG. 2

FIG. 1.—Intraluminal pressure tracings of lower sigmoid and rectum in a three-year-old child with congenital megacolon, showing the mass spasm of the entire segment.

FIG. 2.—The same patient 20 minutes after prostigmine .25 mg. I.M., showing the increased amplitude and frequency of the mass spasm.

function in the postoperative patient. It is not known whether this inability to relax is a function of the external sphincter itself or of the anal wall.

In order not to be confused by the variations in this disease, one must remember that the underlying defect is a loss of the fundamental gut reflex of progressive peristalsis. This reflex is governed by the autonomic ganglion cells in the gut wall, which are mainly parasympathetic. When these autonomic elements are absent or diminished, the gut is not only incapable of progressive peristalsis, but is also kept in a tonic state by the muscle itself, which is

further augmented by unopposed sympathetic innervation which has an inhibitory influence.[7]

While it was obvious to us in 1947 that the underlying physiologic defect was a lack of propulsive capacity in the lower recto-sigmoidal segment, we still had to explain the origin of the rhythmic mass motion found in this segment. This has proved to be a difficult question to answer, and as yet it is not completely understood. However, the possible answer may be found in the following observations:

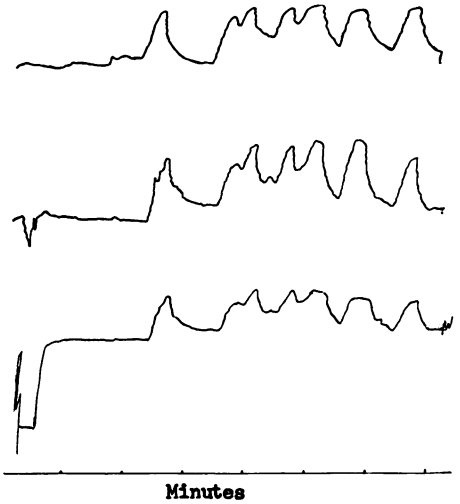


FIG. 3.—Another tracing of the intraluminal pressures of the rectum and lower sigmoid showing the effect of prostigmine .25 mg. I. M.

1. While there is always a reduction of ganglion cells, there is seldom a diminution of nerve fibers.

2. The activity of the mass motion in the lower recto-sigmoidal segment in frequency and amplitude is dependent upon the activity of the colon proximal to this segment.

3. With the finger in the rectum, one can observe that its motion is synchronized with the observable peristaltic wave in the lower sigmoid as seen through the abdominal wall.

4. Prostigmine augments the rhythmic contraction of the lower segment in frequency and amplitude.

The accepted pharmacologic action of Prostigmine on the gut is an inhibition of the choline-esterase mechanism, primarily in the gut wall itself. Therefore, it is logical to conclude that the rhythmic motion found in the nonpropulsive segment is primarily dependent on the intramural parasympathetic system.

These observations suggest that the ganglion cell of Auerbach's plexus is responsible for the integration of the peristaltic reflex into an orderly relaxation-contraction cycle progressing down the gut. In congenital megacolon when this peristaltic reflex reaches the lower recto-sigmoidal segment, it enters a syncytium of nerve fibers over which there is no ganglionic control. This results in mass contraction without propulsive capacity. As fecal material is pushed into the upper portion of the achalasic segment, enough resistance to this mass contraction is offered to result in hypertrophy of the muscle. This explains why hypertrophy and dilatation extend past the point of the reduction in ganglion cells. It also explains the occasional case seen in which the hypertrophy and dilatation extend to and occasionally include the anus.

Observations on patients who have had inadequate resections of the lower achalasic segment lead us to believe that the hypertrophy that develops in the proximal achalasic segment is of great importance in producing the high degree of obstruction. When pressure recordings are taken from the distal hypertrophied segment, transitional area, and collapsed segment simultaneously, the highest degree of contractibility is found in the transitional region and is often initiated by a very small contraction of the more proximal hypertrophied segment. Actually, congenital megacolon is a delicate balance between the distal nonpropulsive segment and the proximal colon which has undergone hypertrophy and dilatation in order to overcome the obstruction produced by this nonpro-

pulsive segment. Many patients with congenital megacolon in the newborn period will show only obstipation, which can be overcome with a moderate degree of help; however, as time goes by, this obstipation reaches the point of actual obstruction. We believe this to be due to the gradual development of hypertrophy in the proximal achalasic segment, which, because of its increased contractility, augments the obstruction. Similarly, in the patients who have had inadequate resections of the lower achalasic segment, there is a marked clinical improvement which persists for many months until the balance is re-established, presumably due to the resultant hypertrophy in the proximal portion of the remaining lower achalasic segment.

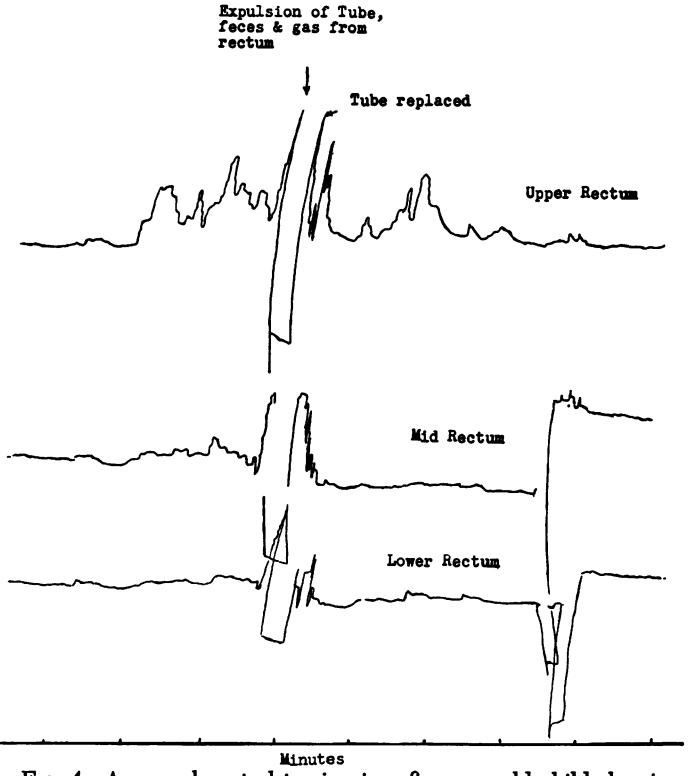


FIG. 4.—A normal control tracing in a five-year-old child showing the peristaltic wave beginning in the upper portion of the rectum resulting in expulsion of the entire apparatus through the anus.

The patho-physiologic defect described above probably can take place at other levels in the gastro-intestinal tract.[6] We have reason to believe that mega-esophagus is due to the same underlying cause, but we lack definite proof.

Congenital megacolon is a dangerous disease. Since 1946 we have seen only four adults in whom the diagnosis could be made. The rarity of this disease in the adult patient led us to investigate the cause of death. Death in the new-born period is occasionally seen when obstruction causes perforation of the sigmoid before the compensatory mechanism of hypertrophy and dilatation can become established. We have seen two such patients. Perforation after the newborn period is rare, although mucosal ulceration is frequent. Four out of 30 patients operated upon by us for congenital megacolon had active ulceration of the sigmoid mucosa at the time of operation. We have been informed of death from perforation in a young adult in whom the resection was confined to the dilated and hypertrophied

segment. The operation succeeded only in removing the compensatory mechanism for overcoming the distal obstruction.

Four years of clinical experience with 42 cases of congenital megacolon have led us to believe that the enema was one of the greatest sources of danger to these patients. Sixty per cent of the patients with severe disease in this series gave a history of extreme weakness, anorexia, and sweating for a variable time following water enemata. Three patients had experienced an acute shocklike state within 20 minutes after having been given a tap-water enema of only moderate size. One patient required admission to a hospital on two occasions for therapy of severe shock, each episode occurring while the patient was straining to have a bowel movement following a tap-water enema. This danger was further emphasized by the death of a five-year-old child with severe megacolon, on our own service, following an apparently routine colon lavage. At postmortem examination the patient had 1000 ml. of fluid in the sigmoid.

This observation, plus the classical symptoms of extreme weakness, pallor, sweating, and occasional vomiting, suggested that in these post-enema crises we were dealing with "water intoxication." Consequently, serial plasma electrolyte studies were made on several megacolon patients following the instillation of tap-water into the colon through a rectal tube. It is obvious, from the results shown on the accompanying graphs, (Figs. 7, 8, 9), that there is a rapid diffusion of water, as water,

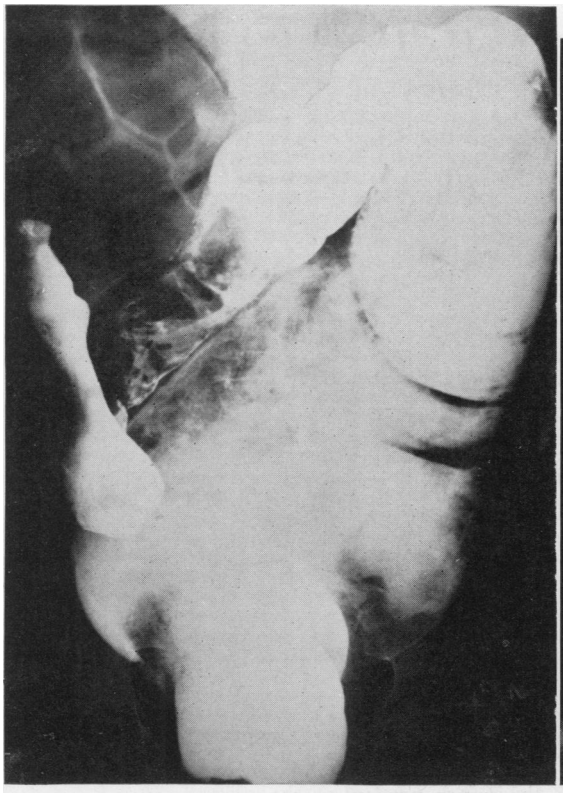


FIG. 5

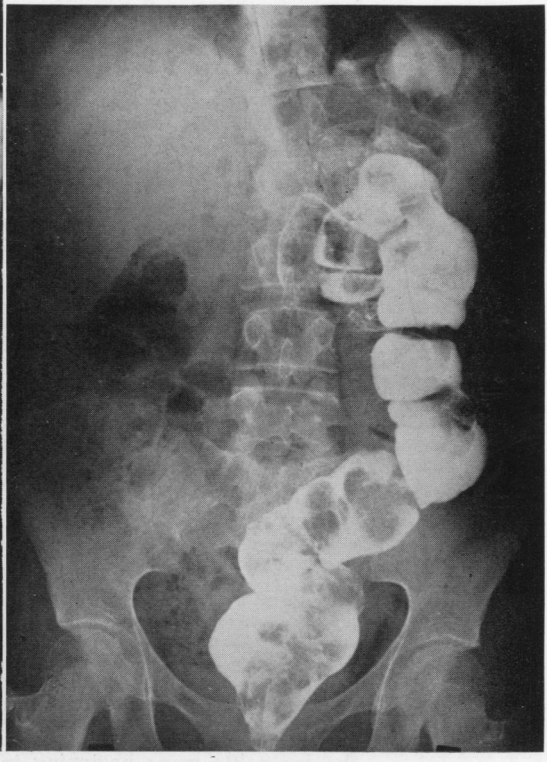


FIG. 6

FIG. 5.—A barium enema in a 23-year-old patient with congenital megacolon with megarectum.
FIG. 6.—The same patient as Figure 5 six months after resection on rectum and lower sigmoid, showing a complete loss of the dilatation. Bowel function normal.

into the circulating fluid. The speed with which this hypotonic solution diffuses through into the blood stream from the gut is dependent upon the hydrostatic pressure to which it is subjected. In congenital megacolon, this fluid is trapped in a tremendously powerful colon with a very large are often placed, result in such a high hydrostatic pressure that the hypotonic fluid in the colon diffuses into the circulating fluid at an extremely rapid rate in an unaltered form. The sudden appearance of a hypotonic fluid in the circulating fluid causes a precipitous fall in the plasma con-

FIG. 7

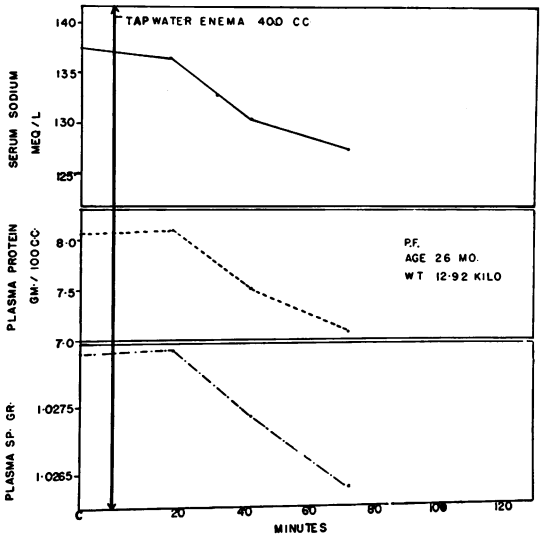


FIG. 7.—The fall in meq/L of plasma sodium, proteins, and specific gravity in a four-year-old child with congenital megacolon after a 400 ml. tap water enema. Violent peristaltic waves visible through abdominal wall.

FIG. 8

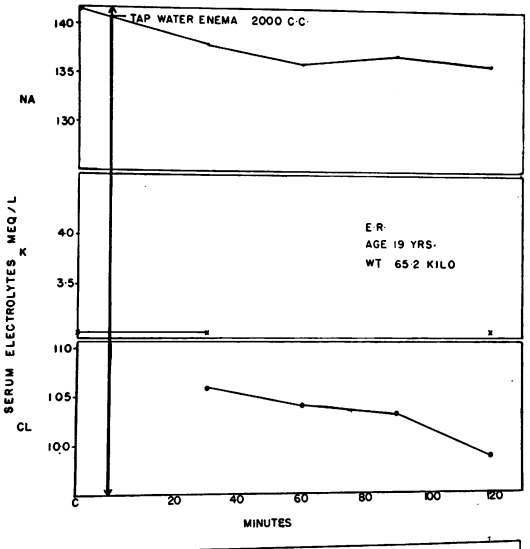


FIG. 8.—The serum Na, K and Cl values after the installation of 2000 ml. tap water into the colon of a 19-year-old boy with congenital megacolon. In this case there was no appreciable peristaltic activity.

FIG. 9.—The serum Na, K and Cl after the instillation of 500 ml. tap water into the colon of a five-year-old child with congenital megacolon. The plasma volume is shown to increase as the electrolyte values fall.

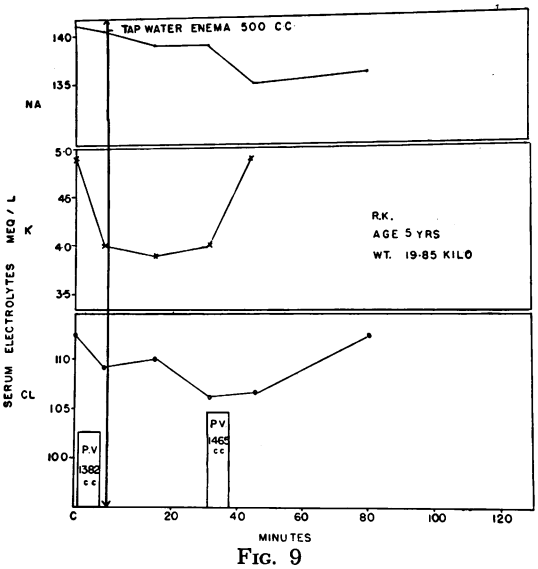


FIG. 9

absorptive surface and is therefore subjected to greatly elevated hydrostatic pressure. Adding to this the act of straining at stool and the action of drugs like Prostigmine and Mecholyl, upon which the patients centration of Na and Cl. The proteins and specific gravity also fall proportionately. This takes place in the presence of an expanding blood volume. The behavior of K concentration is less consistent; appar-

ently it is more capable of maintaining its plasma level, probably because of the intra-cellular reservoir of this ion. The electrolyte changes show that the essential disturbance is a state of low sodium shock, of greater or less severity, depending upon the speed and amount of water diffusion.

One should obviously use an isotonic solution when giving an enema to a patient with congenital megacolon, but this is in itself not completely free from danger since its rapid diffusion results in an increase in the extra-cellular fluid which can result in pulmonary edema. There is, however, a wide margin of safety except in patients with diminished renal or cardiac reserve. In these patients, a solution of gelatin should be used. A solution of 7 Gm. of gelatin per 100 ml. has sufficient osmotic capacity to overcome that of the circulating fluid. Thereupon the fluid exchange is minimal and the enema without danger.

SUMMARY

1. Motility studies suggest that congenital megocolon is a disease in which the underlying defect is a disorganization of the peristaltic reflex in the rectum and/or lower sigmoid, and in which there is a delicate balance between obstruction and the compensatory mechanism for overcoming that obstruction, i.e., hypertrophy and dilatation.

2. In order to cure congenital megacolon, it is obviously necessary to remove this entire segment of lower sigmoid and rectum.

3. The previously noted diminution of intrinsic autonomic ganglion cells in the rectum and lower colon is confirmed. The abnormal physiology thereby produced and certain interesting variations in the pathologic picture are evaluated.

4. Three general groups of congenital megacolon resulting from variations in the pathologic picture are discussed. In our experience the most common type is that in which the hypertrophied and dilated portion of colon ends abruptly just above the recto-sigmoid junction. A second type, much less common but more difficult to treat surgically, is that in which the transition is more gradual. In a third form, also relatively rare, there is megarectum as well as megacolon.

5. The cause of death in congenital megacolon is investigated, with special emphasis on the role of "water intoxication" following tap-water enema.

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