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The Enema : a survey of its physiological function

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I

Introduction

When the ancient priest or tribal medicine man needed some therapeutic aid to assist him in his mystic rituals, probably one of the first devices he contrived was some form of enema. The employment of the clyster dates back to the earliest times and is as old as medicine itself. The early Egyptians, Arabs, Greeks, Romans, Jews, and the primitive people of Africa and the Americas made use of the enema as an important therapeutic measure. Although the enema has been misused and ridiculed throughout the ages, it still holds an important place in medicine. It is hoped that this thesis will clear up some of the misconceptions concerning this important therapeutic agent.

II

History of the Enema

According to Montague (1) and Russell (2), there are early historical records which indicate that the Egyptians, Arabs, Greeks, and Romans made use of the enema as an important medical practice as early as 1550 B. C. The earliest known medical treatises refer to the enema. Friedenwald and Morrison (3) state that there is a well-known legend that the Egyptians

derived their conception of the use of the enema from the observation of a procedure practiced by the ibis bird, a type of stork. It was maintained that the bird flew to the sea shore and injected sea water into its bowel with its beak. This legend has been passed down through medical history, and in the Middle Ages it was the stork that taught men the use of the enema. From the study of ornithology, however, it is now known that this bird, in the process of dressing its feathers, inserts its bill in water and then applies pressure with its beak against the oil glands situated in close proximity to the anus. Chabas (4) made a careful investigation regarding the actual truth of this observation and discovered that the confusion arose from a misinterpretation of a hieroglyphic inscription. The words "ibis" and "King Thot" were written in precisely the same manner. This inscription told of the use of the enema by King Thot, and it is possible that this was the first definite historical evidence establishing the use of the enema by man.

Most of our knowledge concerning the use of the enema by the Egyptians is derived from the work of Herodotus (5). This Greek historian, in describing the Egyptian method of embalming, wrote that, in conducting this practice among the poor at death, the

embalmer, whose whole business this was, employed the special craft of concealing the body for seventy days, embalmed in saltpetre. This was how they prepared the dead who had wished for the most costly embalming procedure. The embalmers charged their syringes with cedar oil and then filled the belly of the dead man with this liquid, neither making any cuts nor removing the intestines, but injecting the drench through the anus and checking it from returning. They then embalmed the body for the appointed day. On the last day, they allowed the oil which they had poured into the body to pass out again. So great was the power of the saltpetre and cedar oil that the flesh was eaten away, the inner parts and intestines were dissolved, and, in the end, nothing was left of the body but skin and bones.

Herodotus also narrated that at every cycle of the moon, the Egyptians purged themselves for three days in succession by means of purgatives, emetics, and clysters and by fasting to preserve their health, as it was their belief that diseases were the result of food consumed. He said that these people were very healthy, but he attributed their health to the climate in which they lived, rather than to their intestinal cleanliness.

Two important medical papyri, one acquired by Edwin Smith (1) at Thebes, in 1862, and that found by

George Ebers (1) in 1872, at the same place, give prescriptions for enemas and directions for their use. The book found by Ebers is thought to be a medical encyclopedia, compiled for the physician-priests in some great temple. It is believed that, since many of the formulae were duplicated, this was a compilation of medical knowledge of different times and places.

Clysters were used in both Greece and Rome. Hippocrates (6) (7), the father of Greek medicine, advised the use of enemata and suppositories. He advocated the employment of an enema for a constipated individual or for one who did not digest his food well, if the patient were strong and in the prime of life. If the patient were weak, however, he believed a suppository to be the best help for an individual whose bowels did not move of their own accord.

Celsus (8), in his medical treatises, gives a clear description of the use of the enema in Rome. He states, "The patient should have his diet regulated on the previous day so as to be properly prepared for the enema, for medicine is generally offensive to the stomach, and if the body be violently purged or clystered too often, it debilitates the patient. Therefore, in sickness medicine ought never be administered with that view unless the disease be without fever. But generally the

bowels are preferably opened with injections. This should neither be too often repeated nor entirely omitted, but used once or, at most, twice if there be heaviness of the head or dimness of the eyes, if there be disease of the greater intestines, which the Greeks call the colon, if there be a bilious accumulation in the stomach, if the bowels do not act spontaneously, if there be scybala retained in the rectum, or if the patient feels a stercoraceous factor arising from his breath whilst his bowels are constipated, or if the excrement be foul. If an enema of a varied type is not required, pure water will suffice. However, if a more active one is needed, a decoction of Greek fennel of barley or mallow may be utilized. An astringent enema is prepared from a decoction of verveine. If a stimulating enema is indicated, sea water or ordinary water in which salt has been dissolved may be employed. The effect may be more beneficial if the water has been boiled. The enema may be made still more active by the addition of oil or saltpetre or even honey. The more acid it is made, the better the effect. However, retention is then made more difficult. The fluid should not be injected too cold nor too hot; that is, it should be of a medium temperature. Following the administration of

the enema, the patient should remain in bed and retain the injected fluid as long as possible." Celsus writes of the use of nutrient enemas and is the first author in history to recommend their use.

The inventor of the syringe is unknown. This instrument, with various modifications, has been used since ancient times. The first syringe was probably the bladder of an animal attached to a hollow reed, or a hollow reed inserted into the anus, the water being forced in from the mouth of a mother or a priest. The Egyptians had syringes which were probably made from bamboo tubes, with leather or cotton forming the piston. Lillico (9) states that cuneiform inscriptions on ancient clay tablets bear witness to the fact that the enema was known to the Babylonians and Assyrians. In Africa, mothers hold their babies across their knees, insert hollow reeds in the infants' rectums, and blow in mouthfuls of warm water. The African tribes also use an enema instrument made of a hollow cow's horn, which they insert in the rectum, either pouring in the liquid, or standing with their backs to a fast rushing stream and letting the water be forced into the rectum in this way. Calabash gourds and funnels made of hollowed-out logs were also used. The American Indians used a syringe composed of an animal's bladder attached

to a reed or the leg bone of a chicken or turkey. The Chippewa syringe was formed of a deer's bladder; the Apaches used a sheep's stomach; and the Guiana Indians employed the bladder of a turkey, jaguar, or sloth.

Marco Gatinaria (10), who has been credited with the discovery of the clyster in the Middle Ages, gave a description of the enema apparatus in his book. He is said to have devoted many years to the completion of this treatise, which, in the course of the sixteenth century, had four editions. He did not dare to introduce so great an innovation into practice on his own authority, so he took refuge behind Avicenna, who, he said, had given a description of it in the fifth century. Gatinaria died on February 14, 1496. He was supposed to have simply described an improvement in the apparatus proposed by Avicenna; this was recognized as a double current syringe, one tube serving for the passage of air, and the other, for water.

The syringe described by de Graaf (11) was a modern instrument compared to those used by the ancients. He should be given credit for developing the instrument so that the patient could give himself a treatment. De Graaf developed the flexible tube between the bag, or syringe, and the tip. This enabled the patient to give himself an enema without danger and without offending

his sense of modesty. After many difficulties in choosing material for the proper type of tube, he finally produced an apparatus consisting of an intermediary tube, flexible and impermeable, through which liquids could be injected with great ease, and without pain or danger, not only into the bowel, but also, by a simple change in the cannula, into the uterus, as well as other parts of the body. The entire originality of this invention and its actual advance lie in the intermediate, slender, flexible tube of sufficient length (five to six feet), which is attached between the syringe at one end and the rectal tip at the other. De Graaf made the first flexible tube from the intestine of a fowl; this, however, proved unsatisfactory. Then, after many unsuccessful attempts, he prepared a tube from a strip of thin leather, which was rolled into a cylindrical form, sewn firmly together, and waxed to prevent leakage. This tube was then covered with black silk.

De Graaf's work, "De Clysteribus", translated into French in 1878, contains a store of information regarding the use of the enema. He refers to various types of enemas, among which are water, sea water, water and urine, and water and honey; however, he prefers water alone, or water mixed with oil and honey, or sea water.

He remarks, "These liquids have the power to dissolve hardened material in the bowel and at the same time stimulate the organ to cause expulsion of the dissolved matter. They, therefore, fulfill a double purpose." He suggests to practitioners, especially those who are consulted by the poor, the fact that enemas composed of water and honey or of water and salt will give relief at small expense.

Most interesting is his chapter on nutrient enemas. De Graaf states that in extreme conditions, when the patient is no longer able to ingest sufficient food, it is but natural to inquire if there is not a method of introducing nourishment through the bowel by means of an enema. Those who consider this possible maintain that it is not absolutely necessary that the stomach digest the food in order to produce chyle, for the bowel has the power likewise to accomplish these changes. Enemas of wine, barley soup, milk, bouillon, yoke of eggs, and similar foods can be utilized for this purpose. These enemas should be administered in larger quantities and should be more forcibly injected than usual, in order to reach beyond the large bowel into the small intestine, where they are absorbed. He expresses his views regarding absorption of nutrient enemas. He agrees with others that this is perfectly possible as to liquids,

but not with regard to solids.

De Graaf tells an interesting story. He states that, "Contrary to the nature of things, Bauhin's valve has been known to relax and open during an antiperistaltic movement of the bowel, and the enema may thus be carried backward into the mouth. This has been observed by Galen, Sennert, Pare, Bartholin, and others, some of whom affirm that even suppositories have been passed through the mouth by the same route."

According to de Graaf, Sennert reported an incident as follows. The story is about a twelve-year-old girl suffering from chronic "ileac disease", who not only could not retain any food, but who also vomited nutrient enemas as rapidly as they were administered. This condition lasted for three days. A large suppository was then inserted, which, according to Sennert, was carried back into the stomach and vomited within the time required to invoke a "pater noster" and an "Ave Maria". A second suppository, with a thread attached, was then introduced; but the thread became detached, and, like the preceding one, it was vomited by the patient, with a bit of broken thread. A third suppository was attached to a stronger thread; it followed the identical course as the others and was expelled by mouth, with fragments of broken thread. At

last, the physician ordered a fourth suppository; but the peristaltic movements became so violent that the girl's mother hastened to withdraw it, fearing that it would follow the same course as the others.

In his book, de Graaf gives the various procedures to be followed in administering enemas. "The clyster should be administered in variable quantities, depending upon the age of the patient; for infants it should be three ounces; for the adult, six ounces. In pregnancy the quantity should be regulated in diminishing quantities with an increase in the development of the foetus. The amount should also be regulated in patients with stones or with inflammatory conditions of the kidneys, as well as in individuals who are not very strong, or in the presence of unusual intestinal distention. Enemas should be given tepid at times, warmer where there is an excessive amount of mucous in the stools or when the patient is suffering greatly from abdominal gas. In fevers, they should be cool.

"Enemas must be retained for a variable period of time, according to the condition at hand. For simple cleansing of the bowel this should be continued over a half hour; for soothing abdominal pains, longer. Those intended for purgation are usually expelled at once. If there is too long a delay, a suppository is inserted to

hasten expulsion.

"Physicians are not in accord as to the position which the patient should assume in receiving an enema. Some consider the right side best; others, the left. Those who claim advantage for the right side believe there is a tendency for the fluid to flow higher in this position, as there is no tendency then to compression of the left bowel or splanchnic area. As for us, we have reached the conclusion, based upon our knowledge of the human anatomy acquired through numerous dissections of cadavers, that it is quite immaterial whether the patient reclines on either side. If we were forced to indicate our preference for a definite position, we would have the patient recline upon his back. Under such conditions, there could not possibly be any compression, either from the right or left side."

De Graaf recommends the enema for the treatment of various intestinal disturbances, such as colic, tenesmus, diarrhea, ulcerations, worms, and similar ailments. He states, "It is also effective in disturbances of the bladder, kidneys, uterus, etc. It is useful in the relief of headaches, as well as the treatment of all fevers."

According to Russell (2), Baron Nordenskiold credits the invention of the rubber enema bag, tube, and

tip to the South American Indians. Baron Nordenskiold (12) describes how the Indians molded rubber over reeds to make the tube and also how they made the bag. The Indians also made rubber syringes much like the modern ear syringe. The hollow rubber ball preceded the invention of the rubber syringe.

The enema was popular in France and became a fad during the reign of King Louis XIV. It was also popular in England.

In 1831, Edward Jukes (13) wrote an article on digestive disorders and costiveness. He recommended the employment of lavements to preserve the bowels in a regular state. He also recommended the use of his own instrument, which he considered far more useful than others. His apparatus was best not only for treatments of constipation, but also for the administration of antispasmodics, astringents, anthelmintics, anodynes, stimulants, and nutrients in the bowel. He had two types of instruments: one, his improved syringe; the other, the clysma-duct, consisting of a tapering funnel of water-proof composition and fitted to an ivory rectum tip. The funnel was hung on a hook when filled, the ivory pipe was inserted into the rectum, and the fluid ran in by the force of gravity. In speaking of the power of absorption of the lower bowel, Jukes

stated,"I have had the opportunity of injecting a quantity equal to eight glasses of gin and water,as it is commonly mixed at taverns for drinking, and in one hour afterward the man was in a complete state of intoxication. His statement to me was that four glasses of liquor thus mixed was as much as his head could bear when taken into the stomach." He condemned the use of purgatives, saying that, "The case at last terminates in irremediable or fatal disease, frequently in the most obstinate constipation, cholera, violent colic, inflammation, ileac passion, gangrene, and death."

The clyster was used in America after 1840. Phillip Jordon (14) remarked that the clyster was an admirable technique in a backwoods community where prepared medicines were scarce. In addition, the enema could be administered with a fair degree of care by the members of the patient's family. "Language almost fails to express the great value of this innocent and powerful remedy," wrote one of the leading domestic medicine volumes (15) of his day. "There are many persons, both men and women, who are constitutionally subject to costiveness: by which I mean being bound in their bowels, so that they cannot have regular stools. This costiveness arises from a variety of causes, such as diseased

liver, indigestion, torpor of the bowels from improper food being taken into the stomach, and always produces spasms or colic pains; for remember this, whenever your stomach and bowels are distended, you will become costive, your head will be confused and otherwise distressed, your spirits will become low and dejected, and the whole train of hypochondriacal feelings and sensations will haunt you. All these symptoms can be relieved by simple clyster made of equal quantities of milk and water and thrown up the bowels; for by this, your bowels will be relieved of their load, which always produces irritation, and your mind and feelings soon experience an agreeable change."

III

Physiological Factors in Colon Pertinent to Enemata

Survey of Function of Gut in Effect of What Enemata Would Change

In a study of the function of the gut as affected by enema, it is difficult to evaluate the material, as so many investigators have achieved different results in their experiments on the colon. Also, there were so many variations in the same experimental animals that workers could not interpret their findings. In many of the experiments the abdominal cavity had to be opened

to study the intestine, and after this was done, the gut did not react normally.

When fluid is injected into the rectum, it does not normally pass beyond the ileocecal valve. This has been noted under fluoroscopy when barium enemas have been given.

If an enema is given slowly, under low pressure, and there is no abnormality present in the colon, the fluid will reach the ileocecal valve in from ten to twenty minutes. If, however, the fluid is irritant, or if too much pressure is used, the ascending colon may go into spasm and reject the fluid. This is thought to be due to too rapid distention of the colon or sigmoid. If the flow of fluid is stopped for a while and the pressure is reduced by lowering the bag, the spasm will usually relax, and fluid can be injected until the colon is filled.

Alvarez (16), quoting Barchardt (17), who used a Vella segment in dogs, found that when he introduced dilute hydrochloric acid at the oral end, it produced a spasm, which traveled caudad so rapidly that it served to block the downward passage of the solution; but when he put the acid solution in at the caudal end, the contraction did not shoot orad. As a result, the fluid moved orad, and as it advanced, it caused local

contractions, which continued to push the fluid orad. Physiologic saline solution, which did not cause a spasm, could be made to flow more easily in the caudal than in the oral direction. The spasm was produced by stimulation of the nerve endings, since when he cocainized the mucosa of the segment, the acid solution ran caudad easily. According to Alvarez (16), the bowel is polarized so that waves travel much more easily in one direction than in another. He states that when water is injected into the caudal end of the gut, it will go orad only a short distance, and then will be pushed back down again. However, water can be pumped into a dog's rectum until it flows out of the mouth. In man, materials introduced by enema may, at times, pass through the ileocecal sphincter into the ileum. Such incompetence may permit the enema fluid to reach the duode-

One of the main functions of the colon is to conserve the water supply of the body. In some cases, constipation appears to be due to too great an efficiency in this condensor-like mechanism. When this condition is present, enemata can soften the feces and prevent constipation by giving the mucosa more fluid to absorb.

Normally, the colon is quiet for long periods of time. The cecum fills with feces, as does part of the

transverse colon. Todd (18) says that there are slow changes in the shape of the cecum, but he thinks these forces are inadequate to propel its contents. Under fluoroscopy, constricting rings can be seen, at times, to pass over the cecum, which have the effect of churning the contents. Although such movements are not seen normally, they do appear when the colon beyond is in a spastic state. From time to time, there is a mass peristalsis or peristaltic rush, which sweeps the contents from the cecum and pushes them over into the descending colon or sigmoid. This mass peristaltic action may take place no more often than two or three times during a twenty-four hour period. Usually there is no consciousness of this movement, and when the contents reach the sigmoid, the defecation reflex is initiated. The mass peristalsis is usually preceded by a rush peristalsis over the small bowel. Normally the descending colon and rectum are empty, except preceding and during the act of defecation. There appears to be a long, latent period between these rushes or mass peristalses. Alvarez (19) states that they are more easily initiated in the morning after a night's rest. At this time, the eating of food or drinking of a glass of warm water may initiate them. A warm or irritant enema will often

produce this mass peristaltic action.

For a varying distance from its commencement the large intestine is supplied with motor fibers from the vagus. Usually the vagal innervation terminates within the first half of the transverse colon. The rectum and the rest of the colon get their motor innervation from the pelvic nerves, the second, third, and fourth sacral segments. The sympathetics supply the inhibitory fibers to the entire colon. They come from the lumbar segments of the cord and reach the proximal part of the colon through the inferior mesenteric plexus. The fibers to the distal colon arise from the second and third lumbar segments. They pass through the lumbar splanchnic to the inferior mesenteric ganglion, and thence to the bowel by the so-called lumbar-colonic nerves and by the hypogastric nerve. Stimulation of the lumbar-colonic nerves causes relaxation of the distal colon. The inhibitory impulses to the colon apparently arise within the lumbar cord, for sectioning of the pelvic nerves relaxes the wall of the distal colon, and the animal subsequently experiences difficulty in emptying the bowel.

The intrinsic nerve plexuses of the colon have a distribution similar to that of the small intestine. Alvarez (19) states that, "The visceral regions keep a

primitive type of nervous organization; that the plexuses of Meissner and Auerbach have a conduction rate similar to that in the ganglionic plexus of the coelenterates (twenty centimeters per second)." He has also shown that the contractions of the circular coat of the bowel continue after it has been stripped from the longitudinal layer and from the submucosa as well; all ganglion cells are in this way removed.

Forces in Absorption

There are many forces that play a part in absorption. Some of these can be explained by physical laws, but there are other forces that are incapable of being explained, which must be due to some vital factors.

A fluid with its dissolved particles may permeate a membrane if the pores are large enough to allow all the molecules to pass through. This is filtration, and the rate depends upon the difference of hydrostatic pressure on the two sides of the membrane.

If two fluids are in contact with one another and both have the same hydrostatic pressure, a mixing will take place, which is known as diffusion. This action will occur between two solutions with a membrane between them, provided the membrane is permeable to the solvents and the dissolved substances. Osmosis is a term which

applies to the process of diffusion through membranes which are not equally permeable to all the molecules of a solution.

Surface activity also plays a part in absorption. The degree of permeability of a membrane is influenced by the amount of swelling; that is, by hydration of the colloids in the membrane.

Electric forces may play a part in absorption. Verzar and McDougall (20) state that the electrical charge of membranes has a great influence on their permeability. Neuberg (21) discovered that certain substances have the power to make water-insoluble substances water-soluble. He termed them "hydrotropic" substances and listed the following examples: benzoic acid, hypuric acid, salicylic acid, phthalic acid, benzene-sulfonic acid, and many others. There are special mechanisms in the intestine which bring insoluble substances into solution.

Many biological factors also affect the mechanism of absorption. Changes in the permeability of the membrane of the intestinal mucosa may inhibit absorption, make the membrane selective, or increase the rate.

Phagocytosis may be a factor in absorption. It may play a part in the absorption of fat, dyes, bacteria, and similar substances.

Nervous influences may affect absorption from the

intestine. This theory, however, has not yet been definitely proven.

The circulation of the blood must have a great influence on the rate of absorption. Barchardt (22) showed great changes in absorption from Vella's fistula of dogs, when the circulation was disturbed. Henning (23) found that iodine was absorbed by a stomach with an inflamed mucosa, but not by a stomach with a normal mucosa. Macht (24), on the contrary, observed that nicotine was less well absorbed by the inflamed mucosa. Only when there were open, bleeding vessels was the absorption of nicotine greater than normal.

Villous movements appear to have a considerable influence on the rate of absorption. King and Arnold (25) report that the villi become shorter, but not thicker, on contraction, which leads one to think that the central lacteal of the villus must be milked out with each contraction. These men suggest that the pressure on the central lymphatic of the villus is the normal stimulus for the pumping movements.

Chemical factors may also play a part in the stimulation of the villi. Kokas and Ludany (26) have shown that the common condiments used in cooking stimulate villous movement. Pepper, paprika, onion, cinnamon, caraway, clove, and garlic in dilutions of 1:10,000 to

1:25,000 of a one per cent extract, caused an increase in the activity of the villi; and dilutions of 1:1,000 increased the movements more than five times. The action was due partly to the number of villi contracting and partly to the speed of the rhythm.

The experiments of these men have shown that there must be a general mechanism for initiating the movements of the villi, apart from the local action of the chyme. They connected blood vessels of an excised loop of intestine in a fasting dog, in which there were no villous movements, to a carotid artery and jugular vein of a fed dog, in whose intestine the villi were pumping actively. After some minutes an intense villous activity began in the intestinal loop of the fasting dog. The converse observation was also made. A washed loop of intestine of a fed dog, showing active villous movements, was connected to the circulation of a fasting dog; shortly after the blood of the fasting dog reached the loop, the villous movements stopped. There seemed to be some factor in the circulation of a fed animal that stimulated villous movement which was lacking in a fasting animal. The authors suspected a hormone; so they injected four-tenths per cent hydrochloric acid into the duodenum of a fasting dog. After two to three minutes the villi began to move, and after ten minutes one-

hundred-eighty contractions per minute were counted. This action lasted thirty to thirty-five minutes. Testing the duodenal contents from time to time, the experimenters showed that the acid was neutralized after ten to fifteen minutes, which probably explained the dying off of activity after that period. They also found, using dogs as their experimental animals, that from a five per cent glucose solution with 1:1,000 of extracts of condiments, such as clove, garlic, onion, and paprika, absorption was increased by 13.6 to 25.6 per cent. Kokas and Ludany (27) also published a report which stated that the absorption of glucose in the dog's jejunum was increased twenty per cent by increasing the villous pumping by injecting four-tenths per cent hydrochloric acid into the duodenum.

Mechanical distention of the colon may affect absorption. According to Gardner (28), distention of the upper rectum may produce symptoms of severe intoxication, which immediately disappear as the pressure is released. Triedell (29) cites a case in which, when the colon was distended, there was a marked reaction, almost like shock, that was relieved with the gradual emptying of the lower bowel. Alvarez (16) believes these symptoms are due to reflex, rather than to toxic products. Dragstedt (30) has shown that if the intestinal mucosa is

damaged by circulatory changes, absorption of toxic substances is increased. Thus, if distention affects the circulation, the absorption of toxic substances may be increased.

There are many substances absorbed in the colon, of which water is probably the most important. The wall of the intestine is permeable to water, but of varied permeability for dissolved substances. The intestines are permeable to water in both directions, and it passes through them with great velocity. The free movement of water molecules through the cells of the epithelial wall and the blood vessels leads to a rapid mixing of water with the body fluids. Corry (31) states that from two to eight pints of rectal fluid can be given in twenty-four hours by utilizing a dripper with a side arm. The side arm allows flatus and fluid to escape, so the patient is comfortable with a tube in the rectum. A glass "T" piece is attached, with one branch going upwards. This serves two purposes: (1) it prevents a siphon effect from developing when the fluid from the dripper escapes out the side arm, and (2) it acts as a vent pipe for flatus. For rectal drip, Corry uses tap water with five per cent glucose. He runs it at the rate of eighty drips per minute for two hours

and then slows it to forty drips per minute. He claims that this method of giving fluid is useful in all post-operative cases except those on the rectum.

There are many conflicting experiments on the absorption of water by the large intestine. Most of the water taken orally is absorbed in the small intestine; yet the colon is able to absorb large quantities. According to Verzar and McDougall (20), the optimal condition for water absorption is a hypotonic solution of a substance which diffuses quickly into the mucosa. Whether or not water is absorbed depends on whether the solution remains or becomes hypotonic. This is true in the small intestine, but is not always true in the large intestine. In the large intestine most of the fluids have become isotonic, and isotonic aqueous solutions are filtered under hydrostatic pressure. These men think that the high hydrostatic pressure may fully explain why an aqueous solution which is isotonic and in diffusion equilibrium with the blood, is almost entirely absorbed from the large intestine.

Water, sodium chloride, glucose, and proteins have been the most studied of the substances absorbed by the large intestine. It has been proven that water and sodium chloride are easily absorbed in quite large

quantities. Mackenzie (32) gives a report of investigations performed with three of the more important substances which are commonly used in nutrient enemata, namely, glucose, normal saline, and predigested saline. He states that the largest number of investigations on absorption from nutrient enemata have been devoted to the problem of the absorption of rectal glucose; but a perusal of available literature reveals a welter of results and conclusions. He concludes from his investigations that glucose is absorbed from a simple solution in water introduced into the lower bowel. The amounts of glucose absorbed vary considerably. Concentrations up to 13.5 per cent were well borne, but definite signs of irritation followed the use of twenty per cent solutions. He was unable to determine the optimum concentration for absorption.

Rectal absorption of sodium chloride has been taken for granted for a long time. One of the most common procedures in postoperative surgical treatment is the administration of rectal saline, either by small, repeated enemata, or by continuous proctoclysis. In most of the modern textbooks of physiology, the statement is made that salts are absorbed by the large bowel; yet there appears to be little experimental evidence to support this claim. A search of the literature revealed

only four works dealing with the absorption of rectal saline. The above author concluded from his experiments that when normal saline is given rectally, it is easily retained and is nonirritating. He also did some experimenting with enemas of predigested casein (amigen) and concluded that non-protein nitrogen is absorbed quantitatively from such an enema. It is apparently metabolized in a similar manner to nitrogenous food taken orally.

Tallerman (33) reports that glucose injected into the rectum is oxidized and absorbed, but absorption into the large bowel is slower than in the small intestine. Many of the experiments recorded in the literature gave conflicting reports on the absorption of glucose by the large intestine.

Much work has been done on the absorption of carbohydrates by the small intestine. These studies show that in most animals there is more absorption of glucose in the jejunum and ileum. Absorption of carbohydrates is affected by the kinds of carbohydrates, the concentration, the pH of the intestine, and a hormonal influence. Glucose has a faster rate of absorption than other sugars, and there are vital factors affecting its absorption that are not understood. Verzar and McDougall (20) state that there is an esterification of the

carbohydrate molecule with phosphoric acid and that this seems to be an important step in sugar breakdown and synthesis.

There was very little in the literature on protein absorption by the large bowel. Most proteins have molecules which are too large to be absorbed. However, Korosy and many other co-workers (34) state that the amount of amino acids decreases toward the ileal end of the small intestine. In the higher parts, great quantities of such amino acids as glycine, gliadine, and leucine may be found, while in the cecum they may be absorbed up to ninety to one hundred per cent.

Fat is not absorbed by the large intestine, and in many instances it is irritable to the colon. Fats have to be digested by bile salts and lipase of the small intestine. Attempts have been made to give fats by rectum, but they are not absorbed unless they are regurgitated through the ileocecal valve.

Alcohol is readily absorbed by the colon. Hanzlik and Collins (35) investigated the absorption from isolated loops of different parts of the intestine and found that from the small intestine absorption is the same as from the stomach, and from the colon it is slightly quicker. Jukes (13) gave a patient rectal administrations of gin as taken orally in mixed drinks and found

that he soon became intoxicated. Neutral fats, such as lecithin and cholesterol from the bile, will reduce the absorption of alcohol.

Alkaline salts are readily absorbed by the colon. Wallace and Cushny (36) showed that monobasic salts of sodium, potassium, and ammonium are readily absorbed in the intestine, while polybasic salts are much more slowly absorbed.

Much work has been done on the absorption of iron. Iron is absorbed in the small intestine and also excreted in the small intestine and in the bile. Large amounts (as much as seventy per cent) are secreted through the epithelial cells of the large intestine and cecum, according to Jacobi (37). Water and salts may be secreted by the large intestine, but its normal function is to remove water. When a hypertonic solution is injected into the colon, the colon attempts to make the solution isotonic with the blood before absorption takes place; this is done by secreting water and salts into the solution. When diarrhea is present, much water and salts can be lost due to secretion in the colon.

IV

Physiological Effects of Enema

There are two main physiological effects from

enemata, which may be classed under physical and chemical effects. The physical conditions will be discussed first.

There are effects when thermal enemas are used. Cold water enemata are used to lower body temperatures in all types of fever. Steenrod (38) writes that tidal irrigations have proven satisfactory in lowering elevated bodily temperatures which have occurred after operations. The procedure may be used for any type of hyperthermia, whether produced by infection, trauma about the hypothalamus, or sunstroke. Tidal irrigation of the colon, when used alone, is capable of lowering bodily temperature several degrees, but is more effective when combined with cold sponge baths of the entire body and the application of ice bags to the axillary and femoral regions. A reservoir to the tidal irrigation apparatus is filled with water at thirty degrees Centigrade.

Hot enemata are used to kill parasites and to stimulate the colon in conditions where megacolon is present. Sir Thomas Lewis (39) showed that the sympathetics are relaxed at a temperature between forty-three and forty-five degrees Centigrade. The response of the colon to a temperature such as this is the same as the response to a local anesthetic. Triedell (29) thinks that by

using a hot saline raised to one-hundred-fifteen degrees Fahrenheit in enemata or colonic irrigations, it is possible to overcome undue tension that may be present in both the sympathetic and parasympathetic control of the colon. He states that under this comfortable heat both factors are probably afforded a period of activity with the handicaps temporarily allayed. Three cases of congenital megacolon were treated with hot daily irrigations at one-hundred-fifteen degrees Fahrenheit with good results. This heat treatment may afford more favorable opportunity for peristaltic activity of the colon and may even reduce it in size because of such activity. Garbat and Jacobi (40) show that hot saline in the upper rectum stimulates the liver, an important detoxifying organ, to greater activity. They have demonstrated that one-hundred-fifty cubic centimeters of one of several hot solutions start the flow of bile in a very few minutes, and the flow may last over an hour. Heat increases the circulation, and there is a direct relationship between peristalsis and increased circulation of blood in the bowel wall. Freyer and Gelhorn (41) show that high temperature above one-hundred-four degrees Fahrenheit stops parasympathetic action and suspends the production of acetylcholine, but does not stop the sympathetic action.

If the colon is distended by too much fluid or if the enema is given under too great pressure, the colon may go into spasm and prevent any more fluid from entering. There are several symptoms that follow distention. Some patients have the symptoms of autointoxication. They have headaches, nausea and vomiting, choking sensations, and holding of the breath. The symptoms vary with different individuals. Overdistention may cause rupture and death if the colon is diseased. One of my professors told of a case in which an infant was given an enema of two quarts of soap suds, and death resulted from the distention.

Cleansing enemas may affect the absorptive function of the colon. Wiltsie (42) states that during the process of softening and loosening mucus and old accumulations of fecal material, the absorption of toxic products in the bowel is increased. The patient often feels much worse after a colonic irrigation; he may have headaches, foul breath, or cramping pains. This may continue for a week, and then the patient will begin to improve.

Gaston and Williams (43) cannot condemn too strongly the routine use of the so-called "internal bath", the commercial colonic irrigation. Flushing the colon with large quantities of water distends the bowel, removes all of nature's normal lubricant--mucus, causes hyperemia,

and eventually results in the presence of abnormal quantities of mucus. These men believe the cleansing enema has its place in cleaning the colon for diagnostic barium enemas and in some cases of constipation.

Retention enemata are useful in restoring water balance following operations. There is usually some dehydration after an operation, according to Lenton (44), and the amount depends on the condition of the patient, the temperature of the operating room, and many other factors. He feels that there are times when other methods of giving fluids are not advisable. There is always the risk associated with the introduction of a foreign substance into the vascular tree with intravenous injection. Also, subcutaneous injection of fluids is effective, but unless novacain is used, it is painful and requires the constant attention of a nurse. An orderly or a parent can give an enema, if necessary, and it is much cheaper if the patient cannot afford a nurse.

Oil retention enemas are useful in softening dehydrated feces. Olive oil or mineral oil may be used in amounts up to one hundred cubic centimeters. They soften the feces and prevent the growth of bacteria and the absorption of toxic products. Many physicians feel that normal saline or plain water is just as effective

in softening hard fecal material and in relieving constipation.

The colon will absorb most substances which are soluble in water, although, in most instances, the colon absorbs more slowly than the stomach or small intestine. Most drugs which are absorbed by the stomach or intestine are readily absorbed in solution in the colon. Some drugs, such as digitalis and salicylates, which cause irritation of the stomach and intestines, are well tolerated and absorbed in the form of enemas by the same patients who cannot take them orally. Wood (45) made a study of giving sulfanilamide per rectum by enemata and found that it was well absorbed. He suggested using 1/200 grains of atropine, given hypodermically every four hours, when rectal fluids were being administered following an operation. This kept the bowel at rest, assisted in retention and absorption of fluids, lessened the pain, and inhibited the swallowing of air, thus reducing the distention. Mackenzie (46) also experimented in giving rectal suppositories with sulfanilamide and found that absorption was poor.

Some colons are more permeable or show more selective absorbability than others. Fawcett and Gens (47) reported two cases in which epsom salts were given in an enema. Both cases expelled the fluid with good

results as far as the constipation was concerned. Both cases immediately became limp, stopped breathing, and were in coma. One, a boy of two, was given artificial respiration and oxygen, venous injection of fluids, and blood transfusion; but he died a few hours later of respiratory failure. The other case, a woman aged twenty-three, was unresponsive in forty-five minutes after the enema was given. She was given one gram of calcium glucosote intravenously; ten minutes later, she was given another gram, and she revived.

Water balance can be restored by giving fluids per rectum. Corry (31) states that English surgeons often use a rectal drip apparatus in giving fluids per rectum following an operation. In this way, two to eight pints can be given in twenty-four hours. He uses tap water with five per cent glucose for his solution. Others have used normal saline solution with five per cent glucose. He writes that his patients are comfortable, and they get along very well without suffering from dehydration. During the war attempts were made to see if the colon could concentrate sea water and thus combat dehydration. Bradish, Everhart, McCord, and Witt (48) conducted some experiments on soldiers on a beach, under conditions such as would be found on a raft at sea. They gave no water other than sea water enemas and kept their

subjects exposed to the weather. By both subjective and objective observations, they were able to prove that the colon will not concentrate sea water and thus make water available to the organism. They showed that sea water will not alleviate the symptoms of water deprivation and that sodium chloride as contained in sea water is absorbed from the colon.

The chemical effects on the colon are so varied and numerous that it is impossible to discuss all of them. Many of the chemical effects are not understood at the present time, since the colon responds differently in different individuals and since the effects may vary in the same individual at different times. Also, different experimental animals react differently to drugs and stimulants, and it is hard to predict how human beings will react. Experimental studies on man are difficult to perform, and it is often impossible to interpret the results.

Alvarez (49) made a study of seventy-six substances and their effect on the motility of the stomach, intestine, and colon of rabbits. He found that the depressant effects of alum, carbon dioxide, cascara, senna, and sodium nitrate were usually more marked in the colon than in the small bowel. Mercuric chloride generally stimulated the colon less than the small intestine.

Sodium salicylate at times stimulated the colon more than it did the small bowel.

The effect of heat in stimulating the bowel is well known. Many substances in concentrated form will throw the bowel into spasm. The ancients and barbers in the medieval days often introduced such concentrated solutions into the colon that shock and even death were produced. Sodium chloride and soap suds have been used since ancient times as stimulating enemas. Epsom salts in solution has been used, but it is now considered dangerous due to the toxic reactions that some individuals show.

Many substances that stimulate the colon are also irritative. Heat about one-hundred-fifteen degrees Fahrenheit will irritate the colon. Proteins in any concentration may prove irritating, and many allergic reactions may result from injecting substances such as raw eggs and milk into the colon. Mackenzie (46), from his experiments, concluded that normal saline solution or glucose solutions under 13.5 per cent were not irritating when injected into the bowel. Gaston and Williams (43) claim that a large quantity of water, such as is used in colonic irrigations, is irritant, as it distends the bowel and causes hyperemia. Irritation is met by the colon with the production of large quantities

of mucus. These men maintain that an irritating enema causes the content of the ileum, with its essential vitamin and mineral elements, to be literally vomited through the colon. The administration by enema of chemical solutions--formerly much in vogue in the treatment of dysentery, ulcerative colitis, and other inflammatory processes--should be abandoned. They produce irritability and spasm of the colon, aggravating rather than arresting the pathological process. According to these men, the mucous membrane of the rectum and colon is intolerant to any liquid that contains even a small amount of soap. They have observed that many cases of colitis and anorectal disease showed an onset which coincided with the administration of soap suds enemas. By reason of the angry appearance of a diffusely hyperemic mucosa, many patients have received a diagnosis of proctitis and colitis following a soap suds enema in preparation for sigmoidoscopy. For a nonirritating enema, these workers believe that plain water, normal saline, sodium bicarbonate, oil, alum, and peroxide are the best.

Anesthetic enemas have been used since ancient times; in the Roman period, Celsus (8) wrote about them. In modern times, however, anesthetic enemas were not used much earlier than the outbreak of World War I. Following

this war, the ether-olive oil enema was quite extensively used, especially in obstetrics; but it was found to be quite dangerous, in that once it was injected and absorbed, the ether could not be removed. Different individuals absorbed the ether at different rates, and many physicians, therefore, were afraid to use it. In the last three or four years the avertin enema has largely taken its place. This anesthetic is quite safe, and the dosage is pretty well worked out. It is used quite extensively, as it is good for a short operation, and it lessens the amount of general anesthetic needed.

The antiseptic enema has been the subject of much controversy. Most physicians are of the belief that it is impossible to sterilize the bowel with a solution which is nonirritating to the colon. Some of the antiseptics which have been used are bichloride of mercury solution 1:1,000, phenol derivatives, such as lysol and zonite, and many others. Recently mercurochrome, metaphen, acriflavine, and others have been used.

Astringent enemas have been useful to contract tissue of the bowel. They are used in cases of bleeding or ulcerations of the colon. Silver nitrate, tannic acid, lead acetate, zinc sulfate, and alum are the agents usually used. The usual proportions for five hundred cubic centimeters of water are: six cubic

centimeters of silver nitrate, 1.8 cubic centimeters of tannic acid, and 1.8 cubic centimeters of alum. These enemas should not be retained long in the bowel. Thromboplastin injected into the bowel is also good. Since the advent of Vitamin K, there is not so much use for the astringent enema.

Attempts have been made to soothe the mucosa of the colon by the use of enemas. Corn starch, barley, oatmeal, and flax seed are the ingredients usually used. Opium, laudanum, and other drugs have been given with these for their sedative effect. Sedation can be accomplished with an enema if it is not possible to give the sedative orally or parenterally.

As has been mentioned previously, it is possible to give considerable nutrition by means of enemas. Sugars, minerals, and possibly vitamins can be given rectally. Many attempts at prolonged rectal feeding have been made, with poor results. Very little literature on rectal feeding, except for glucose, is available. Honey is one of the ingredients used in enemas since ancient times. McClendon, Cavett, and Johnson (50) had a case that refused to take food orally, and an experiment was performed to see how well the patient could be fed rectally. The patient had undergone an ileocolostomy, and it was finally determined that regurgitation from

the colon to the ileum could occur. A prolonged rectal feeding was maintained for two months, after intermittent trials for one month. Rectal food was prepared in the following manner. The following amino acids were dissolved in nine hundred cubic centimeters of N/10 sodium hydroxide: ten grams glutamic, ten grams aspartic, five grams alanine, one gram tyrosine, one gram phenylalamine, one gram creatine, one gram serine, one gram valine, one gram lysine, one gram tryptophane, one gram histidine, one gram proline, one gram hydroxyproline, and one gram cystine. These were warmed until the amino acids dissolved and then were mixed; two hundred cubic centimeters of a ninety-five per cent alcoholic solution of yeast-vitamin-Harris were added. One hundred grams of glucose were then added to the other ingredients. This mixture was sufficient for a ten-day feeding. On this mixture, the total nitrogen intake varied, averaging around 6.2, with urine nitrogen 3.6, and a gain of 2.6 per day.

Then a casein hydrolysate was made, refluxing casein for twenty-four hours with five times its weight of constant, boiling hydrochloric acid. The hydrochloric acid was then evaporated to near completeness, treated with decolorizing carbon, and neutralized with sodium hydroxide, making the sodium chloride content up

to N/10 and the nitrogen equivalent up to 3.7 grams in four hundred cubic centimeters. For several days the patient was given only water; at the end of this time he was losing 3.7 grams of nitrogen per day. He was then given four hundred cubic centimeters of rectal protein hydrolysate (3.7 grams of nitrogen), and the total eliminated was 3.9 grams of nitrogen, showing a very good utilization of rectal nitrogen feeding. The patient was then continued for two months more on this feeding, with the addition of twenty per cent alcohol, five per cent glucose, vitamin C, and cod liver oil. It was discovered that the patient could absorb twenty cubic centimeters of cod liver oil per day, presumably by regurgitating it into the ileum. The main source of calories, however, was alcohol, and loss of weight was then rather small--in fact, only a pound a week, as well as it could be determined by weighing the whole bed with the patient on it. This was the only article discovered in the literature on prolonged rectal feeding. There is very little literature on the administration of protein per rectum.

V

Clinical Use of the Enema

One of the most important uses of the enema at this

time is for diagnostic purposes. As soon as x-ray was understood, the idea of investigating the body cavities with some opaque substance was brought forth, and a search was made for such a substance. Barium and bismuth were the first substances used, and this was given in the form of a barium meal.

The idea of using an opaque substance in an enema was first tried in Germany; this practice soon spread to the rest of the world. According to Moore (51), the information furnished by the barium enema is so much more complete than that from a barium meal followed through the colon, that it is a waste of time to follow the barium meal further than the ileocecal valve. When a competent proctologist is available, a better diagnostic opinion can be reached by this specialist in proctoscopic examination, as far as the rectosigmoid is concerned. Unless the proctologist is an expert, a competent radiologist may furnish a better diagnosis or opinion of the rectum, rectosigmoid, and the rest of the colon as well.

The barium enema is very valuable in diagnosing tumors, diverticulitis, and obstruction. It is of little value in the diagnosis of chronic appendicitis. Henderson (52) states that the "classical" barium enema is

still the most generally useful method of examination of the large intestine.

The small intestinal enema was reported by Schatzki (53). A Rhefuss tube with a small, metal, olive tip was introduced into the duodenum. A thinner barium mixture was used than was used in the barium meal. A warm mixture was allowed to run in from a pint container. If there was a reflux in the stomach, poor results were obtained. However, in most cases, the barium reached the cecum in from fifteen to twenty minutes. Constant flow of the fluid was necessary. Any interruption delayed the examination markedly. Its advantages were that the small intestine was seen filled in its entirety and that the actual filling of the loops could be observed.

Stimulating enemas are frequently used in cases of poisoning or shock. These are usually made of black coffee, and in some cases brandy or whiskey is added to the enema. This is a very useful procedure to keep in mind if one does not have other equipment handy.

Narcosis can be produced by enemas. This is done by adding one gram of chloral hydrate or eight cubic centimeters of paraldehyde to barley gruel or cornstarch thinned to the proper consistency for easy injection.

For the relief of constipation, stimulating or oil

retention enemas are frequently used. Soap suds enemas are the ones most frequently ordered. More and more physicians are using normal saline and plain tap water for enemas, and the results are better, in most cases, than when more irritating ones are used.

Hot enemas are useful in reducing congenital megacolons in infants. There have been cases of cures reported. In most cases, however, there is not a cure, but there is improvement in the condition.

Basing his report on experimental studies in vivo and on clinical observations, de Rivas (54) believes that he has found a more efficient and a safer procedure for the eradication of parasites from the large intestine by hot instillations to the colon of 1:5,000 copper sulfate solution. He injects from five hundred cubic centimeters to two liters, and the temperature is regulated at forty-five to forty-seven degrees Centigrade and watched with a rectal thermometer. He makes injections two or three times a week for the first week, twice a week for the next two to four weeks, and once a week for two to three months longer. He believes that, when properly administered in suitable instances, the daily or twice-daily instillations of several liters of normal saline solution, at a temperature of one-hundred-ten degrees Fahrenheit, act favorably against the

Endamoeba histolytica trŏphozoites and perhaps against the cysts, cleanse the lower bowel, limit the quantity and kind of the so-frequently associated dysentery bacteria, and, to a patient already greatly shocked and dehydrated by frequent bowel movements, contribute fluid in such quantities as may enable him to weather the crisis.

Enemas are useful in preventing dehydration in infants and in postoperative cases. In these cases, normal saline or tap water are most frequently used. Emollient enemas were very helpful in dysentery or diarrhea cases before the discovery of the sulfonamides and penicillin.

VI

Technique of Giving an Enema

The patient should be placed on either side, with the hip raised by a pillow. This position allows the fluid to flow in with the least resistance, and there is less apt to be spasm of the colon. The patient never should take an enema in the sitting position. Ault (55) shows that in the sitting position, on the back, or on a bed pan there is danger of perforation of the gut. Carelessness, coughing, straining, sneezing, or a sudden change in position by the patient favors trauma, according

to him. Proctologists are all familiar with the abrupt and forceful "excursion" of the rectum or sigmoid against the distal end of the proctoscope when a patient coughs, sneezes, laughs, or suddenly strains during an examination. This "excursion" is greater in older individuals, who also have less visceral sensation in the middle and upper rectum than younger persons. This author also recommends the use of a soft rubber tip for the apparatus. He suggests using a twenty-eight F. male catheter and slipping it on the end of the hard rectal tip. He reports the following injuries from enemas given with too much pressure, hard tips, or the improper position. They are perforation of the anal canal, injury and perforation of the rectal mucosa, perforation into the pelvic fascial spaces, and perforation into adjacent viscera and organs. Ballon and Goldbloom (56) report that, "The most essential factor in production of injury is the use of a hard nozzle, usually of bone or hard rubber and several inches in length. Since such nozzles are usually attached to syringes or rubber bulbs, the pressure with which the enema is given becomes another important consideration. The injury may be caused by first sucking the rectal mucous membrane into the opening of the tube. The relatively insensitive rectum will cause little or no complaint on the

part of the patient, and hence the enema fluid may be injected into the lacerated rectum. Irrevocable damage may thus result, for it may be hours or days, as has been noted by others, before the patient may complain of pain, which by this time is usually deferred either to the abdomen or rectum or peritoneum." In giving an enema, never use a syringe or a hard tip.

The enema is best given using a bag or funnel which is not raised over eighteen inches above the anus. The enema fluid should not be allowed to run in too fast at the start. It is better to insert the enema tip not over two inches and to start the fluid very slowly at first. If the colon goes into spasm, the fluid should be stopped, and there should be a few minutes' pause. Then the fluid should be started again. In this way, the fluid may be taken in until it reaches the ileocecal valve. Care should be taken not to distend the colon by giving too much fluid. In most cases, the fluid should be given at body temperature unless given for reducing hyperthermia or to attempt to kill parasites or reduce megacolons.

Conclusions

1. Barium enemas are a very useful procedure for

diagnosing lesions of the colon.

2. Dehydration can be successfully treated by frequent normal saline or tap water enemas.

3. Constipation can be successfully relieved by normal saline or tap water enemas.

4. There is considerable clinical evidence that soap suds and other irritating enemas do more harm than good.

5. Considerable nourishment can be given per rectum in the form of five per cent glucose solution.

6. Serious injury to the rectum can result from ignorance, using too much solution, having the patient in an incorrect position for taking an enema, or using too much pressure or a hard enema tip.

Bibliography

1. Montague, J. F.: History and appraisal of the enema, Med. Rec. 139: 91-93, 142-194, 245-297, '34.

2. Russell, W. K.: Colonic irrigation. New York, Wm. Wood and Co., 1932. Pp. 5-21.

3. Friedenwald, J. and Morrison, S.: The history of the enema with some notes on related procedures, Bull. Hist. Med. 8: 18-114, 239-276, (Feb.) '40.

4. Chabas, F.: "La medecine des anciens Egyptiens", melanges Egyptologiques, Paris, 1862. Ch. V, p. 66. Cited by: Friedenwald, J. and Morrison, S. (3).

5. Herodotus: Book II, Ch. 86 and 87. Trans. by A. D. Godley. Vol. I. New York and London, Loeb Classical Series, 1926. Pp. 371-373.

6. Hippocrates: Trans. by W. S. Jones. Vol. II. New York and London, Loeb Classical Series, 1923. Pp. 60-79.

7. Adams, F.: The genuine works of hippocrates. Vol. I. London, The Sydenham Society, 1849. Pp. 85, 95, 103, 289, 314, 332.

8. Celsus, A. C.: On medicine, in eight books. Trans. from Targa's edition. By Alexander Leer. Vol. I. London, 1831. Ch. XII, pp. 108-110.

9. Lillico, J.: The use of enemata by primitive peoples, Ann. M. Hist. 3: 55-59, (Jan.) '41.

10. Gatinaria, M.: "De curis aegritudinum particularium noni almansoris, etc.", Lyon, 1532. Cited by: Friedenwald, J. and Morrison, S. (3).

11. de Graaf, R.: "De virorum organis generationi inservientitius, de clysteribus et de usu siphonis in anatomia", Leyden and Rotterdam, 1668. French translation: L'Intrument de Moliere, Paris, 1878; the translation was published anonymously, said to have been done by the surgeon Cusco. Cited by: Friedenwald, J. and Morrison, S. (3).

12. Nordenskiold, E.: The American Indian as an inventor, J. of Roy. Anthrop. Inst. Gr. Brit. and Ireland 59: 279-290, '29.

13. Jukes, E.: Indigestion and costiveness in 1831, J. Internat. Col. Surg. 1-2: 203-206, (Oct.) '38.

14. Jordon, P. D.: The clyster in early medical practice, Ohio State M. J. 40: 441-443, (May) '44.

15. Gunn, J. C.: Domestic medicine or poor man's friend. Madisonville, Tenn., 1834. Pp. 497-500. Cited by: Jordon, P. D. (14).

16. Alvarez, W. C.: An introduction to gastro-enterology. Third edition. New York, Hoeber, 1940.

17. Barchardt, W.: "Gibt es Nervose Chemorezeptoren in der Dunndarmschleimhaut? Zugleich ein Beitrag uber die Einwirkung der Psyche auf Tonus und Bewezung des Dunndarms nach Versuchen und Hundri mit Vella Fisteln", Arch. f. d. ges. Physiol. 215: 402-426, '26-'27. Cited by:Alvarez, W. C. (16), p. 20.

18. Todd, T. W.: Behavior patterns in alimentary canal. Baltimore, Williams, 1930. Pp. 1-79.

19. Alvarez, W. C.: The mechanics of the digestive tract. New York, Hoeber, 1922. P. 13.

20. Verzar, F. and McDougall, E. J.: Absorption from the intestine. London, Longman's, 1936. Pp. 1-254.

21. Neuberg, C.: Biochem. Z. 76: 107, '16. Cited by: Verzar, F. and McDougall, E. J. (20).

22. Barchardt, W.: Pfluger's Arch. 219: 213, '28. Cited by: Verzar, F. and McDougall, E. J. (20), p. 52.

23. Henning, N.: Dtsch. Arch. klin. Med. 166: 205, 167, 343, '30; 168: 374, 445, '32. Cited by: Verzar, F. and McDougall, E. J. (20), p. 52.

24. Macht, D.: Absorption of drugs through normal and pathological mucous membranes, Amer. J. Physiol. 105: 67, (July) '33.

25. King, C. E. and Arnold, L.: Activities of intestinal mucosal motor mechanisms, Amer. J. Physiol. 59: 97, (Febr.) '22.

26. Kokas, E. and Ludany, G.: Arch. Exp. Path. Pharmak. 231: 20, '33. Cited by: Verzar, F. and McDougall, E. J. (20), p. 64.

27. Kokas, E. and Ludany, G.: C. R. Soc. Biol. 119: 283, '35. Cited by: Verzar, F. and McDougall, E. J. (20), p. 69.

28. Gardner, E. L.: The indications for the examination of the colon, Minn. Med. 14: 992-995, '31.

29. Triedell, A.: Congenital megacolon treated by daily hot irrigations of normal saline solution at 115 degrees, Minn. Med. 21: 175-178, (Mar.) '38.

30. Dragstedt, C. A.: Intestinal obstruction, J. of Exper. Med. 30: 109-121, '19.

31. Corry, D. C.: Rectal administration of fluid, Brit. Med. J. 2: 13, (July) '42.

32. Mackenzie, J. W. A.: The nutrient enema, Archiv. Dis. Child. 18: 22-27, (Mar.) '43.

33. Tallermann, K. H.: Rectal absorption of glucose, Quart. J. Med. 13: 356-362, '20.

34. Korosy, and many other co-workers: 1907. Cited by: Verzar, F. and McDougall, E. J. (20), p. 227.

35. Hanzlik, P. J. and Collins, C.: Qualitative studies on gastrointestinal absorption of drugs, Am. J. Physiol. 3: 397-421, '11.

36. Wallace, G. B. and Cushny, A. R.: Preliminary notes on action of saline cathartics, Amer. J. Physiol. 1: 411, 1897.

37. Jacobi, C.: Arch. Exp. Path. Pharmak. 28: 256, 1891. Cited by: Verzar, F. and McDougall, E. J. (20), p. 110.

38. Steenrod, E. J.: Tidal irrigation of the colon to reduce hyperthermia, Staff Meet. Mayo Clin. 12: 618-621, (Sept. 29) '37.

39. Lewis, T.: The blood vessels of the human skin and their responses. London, Shaw and Sons, 1927. P. 143.

40. Garbat, A. L. and Jacobi, H. G.: Secretion of bile in response to rectal instillations, Arch. Int. Med. 44: 455-464, (Sept.) '29.

41. Freyer, A. L. and Gelhorn, E.: Heat principles of autonomic nervous action, Amer. J. Physiol. 103: 392-399, (Febr.) '33.

42. Wiltsie, J. W.: Common causes of failure from colonic therapy, Arch. Phys. Ther. 19: 1140-1144, (July) '30.

43. Gaston, C. D. and Williams, H. B.: The enema, its uses and abuses, Med. Assoc. State of Ala. 9: 143-145, (Nov.) '39.

44. Lenton, G. I.: Postoperative rectal injection, J. S. Carolina M. Assoc. 33: 291-292, (Dec.) '37.

45. Wood, E. H.: Sulfanilamide per rectum, Canad. M. J. 44: 592-594, (June) '41.

46. Mackenzie, J. W. A.: Absorption of drugs from the rectum, Arch. Dis. Child. 18: 28-33, (Mar.) '43.

47. Fawcett, D. W. and Gens, J. P.: Magnesium poisoning following an enema of epson salt solution, J.A.M.A. 123: 1028-1029, (Dec. 18) '43.

48. Bradish, R. F., Everhart, M. W., McCord, W. M., and Witt, W. J.: Some physiological aspects of the use of sea water to relieve dehydration, J.A.M.A. 120: 683-685, (Oct. 31) '42.

49. Alvarez, W. C.: Differences in the action of drugs, J. Pharm. Exp. Ther. 12: 171-191, (Aug.) '18.

50. McClendon, J. F., Cavett, J. W., and Johnson, R.: Prolonged rectal feeding, J. Lab. Clin. Med. 22: 1000-1002, (July) '37.

51. Moore, C.: The barium enema as the most accurate procedure in the diagnosis of the colon, Med. Ann. Dist. Col. 7-8: 324-325, (Oct.) '38.

52. Henderson, N. P.: The value of the opaque enema and its modifications, Brit. J. of Radiol. 17: 140-149, (May) '44.

53. Schatzki, R.: Small intestinal enema, Am. J. Roentgen. 50: 743-751, (Dec.) '43.

54. de Rivas, D.: Treatment of colon infestation by irrigation and hot instillations, Arch. Phys. Ther. 19: 756-761, (Dec.) '38.

55. Ault, G. W.: Perforation of the rectum with enema tips, Tr. Am. Proct. Soc. 40: 203-213, '39.

56. Ballon, H. C. and Goldbloom, A.: Serious injury to the rectum from improperly administered enemas, Canad. M. A. J. 44: 592-594, (June) '41.