INTESTINAL CONCRETIONS

AND THEIR

CLINICAL MANIFESTATIONS.

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Intestinal Concretions and their Clinical Manifestations.

INTRODUCTION.

The clinical manifestations of intestinal concretions have afforded a considerable field of research and of much interesting speculation.

In the author's surgical practice he has had an admittedly favourable experience of enteroliths and intestinal sand—that of two enteroliths, one faecolith, three concretions in the appendix and five cases of intestinal lithiasis. This experience is the more singular when it is realised that the number of cases of this kind, or at least the number of recorded cases, is not large. More particularly in the matter of *true* enteroliths is the literature on the subject somewhat scanty.

The purpose of this thesis is to draw attention to an aspect of the subject of enteroliths which, as far as is revealed by a careful search of the literature, has not been previously commented upon.

Whilst the treatment of obstruction is a matter for pride in modern surgery, nothing, in but a few cases, can be done to prevent its development. The particular type of true enterolith to which special attention will be directed in the following pages assumes, therefore, an importance more than its mere numerical incidence would warrant in that, if the contention of its origin be correct, it is definitely preventable.

CLINICAL.

Obstruction or obturation of the intestine may be caused by concretions of varying origin :—

(i) Foreign Bodies,
(ii) Gallstones,
(iii) True Enteroliths,
(iv) Faecoliths and
(v) Faecal Accumulations.

This thesis is concerned more particularly with obturation caused by *true* enteroliths. Faecal accumulations are definitely outside its scope—these probably cause obstruction more frequently than any other intestinal concretion ; obstruction from this cause occurred in 69 of the 669 consecutive cases of intestinal obstruction in the London Hospital during 13 years as recorded by Barnard. The sex incidence was about equal and the operation mortality about 3 per cent. Obstructive symptoms are not due solely to the mass but also to the atonic state of the bowel muscle, which is often the primary cause of the condition. Forsyth gives an interesting account of a series of these cases ; he suggests that the masses usually lodge in the cul-de-sac of the caecum and give rise to an active process of sulphuretted hydrogen formation. He draws a clinical picture of sufferers from the condition—in a " quiet and uneventful life, they bear the marks of sorrow and anxiety in their faces and deportment. Emaciation is distinct ; aged before their time, they look gloomily on everything and everybody." He suggests that these accumulations may play a large part in the production of lunacy. His treatment consisted of high and persistent enemata and large doses of olive oil.

Outside the bounds of this thesis is the alleged obstruction by masses of intestinal worms and by intestinal casts. Foreign literature contains suggestions of the blocking of the bowel by the ascarides and as a diagnostic indication stresses the characteristic movement which may be felt in such a mass. It appears improbable that obstruction may be caused in this manner and reliable evidence is somewhat lacking. It seems to be equally improbable that obturation may be caused by intestinal casts. Harley reports a case in a woman, aged 28, in which obstruction was occasioned by four fibrinous concretions. A possible explanation of such cases may be that constipation is a marked symptom in those who suffer from membranous colitis. In the train of constipation often come flatulence, colic, nausea and sometimes vomiting—such symptoms, if severe, may simulate a partial obstruction. The evacuation of the bowels causes amelioration of the symptoms, while the improvement may be attributed to the removal of the membranous casts which would accompany such a motion.

In all segments of the gut intestinal calculi and concretions are to be met with. Some statistics tend to show that they are more commonly encountered in the small bowel while other observers suggest the colon. Gant, who in 1901 made a collection of all the cases he could find—54 in number, finds that they are more frequent in the rectum than in all other sections. Before proceeding with a detailed consideration of the various types of concretion it might be well to summarise the cases of Gant—the largest collection that appears to have been made by any one observer.

35 were found in the rectum,
5 in the sigmoid,
4 in the ileum,
3 in the jejunum,
3 in the caecum,
3 in the transverse colon and
1 in the descending colon.

35 occurred in females, 19 in males. The age incidence ranged from 6 to 92 years :—

3 under 8 years,
6 between 14 and 25,
4 between 25 and 40,
15 between 40 and 50,
9 between 50 and 60,
9 between 60 and 70,
7 between 70 and 80 and
1 over 80.

The average age was approximately 50 years. The number of calculi varied from one to 38 ; only one stone being found in 41 cases, while in 13 there were two or more. The composition of the concretions

in 8 cases was not reported,
in 5 principally bile and faeces,
in 5 the nuclei were fruit stones of the plum, cherry and peach,
in 5 bile-pigment and cholesterin,
in 6 cotton fibres, hairs, etc.,
in 1 oat husks,
in 1 magnesium, bismuth and potassium,
in 2 sodium chloride, potassium sulphate and calcium sulphate,
in 13 the phosphates, sulphates and carbonates of ammonium, magnesium and potassium, while
8 resembled these 13 with, in addition, salts of calcium.

Of the 10 stones reported as containing calcium salts 7 were found in the rectum and one in the transverse colon, the descending colon and the sigmoid. A commentary on the rarity of intestinal concretions is that while Gant reported three cases of his own the

other 51 cases were reported by 49 surgeons, only two of whom reported two cases. The Hunterian Museum of the University of Glasgow contains an interesting collection of a hundred specimens of gastric and intestinal concretions but with the exception of one hair ball and some of the oat-seed concretions they are all probably from the lower animals.

Foreign Bodies. Any substance which can resist the action of the gastric and intestinal secretions may be described, in this connection, as a foreign body. For descriptive purposes foreign bodies may be classified as (1) articles which on account of their shape will readily pass through the intestine without hindrance; examples of this class are coins, pebbles, marbles, fruit stones, Murphy's buttons and kindred objects: (2) substances, sharp or irregular, which become easily arrested in their course through the alimentary canal. Instances of these objects have been many ; they comprise nails, needles, pins, pieces of porcelain or metal, plates of artificial teeth, pieces of bone and many others. Gant reported the removal from the rectum of a concretion composed of tooth-picks and faeces.

Foreign bodies may be swallowed accidentally or intentionally or during fright. There are instances of burglars and thieves who have swallowed coins and valuables to avoid detection ; jugglers may swallow objects either accidentally or by intent; many strange substances have been recovered from lunatics and hysterical girls. Dressmakers, carpenters and cobblers are particularly liable to the accidental swallowing of pins and nails,

The museum in London of the Royal College of Surgeons contains many specimens of foreign bodies removed at operation or passed *per vias naturales*—the glass drop of a lustre and a vulcanite tooth-plate are examples, while there is one specimen of a mass of pins weighing nearly one pound which was removed from the duodenum. Marshall reports another such case. The classical and most remarkable instance was reported in the British Medical Journal of 1894 under the description of " the human ostrich "—this patient had swallowed pipes, string, coins, pieces of glass and crockery and many other articles.

These foreign substances are apt to become arrested particularly in the stomach, the duodenum, the lower end of the ileum, the caecum and the rectum ; of these the caecum probably affords the commonest lodgement. More often than do gall-stones or enteroliths, foreign bodies give rise to chronic peritonitis or constriction by cicatricial bands at the site at which they become lodged. Obstruction may arise in this way or by the gradual accumulation around the foreign body of faecal matter or inorganic salts.

Even after the passage of the foreign body death may ensue from ulceration or stenosis. The occasions on which foreign bodies cause obstruction must be extremely

rare—in a record of 669 consecutive cases of intestinal obstruction at the London Hospital in 13 years only one case was due to a foreign body. In the great majority of cases the object passes uninterruptedly in from two to twenty days—one case has been reported of the passing of a foreign body after as long as ten years—with as a rule few symptoms such as a mild colic, a little nausea or it may be slight vomiting ; in cases where the passage is delayed the symptoms are usually referred to the right iliac region since the ileo-caecal valve and caecum are the common sites of arrest. While it is uncommon to find a complete obstruction of the normal bowel relatively small objects may obstruct where the lumen of the intestine has been narrowed by cicatricial bands or by pressure from without. Pins and needles may perforate and may wander to parts of the body far remote from the original situation ; they may give rise to an abscess from which they may pass to the surface of the body or into some hollow viscus, while yet others become surrounded by fibrous tissue which may become so dense as to simulate a malignant growth.

(3) The third class of foreign bodies are those which, while in themselves relatively small and harmless, exhibit a tendency to become matted together and thus form considerable masses. These include oat husks, fibres, finger nails, hair, fruit skins, wool and even the fine down of fowls.

Bezoars, or stones composed of impure gallic acid and a substance to which the name ellagic acid has been given, are sometimes found. The Hunterian Museum contains a considerable number of specimens but it is improbable that these are of human origin. These stones derived their name from the Bezoar goat in which they were commonly found. For many centuries bezoars enjoyed a therapeutic reputation of almost miraculous power. The earliest records are from the beginning of the tenth century when decoctions of them were employed by the Arabian physicians as a specific antidote to poisons. Indeed the method of preparation of the powder of Bezoar is to be found in the London Pharmacopœia as late as the year 1746. So famed did they become as a charm against the plague that they became expensive and were often mounted in gold and other precious metals.

Hairy concretions are masses or balls of hair matted together and often reaching the size of an orange. They are common in the stomach and intestines of horses, cows, cats and other animals that lick their coats. In the human subject, occasionally as the result of insanity when hair is chewed and swallowed, these masses occur—sometimes like balls, sometimes sausage-shaped, sometimes single, sometimes multiple. They have been found in the stomach, the small intestine, the colon, the rectum and at times in more than one segment of the gut. A specimen in the museum of the Royal College of Surgeons weighs 5 lbs. 3 ozs. and consists of a mass of black human hair which was removed from the stomach. Anderson records a case in a ploughman, aged 39 years ; the concretion, which measured 19½ cm. in length by 24cm. in circumference, was com-

posed mainly of faecal and vegetable matter bound together by fine hair and with a capsule and nucleus of calcium phosphate. Porridge had been his staple article of diet and he had been in the habit of biting and swallowing hairs from his moustache. Gant reports a case in which the mass was the size of a hen's egg while faecal matter accumulated around it until, reaching the size of an orange, it completely obstructed the rectum. Cases are on record of hair balls reaching the rectum by the degeneration of ovarian dermoid cysts.

Avenoliths, or oat-stones, have been described from time to time ; it is said that they occur more frequently in Scotland than in other countries owing to the larger use made of coarse oatmeal. They usually occur singly and are of small size but Harley has reported twenty oat-stones being passed by one patient at different times. The collection in the Hunterian Museum consists of fifteen specimens but many of these are probably from the lower animals. They were light brown in colour, on section looked like felt and floated in water. Leichtenstern states that it is rare for more than two to co-exist and that they may vary in size from a chestnut to an orange.

Many other types of concretions have been described ; Maylard had a case of obstruction due to a concretion of gooseberry skins ; during the Irish famine of 1846 it is said that concretions were found which resembled avenoliths but proved to consist of the skins of potatoes ; Ferguson and Reuter found a concretion weighing 3½ ounces which consisted of vegetable matter and salts around a nucleus of a large hazel-nut ; the museum of the Royal College of Surgeons contains a concretion as large as a hen's egg, of down taken from a boy who was in the habit of licking his fingers while plucking fowls. Khalofoff removed two very light concretions measuring respectively 6 and 4½ cm. in diameter composed of the fine fibres of some tree with an admixture of rye and oat scales—the patient had habitually eaten bad bread made from adulterated flour ; Harley reports two cases, one composed of undigested animal matters of various kinds densely felted together and the other consisted solely of starch ; Coerr removed a concretion the entire cut surface of which presented coarse husks, seeds and the stems of plants—it weighed 2½ lbs. ; while Down records a case of fatal obstruction in a mat-maker caused by the impaction in the lower ileum of a concretion of densely packed cocoa-nut fibres—in his opinion it had probably been formed in the stomach and then passed into the bowel.

Occasionally other foreign stones make their appearance in the intestine—these have formed in other organs and by pressure, ulceration and necrosis have found their way into the bowel. Pancreatic calculi may by this way, or by the duct, reach the gut but they are small and unless augmented by faecal accumulation are not likely to give rise to serious symptoms. Gant has recorded an urinary calculus, four ounces in weight, half in the bladder and half in the rectum—he removed it by perineal section. It is said that prostatic calculi also may reach the bowel ; there is no record of such a case and being small they are unlikely to cause any serious annoyance.

Gall-stones. Judging from the reported cases it appears that gall-stones are the most frequent cause of intestinal calculi in the human subject. During the last nine years all the cases of intestinal obstruction due to calculi admitted to the Sheffield Royal Hospital have been cases of gall-stones ; Leeds General Infirmary has had only one case in ten years ; St. George's Hospital, one case in 15 years ; while in 669 consecutive cases of all varieties of intestinal obstruction in 13 years in the London Hospital 15 have been due to gall-stones. The incidence of obstruction by gallstones is thus one in 45 at the London Hospital but Gibson places it as high as one in 17. Its sex incidence is about the same as the incidence of gallstones in the gall-bladder, namely about five times more common in women. The average age is stated—

by Treves to be 57,
by Rolleston as 62 and
by Eve as 64 years.

Fairly frequently small gallstones are passed without giving rise to any symptoms—these probably reach the intestine by the common bile duct. Sometimes they have caused obstruction by acting as a nucleus as in the case reported by Treves, when the calculus reached $1\frac{1}{2}$ inches in diameter by adhesion of magnesia and faecal matter. A similar case, in a lady of 82 years, was recorded by Eliot. This case is of interest as being associated with a strangulated umbilical hernia, while the gallstone was finally discharged through an abscess opening through the abdominal wall. Other gallstones causing obstruction are reported ; one $4\frac{1}{2}$ by $2\frac{1}{4}$ inches by Smith and Fye ; one of $3\frac{3}{8}$ inches in circumference, blocking the lower jejunum, by Baly ; 4 by $3\frac{1}{2}$ inches in circumference by Abercrombie ; while Murchison reports the obstruction of the ileum by one which was one inch in length. Marshall records the passing of a gallstone $2\frac{1}{2}$ by $1\frac{1}{2}$ inches. As in the case of other calculi a relatively small gallstone may cause obstruction in a bowel the lumen of which has been narrowed—Garrett had such a case where the constricting band was of omentum ; the case ended fatally. Numerous specimens are to be found in the various museums ; in the Royal College of Surgeons, one measuring 2 by $1\frac{1}{4}$ inches which blocked the ileum, and the largest stone on record which weighed five ounces ; while one $2\frac{1}{2}$ inches in length is to be found in the College of Medicine Museum in Newcastle.

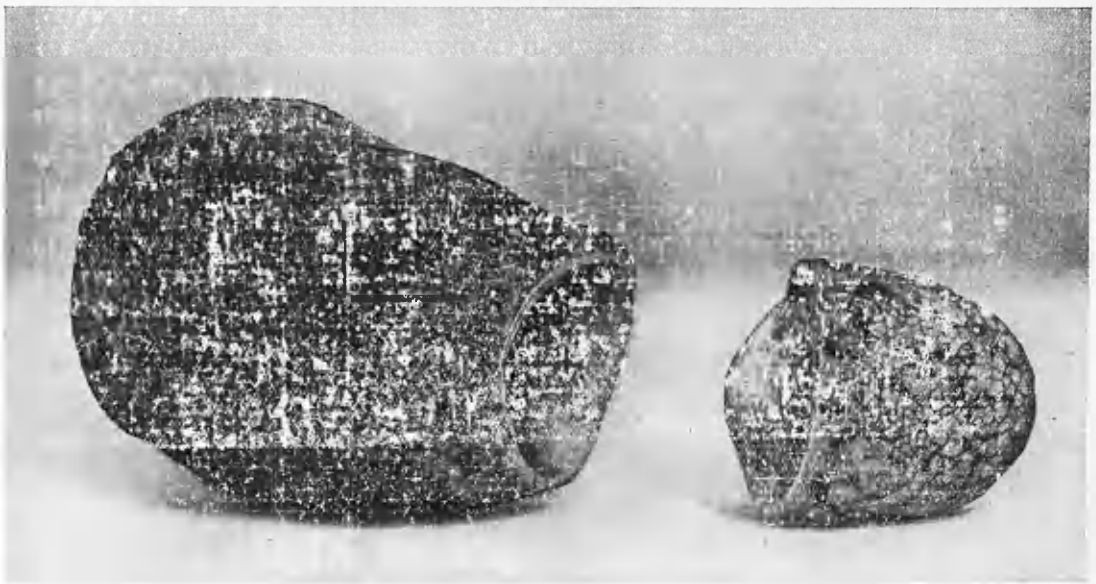
Treves, Grey Turner, Gant and others all appear to be agreed that it is most improbable that a stone which has succeeded in negotiating the common bile duct could give rise to obstructive symptoms on reaching the intestine. They consider that adhesions are formed around the gallbladder, then ulceration and finally the stone passes by a fistula either into the duodenum or the colon. Grey Turner reports a fistula between the gallbladder and the stomach ; the actual vomiting of gallstones has been reported, whilst there have been cases of the ulceration of gallstones into the urinary bladder and even into the uterus. Even when a stone traverses the bile duct, Grey Turner considers

that it probably ulcerates from the ampulla directly into the bowel. The routes by which the intestinal tract is entered were investigated by Courvoisier in 36 autopsies ; seven stones appeared to have travelled by the common bile duct while in the other cases there was a fistulous opening from the gallbladder—in25 instances this was to the duodenum, in two to the duodenum and colon, while in one it was to the colon and in one to the ileum.

It is reported that in 32 cases collected by Leichtenstern the duodenum and upper jejunum was the site of impaction in 10 cases, the middle ileum in five and the lower ileum in 17. Courvoisier's figures of 53 cases show the ileum to be the site in 65.4 per cent., the duodenum and jejunum in 21.4 per cent., the ileo-caecal valve in 10 per cent. and the sigmoid flexure in 2.4 per cent.

In passing it may be observed that Mayo Robson associates gallstones with intestinal obstruction in three other connections—(1) volvulus of the intestine due to gallstone colic or to the passage of a calculus ; (2) stenosis of the bowel due to adhesions around the gallbladder, and (3) obstruction dependent on local peritonitis around the gallbladder occasioning paralysis of the gut.

The author has been fortunate in receiving his published works from Professor Grey Turner who has had the rather unusual experience of ten cases. In one of these cases the stone weighed 4,800 grs. (Fig. 1) and the clinical picture before operation was



"Giant Gallstones" (Actual Size) **Fig. 1.** *Reproduced by Courtesy of Professor Grey Turner.*

one of obstruction due to a malignant growth. In his opinion pain usually ceases with the relief of tension when the gallbladder begins to leak into the bowel and the gradual extrusion of the stone is unattended by symptoms. In his ten cases of gallstone ileus only two were in the large bowel and then had probably ulcerated directly into that organ for if a stone passes the ileocaecal valve it will probably pass through the colon without interruption. It is interesting to note that in two cases there was an absence of previous gallstone illness while in a third it was indefinite. Since the stone which causes obstruction is usually of large size and does not pass by the duct, jaundice as a symptom is not to be expected.

The stones are composed largely of bilirubin pigment and cholesterin. A stone not unlike a gallstone in appearance was removed by Phillips of Bradford Royal Infirmary ; Raper reported it to consist of fatty acids 10.85 per cent., neutral fat and unsaponifiable substances 5.52 per cent., unconjugated bile acids (choleic acid) 72.5 per cent. and food residues 8.4 per cent. The gallbladder was free and normal. Choleic acid has been detected in the gallstones of the ox but never in human stones, thus there is no evidence that the gallbladder was the seat of origin. It was suggested that such deposits of choleic acid may have been mistaken for true gallstones in some of the reported cases.

Faecoliths. A patient showing signs of incomplete obstruction came under the author's care. A laparotomy was performed and several coils of intestine were found to be matted together by adhesions—these were broken down by gentle manual manipulation. At the centre of the mass was discovered a faecolith measuring one inch in length by half an inch in diameter ; on section it was found to be composed almost entirely of faecal matter concentrically arranged and with no foreign nucleus. When a portion was burned practically no ash was left. The stone had obviously ulcerated through the bowel wall. The patient made a perfect recovery.

These concretions are usually light brown in colour and differ from impacted faeces by their stony hardness and smaller size. They are oval in shape and usually smooth on the surface but may be faceted when there is more than one stone. It is extremely rare for intestinal obstruction to be due to this cause ; in the 13 years at the London Hospital quoted above only one was reported.

Morris operated on a woman of 68 years after making a diagnosis of malignant disease ; the stone, as reported by Raper, was 14 per cent. moisture, 7.3 per cent. fat and cholesterin while the residue was entirely faecal in nature ; the whole stone weighed 33.4 grs., measured 5.5 by 3.8 cm. while in parts the specific gravity was less and in others greater than unity.

Childs recorded a faecolith, interesting on account of the somewhat rare pre-operative diagnosis ; the X-ray showed a dense shadow which resembled a bladder calculus.

A faecolith the size of a lawn-tennis ball and weighing six ounces was removed by Cripps from the rectum. It consisted of concentric layers of faecal matter and no nucleus in the form of a foreign body could be discerned. The mucous membrane showed patches of comparatively superficial ulceration.

Enteroliths. For the purposes of description true intestinal stones will be classified into three sections : (1) those produced by a prolonged course of certain drugs, (2) concretions composed largely of inorganic salts resulting from chronic inflammatory processes in the wall of the gut and (3) enteroliths which do not appear to have been previously described and which, in the author's view, are progressively accumulated by the ingestion of large amounts of calcium salts in hard drinking water.

(1) Calculi which owe their origin to drugs taken as medicine are usually of bismuth ; they are often black masses of putty-like substance and occur in patients who, for diarrhœa or enteritis, have taken from ten to fifty grains of bismuth three or four times daily. Acute intestinal obstruction has resulted. Gant reports one colotomy for these bismuth concretions which would have filled a two-pint measure ; in his opinion such enteroliths are mostly to be encountered in the rectum. Nineteen distinct calculi were removed from a girl of seven years at an autopsy by Hadden ; they varied in size from an orange pip to the size of a large cherry. The chemical composition was shown to be—

Tricalcium phosphate	...	67.65 per cent.,
Calcium carbonate	...	1.22 per cent.,
Nitrogenous matter	...	23.47 per cent. and
Moisture	...	7.41 per cent.

This child had, for several months, suffered from chronic diarrhœa, dependent on intestinal catarrh, and had been treated with chalk in various forms and bismuth. Mentin mentions a concretion found post mortem in the caecum which had occasioned no symptoms. The patient had taken much subnitrate of bismuth for chronic intestinal catarrh and the stone was found to consist of 85 per cent. subnitrate of bismuth and 15 per cent. organic substances.

Other stones are frequently composed of magnesia. A man aged 53, as recorded by Schroeder, suffered for years from meteorism and obstinate constipation ; he passed a calculus weighing 62 grains and composed of carbonate and phosphate of lime with a considerable admixture of red oxide of iron and gradually lost all his symptoms. He had had a long course of treatment by Marienbad-Kreuzbrunnen water which contains chalybeates in the form of carbonate of iron. Hutchinson removed a concretion about 15 inches in circumference from the rectum ; it was hard and rough like an oyster shell on the surface and was composed of magnesium and iron with some earthy matters and many thousands of strawberry seeds. For thirty years she had taken large doses of carbonate of magnesium and iron but it is interesting to note that this treatment had been discontinued for twelve years previous to the operation and that her only discomfort

had been constipation for the preceding eleven years. Very slow formation is thus indicated and the further interesting point that the stone remained dormant or with only insignificant symptoms for years.

Other medicines have been reported as capable of forming enteroliths ; two cases of salol calculi are recorded by Treves and one by Marshall, who quotes similar cases of Bradbury and Brossard. A patient of Erichsen, after much intestinal irritation, passed a concretion composed of gum benzoin ; the patient was a singer and had taken pills of the drug with the object of improving the voice.

(2) In this sub-division fall the enteroliths which are composed largely of inorganic salts and are formed owing to abnormal conditions associated with the bowel wall. It is rare to encounter these calculi and still more rare for obstruction to be caused by them. In the 669 consecutive cases of intestinal obstruction admitted to the London Hospital in 13 years only one was due to a true enterolith ; in the long series of 1,152 cases collected by Leichtenstern there were only 20 examples of enteroliths ; in recording a series of 35 cases, Taylor states that he did not find one to be due to an enterolith ; Gant operated on only one case of true enterolith ; owing to the kindness of Professor Graham Simpson, the author has been able to ascertain that in the last nine years not one case of obstruction by an enterolith has been admitted to the Sheffield Royal Hospital. In a review of the literature from 1919 to 1927 Jeck and Wehrbein found only five cases. The relatively small number of the reported cases makes any generalisation as to sex and age incidence a matter of great difficulty ; it is also extremely difficult to state the most frequent site of impaction with any certainty. Treves states that they are most commonly met with in the colon and especially in the caecum and rectum, more rarely in the ileum and diverticula ; and that they occur most often in young adults. While in the 20 cases mentioned above the incidence in males is three times as great as in females. It might appear, however, that women of or just beyond middle age are the most frequent sufferers. Closely associated with, and to some extent throwing light on the formation of enteroliths is the subject of intestinal sand which will be considered later.

These calculi are hard and stone-like ; grey or pale brown in colour when cleaned of faecal matter. On section they present a concentric arrangement of chalk-like or dirty white layers ; in some of them these layers alternate with others of a brownish colour. They may be rounded but are more often oval in shape and may be polished by the peristaltic movements of the intestine. Chemically the majority appear to consist of phosphate of lime or magnesia or of triple phosphates together with a certain amount of animal matter and probably some cholesterin.

Most of those who have reported cases of true enteroliths appear to be agreed on certain constant factors necessary for the production of this kind of calculus. From the various writings these conditions may be summarised as follows :—

(a) A nucleus of organic matter around which the salts are deposited, such as epithelial cells, fruit stones, gallstones, husks, foreign bodies and masses of animal or vegetable hairs or fibres.

(b) Some cause which produces arrest—a saccule or diverticulum is considered necessary by many; the appendix and cul-de-sac of the caecum are suggested as affording this necessary condition.

(c) Substances capable of adhering to the nucleus are necessary to the production of the concretion. It is suggested that lime salts adhere by the process of crystallisation. The origin of these salts has been the subject of much investigation and speculation. It has been shown that milk contains more lime than an equal volume of lime water and it has been suggested that the milk taken in large quantities for the relief of enteritis may in fact have much to do with the production of enteroliths. The more commonly accepted view is rather that the bowel is the organ of excretion for calcium salts and that in certain abnormal conditions of the bowel, such as chronic catarrh, the salts may be derived from the copious fluid which results from such a condition.

(d) The nucleus, by irritation, is believed to start a chronic enteritis which provides an organic element and a colloid menstruum in which crystallisation may take place. Bacterial decomposition of proteins produces ammonium phosphate which, in the presence of magnesium or calcium, produces triple phosphates.

These stones vary greatly in size ; according to Winterstein the largest enterolith ever found weighed 1,500 grams. Treves states that they usually occur singly and seldom exceed the size of a chestnut. Gant reports the evacuation of 32 stones which collectively weighed two and a half pounds in a case of Niemeyer ; Monro had one where 12 calculi were evacuated. Hector Mackenzie reports a concretion weighing 497 grains in a woman of 70 years—this was composed of ammonio-magnesium phosphate and had for a nucleus a broken incisor tooth. Watson reports a stone measuring $1\frac{3}{8}$ by $1\frac{1}{8}$ inches.

Interesting indications regarding the use of the X-rays in diagnosis are given in the cases of Anderson and of Jeck and Wehrbein. In the former case the X-ray revealed the cause of attacks of colic recurrent over a period of eighteen years, while in the latter an enterolith, measuring $8\frac{1}{2}$ by $7\frac{1}{2}$ cms., was shown by a shadow which resembled a urinary calculus and it was only after a cystogram and a barium enema radiogram had been made that the diagnosis was established.

So far, the most thorough investigation of the subject of true enteroliths appears to have been made by Williams and his account contains some very interesting suggestions. He considers that these cases have not been fully described in many instances and too often are dismissed as " faecal concretions," " faecal accumulations " or " enteroliths " ;

he regards them not of a simple nature but as manifestations of some abnormal condition of the excretion of the intestine and its appendages. He cites rhinoliths, gallstones, appendix concretions, enteroliths and intestinal sand and shows that there is a close similarity in their chemical composition and suggests a common factor—this factor he believes to be the abnormal excretions by the mucous membrane. Sir William Macewen has demonstrated the presence of a secretion or excretion of the appendix during life. Williams quotes a case of Paul's where the enterolith was the size of a tangerine orange, and composed of a bright yellow pultaceous mass held together by a stroma of vegetable material around a raisin. The principal constituent was shown to be fat and cholesterin 31.4 per cent. The nature of the fat precluded its formation from the administration of olive oil and it was not a gallstone. In another case,where the calculi largely contained saturated fat,the continuous administration of olive oil caused the passing of concretions to cease and mucous to disappear. He refers to the three cases in which Moynihan operated for gallstones but found only a peculiar condition of the gallbladder wall, which was studded and impregnated with a white deposit. Further he states that the presence of calcium pigment stones in the gallbladder is not associated with an increase of calcium in the bile. From these considerations he suggests that gallstones may be due to a lithogenous catarrh and are probably the product of the gallbladder wall and not of the bile, and further that the presence of cholesterin in some intestinal concretions may indicate the possibility that some of the large " so-called " gallstones may have been formed in the intestine itself. An interesting suggestion is that symptoms may be produced in the gallbladder before the formation of gallstones, and that these may be the cases where cures have been reported from the administration of olive oil, which as an unsaturated fat influences fat metabolism and so minimises the excretion of the abnormal compounds.

Intestinal Sand. Intestinal sand has been described as " true " or " false." False sand has little to do with the subject of this thesis. It is composed of the remains of vegetable foods which have resisted the action of the digestive juices. Intestinal sand appears to be of singular infrequency in this country although Continental and American literature contains many reports of such cases. Its occurrence was reported by Robin in 1873, in which year other cases were recorded by Laboulbéne while Delépine and Shattock brought it to the notice of the Pathological Society of London in 1890 and 1897. The flesh of pears appears to be particularly liable to produce false intestinal sand; such cases have been reported by Marcet and Garrod, who found pear sand to be pale in colour and coarsely granular and when burned left only 1.76 per cent. of inorganic residue. Shattock's case was one of a woman aged 45 years who was particularly fond of pears ; after an aperient she would pass as much as two ounces of the sand which was composed of cells lying in natural clusters like those in the fruit of the pear. Talbot records a similar case in which the organic matter accounted for 95.8 per cent. of the sand, which was found in chains corresponding in arrangement and shape to the cylindrical cells in the milk-ducts of the banana.

During the late war sand diarrhœa was common among the soldiers on the sands dunes of Belgium but this sand is rather in the nature of a foreign body.

True Intestinal sand occurs in women with twice the frequency with which it occurs in males and the average age is over 35 years. In most cases there is the co-existence of muco-colitis and paroxysmal colicky pain, attended by flatulent distension and vomiting, is a marked feature. Duckworth and Garrod describe a case with the analysis of the sand which owed its colour to urobilin. The sand contained 12.4 per cent. moisture, 26.29 per cent. organic matter, while the inorganic salts amounted to 61.31 per cent. The inorganic part was largely composed of calcium phosphate. In this case there was a marked gouty family history and they are inclined to the view that the sand represented an irregular manifestation of this disorder. Mongour found calcium carbonate to be the principal constituent in one case but calcium phosphate, or tricalcic phosphate, was the main component of cases described by Mathieu and Richaud, Thomson and Ferguson and Marquez and Biaggi. Bedford reports intestinal sand in a lady, aged 44 years, who suffered from muco-colitis and had a marked history of gout. In this case the proportion of inorganic matter was rather smaller but it was largely composed of calcium phosphate. Chalk-stones in gout contain sodium urate and phosphate and urate of calcium ; he suggests that the urates are excreted by the kidneys while the calcium is excreted by the intestine. His conclusion is that the condition is closely related to gout and favoured by a milk diet.

While in false sand the inorganic constituents rarely exceed 2 to 3 per cent., in true sand the proportion is from 28 to 70 per cent. Bokenham considers that the sand is not formed in the jejunum but much lower down, possibly in the neighbourhood of the appendix. Crombie states that intestinal sand in India is of much more frequent occurence than in this country and he considers that colic varies directly with the quantity of sand passed.

Kobert and Koch found calcium, magnesium and phosphoric acid in the material which accumulated in the empty and cleansed colon of a patient with a faecal fistula. Garrod is of the opinion that the sand is formed in the intestine, while the richness in urobilin and poverty in unaltered bile-pigment suggests its formation in a region in which conversion of the bile-pigment into urobilin is somewhat advanced—probably in the upper colon.

Thus it would appear that this type of sand, closely associated with the enteroliths above considered, is composed very largely of calcium phosphate and the product of an abnormal intestinal mucosa.

(3) The third and last class of true intestinal stone has now to be dealt with ; it consists of concretions composed very largely of calcium carbonate. The author's series

of cases consists of two intestinal concretions, three appendix calculi and five cases of intestinal sand.

In 1923 a woman, 51 years of age, drew attention to a white gritty looking sand in the motions ; she was in excellent health and the bowels were acting with their usual regularity. The stools were formed and the sand could be seen speckled on the surface. There was not, nor had there been, any suggestion of enteritis. The same year a very similar case occurred ; this time the patient, a woman of 60 years, was about to undergo an operation for fibroids of the uterus. In the routine inspection and examination of the excreta, which preceeded operative interference, sand was noticed in the liquid faeces—liquid on account of an aperient which had been administered. The sand was identical in appearance with that noticed in the previous case. Notes were entered on the findings but unfortunately no further investigation was made and the matter to a large extent passed out of mind until recalled by the next case.

Early the following year the author was asked to see in consultation an old lady who had recently celebrated her seventy-second birthday. When first seen she was unconscious, the eyes sunken and the skin bathed in cold perspiration. The pulse was thready and uncountable, the temperature sub-normal and the condition in general that of impending dissolution. A bowl by the bedside contained the foul-smelling faecal vomit of which the pillow bore traces. The abdomen was very little distended and the most remarkable feature was that, while she was surrounded by an intelligent family, no previous history bearing on the case could be elicited. She had felt rather unwell about forty-eight hours previously ; had complained of colic which had returned intermittently, and had vomited on many occasions. With typical independence and stubbornness she had resolutely declined to summon medical aid and indeed her doctor had been notified only two hours before the present examination. An examination of the abdomen revealed the presence of a tumour in the middle line considerably below the umbilicus ; it was movable to a limited extent and felt hard although the small amount of distension prevented further investigation. What appeared to be the obvious diagnosis, a malignant growth, was made and the relatives informed that a fatal issue seemed inevitable. An operation in her present condition seemed almost impossible and while mentioned was not pressed. Her son, however, decided that she must have whatever chance of recovery an operation offered and she was rushed to hospital. On opening the lower abdomen by a medial incision, the author was surprised to find that the mass which had been palpated was entirely in the lumen of the gut. The mass was gently forced upwards into a dilated segment of the ileum which was incised over the mass and the enterolith removed. The bowel was closed by two layers of satures, the peritoneum approximated and the remaining layers closed by through-and-through silkworm gut satures. No diverticulum or pouch was seen at the operation. Intravenous salines were administered before the patient was removed from the table and her condition gradually showed signs

of improvement. Since the unexpected dénouement is always interesting, it may be recorded that she made an uninterrupted recovery, was discharged from hospital at the end of a fortnight with very definite instructions which she chose to ignore and was seen at the gate of her house on the twenty-first day after the operation. The old lady was seen four years later in very excellent health. Not even "leading" questions could obtain any admission of previous illness and it would appear to be beyond all doubt that she had never suffered from anything approaching enteritis.

The enterolith, of which the chemical analysis will be given later in the section on Biochemistry, consisted largely of calcium carbonate and was of a dirty grey colour in appearance. It was oval in outline, rather the shape of a hen's egg, measured $2\frac{3}{8}$ inches in length by $1\frac{3}{4}$ inches in diameter and weighed 1,605 grains. On section the cut surface was white and laminated with layers of a brown substance, which proved to be of faecal matter, alternating with the white (Fig. ii). There was no organic nucleus. Microscopically the inorganic matter was practically amorphous.

Fig. 2. Enterolith of Calcium Carbonate, removed by the Author. (Actual size.)

The three cases already described presented features which did not harmonise with recorded cases of intestinal concretions and nothing in the diet or the habits of the patients appeared to suggest any solution. Shortly after this the author had occasion

to fill a kettle which had been used continuously for some years and the similarity of the thick layer of fur inside the kettle to the appearance presented by the cut surface of the enterolith suggested a possible explanation.

It would serve no useful purpose to describe in detail all the cases in the series since they presented almost identically the same features. Other three cases of intestinal sand were noted; the composition varied but little from the large concretion; two occurred in women and one in a man all past middle life. In other respects the clinical history tallied with the history in the two previous cases of sand; no discomfort had been experienced and there was nothing which suggested enteritis, while all were of a costive nature.

A second enterolith of small size, measuring $\frac{5}{8}$ by $\frac{3}{8}$ of an inch, was passed by a woman of 47 years of age. The composition of the stone and the history of the case were again very much the same as the previous cases. The intestinal tract, when examined by a barium series, failed to show any diverticulum orabnormal structure; the radiograms were, in every respect, normal except that the meal took rather longer than the average time to reach the rectum.

In three cases in which the author performed appendicectomy he found concretions in the lumen of the appendix; two were in women aged respectively 29 and 37 and the third was in a man aged 41 years. The concretions bore a very remarkable similarity to the two enteroliths both in appearance and composition. In one the mucosa was thickened and inflamed but in the other two it appeared almost normal to the naked eye and it is to be presumed that the symptoms were due to the efforts of the organ to discharge the concretions. Short has estimated that concretions are present in 15 to 20 per cent. of cases of appendicitis and in 10 per cent. of appendices which appear normal—this estimate would appear, however, to be rather high.

Ord in 1897, reported an instance of a similar enterolith; it was passed by a patient suffering from severe intestinal pain and vomiting almost amounting to obstruction. With the calculus was passed a large quantity of fine white sand; there was no nucleus and the stone consisted almost entirely of carbonate of lime in an amorphous form. Neither diet or medicines could be held responsible. It may be that this enterolith belonged to the class here described but it is to be regretted that the record of the investigation is insufficient to draw a definite conclusion.

Some interesting problems emerge from this series of cases; both the stomach and colon have been suggested as the place of origin of true enteroliths but it would appear that the ileum is the more likely place. In view of the experiments reported in the next section it is very improbable that stones consisting of the carbonate of calcium could be formed in the acid stomach and higher parts of the intestinal tract. The colon is fitted to propel hard masses while the ileum, by virtue of the valvulæ conniventes, is

specially adapted to retard the progress of the fluid contents. Other conditions help to slow the progress and so give time for the formation of the concretions ; some degree of constipation is invariably present while the lower ileum is the most dependent part of the canal. Adhesions from appendicitis and from salpingitis would have an effect in the same direction. In the large enterolith described by the author the interlarding of the inorganic salts with layers of faecal matter presupposes the growth of the stone in the intestine itself.

The age and sex incidence also may be capable of explanation on the same lines. In women, especially in those past middle life, owing to more sedentary habits and the greater tendency to neglect the calls of nature, greater stasis of the intestinal contents is to be expected.

Finally, the sudden appearance of the symptoms of acute intestinal obstruction without previous warning requires elucidation. It has been believed that the final attack of obstruction is due to the sudden displacement of the enterolith from a pouch or saccule into the lumen of the gut. In the cases described it does not appear that the existence of a diverticulum or pouch is probable. Another explanation has been that the inflammatory swelling of the mucosa completes the obstruction ; against this view is the fact that an intestinal calculus interferes but little with the blood supply of the wall of the gut and at least in the last class there is little or no inflammatory change. The author examined the mucosa where the large enterolith had become impacted and found neither inflammationn or ulceration; it thus seems improbable that the presence of the concretion excites inflammatory changes in the mucosa at least not until a very late stage. Although carefully examined, the excreta of the bowel in all the cases of the author failed to reveal any trace of mucous, pus or blood. Conversely, it appears probable in the other class of inorganic concretion that the enteritis is the cause and not the effect of the condition ; this view appears to be in accord with the conclusions of investigators on the subject. In the author's opinion the concretions of calcium carbonate originate and increase in the ileum ; the slow growth of the stone allows of the gradual adaptation of the bowel to the unusual condition. The work of the intestine thus continues until the stone reaches a large size and becomes more continuously applied to the intestinal mucosa, then a sudden irritation produces a spasm of the muscle and obstruction is complete. Irritation of the mucosa and enteritis would cause colic, vomiting and other symptoms ; the absence of these conditions with carbonate of lime enteroliths means that the final catastrophe is unheralded by warning signs.

BIOCHEMISTRY.

There was no common factor in the diet or habits of the patients to account for the production of the carbonate of lime enteroliths; only the drinking water was common to all cases. The water was clear, without colour or smell, contained no deposit and was neutral in reaction. On analysis it gave the following result in parts per 100,000—

Lime (CaO)	14.91	Chlorine (Cl)	5.32
Magnesia (MgO)	8.70	Sulphuric Anhydride (SO_3)	27.81
Iron (Fe)	(Nil)	Nitric Anhydride (N_2O_5)	2.50
		Carbon Dioxide (CO_2)	1.32

or combined thus:-

Calcium Bicarbonate	43.09
Magnesium Sulphate	25.05
Magnesium Bicarbonate	1.27
Sodium Nitrate	3.92
Sodium Sulphate	18.42
Sodium Chloride	8.78

As grains of calcium carbonate per gallon the temporary hardness was 19·25 and the permanent hardness 14.61, making a total hardness of 33.86. This would appear to offer a satisfactory explanation of the source of the lime.

A piece of the large calculus was ground up and placed in a desiccating apparatus and then burned to an ash; it was found that it consisted of :-

Moisture,	11.03 per cent.
Organic matter of faecal origin,	23.71 per cent.
Inorganic salts,	65.26 per cent.
	100.00

The inorganic part proved to be almost entirely of calcium carbonate as the following analysis shows—

Calcium Carbonate	93.14 per cent.
Calcium Phosphate	3.42 per cent.
Magnesium Carbonate	3.44 per cent.
	100.00

The other enterolith and the three appendicular concretions markedly resembled the large stone varying slightly only in the proportions. One point should be mentioned; the calcium phosphate had a somewhat larger per centage in the appendix concretions, the average being 7.1 per cent. It will be seen that the appendix concretions, like the others, were composed mainly of calcium carbonate.

The three cases of intestinal sand showed a very noticeable similarity to all the other specimens, and indeed differed mainly only in the relative amounts. The average of the three analyses was —

Calcium Carbonate	86.88 per cent.
Calcium Phosphate	5.78 per cent.
Magnesium Phosphate	7.34 per cent.
	100.00

A sample of the water was concentrated by evaporation and treated with normal gastric juice for one hour at 18 degrees centigrade. It was found that the lime existed mainly in the form of calcium chloride with some calcium carbonate. An attempt was made to treat this with the secretion of the lower small bowel but owing to the difficulty in obtaining sufficient juice and the absence of proof of its normality the results were unreliable. As far as could be judged the calcium chloride had disappeared and the calcium existed only in the form of the carbonate.

The microscopic examination showed that the inorganic salts existed in a state almost amorphous.

The succus entericus, according to Noel Paton, owes its alkalinity to the presence of sodium carbonate ; it would appear reasonable to suppose that the bulk of the lime is acted upon by the intestinal secretions and formed into the carbonate. Part of it may be saponified and the calcium soaps, by reduction, would also produce calcium carbonate ; such an action is seen in the production of atheroma and in the calcification of degenerate glands. It is suggested that the production of enteroliths of calcium carbonate from the calcium ingested in the drinking water is mainly of a chemical nature and that the aid of an abnormal mucosa, as in the case of other calculi, is unnecessary. This view appears to be further confirmed by the amorphous character of the salts ; this would suggest that the precipation has taken place from a thin fluid. The abnormal mucosa supplying a colloid in the case of the phosphatic calculi favours crystalisation and a spherical form of the salts.

The softening of the water on a commercial scale reduced the total hardness to 15.42 degrees and the result of the analysis (expressed as parts per 100,000) was as follows:-

Calcium Bicarbonate	17.40
Magnesium Bicarbonate	16.41
Sodium Nitrate	3.92
Sodium Sulphate	26.63
Sodium Chloride	11.71
Sodium Bicarbonate	7.50

DIAGNOSIS AND PROGNOSIS.

Diagnosis. It is unfortunate that no classical clinical picture can be drawn—the symptoms vary with the number, size, shape and position of the enterolith in the intestinal tract. Thus the diagnosis is to be arrived at usually by a process of elimination.

Small concretions usually pass without trouble and, it would appear reasonable to suppose, in many cases without notice. At most they may scratch or irritate the anal canal during evacuation. Larger stones, especially those with sharp edges or rough surfaces, may cause irritation of the intestine and thus incite spasm and intermittent colic accompanied, it may be, by constipation and retention of gas. These stones may produce lancinating pain when passed and post-defaecatory pain may be marked. Still larger enteroliths, either by themselves or by the accumulation of inspissated faecal matter around them, may give rise to obstruction, either partial or complete.

As Cowan and Coerr have pointed out, pre-operative diagnosis is rare and most records show that the enterolith has been discovered on the operation or on the post-mortem table.

The pre-operative diagnosis depends on a consideration of various factors which may be dealt with in five divisions, namely :—

(1) Previous History,
(2) Symptomatology,
(3) Physical Examination,
(4) Laboratory Investigation and
(5) Radiograms.

It would appear that the family history has little significance unless it be in certain types of enteroliths where a gouty history may be a factor. As regards the sex and age incidence it has been said that two-thirds of the cases occur in females and that middle or later life is the usual period.

(1) Previous History.

(a) The swallowing of foreign bodies such as fruit-stones may arouse suspicion.

(b) Food containing a large proportion of indigestible residue, or certain drugs may have been taken over long periods ; peculiar habits such as biting the nails or chewing hair may be discovered and the water supply of the district should be enquired about.

(c) A previous history of attacks suggesting gallstones, urinary or pancreatic calculi may be obtained.

(d) Reports of repeated, and progressively severer, attacks of colic, of obstinate constipation or of constipation alternating with diarrhœa may be of value.

(e) The patient's observation of a small lump in the abdomen which gradually increased in size may suggest the cause.

(2) The symptons of the present illness.

If a clinical picture could be drawn it might be of a woman in middle life who has suffered for years from periodic attacks of abdominal pain attended by slight distension, vomiting and constipation. A concretion, in process of formation in the ileum, gives rise to recurring attacks of colicky pain, vomiting and diarrhœa usually coming on from two to three hours after a meal. As it increases in size there are repeated mild obstructive attacks—constipation, moderate distension and sometimes visible peristalsis with persistent vomiting. Digestive disturbances and abdominal soreness may be present. Before the stone reaches its full dimensions it appears to act as a ball-valve causing intermittent partial obstruction ; later, when it becomes impacted, it may occasion complete obstruction. Perhaps the most characteristic symptom is the persistent attacks of incomplete obstruction. But it must be remembered that obstructive symptoms are rare and occur very late.

In the earlier attacks the symptoms are rather those of enteritis—colic, diarrhœa, a variable degree of vomiting and it may be of pyrexia. Later the symptoms may suggest ulcerative enteritis ; while later still, especially in cases of sharp foreign bodies, localised or generalised peritonitis or abscess formation. Ulceration may produce local tenderness, pyrexia and the frequent evacuation of fluid stools containing pus and blood while rapid wasting may be marked.

Whilst the concretion is making its way alorg the ileum the pain is usually referred to the umbilicus. In the colon, the symptoms may be those of ulcerative colitis and the patient may waste progressively ; it is said that the concretion is more often palpable in this situation than when it is in the small bowel. When the rectum has become occluded there may be constipation or diarrhœa alternating with constipation, tenesmus, incessant calls to stool, a sensation of weight and fulness in the rectum and the passage of blood and pus in the motions. Many enteroliths, including those specially described in this thesis, may not give rise to any symptoms until those of obstruction. In other cases it is remarkable that symptoms may be present for many years without disturbance sufficiently grave to necessitate medical attention. The symptoms appear to be so insidious in their onset that it is common for medical aid to be summoned only when there is obstructive evidence.

In obstruction, due to an enterolith, abdominal distension is usually not so marked as in other forms unless peritonitis co-exists. The same is true of tenderness and rigidity of the muscles. Shock and collapse also are less marked and longer delayed probably because the vascular and nervous mechanisms of the bowel suffer little interference. One other point is worth attention ; the final impaction of the stone may be determined by the administration of a strong purgative and so the clinician may be misled by the passage of several motions after the onset of pain and vomiting.

(3) Physical Examination.

In some instances, although not by any means in all, a mass may be palpated in the abdomen—often in its lower part. This tumour is of extreme hardness which helps to distinguish it from faecal masses which are indentable on pressure. New growths—both benign and malignant—may sometimes be excluded by the mobility of the mass while its lack of tenderness, unless accompanied by ulceration, is in marked contra-distinction to the condition produced by acute or chronic inflammation. The swelling is oftenest to be discovered in the right iliac region. When it is situated in the rectum or lower sigmoid flexure, its presence may be demonstrated by a digital examination of the rectum or vagina or use may be made of the sigmoidoscope.

(4) Laboratory Investigation.

The chemical analysis and microscopic examination of the stools of a patient may reveal intestinal sand or the presence of mineral salts which may point to the existence of certain types of concretions. Occult blood may mark the entrance into the bowel, by ulceration, of gallstones or calculi while ulcerative enteritis will cause mucous, blood and pus to be present.

An indication that the passage of the intestinal contents is being unduly delayed may be obtained from the increase of potassium indoxyl sulphate and potassium skatoxyl sulphate—derivatives of indol and skatol—in the urine.

It may well be, however, that the importance of laboratory tests in this condition lies more in the negative findings.

An analysis of the drinking water may be of value.

(5) Radiograms.

Perhaps the only pathognomonic sign of enteroliths is to be found by the use of the X-ray and its employment in all doubtful conditions would be a wise procedure. An enterolith usually offers considerable obstruction to the passage of the rays. The large stone removed by the author, if placed over a film and the rays passed through the whole thickness of the abdomen, shows a definite and fairly dense shadow. In cases where the shadow may be ambiguous, cystograms, cholecystograms, barium series and barium enemata may assist in the differential diagnosis.

With regard to gallstones, it is sometimes possible to diagnose this condition by the unusual grouping of symptoms it presents. The clinical picture is that of a woman, obese and past middle age, suffering from an acute obstruction of the small intestine, of sudden onset and with rather less than the usual distension. If the stone has ulcerated into the duodenum there is intermittent and colicky pain, localised in the epigastrium for a day or two. As the concretion passes to the jejunum the pain is referred to the

umbilicus. The most marked symptom is vomiting, dark in colour and containing blood and bile. Irritation of the duodenum from the sudden entry of the stone accounts for the early symptoms. The vomiting is continuous, of large quantity and causes severe discomfort to the patient. The blood probably comes from the raw edges of the fistula and is increased by the venous congestion set up by the vomiting. As the stone passes lower in the small bowel vomiting becomes a less prominent symptom but is often more green in colour. Later still, when impaction occurs, vomiting recurs and becomes faecal. The unusually large volume of the vomited matter probably illustrates the general rule that vomiting is the more profuse the higher the obstruction.

The patient may have suffered for years from occasional exacerbations of an epigastric pain which may have been thought to be due to dyspepsia. Later ulceration and localised peritonitis around the gallbladder may have aggravated the pain and caused it to have become more diffuse. In other cases few, if any, symptoms have existed prior to the sudden attack for which the patient has sought medical aid. In the nine cases investigated in the London Hospital, one had never had any symptoms, four had dull dyspeptic pains, two recurrent spasms with vomiting while two had had colic associated with jaundice. In the eight cases tabulated by Mr. Grey Turner a history of gallbladder illness was absent in two and indefinite in a third, while in a later case the patient had had no gallbladder pain until twelve months previous to the acute obstruction. Gallstone ileus is not usually preceded by attacks of jaundice; as has been shown gallstones sufficiently large to produce obstruction do not usually traverse the common duct and hence jaundice is not to be expected as a symptom of such cases.

Finally, since so many cases of enteroliths come into the hands of the surgeon for the first time in the stage of obstruction it might be well to consider more fully the diagnosis of intestinal obstruction. Owing to the better education of the people and the advances in medical diagnosis cases are seen by the surgeon at a much earlier stage than was formerly the case. At the present time the author has under his care a case of partial intestinal obstruction; the patient was referred to him when the only symptoms were constipation and recurrent attacks of colicky pain. Complete obstruction is indicated by attacks of intermittent colicky pain in the abdomen accompanied by vomiting, visible peristalsis, some distension and the inability to obtain a passage of flatus. Stercoraceous vomiting, collapse with subnormal temperature, cold clammy skin, a running thread-like pulse and sunken eyes, marked tympanites, absolute fastness of the bowels and sometimes the signs of general peritonitis belong to a later stage of the condition than should be seen now-a-days.

Prognosis. The prognosis of a foreign body which has reached the intestine is extremely good and by far the majority are passed without any untoward result. Some of these cases may later develop obstructive symptoms through cicatricial contraction. When death does occur it is usually from marasmus and wasting due to ulcerative enteritis; more rarely to abscess and peritonitis and least commonly to intestinal obstruction.

With the exception of sharp foreign bodies, which may produce perforation, and gallstones the prognosis is usually good in the case of enteroliths. Practically all cases should recover when they have been seen in an early stage ; there is very little interference with the vascular and nervous systems of the intestine and thus the bowel may be expected to make a good recovery. In the later stages, when the signs and symptoms of toxæmia have developed, the case passes into a different category.

Gallstones usually occur in fat persons of advanced age and often reach the Surgeon in a late stage of the condition ; these factors render them unfavourable subjects for operation. In cases treated with the object of relaxing the muscleature of the gut it is said that fifty per cent. of stones will be evacuated even as late as the twenty-eighth day but many of these may succumb subsequently. In most of these cases when evacuation is not obtained death will take place from the fifth to the tenth day. Of the 15 cases in the London Hospital, 13 were submitted to operation with a mortality of 61.6 per cent. In Grey Turner's eight cases the death rate was 25 per cent. Barnard records seven operations with three deaths. In the London Hospital the average age of the patients in whom the results proved fatal was 63 years while amongst recoveries it was 53. Among recoveries the average duration of obstructive symptoms was four days ; among fatal cases it was eight days. It is to be noted that in this series no case recovered in which obstruction had existed for five, or more days.

TREATMENT.

Since a very large proportion of foreign bodies pass *per vias naturales*, treatment should be persistently expectant; a foreign body which has successfully negotiated the oesophagus and the pylorus is almost certain to be able to pass the ileo-caecal valve and the anus. It is usually advised to give porridge, vegetables and other coarse food in such cases and to withhold purgatives and fluids. Operative interference is contra-indicated unless the course of the body has become arrested or symptoms are being produced by its presence.

Expectant treatment has been adopted in cases of gallstone ileus; opium, belladonna and general anaesthetics have been used to relax the muscular coat of the gut but it would appear that this treatment, to say the least, is not without an element of risk. If practised at all it should be with due regard to economy of time which influences very largely the subsequent result of operation.

When an enterolith has become impacted the only rational treatment lies in its removal. When the seat of arrest is in the rectum or lower sigmoid the enterolith, if small, may be removed through the sigmoidoscope; if larger, it may be broken up by bone forceps and removed by irrigation. The sphincter will require to be forcibly dilated and, in some instances, to be split; when the sphincter requires to be divided it should always be cut at right angles to its fibres -- an oblique division often entails subsequent loss of control.

When the enterolith is impacted higher in the alimentary tract laparotomy is usually indicated. Attempts have been made to pass the stone by castor oil, massage and high warm enemata but this may be worse than useless when the bowel is in spasm, when it is inflamed and irritable or when the calculus is impacted at an angle of the intestine. Warm oil by the mouth, hot fomentations to the abdomen and a quarter of a grain of belladonna, administered three or four times daily, to diminish irritation and muscular spasm have been used with success. Due regard must be had to time; it appears, therefore, that when the concretion is causing obturation immediate surgical interference must be the procedure of election and offers the best hope for the patient

An enterotomy or colotomy will usually be the operation to be performed but, in individual cases, the surgeon must be guided by the condition he finds when the abdomen is opened. It must indeed be rare for a resection of gut to be required although, in very advanced ulceration and damage to the bowel, it might be necessary. The opening of the intestine and removal of the stone in most cases is a matter of so little time that it must be seldom that the necessity will arise for performing an enterostomy or colostomy above the site of impaction.

The abdomen opened, a search is made for the seat of the obstruction—many surgeons prefer to find a collapsed segment of the gut and trace it until it meets the distal part of the distended portion. The bowel mucosa will, in many instances, have sustained some little injury and so it is advisable very gently to try and dislodge the enterolith and move it into a segment of healthy intestine; it will usually be found easier to move it to a more proximal part for in that direction lies the dilated gut. Only the small section of the bowel containing the enterolith need be delivered through the abdominal wound. A large tetra, wrung out of warm saline, is packed around it. The author finds it useful at this stage to use coloured towels—usually green - these are placed around the knuckle of bowel and over the instruments which have been used in opening the abdomen. The intestine is now incised in its longitudinal axis and diametrically opposite to the attachment of the mesentery; the incision is made over the concretion which is then removed. The wound in the bowel is closed by a continuous through-and-through suture of number 0 or 1 chromicised catgut, reinforced by a continuous Lambert suture of number 00 or 0 chromicised catgut which inverts the edges and secures accurate coaptation of the peritoneum. The green towels are now removed together with the soiled instruments which leaves the original instruments and white towels ready for the closure, in layers, of the abdominal wound. If time be a matter of serious consequence, after the closing of the peritoneum the remaining layers may be united by interrupted through-and-through sutures of silk-worm gut. Drainage of the abdomen is unnecessary unless perforation had occurred.

When a chemical analysis has shown the enterolith to be of calcium carbonate and of the kind described in this thesis and the drinking water to be hard, prophylactic action is required and the need for softening the water supply should be urged on the local authority. Before this was done the author advised the softening of the water by boiling. A large jug was scalded, filled with boiled water and covered with brown paper which had been scorched before the fire. It was then placed in a cold cellar overnight for use the following day. During its stay in the cellar the water became cold and to some extent aerated and thus pleasant as a drinking water.

Since the water was softened to the extent shown in the section on Biochemistry no further case of enterolith or intestinal sand came under the observation of the author; owing to the smallness of the number of cases encountered and the lack of corroborative instances in the literature on the subject such a statement may not carry much weight and is made for what it is worth.

CONCLUSIONS.

(1) The enteroliths of calcium carbonate, described in this thesis, differ in chemical composition to those previously recorded. Most of the factors universally acknowledged as necessary for the production of the phosphatic enterolith are absent—the nucleus of organic origin, the diverticulum and the abnormal intestinal mucosa. The amorphous character of the salts and the absence of paroxysmal colicky pain, vomiting and flatulent distension suggests the absence of chronic catarrh with its colloidal menstruum which is necessary for the formation and crystallisation of the salts of the phosphatic calculi. Thus it appears reasonable to conclude that these enteroliths are entirely different to those previously described.

(2) The phosphate and triple phosphate of calcium is derived from the excretion of the mucosa and the bacterial decomposition of proteins ; the carbonate of calcium would appear to be the result of simple chemical action on ingested calcium salts.

(3) Regarding the source of the calcium, since the hard water was the only common factor in ten cases of calcium carbonate deposition it may be suggested that the lime was supplied from the drinking water.

(4) The accumulation of the carbonates does not seem to give rise to enteritis ; therefore it is contended that, in the case of the phosphates, the catarrh is the cause of the condition and not its effect. Gallstones may be the result of catarrh of the gall-bladder mucosa and it may be that the intestinal mucosa shares in the catarrhal processes ; this would offer an explanation of the production of phosphatic deposits around a gallstone nucleus.

(5) The structure, position in the abdomen and chemical reaction of the contents of the ileum makes it probable that the enteroliths are produced in this segment of the gut. The striations of faecal matter in the stones further presuppose the formation of the calculi in a section of the bowel where the contents are not yet in a formed state.

(6) The absence of previous symptoms may be explained by the absence of a catarrhal condition, while the sudden onset of signs of obstruction is most probably due to a spasm of the intestinal muscle.

(7) The softening of the water supply would appear to be a logical prophylactic measure for the prevention of the formation of calculi of the calcium carbonate order.

The relatively small number of observed cases makes definite conclusions inadvisable.

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