most show fairly definite luminosity with crossed Nicol's prisms, at least in parts—even a specimen which had been eighty-one days in the tissues.

I beg to express my great indebtedness to Professor J. H. Teacher and Dr. J. G. Greenfield for the loan of valuable material, and to Mr. E. R. Flint for useful criticism and suggestions.

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A Clinical Lecture ON GALL STONES.

DELIVERED AT GUY'S HOSPITAL

BY

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I PROPOSE to make some general remarks upon gall stones and to illustrate my lecture by three interesting cases.

Nearly all gall stones form in the gall bladder, and are due to:

- (a) Infection of the gall bladder.
- (b) Over-concentration of the bile.

(a) The infection may occur through the blood stream, through the lymphatics, or ascend along the ducts from the duodenum. The researches of Rosenow indicate that infection by the blood stream is by far the most important, and cultivations obtained from infected human gall bladders often produce similar lesions in animals. It is very probable also that infection spreads to the gall bladder along the lymphatics from diseases of neighbouring organs, as, for instance, the appendix, duodenum, and stomach. The most common organisms to be found are the streptococcus, *B. typhosus* and *B. coli*. These have been cultivated from the centres of gall stones, from the bile, and from the wall of the gall bladder. It is well known that infection of the gall bladder often occurs in enterica and that gall stones frequently follow it.

(b) That concentration of the bile, leading to the deposition of mucus and crystals, is an important factor is clear, for nearly four-fifths of the patients suffering from gall stones are women who have had children, and in them symptoms often date from the time of pregnancy, when the bile is very concentrated. Stasis of the bile in the gall bladder is an important additional factor, therefore in a pendulous weak gall bladder, or in one the duct of which is linked or obstructed in any way, gall stones are likely to form.

The cystic duct is very narrow and tortuous and its mucous membrane is raised into valvular folds, so that it is very difficult for any but very small stones to pass through it (Fig. 1). Moreover, it is much narrower than any part of the common bile duct, except the termination of the latter at the duodenal papilla, therefore the large majority of sufferers from gall stones never develop jaundice.

It is also important to remember that the part of the common bile duct traversing the pancreas is not as easily distended as the first part of the duct; hence it often happens that the common bile duct is shaped like a funnel, and stones become impacted in the upper part of the pancreatic portion of the duct. The duodenal papilla is very narrow, and minute stones which will pass freely through the other parts of the ducts become arrested here. A stone smaller than a pea may thus lead to death; when it is impacted at this point it dams up both the bile and the pancreatic juice.

SYMPTOMS.

1. *Stones in the gall bladder* may cause (a) recurrent attacks of pain in the right hypochondrium associated with vomiting and local tenderness. These attacks are often mistaken for gastritis. It may be possible to feel the gall bladder during the colic, or on deep inspiration there may be "a catch" or pain in the gall-bladder region, and local tenderness on palpation. Or (b) a dull aching pain in the right hypochondrium and right shoulder, with a distaste for food and flatulent dyspepsia. It may not be possible to feel any swelling unless the cystic duct be obstructed or cholecystitis with local peritonitis develop. There is no jaundice unless the common duct also is obstructed.

2. *A stone in the cystic duct* may cause colic at intervals, with a swelling having the characteristics of a distended gall bladder. Usually this is in the right hypochondrium, but it may reach the right iliac fossa. Jaundice is absent unless the stone is junctional and presses upon or otherwise obstructs the common or hepatic duct. The stone usually falls back and the colic abates after a few hours, but it may remain impacted and cause inflammation with suppuration, or even sloughing of the gall bladder. Grey patches appear at the fundus of the gall bladder or below the stone in the duct. Perforation may take place and local or general peritonitis ensue, or adhesion to the duodenum, colon, or stomach may take place, with the formation of a fistula. It is still a common error to believe that gall stones are unlikely without a history of jaundice, but it should be remembered that as the cystic duct is narrower than the common duct, except at the papilla, more stones get impacted in the cystic duct than elsewhere, and that jaundice is really an exceptional and late sign of gall stones. This error has condemned many patients to years of unnecessary suffering, a diagnosis of gastritis or hysteria being commonly made.

3. *A stone in the common bile duct* usually causes colic and jaundice sooner or later, and fever due to an ascending infective cholangitis is sometimes present during the attack of jaundice. Sometimes stones impacted in the common duct do not cause colic but only nausea. There is often tenderness on deep palpation over the common duct above and to the right of the umbilicus. Small stones in a dilated common bile duct, although they may cause frequent colic, may not obstruct long enough to produce jaundice. It is imperative, therefore, to examine the common duct carefully at the operation in every case, even when there is no history of jaundice. The gall bladder is usually contracted, shrunken, and matted

FIG. 1.—Anatomy of the biliary apparatus.

down by adhesions in these late cases, so that no gall bladder swelling is evident. In fact, if the gall bladder can be felt in a jaundiced patient, the obstruction is probably due to other causes, such as growth of the head of the pancreas or chronic pancreatitis.

DIAGNOSIS.

(a) *Stones in the Gall Bladder.*

The diagnosis of gall stones in the gall bladder when there is no history of definite biliary colic may be very difficult, for the symptoms may closely resemble those of

gastric or especially duodenal ulcer or chronic appendicitis. Gall stones may give rise to reflex disturbances in the stomach and duodenum, altering the secretion and the movements of the stomach, and thus adding to the difficulties. The absence of hyperacidity on repeated examination is against peptic ulcers and in favour of gall stones. The researches now going on at Guy's by the analysis of the gastric juices every quarter of an hour may throw some additional light on this subject. The repeated presence of even minute quantities of blood in the vomit, gastric juice, or faeces is much in favour of peptic ulcer and against gall stones. I have, however, seen profuse melaena due to the erosion of the cystic artery by a gall stone impacted at the neck of the gall bladder. I have also known the same sign to be due to ulceration of the gall bladder and the formation of a fistula into the bowel. Anaemia and wasting are more commonly associated with peptic ulcers than with gall stones.

The time relationship of the pain to food is not so constant and striking with gall stones as with duodenal ulcer. Marked local tenderness on palpation below the ninth right costal cartilage on deep inspiration is much in favour of gall stones. Radiography may help by giving evidence of pyloric or duodenal obstruction or distortion of the shadow due to gastric or duodenal ulcer. It is unfortunate, however, that it does not often show gall stones; even with the greatest care in the examination and a good apparatus, only large gall stones or large collections of small stones are shown by the x rays. This fact is rather important, as many people are led to believe that they have no gall stones if the x rays do not show any. It is sometimes practically impossible to distinguish cholecystitis due to gall stones from chronic appendicitis, especially when the appendix is unusually high and near the gall bladder. If one is fortunate enough to see the patient in an acute attack the difficulties are less, for a local fixed swelling may be palpable over the appendix or the enlarged gall bladder may be felt moving on respiration.

(b) Biliary Colic without Jaundice.

This has to be distinguished from other colics, especially right renal colic. Here the distribution of the pain is of the greatest importance, renal colic shooting from the loin along the course of the ureter and causing pain and retraction of the testicle with urinary symptoms, and biliary colic being confined to the front and upper part of the abdomen and associated with local tenderness in the right hypochondrium. Pancreatic colic due to stones impacted in the pancreatic duct is very rare; the pain is mesial and lower down. Intestinal colic is a far more common source of error, but it is rarely so very violent as biliary colic. I have several times been temporarily misled by colic due to obstruction by a growth at the hepatic flexure, but on watching the abdomen carefully peristalsis may be noticed in the distended caecum and ascending colon. Appendical colic is rarely so severe and the pain is lower, generally referred to the navel. There is marked local tenderness over the appendix during the attack.

(c) Biliary Colic with Jaundice.

Jaundice due to gall stones has to be distinguished from that due to other causes, such as cirrhosis, or growth, or hydatid cysts of the liver, or obstruction of the main bile ducts by growth in their walls or pressing upon them from the head of the pancreas or lymphatic glands. To these conditions chronic pancreatitis and catarrhal jaundice must be added. The absence of severe pain is against gall stones and in favour of catarrhal jaundice or chronic pancreatitis. Jaundice due to cancer may cause severe pain, but rarely so acute and abrupt a colic as that due to gall stones. Moreover, the jaundice is gradual in its onset, progressive and severe, and not sudden, remittent or intermittent and moderate as it generally is with gall stones. Long-continued and black jaundice is very rarely due to gall stones. The age, sex, and especially the general condition of the patient, assist in the diagnosis, for with pancreatitis, and especially with malignant disease, the patient looks more ill and wastes more rapidly than with gall stones.

Small hydatid cysts may become impacted in the common bile duct, and give rise to jaundice and colic simulating that due to gall stones. Under these conditions the absence of a palpable stone in the common bile duct at the

operation may be very disconcerting; but on examining the liver carefully the parent hydatid cyst may be felt. In a case of this kind I enucleated the cyst from the upper surface of the liver five years ago, and the man is quite well now.

With secondary cancer of the liver there is usually some indication of the primary growth, and definite local swellings may be felt in the liver; but with primary cancer of the liver jaundice may appear early. In one case I found a diffused primary endothelioma of the liver. Hypertrophic cirrhosis of the liver may also mislead, for the patient often denies the essential history. The peculiar congestion of the face, and the marked wasting associated with the enlargement of the liver, may help.

INDICATIONS FOR OPERATION.

For obstruction of the cystic duct or neck of the gall bladder with distension of the gall bladder which is unrelieved within forty-eight hours, it is imperative to operate in order to avoid suppuration and its complications, such as sloughing of the gall bladder, localized or even general peritonitis, pylephlebitis, and pulmonary complications, and such late complications as intestinal obstruction secondary to perforation of the gall bladder into the duodenum or colon. In the former case the stone is generally impacted in the lower part of the ileum. In the latter case it generally gets impacted in the narrow part of the pelvic colon. This complication is generally very grave, because it is not often recognized in time for a hopeful operation.

It is of the greatest importance to realize that jaundice which is neither slight nor transient, and is therefore not catarrhal, calls for early exploration and treatment. In this way only can such dangerous complications as infective cholangitis and post-operative haemorrhage be avoided with certainty. Sometimes it is advisable to wait for a few days when there is fever due to an exacerbation of existing cholangitis, for it is safer to operate in a quiet period.

When gall stones in the gall bladder give rise to symptoms, such as repeated attacks of colic or localized pain with flatulent dyspepsia, it is wise to advise operation unless there are grave contraindications to the anaesthetic. It is wise to do this in order to avoid the complications already mentioned, and also carcinoma of the gall bladder, which is apt to follow the chronic irritation of gall stones and to involve the liver early and to become irremovable by the time it is recognized.

OPERATION.

In operating it is of the greatest importance to obtain the best possible access to the bile apparatus, for the operation, although sometimes easy, may be one of the most difficult in surgery. After trying many incisions, I have come to the conclusion that that of Kocher is the best (Fig. 2). I have used this almost exclusively now for some years because it gives such a wonderfully good view, and also because it is so rarely followed by hernia, even after drainage. The incision begins above and to the left of the tip of the ensiform cartilage, and runs downwards and outwards nearly parallel to the costal margin and an inch below it across all the fibres of the rectus muscle. Occasionally it is necessary to prolong it into some of the fibres of the oblique muscles. It is not necessary to divide any intercostal nerves and thus weaken the abdominal wall. The muscular fibres join well. I make no apology for describing this incision, for several writers on operative surgery figure and describe it as being placed much further out where it would not give anything like as good access. In addition to this, the fatty coverings, which are often abundant, are divided for one or two inches more than the deep part of the wound, and a lumbar cushion is invaluable to bring the biliary apparatus prominently forward into the wound. If necessary, the falciform ligament also can be divided without detriment. In every case the operation should begin as an exploration of the whole abdomen, special attention being paid to the stomach, pancreas, and

FIG. 2.—Kocher's incision, K. All the fibres of the right rectus but no nerves are divided, although the incision may be prolonged across the linea alba and outwards into some of the external oblique muscle.

appendix. Then the whole bile apparatus, including the liver, are carefully examined before any operation is decided upon. When the stones are limited to the gall bladder and cystic duct I always remove the gall bladder if the condition of the patient and the mobility of the parts allow it to be done without undue risk.

I believe that under these conditions cholecystectomy is not only more radical in that it removes the source of gall stones but also that it is safer, there being less risk of infecting the wound. In this way the considerable risk of recurrence of gall stones or the occasional occurrence of a biliary or mucous fistula and the danger of cancer of the gall bladder are avoided. The need and duration of drainage are lessened, a firmer wound is obtained, as well as a more comfortable and rapid recovery. It would, of course, be foolish to adopt cholecystectomy in old, feeble, or jaundiced patients, or when adhesions clearly add to the risk of the operation. A stone impacted in the cystic duct may be extremely difficult to remove by backing it into the gall bladder, and its impaction in the duct for some time may be followed by stricture with mucous fistula or mucocele. It is generally much easier and safer to remove the whole gall bladder and duct without opening them. Recurrence of symptoms is much rarer after cholecystectomy than after cholecystostomy.

Stones in the Common Bile Duct.

Whenever possible stones in the common bile duct should be removed through an incision in the anterior wall of the first part of the duct well above the duodenum. When a stone is impacted in the lower reaches of the duct it may be very difficult to press it back into the first part. It is much easier to do this before the bile is allowed to escape; therefore the stone should always be pushed back before the duct or gall bladder is opened. The incision is made well above the duodenum in order to avoid a branch of the hepatic artery which often runs down to the upper border of the duodenum, and in every case the left index finger is passed into the foramen of Winslow, and the stone is held up and fixed before an incision is made into the duct. When the stone cannot be dislodged from the lower part of the common bile duct it may be removed by displacing the second part of the duodenum forward and incising the duct as it runs through or grooves the pancreas. To allow this to be done the posterior peritoneum has to be incised vertically a little to the right of the duodenum. It is also of the greatest assistance to pass a blunt-pointed probe downwards from the first part of the duct. This serves to tilt the duct to the right and forward into the wound. When a stone is firmly impacted at or near the papilla and cannot be dislodged, the trans-duodenal route has to be adopted and the mucous membrane covering the stone incised, either at or above the papilla, and the stone thus removed. The wound in the anterior wall of the duodenum is closed with the greatest care, and sealed over by displacing and fixing some of the omentum over it. Without this care the trans-duodenal route does undoubtedly add considerably to the risk of the patient. In all cases the common bile duct must be proved to be clear by the insertion of the finger whenever possible, or by the passage of a blunt-pointed probe down the duct into the duodenum. The probe should also be passed up into the hepatic ducts, for a stone may have become displaced upwards into one of them. Whenever I have to open the common bile duct for stone, I drain it by inserting and fixing a small tube in it. I believe this is much safer than sewing up the duct and placing a tube near the incision. In one of my cases in which I did not fix a tube in the duct, bile escaped into the lesser sac, distended it enormously, and had to be evacuated ten days later. The patient had been very collapsed when the sac became over-distended, and she was then thought to be suffering from acute cardiac failure. She made a good recovery after the second operation. In another instance, which I published in the *Guy's Hospital Reports* (vol. lxvi, p. 219), a large clot formed in the sutured common bile duct, and gave rise to colic and collapse. At the second operation the healed duct was incised, the clot evacuated, and the patient made a rapid recovery.

MORTALITY.

The mortality of operations for gall stones has greatly diminished in recent years owing to improvements in technique.

D

Cholecystectomy and Cholecystostomy.—For the three years 1913–15 inclusive the Mayos¹ had a mortality of 1.2 per cent. in 1,767 cholecystectomies and 3.4 per cent. in 435 cholecystostomies. From 1907–15 inclusive they had a mortality of 1.3 per cent. in 2,493 cholecystectomies and of 1.5 per cent. in 2,854 cholecystostomies. It is very interesting that during the last three years of the period given the mortality of cholecystectomy should have been reduced below that of cholecystostomy. This is doubtless due chiefly to the fact that with increasing experience the Mayos have become more radical, doing cholecystectomy as an operation of choice and reserving cholecystostomy for the graver cases unsuitable for cholecystectomy.

Choledochotomy.—The mortality of simple choledochotomy in the absence of serious symptoms of infection or jaundice of long duration is about 2.5 per cent., but when infection of the bile ducts has occurred with remittent fever and deep jaundice and infective cholangitis has occurred, the mortality is about 15 per cent. The operation should, whenever possible, be done before the onset of this grave condition, or, failing this, it should, if possible, be performed during a remission of the fever and jaundice.

Duodeno-choledochotomy has a mortality of about 8 per cent. It is done for the removal of stones impacted at or near the ampulla of Vater, is often deferred until too late, and is in itself a severer operation, apt to be followed by duodenal fistula. Whenever possible the stone should be backed into the first part of the duct, whence its removal is much safer.

CASE I.—Stone Impacted at Duodenal Papilla: Cholecystostomy: ? Pancreatic Growth: Biliary Fistula: Cholecystectomy: Choledochotomy: Recovery.

The patient, a man aged 67, kindly wrote the following account of his symptoms:

Family History.

"Father never ill until age of 65, when he had a severe illness, at first thought malignant, but was no doubt due to gall bladder. He was not jaundiced. I, a student at the time, examined faeces for gall stones, but found none. He completely recovered for seven years, and then after a long walk died of haemorrhage from the stomach in twelve hours. I was then abroad. Father's brother, a healthy man, was treated for gall stones at the age of 45. Recovered and died at 74. Mother died at 85.

Personal History.

"Born 1852, never robust, but seldom laid up. Had typhoid badly in Argentina at the age of 20 and malaria badly in Persian Gulf at age of 24. Came home and malaria disappeared. Always lived a moderate life.

History of Present Illness.

"About five and a half years ago, after about twenty-four hours' dull pain in the back, I became slightly jaundiced, which lasted a few days. I had about two similar attacks in four years up to March, 1918. During this night (March 21st, 1918) I awoke at 1.30 with a strong rigor lasting twenty minutes. No pain; resembled malaria but without subsequent sweating. The day before this I had felt some malaria and discomfort in the back. Slightly jaundiced next day, which went off in four days' time. Day after attack motored twenty-one miles and sat on Recruiting Board. Got home very weak in afternoon. Went again next day, but could scarcely eat my lunch. Kept on the same for five days, but then awoke in the night with severe rigor and high temperature (104° or 105°). Stayed in bed three days, and symptoms, including jaundice, gradually subsided, but felt very weak. For some months before this attack was conscious of tenderness over gall bladder, which was always improved by doses of castor oil, even before bowels responded. Weight (stripped) after attack, 8 st.; about three or four years before, about 10 st. Went into a nursing home July, 1918. Had a rigor the first night there and about every six days; was operated on after about three weeks and three small gall stones removed. I noticed that the first two motions after operation contained bile, but no bile in the subsequent motions. Came home about a month after the operation. Nearly all bile came through sinus in wound, and I was slow in picking up strength. Had three or four loose motions every day, with ravenous appetite for the six months until the second operation. There was occasionally a streak of darker colour in the almost uniformly pale motions."

Second Operation.

I saw the patient for the first time in January, 1919. At the first operation the pancreas had been hard, and malignant disease was feared, but the patient's general condition improved, and he put on some weight during the next six months, but his biliary fistula became very irksome. When I saw him all the bile escaped at the biliary fistula, and the patient was still thin and in a bad state of nutrition. He was willing to undertake any risk in order to get rid of the fistula.

The lips of the fistula were separated and clamped to avoid spilling of bile infecting the wound, and also to maintain the

pressure inside the ducts. Kocher's incision was adopted; a vertical incision had been used at the first operation. The gall bladder was very large, the common bile duct was distended, no stone could be felt at first, but later, on feeling the third part of the duodenum, a large stone was felt evidently at the end of a very much elongated bile duct or pedunculated papilla. With some difficulty the pedunculated part of the duct was steadied with one hand while the stone was squeezed back into the duct with the other. In this way the need of opening the duodenum was avoided, and the stone then extracted from the first part of the common duct. In order to avoid recurrence, the ducts having been proved to be clear, the gall bladder was removed, and the common bile duct drained. The stone was the size of a filbert. The patient wrote on March 1st, 1920, stating that:

"Since my second operation there has been no looseness of bowels, and the appetite became very moderate. The motions are always uniformly stained dark-brown with bile. Unless the gall bladder has some beneficial secretion of its own—I have only heard of mucus—I think we should be better without it."

CASE II.—Cholecystostomy: Cholecystectomy: Choledochotomy.

Mrs. J., aged 52 years, was a patient of Dr. Talfourd Jones. After suffering some twenty years from symptoms of gall stones with intermittent attacks of jaundice and colic, she had been operated upon by a woman surgeon in March, 1916. Cholecystostomy was then performed and several stones removed from the gall bladder. The attacks continued. The second operation was performed in January, 1917, by the same surgeon, who then removed the gall bladder. The attacks continued. The patient had a slight attack of jaundice while she was still in the hospital. On several occasions she has been deeply jaundiced, and has suffered very severe colic. She has been very reluctant to consider another operation, but she found life intolerable, and at last consented to see me. A vertical incision had been adopted at the former operation.

She was admitted into Guy's Hospital in November, 1919. Kocher's incision. Six stones removed from the common bile duct, the stones serving as excellent guides to the dilated common bile duct, although the gall bladder had been previously removed. The patient made a good recovery, and has remained well since. It is probable that a larger and more suitable incision would have enabled the surgeon to find and remove the stones from the common bile-duct at the first or second operation.

CASE III.—Gall Stone in Neck of Gall Bladder: Cholecystectomy.

Mrs. A., aged 45, patient of Dr. Phillips, Croydon. She had had three children, and is a very active woman who eats very little owing to indigestion. She has never had a bilious attack, but often has slight attacks of diarrhoea. On the evening of November 7th, 1915, she ate a piece of unripe pear. At 1 a.m. on November 8th she was seized with violent abdominal pain, and did not sleep again. She got up and went into another room and lay on a bed there, but could not sleep. She was sick a good many times. She then went downstairs and lay before the gas fire, as she was so very cold and in much pain. She did not bring up anything but watery fluid, and later bile. Dr. Phillips saw her in the early morning, and thought she had intestinal colic due to the pear. The pulse and temperature were subnormal and she was cold. As she was very tender in the epigastrium, he wondered whether she had a perforated gastric ulcer, and got Dr. Male to see her. Dr. Male found that the tenderness and pain were then lower down towards the appendix, and he suggested an operation for (?) acute appendicitis. I saw her at 4 p.m. on November 8th, and felt two swellings, which Dr. Male and Dr. Phillips had also felt, in the right flank. Dr. Phillips thought that they might be scybala or a piece of pear, and found that they were movable. After getting the abdomen thoroughly relaxed, I was able to make out that the swelling was of the same size, shape, and attachments as the gall bladder, but it was lying very far back and a little lower down and farther out than usual. As I felt it the patient was seized with nausea and vomiting, and the consistence of the swelling seemed to vary. Once it seemed to consist of one lump, and another time of two. At the operation this was explained, for I clearly felt the fundus and at times also the bend of the neck of the gall bladder. I diagnosed gall stones impacted in the cystic duct, and advised an immediate operation, as the patient was so ill and would probably get worse. After some delay she was moved to a nursing home.

Operation.

Dr. Male gave the anaesthetic (November 8th, 1915). The gall bladder having been more definitely made out under the anaesthetic, a Kocher incision was made. The gall bladder was found. It was considerably enlarged, uniform in shape, and very oedematous. There was also some bloody fluid in the kidney pouch. A stone was felt impacted in the neck of the gall bladder. This was backed a good deal, but in view of the absence of stones in the common bile duct and the pendulous nature of the gall bladder, it was clearly safer to remove the latter, and this was done in the usual way, the raw area on the under surface of the liver being covered over with peritoneal flaps sewn with catgut. The abdominal wall was closed as usual, but a small tube was left at the inner and upper angle of the wound. She made a good, rapid, and complete recovery, and is now well, four and a half years later.

REFERENCE.

¹ *Collected Papers of the Mayo Clinic*, 1916, p. 274.

AIR-WAY INFECTIONS.

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It is probable that in considering the mode of infection of the trachea and bronchial tubes sufficient attention is not paid to the normal protective mechanisms of these regions. At present methods of prophylaxis are directed mainly towards an internal immunity designed to lessen the severity of an infection when once it has taken place. It seems not improbable that an attempt to turn the natural mechanisms of prevention to account might be worth considering with the intention of actually preventing infection from occurring.

The respiratory passages from the anterior nares to the infundibula are so constructed by their plications and subdivisions and by their moist and sticky surface to take up the particles of dirt and bacterial organisms that may enter in the inspired air. Such foreign matter as may get right through into the alveoli is carried away into the body by the lymphatic system; but for dealing with that which settles in the air-ways—and this is the enormous bulk—we have, in all except the very smallest tubes, two essential mechanisms: they are the mucous secretion and the ciliary action of the mucous membrane.

The value of the mechanical self-cleansing process due to the sweeping action of the cilia is self-evident. Whilst the cilia are acting effectively any bacterial organisms deposited on the surface will be swept along and not allowed time to affect the underlying cells, for a stationary state would be necessary before invasion of the epithelium could occur. The sweeping-up function culminates in cough and expectoration of the offending matter.

As regards the protective functions of the mucoid matter lining the mucosa of the air tubes, apart from its capacity for maintaining an even supply of moisture so essential for ciliary action, there is experimental evidence that this type of substance protects the tissues in various parts of the body against the action of ferments. For instance, in the alimentary tract, Bayliss,¹ quoting Klug, states that it is the mucin which protects the alimentary canal from the action of its own digestive juices; this it apparently does by adsorbing the excess of enzymes. Now it is probable that the damage to the wall of the air passages that may follow the implantation on it of pathogenic organisms is in part effected by ferment action, the ferments being derived from the infecting organisms, either from their living or dead bodies. Apart from a direct breach in the epithelial wall from ferment action, there is also the probability of the absorption of toxic bodies if these lie directly on the epithelial surface. With the exception quoted below, I do not know of any experimental evidence on this latter point, although the same probabilities exist as in the case of ferment action, but it can be shown by staining experiments that large molecular bodies do not easily pass through a layer of mucilage. It follows that the action of bacterial ferments and toxins on the epithelial cells is likely to be inhibited by a free supply of mucus.

In the various examples of the "carrier" state we find the body protected from the action of pathogenic organisms, not by a true immunity of the internal type—for these patients are often not immune and may suffer reinfection—but apparently by the mucous environment of the bacteria. In these "carrier" conditions, if we except urinary tract infections, which are not properly to be considered in this class, we find the bacteria bedded in a mass of mucus: The typhoid bacillus in the gall bladder, the dysentery bacillus in the mucous crypts of the large bowel, the gonococcus in the prostate, the meningococcus in the nasopharynx, and the diphtheria bacillus in the muco-purulent discharge of chronic rhinitis. All these instances suggest that the body obtains protection from bacterial invasion in this manner.

I have shown elsewhere,² using bacteria embedded in mucilage of tragacanth, that the animal organism could be protected against the highly toxic Shiga's bacillus. The organism remained alive in the body for months, leading neither to the production of toxic symptoms nor to the production in the host of antibodies directed against the infecting bacillus.