

**Staff Meeting Bulletin
Hospitals of the » » »
University of Minnesota**

The Common Bile Duct

STAFF MEETING BULLETIN
HOSPITALS OF THE . . .
UNIVERSITY OF MINNESOTA

Volume X

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Published for the General Staff Meeting each week
during the school year, October to May, inclusive.

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William A. O'Brien, M.D.

I. LAST WEEK

Date: October 28, 1938

Place: Recreation Room,
Powell Hall

Time: 12:15 - 1:20

Program: Movie: "All In One"

Announcements

The Premature Infant
A. V. Stoesser
John A. Anderson

Discussion

Irvine McQuarrie
J. L. McKelvie
O. H. Wangenstein

Present: 134

Gertrude Gunn,
Record Librarian

II. MOVIE

Title: "Reproduction Among Mammals"

Released by: Erpi Picture Corp.

III. ANNOUNCEMENTS

Married: Former pathologist, A. A. Nelson of Washington, D.C. writes "I am married."

Babies: Baby girl Boehrer was born to Dr. and Mrs. John Boehrer Sept. 14. They have already heard the pun "Every baby is born bare." Congratulations!

Baby boy Baker was born to Dr. and Mrs. A. Baker, October 26, 1938. Congratulations!

Thank You:

Dr. William C. Bernstein of New Richland, Minnesota asks for the Staff Meeting Bulletin for another year and writes "All I can say for them is that they are swell."

Dr. N. O. Brink of the Quain & Ramstad Clinic, Bismarck, N.D. thanks all of us for the Bulletin and especially the Citizens' Aid Society for their courtesy in making the copies of the Bulletin available.

Dr. E. L. Tuohy of the Duluth Clinic, Duluth, Minnesota asks that the much appreciated copies of the Staff Bulletin be continued. "As always we congratulate you on the orderly manner in which these records are assembled and we thank all concerned for the opportunity to profit by their contents."

Sister M. Patricia, O.S.P., Administrator of St. Mary's Hospital, Duluth, Minnesota writes, "Thank you very kindly for the first copy of the Staff Bulletin of the University of Minnesota Hospitals. These bulletins have been of much interest to our Staff and Personnel. We will be truly grateful to have you put our name on the mailing list."

Dr. F. P. McNamara of the Finley Hospital, Dubuque, Iowa writes, "We can't get along without the bulletins! Really, we get the most information in the shortest time through reading them."

Wedlock:

Charles Rea and Mary Laughlin will be married tomorrow at high noon at the Church of the Incarnation, Minneapolis. All preparations have been completed, and by this time tomorrow Charlie and Mary will be starting on their honeymoon. He has been fully instructed as to how to act after his years of bachelorhood. Further advice will be given him as the occasion arises. God bless you.

IV. THE COMMON BILE DUCT

G. S. Bergh

Introduction

The purpose of this bulletin is to present briefly some of the known facts concerning the common bile duct in man. We have drawn freely from the reports of many investigators and have also introduced observations and opinions of our own. It is apparent that the subject is too large to be covered adequately in such a brief space, and we have omitted much important experimental work and have intentionally failed to include such phases of the subject as a consideration of jaundice, pre-operative preparation of patients (including the value of administration of dextrose bile, vitamin D, vitamin K, blood transfusion), non-surgical biliary drainage, etc. Although the discussion has been restricted to a narrow field, it must be recognized that the common duct is only a small part of the biliary tract, and one should not consider it without correlating it with the remainder of the system.

Normal Anatomy

The ductus choledochus is formed by the junction of the cystic and hepatic ducts and conducts the bile from that point into the duodenum. The length of the duct varies but the average is approximately 7.5 cm. (Jackson). According to Puestow and Morrison, the circumference of the common duct measures 6 mm. in infancy and increases to an average maximum of 14 mm. at the age of seventy. The most rapid increase occurs in the first thirty years of life, after which there is a slow increase with no appreciable decline in old age.

Jackson traces the course of the common duct as follows: "It passes down between the layers of the lesser omentum, in front of the portal vein, and to the right of the hepatic artery; it then passes behind the first part of the duodenum, then between the descending duodenum and the head of the pancreas, being almost completely embedded in the latter. The ductus choledochus ends a little below

the middle of the descending duodenum by opening into that part of the intestine on its left side and somewhat behind."

"The common bile duct pierces the intestinal wall very obliquely, running through the wall obliquely for a distance of about 1 to 2 cm. There is a slight constriction at its termination. The pancreatic duct is generally united with the ductus choledochus just before its termination, and there is a slight papilla (papilla major) at their place of opening on the mucous surface of the duodenum. This papilla is about 8 or 10 cm. from the pylorus."

"In its oblique course through the duodenal wall, the common bile duct is accompanied by the pancreatic duct, the two together usually causing the plica longitudinalis duodeni."

The bile duct and pancreatic duct do not always have a common opening into the duodenum. Mann and Giordano found separate openings in 31% of 200 cases.

In the extramural portion the common bile duct consists of a fibroelastic tube, richly supplied with nerve fibres and lined by tall columnar epithelium. There is only a small amount of smooth muscle occurring as irregularly scattered fibres. (Nuboer) There are usually a number of relatively large crypts or glands in the duct wall.

The extramural portion of the common duct is covered anteriorly by the venous plexus of Zuckerkandl, and it is also crossed by a few small arteries. During surgical exposure of the duct bleeding from these vessels may be troublesome.

The intramural portion of the common duct (pars intestinalis), including the sphincter of Oddi, is of particular physiologic significance and has been the subject of much investigation. The description of the anatomy of this region is based on the reports of Boyden, and his co-workers. They state that: "In most adults the ampulla is a vestig-

ial structure. According to Mann and Giordano, 76% of individuals have an ampulla 2 mm. or less in length."

"Short as it is, however, the human ampulla subserves one important function: It gives rise to valvules which guard the orifice of the ducts and so prevents the regurgitation of the intestinal contents." (Schwegler and Boyden I)

"The sphincter of Oddi or musculus proprius of the pars intestinalis of the biliary tract is a continuous sheath of fibers extending from the choledochal window of the duodenum to nearly the end of the ampulla of Vater. It invests not only the bile duct and ampulla but also three sides of the ductus pancreaticus. Its most important segment is the 'sphincter choledochus,' a sheath of annular fibers enclosing the preampullary portions of the bile duct. This muscle is so well developed and so strategically placed as to be capable of stopping the flow of bile into the duodenum independently of the intestinal muscle." (Schwegler and Boyden III)

There are also "two columns of longitudinal fibers (fasciculi longitudinales) which cover in the interval between the two ducts, anteriorly and posteriorly." Schwegler and Boyden state that contraction of these fibres would shorten the pars intestinalis of the common duct and facilitate the discharge of bile.

Finally, there is a meshwork of fine muscle fibers that encloses the ampulla, constituting a "sphincter ampullae." In most cases this "sphincter ampullae" is rudimentary but Kreilkamp and Boyden report it to be well developed in about 16% of maceration specimens of the major papilla. Leven, Saralegui, Doubilet, and others have presented evidence to show that spasm of the sphincter ampullae may lead to reflux of contents of the common bile duct into the duct of Wirsung.

Anatomical Variations

Variations in the relations of the common duct to the hepatic and cystic arteries are fairly common and are important because they sometimes lead to

serious surgical accidents. The cystic artery passes ventral to the ductus choledochus in approximately 2% of cases. The right hepatic artery itself may cross in front of the common duct and in such a position is liable to injury at the time of surgical procedures. Supraduodenal choledochostomy is especially difficult in the presence of such an anomaly. In other instances the right hepatic artery may arise from the superior mesenteric artery and pass behind the common duct and sometimes also behind the portal vein.

Congenital obliteration of the bile ducts occurs occasionally. Complete absence of the common duct is very rare, but stenosis or atresia of the duct is more common. When obstruction is complete, death usually results within four to twelve months unless the condition is relieved by some operative procedure. Unfortunately, in many cases the obliteration extends into the hepatic ducts and surgical correction may be extremely difficult or impossible.

Duplication of the common bile duct is a rare anomaly. Boyden has discussed its development and reviewed eighteen reported cases, adding one of his own. Swartley and Weeder reported a case of choledochus cyst occurring in conjunction with a double common bile duct.

Choledochus cyst, cystic enlargement of the common bile duct, is also uncommon. Judd and Greene observed it only once in 17,881 operations on the bile ducts. Blocker, Williams, and Williams reported in 1937 that they had been able to find reports of 130 such cases, and they added an unusual case of traumatic rupture of a choledochus cyst in a fourteen year old boy.

Accessory biliary vesicles (mostly of the ductular type) may arise from the bile ducts. Boyden reported in 1926 that up to that time twenty instances of accessory biliary vesicles had been observed in man.

Physiology

The obvious function of the bile ducts is to conduct the bile from the

liver into the intestinal tract. Secretion of bile, however, is continuous, while the flow from the common duct into the duodenum is intermittent, due to the action of the Sphincter of Oddi.

Normal Sphincter Activity:

There is still much to be learned concerning the physiology of the sphincter mechanism, but certain data concerning its action have been collected.

One of its functions appears to be the prevention of regurgitation of duodenal contents into the common bile duct, and prevention of ascending infection of the liver. When the sphincter action is eliminated (such as occurs in cases of internal biliary fistula) some degree of ascending infection invariably follows. Gorham and Ivy have found that in some animals devoid of a competent sphincter there are other mechanisms for preventing this regurgitation. There may be a one-way valve, large quantities of hepatic bile may keep the ducts flushed out, or the extra-hepatic ducts may show peristaltic activity.

Another function of the sphincter is to regulate the flow of bile into the intestine. Whether or not the gall bladder will evacuate when stimulated depends upon the resistance to flow of bile from the common duct into the duodenum. A spastic sphincter can resist up to 75 cm. of bile pressure or more, whereas the maximum expulsive pressure of the normal gall bladder is 30 cm. (Ivy). Gorham and Ivy have pointed out that, since physiological studies have not yet demonstrated detectable disturbances of digestion or nutrition after cholecystectomy, it is not generally agreed that the gall bladder serves for the storage of bile for digestive purposes. They state that: "If no direct digestive disturbances result from cholecystectomy, then the chief function of the organ in man, the dog, and the cat, for example, is to regulate the pressure in the extra-hepatic ducts, and this regulation is rendered necessary by the sphincter of Oddi. Hence, from an evolutionary viewpoint, a gall bladder was developed secondarily to the sphincter, and the sphincter served primarily to prevent regurgitation from the intestine.

However, given an animal whose liver produces relatively small quantities of bile, it is then reasonable to assume that such an animal might possess a better digestive apparatus if a gall bladder and a sphincter were present to render possible the storage of bile for digestive purposes. The following facts force the consideration of such an hypothesis: (a) Bile plays an important role in the digestion and absorption of fats; (b) It is essential for the absorption of vitamin D and carotene, the precursor of vitamin A; (c) It is important in the absorption of iron and calcium; (d) All domestic animals that form a small quantity of bile have a gall bladder of large physiologic capacity; (e) The absorption of bile salts from the intestine augments the secretion of bile by the liver. From this, it seems that a reserve supply of concentrated bile, which may be discharged into the intestine in small amounts during the first 20 or 30 minutes after a meal, would have a favorable effect in initiating digestive processes in the intestine. It also acts as "ignition bile," causing the liver to increase the output of hepatic bile. They point out further that there is no anatomical evidence to indicate that the sphincter developed before a gall cyst. If the storage of bile for digestive purposes is a function of the gall bladder, the regulation of the flow of bile into the intestine is an important function of the sphincter.

A third function of the sphincter is the part it plays in filling the gall bladder. If the sphincter mechanism be destroyed, the gall bladder does not fill -- instead, the bile flows directly into the intestine. Some physiologists believe that the chief function of the gall bladder is as a pressure-regulatory mechanism to prevent the intraductal pressures from rising too high at times when the sphincter is closed. If such be the case, this third function of the sphincter is subordinate to the function of preventing duodenal regurgitation; but if concentrated gall bladder bile has any advantage over unconcentrated hepatic bile in the processes of digestion, then the part of the sphincter in causing the gall bladder to fill

serves a very useful purpose.

The behavior of the sphincter in response to certain physiologic and pharmacologic stimuli will be discussed later.

Motor Activity of Duct

While peristaltic activity of the common duct has been observed in some animals, it is not seen in man. Considering the small amount of smooth muscle in the duct wall, this lack of motor activity is to be expected.

Secretory Activity of Duct

The bile duct differs from the gall bladder in that its secretory activity is greater than its absorptive activity. The material secreted is a thin, colorless liquid.

Absorptive Activity of Duct

Rous and McMaster showed that there is a slow absorption from the ducts in animals but several days are required for the disappearance of pigment and cholates from isolated segments. Secretion exceeds absorption, and retained bile is diluted rather than concentrated. Experimental evidence indicates that the ducts do not assume the concentrating function of the gall bladder after cholecystectomy.

Sensory Innervation

Painful sensations identical with biliary colic can be produced in man by sudden distention of the bile ducts. Gradual distention does not produce this effect. Unpublished observations by Layne and Bergh indicate that spasm, presumably at the sphincter of Oddi, produces a pain which is similar to, but more intense than, the pain produced by simple distention. The pain in some cases remains localized in the epigastrium or right upper quadrant, while in other cases there is radiation to the interscapular or right subscapular region. Associated with the pain there is marked rigidity of the muscles of the abdominal wall, greatest in the right upper quadrant, and there may be inspiratory distress and occasionally nausea and vomiting.

Schrager and Ivy demonstrated that in animals similar pain responses may be abolished by splanchnic section, nausea and vomiting may be abolished by section of the vagi, and the respiratory disturbances are reduced by section of either the splanchnics or vagi. Section of both vagi and splanchnics abolishes all responses. The sensory innervation is probably similar in man.

Motor Innervation

The extent to which the sphincter of Oddi is under nervous control cannot be stated. The so-called "Doyon-Meltzer concept of reciprocal innervation of the gall bladder and sphincter of Oddi" maintains that when the gall bladder contracts the sphincter relaxes as a result of reflex excitation, and during the storage of bile, the sphincter is contracted and the gall bladder is relaxed. The evidence does indicate that there is a relationship between the gall bladder and the sphincter of Oddi, and they do appear to constitute a functional unit, but the mechanism of this relationship is not yet understood and the part played by the sympathetic and parasympathetic nervous systems is not clear. Some evidence obtained from animal experimentation indicates that the predominant effect of parasympathetic stimulation is to increase sphincter resistance, while splanchnic stimulation decreases the resistance. Doyon further found relaxation of the sphincter following stimulation of the central end of the divided vagus. This was confirmed by Lueth. In man, however, nervous control of the sphincter may be less important than hormonal control. This contention is supported by observations that pilocarpine and atropine do not influence the sphincter in man, whereas a fatty meal will cause relaxation. In the dog, on the other hand, pilocarpine causes increased sphincter resistance, while atropine produces relaxation. Boyden and Rigler, as a result of their studies of reflex responses of the biliary tract, have emphasized a marked species difference in this respect between man and animals.

Normal Sphincter Resistance

It has been impossible to measure the sphincter resistance in normal human patients, but several investigators have studied the physiology of the common bile duct in patients with choledochostomy tubes. In such patients, after subsidence of postoperative oedema and inflammation, the sphincter will usually withstand pressures similar to the pressures which Ivy gives as the normal intra-mural resistance in unanaesthetized fasting dogs -- namely 9.0 to 25.0 cm. of water. Our figures indicate that the average sphincter resistance in such cases is probably around 15 cm. of water. This is also the figure given by Doubilet and Colp as the average normal. Our observations confirm the statement of Doubilet and Colp that frequently the first measurements are higher than subsequent readings, indicating that a greater force is required to break through the initial resistance, and stabilization usually, but not always, occurs at a slightly lower level than that obtained as an initial reading.

Changes of a few millimeters in the intra-ductal pressure occur during respiration, and marked changes occur during coughing, laughing, vomiting, etc., due to the temporary increase in intra-abdominal pressure.

Even when the sphincter resistance appears to be stabilized, changes of several centimeters resistance may occur spontaneously from time to time. Whether these are the result of changes in intra-abdominal pressure or of altered tone of the duodenal musculature or the sphincter itself cannot be stated, and just what initiates these occasional changes in tone is not clear.

In patients with inflammatory lesions, such as cholangitis secondary to stone, it is not uncommon for the sphincter to remain irritable for weeks after removal of the stone by operative procedure. In such cases the sphincter readily goes into spasm and the intramural resistance may be thirty, forty, or fifty centimeters of water or even higher, and it usually fluctuates from moment to moment through a wide range instead of becoming stabilized.

Effect of Ingestion of Food upon the Sphincter

Boyden's discovery that egg yolk would cause maximum evacuation of the gall bladder stimulated interest in the effect of various foods upon the biliary tract. (For modified "Boyden Meal," see Dorland's Medical Dictionary.) It has been demonstrated that fats produce the greatest contraction of the gall bladder, proteins rank next, and carbohydrates are practically ineffective in causing gall bladder evacuation. Experimental evidence indicates that the effect of a fatty meal in causing the gall bladder to contract is not due to post-absorptive circulating substances originating from the food, but rather to a humoral mechanism initiated by the meal. Presumably the fatty meal stimulates the production of the hormone, cholecystokin, which causes the gall bladder to contract.

It is of interest, then, to know the effect of the ingestion of food upon the sphincter of Oddi. McMaster and Elman and others have shown that during digestion there is a decreased intramural resistance in the dog, and during periods of fasting the resistance is increased. In man there has been little direct investigation of this subject, although it has been assumed that there must be a reciprocal action between the gall bladder and sphincter mechanism, so that when the gall bladder contracts the sphincter relaxes.

Other than our own, the only direct observations of the sphincter resistance in man following the ingestion of food that have come to our attention are those of Doubilet and Colp. In one case these investigators observed a very slight fall in sphincter resistance, which they interpreted as being insignificant, following a meal of soup, two eggs, and ice cream. In a second case there was a slight, but insignificant increase after a meal of soup, fish, and potato.

Carter has stated that the external drainage of bile from a choledochostomy tube is decreased after a meal, indicating a relaxation of the sphincter.

Our observations indicate no significant change in sphincter resistance following a carbohydrate meal (8 cases), but we have found a definite and significant fall in the intramural resistance following the ingestion of a fatty meal (13 cases). We have no data concerning the effect of a protein meal.

Effect of Anaphylaxis upon the Sphincter

Deissler and Higgins, working with the isolated extrahepatic biliary tract of guinea pigs, found that during an anaphylactic shock there was a contraction of both the gall bladder and the sphincter. The force exerted by the sphincter mechanism was found to be greater than that which was exerted by the gall bladder, apparently explaining why the gall bladder ordinarily does not empty during an anaphylactic shock.

Effect of Drugs upon the Sphincter

Unless specifically stated to the contrary, the observations listed under this heading have been made upon human subjects having choledochostomy tubes.

Acetylcholine

Lueth and Kitakoji found that acetylcholine increased the intramural resistance in animals. Butsch, McGowan, and Walters observed no effect in man.

Alcohol

Butsch, McGowan, and Walters observed a decrease in the intramural resistance following the administration of amyl nitrite. This relaxation of the sphincter occurred in individuals who were presumably normal, and also in patients with sphincter spasm induced by the administration of morphine. Our observations confirm the report of these investigators (14 cases). Among all of the drugs studied, amyl nitrite is the most effective in causing relaxation of the sphincter. The relaxation is almost immediate and then, according to our observations, the resistance rises until after about ten minutes it has returned to the original level.

Atropine

Although atropine apparently causes relaxation of the sphincter in animals, it has no effect upon the human sphincter in doses of 1/50 to 1/150 grain. (University Hospital observations and also Butsch, McGowan, and Walters).

Benzedrine

Benzedrine sulphate in doses of 20 to 30 mg. hypodermically caused a slight elevation of sphincter resistance in 6 cases, but the increase was so slight as to be insignificant.

Benzyl Acetate and Benzyl Alcohol

We have no studies of the effect of these drugs on the human sphincter. Lueth found no effect in dogs.

Caffeine

Lueth reports no effect in dogs. Butsch, McGowan, and Walters found no effect from doses of $7\frac{1}{2}$ grains in man.

Calcium Chloride and Calcium Gluconate

We have found no significant change following the intravenous injection of calcium chloride or calcium gluconate. (8 cases). Butsch, McGowan, and Walters also found that calcium chloride failed to lower the intrabiliary pressure.

Cholecystokin

There have been no direct observations of the effect of cholecystokin upon the human sphincter. Ivy, Voegtlin, and Greengard have conducted a series of experiments in which secretin, containing some cholecystokin, was injected intravenously into human subjects while a duodenal tube was in place. The injection usually promoted a copious flow of pancreatic juice and bile, but in one subject a spasm of the sphincter was produced, lasting 49 minutes until it was relieved by the instillation of magnesium sulphate into the duodenum. Sandblom, Voegtlin, and Ivy report that in dogs cholecystokin produces an initial increase followed by a decrease of

sphincter resistance.

Codeine

Butsch, McGowan, and Walters report that codeine in one grain doses increases the resistance of the sphincter in man.

Decholin (Sodium dehydrocholate)

Neubauer states that the intravenous injection of Decholin decreases the sphincter resistance. In 8 cases we have observed a slight transient fall in resistance following the intravenous administration of 10 to 20 cc. of a 20% solution. In our opinion the change was so slight as to be insignificant.

Dilaudid

Butsch, McGowan, and Walters report that 0.002 gm. of dilaudid produced an elevation of the sphincter resistance, but the elevation was slower and not so high as that following morphine.

Ephedrine

The effect of ephedrine on the human sphincter is variable. There appears to be no significant effect. This conclusion based on our observations is in agreement with that reported by Butsch, McGowan, and Walters.

Epinephrine

In 9 cases in which we have observed the action of epinephrine the effect was variable; but the resistance rose more often than it fell. Doubilet and Colp in one case observed a slight but insignificant rise. Butsch, McGowan, and Walters found no effect. Lueth states that the effect is variable in animals.

Ergotamine tartrate

In animals, Lueth found that 0.25 to 0.5 mg. of ergotamine intravenously usually caused an initial increase in intramural resistance with a subsequent decrease. In man, Butsch, McGowan, and Walters observed no decrease in the intrabiliary pressure following the hypodermic injection of 0.5 cc. of a 1:2000 solution.

Erythrol tetranitrate

In two cases we observed no effect

upon the sphincter following the oral administration of one grain of erythrol tetranitrate.

Ether

Lueth found that ether anaesthesia decreased the sphincter resistance in dogs. There have been no such observations upon human subjects.

Histamine

In 6 cases, after the injection of 0.5 mg. of histamine phosphate, we observed a slight initial increase followed by a decrease of the intramural resistance. The maximal decrease occurred after approximately 25 minutes and after 45 minutes the resistance had returned to the original level. Butsch, McGowan, and Walters report that injection of histamine fails to relax the spasm of the sphincter induced by morphine. Lueth states that in dogs histamine produces a rise in the intramural resistance.

Hydrochloric acid

In five cases Doubilet and Colp observed a marked sphincter spasm following the instillation into the duodenum of 0.9% HCl. We have confirmed this in one case. The results of experiments on animals are variable.

Hyoscine hydrobromide

Butsch, McGowan, and Walters state that hyoscine fails to relax the sphincter spasm induced by morphine.

Magnesium sulphate

In 6 cases (University of Minnesota) magnesium sulphate by mouth or by duodenal tube caused a slight initial increase and then a decrease of sphincter resistance. Doubilet and Colp observed a decreased resistance in two cases. It has been known for some time that magnesium sulphate will generally cause some evacuation of the gall bladder in normal human subjects, and this drug has been used clinically for the "non-surgical drainage" of Lyon. There has been some question as to the effectiveness of

oral route of administration as compared to duodenal instillation. Soper, and Boyden and Birch believe that it is almost as effective when taken by mouth as when it is instilled intraduodenally. Our results are in agreement with this, at least as far as the effect upon the sphincter is concerned.

Morphine

Lueth and Kitakoji observed that morphine causes an elevation of the sphincter resistance in animals. Butsch, McGowan, and Walters showed that this same effect occurs in man. This has been confirmed by Doubilet and Colp (2 cases) and by our own observations (11 cases). The spasm induced by the injection of morphine can actually produce biliary colic.

Muscarine

Butsch, McGowan, and Walters cite Kitakoji's observation that muscarine stimulates the sphincter in animals.

Muscle Adenosine Phosphoric Acid

Butsch, McGowan, and Walters state that a 40 mg. dose of this substance failed to relax the sphincter spasm which was induced by morphine.

Nicotine

No observations have been made on human subjects. Lueth found in animals that the intravenous administration of 2 to 5 mg. of nicotine produced a decrease in the intramural resistance, while Kitakoji found an increased resistance.

Nitroglycerine (glyceryl trinitrate)

Butsch, McGowan, and Walters found that 1/100 grains of nitroglycerine (under the tongue) would cause relaxation of the sphincter. We have confirmed this observation. The Mayo Clinic group have reported clinical relief from biliary colic following the administration of glyceryl trinitrate, and Best and Hicken have noted by means of cholangiography that this drug can cause relaxation of a spastic sphincter and at the same time afford relief from pain.

Olive oil

Best and Hicken noted from their cholangiographic studies that olive oil by mouth or instilled into the duodenum favored the passage of contrast medium from the common duct into the duodenum. In 3 cases we have observed only a slight relaxing effect from olive oil.

Pantopon

Butsch, McGowan, and Walters and Doubilet and Colp observed a marked increase in sphincter resistance following the administration of pantopon to human subjects. We have confirmed this observation in 5 cases. The response is similar to that produced by morphine.

Papaverine

Butsch, McGowan and Walters found that neither a $\frac{1}{2}$ grain dose intravenously nor a 3 grain dose intramuscularly would alter the intrabiliary pressure. In one case we observed no effect upon the sphincter following the oral administration of $\frac{1}{2}$ grain of papaverine. Doubilet and Colp studied the effect of papaverine in two cases and observed that this drug may produce a temporary relaxation of a spastic sphincter, but that ordinarily it has slight effect.

Phenobarbital

According to Butsch, McGowan, and Walters, two grains of phenobarbital-sodium hypodermically fails to affect the sphincter resistance. We have had an opportunity to measure the sphincter resistance in one case of phenobarbital poisoning and in that case the readings obtained were within normal limits. (Control observations, of course, were not available in this case.) Lueth has pointed out that in animals the barbiturates have slight effect upon sphincter tone.

Physostigmine

Butsch, McGowan, and Walters state that physostigmine (gr. 1/25) hypodermically does not relax the sphincter spasm induced by morphine. In one human

Effect of Cholecystectomy upon the Duct and Sphincter

Since the time of Oddi, it has been recognized that extirpation of the gall bladder is often followed by dilatation of the biliary ducts. Puestow and Morrison measured the circumference of the choledochus in 527 routine autopsies showing no pathology of the biliary tract and found the average circumference in adults to be 12.1 mm. These investigators also made measurements in 9 subjects who had had a previous cholecystectomy but no history of jaundice. Each of these had a markedly dilated duct, the average circumference being 20.9 mm. On the other hand, very little enlargement of the choledochus accompanied untreated cholecystic disease.

Several explanations have been advanced to account for this dilatation of the duct, but the question is not yet settled.

1. It has been said that the dilatation is the result of increased intraductal pressure following cholecystectomy. This theory depends upon a persistence of action of the sphincter of Oddi. In the absence of the gall bladder, which normally acts as a pressure regulator, the increased pressure must be accommodated by dilatation of the duct. Judd and Mann reported that dilatation did not occur (except in 1 case) when the sphincter was cut, unless there was a mechanical obstruction due to scar formation.

Colp, Doubilet, and Gerber in experimental work on dogs found that section of the sphincter in four animals in which dilatation of the duct was present after cholecystectomy resulted in shrinkage of the ducts to normal diameter. They also noted that dilatation of the duct occurred only twice in a series of twelve animals in which both cholecystectomy and sphincterotomy were performed.

Brendolan, on the other hand, found dilatation of the duct following section of the sphincter.

Puestow, however, states that there is permanent loss of function of the sphincter of Oddi following cholecystectomy. He

first observed this in dogs with a special type of biliary fistula in which the duodenum was slit open. From his experience with human subjects with choledochostomy tubes, he believes that there is a similar result following cholecystectomy in man. Our observations in a considerable number of cases, however, lead us to believe that such an incompetence of the sphincter following cholecystectomy in man is not the usual occurrence. (We have made no observations during the first week after operation, so cannot state that an early temporary loss of sphincter tone might not occur.)

Furthermore, it seems beyond doubt that spasm of the sphincter can occur after cholecystectomy. In fact, cases of postcholecystectomy colic have been explained on this basis, and some surgeons (Archibald, Colp and Doubilet, and others) have relieved colic in such cases by cutting the sphincter.

2. A second explanation is that pressure transmitted into the common duct from the duodenum as a result of incompetence of the sphincter together with a weakening of the duct wall by infection may be an important factor in the production of dilatation in many instances. This theory is based upon the observation that dilatation of the duct occurs following implantation of the common duct directly into the intestine and following choledochoduodenostomy. Under such conditions the action of the sphincter is eliminated. On the other hand, when the common duct is implanted obliquely so that the duodenal musculature may act as a sphincter, no dilatation results. Furthermore, it has been observed that in a series of cholecystectomized dogs, the animals which developed dilated ducts following the operation generally had a lower intramural sphincter resistance than the dogs whose ducts were normal in size.

Puestow, however, points out that if duodenal pressure transmitted through a patent orifice produces dilatation of the choledochus, one might expect duodenal contents to drain through T-tubes, but this rarely occurs. Furthermore,

during x-ray examinations regurgitation of barium into the ducts following cholecystectomy is unusual. The observations of Colp, Doubilet, and Gerber that dilated ducts may decrease in size after the sphincter is cut, and that dilatation rarely occurs after cholecystectomy when sphincterotomy is performed at the same time, also are cited by Puestow as being against this theory.

3. Puestow offers a third theory: "If the loss of tonus of the sphincter of Oddi following cholecystectomy is on the basis of a disturbed innervation, the same nervous derangement may conceivably cause a loss of tonus of the wall of the choledochus and a resultant dilatation. The small amount of muscle of this structure is an argument against this theory."

Diseases of the Common Duct

A. Injuries:

In addition to surgical injuries, the common duct is subject to both direct injury by penetrating agents and subcutaneous injury. Such accidents are not common. When they occur there is danger of the development of bile peritonitis.

According to Lewis the clinical picture is that of immediate shock from which there is spontaneous recovery, pain in the right upper abdominal quadrant, jaundice which usually appears within the first three days after the accident, bilirubinuria, and acholic stools. A bile-stained fluid accumulates in the peritoneal cavity. After a week or ten days the patient shows exhaustion, rapid pulse, and a moderate elevation of temperature.

For treatment Lewis advises simple drainage to the outside. Kirschner advises that, when possible, the duct should be sutured. At times it may be difficult to find the point of injury. Garre has advised that in such cases air should be injected into the gall bladder so that one might observe the escape of air at the point of perforation. Sometimes extensive defects may be repaired by plastic procedures.

B. Foreign Body

In the duct, exclusive of common duct stones, is rare, but such foreign objects as surgical sponges, steel needles, fruit seeds, cherry stones, bullets, rubber drains, thread, and even a spoon have been found. (Toland)

C. Benign Strictures

of the common duct are either congenital or acquired. Acquired strictures are of four types:

1. The majority are due to injuries of the duct during operative procedures. The damage may be due to partial or complete severance of the duct, or its inclusion in a ligature. Predisposing factors are unusual anatomical arrangements of the ducts or arteries. It has been suggested also that denudation of the duct might injure its blood supply and cause subsequent scarring and constriction.

2. A few are due to cicatricial contraction of ulcers from impacted calculi. These are limited in extent and are usually situated at or just above the ampulla.

3. Another group are due to obliterative cholangitis. Twenty-five per cent of 64 cases reported by Judd were of this type. These are generally diffuse and may involve a large part of both common and hepatic ducts. Nygaard, Sheldon, and Walters state that primary obliterative cholangitis as an etiologic basis for stricture is rare, but point out that cholangitis associated with other lesions may be important, and the fact that operation precedes the development of a stricture does not mean that the stricture has been caused by trauma.

4. A very small group of benign strictures are due to miscellaneous causes such as benign tumors, syphilitic inflammation, and inflammatory constriction following perforated duodenal ulcer.

Diagnosis: In acute complete occlusion, as after accidental ligation of the duct, there is a rapid onset of jaundice and hepatic failure. Slowly developing strictures are often associated with external biliary fistulas. Symptoms of jaundice appear intermittently when the associated fistula is temporarily occluded, until after months or years the obstructive jaundice becomes persistent, hydrohepatosis and obstructive biliary cirrhosis develop, and finally death results if the condition is not corrected. Lahey has pointed out that a stricture of the common duct may exist for a number of months or years without the occurrence of marked jaundice if the lumen of the strictured duct is still of sufficient caliber to permit the passage of bile of normal thin consistency. Under such circumstances jaundice may follow if an inflammatory reaction causes obstruction by swelling of the mucosa or a mucus plug.

In the absence of previous operation, the symptoms of benign stricture are usually gradual development of jaundice with or without intermittent attacks of cholangitis. There is often a long history of recurrent biliary colic.

In the presence of a fistula, diagnosis may be aided by roentgenographic study after the injection of a contrast medium into the sinus.

The treatment of biliary stricture is surgical, and various operative procedures have been employed:

1. Simple dilatation of the stricture may be used in occasional cases if the stricture is incomplete. The late results are variable, with recurrence of the stricture in most cases. When this method is used, it is advisable to insert a T-tube or a buried tube to maintain the lumen.
2. Choledochotomy, or simple division of the stricture is generally unsatisfactory.
3. End-to-end anastomosis after excision of the stricture is followed by relatively good results if the ends of the duct can be approximated without undue tension. If the ends cannot be approximated without tension end-to-end anastomosis should not be attempted. When such a repair is feasible it

is the method of choice, since the protective action of the sphincter of Oddi is not eliminated. For strictures which are not too extensive it is a frequently used procedure.

4. Indirect anastomosis of a divided bile duct, using a rubber drainage tube to bridge a gap between the bile duct ends, is usually unsatisfactory.
5. Implantation of a portion of the biliary tract into the alimentary tract is used when the extent or location of the stricture makes a more simple type of repair impracticable. When the gall bladder and cystic duct are normal, cholecystgastrostomy or cholecystenterostomy may be the simplest procedure. Unfortunately, however, in most cases the gall bladder has already been removed. When the stricture involves the terminal portion of the common duct choledochoduodenostomy is often the most efficient method of relieving the obstruction. If the stricture is so extensive that such an operation is not feasible hepaticoduodenostomy, -gastrostomy, or -jejunostomy may be used.

In a few cases, indirect implantation of the biliary tract into the alimentary tract has been successful. However, Horgan advises against using this method if any procedure is possible by means of which a mucous-mucous union can be established.

6. Implantation of a biliary fistula into the gastrointestinal tract may be a useful procedure in cases in which it is difficult to mobilize the duodenum and in which the stricture is extensive.
7. Plastic reconstruction of the duct has been accomplished by a variety of procedures. The strictured duct may be cut longitudinally and sutured transversely. In such cases Lahey advises the insertion of a T-tube with the upright limb of the tube emerging through the unstricted portion of the duct. Also, the stricture may be divided longitudinally and the edges of the incision may be held apart by the insertion of a rubber tube. The defect is then reconstructed with adjacent tissues.

Various methods of plastic reconstruction of the duct with the use of pedicle flaps have been devised and have been fairly successful. Autogenous transplanted grafts have been tried experimentally and clinically, but the results have

not been good.

The operative mortality is 10 to 20% (Walters). According to Walters, the end results of the operation are dependent upon three factors: "First of all, that infection in the wall of the duct above the stricture, and within the liver, is not so severe that it cannot subside when the obstruction has been relieved by the anastomosis; second, that sufficient duct be present to allow accurate anastomosis between it and an opening made in the duodenum; and third, that so much damage has not taken place to the hepatic parenchyma, as a result of obstruction and infection from the stricture, that it cannot return to a reasonably normal function after relief of the biliary obstruction."

Walters reported excellent results in 57% of fifty-one cases of patients with biliary stricture upon whom he had operated. He stated that in his experience choledochoduodenostomy or hepaticoduodenostomy had been the preferable procedures.

Nygaard, Shelden, and Walters have pointed out that the greatest danger in the immediate postoperative period is from cholemic haemorrhage. If the patient recovers from the operation, failure may be due to a recurrence of the stricture or to the development of cholangitis and liver abscesses. In order to prevent the latter complication, it appears advisable to preserve the sphincter mechanism (which guards against ascending infection) whenever possible. Bile salts may also be given in order to increase the flow of bile in the hope of decreasing the danger of ascending infection.

D. Cholangitis

is a term designating inflammation of the bile ducts and includes several types. Infection may be ascending (from the intestinal tract), descending (from the liver or gall bladder), haematogenous, or by extension from inflammation in a neighboring region. Graham discusses this condition under four headings:

1. Calculous cholangitis is the most important type. Some degree of inflammation probably almost invariably is associated with common duct stone and occasionally a severe suppurative cholangitis is

present.

2. Non-calculous infective cholangitis may arise in conjunction with general diseases such as typhoid fever, pneumonia, and influenza.

3. Cholangitis associated with malignant disease: Carcinoma in the region of the papilla of Vater, producing biliary stasis and favoring an ascending or enterogenous infection, may lead to the development of cholangitis.

4. Parasitic cholangitis is caused by the entrance of intestinal parasites into the bile duct. Among the parasites which have been found in the bile ducts are: ascaris lumbricoides, distomidae (liver flukes), Coccidium Cuniculi (psorospermiosis), porocephalus constrictus (pentastomum constrictum), balantidium coli (paramecium coli), and giardia (lamblia) intestinalis.

E. Choledocholithiasis

is the most common cause of biliary obstruction. There may be a single stone, there may be several, or there may be 100 or more. Usually the stones are formed in the gall bladder, but presumably primary stones occasionally are formed in the common duct or small biliary radicles.

There is almost always some degree of calculous cholangitis and an associated chronic cholecystitis. Courvoisier found the gall bladder to be shrunken in approximately 80% of cases of calculous obstruction of the common duct, whereas in other types of obstruction distention of the gall bladder is most frequent.

The duct is usually dilated and the dilatation may be very great, especially in cases with high grade obstruction of long duration and with a functionless gall bladder.

An interstitial pancreatitis may also be associated. At operation the head of the pancreas may feel so firm as to simulate carcinoma.

Judd and Marshall reviewed 1,768 cases of common duct stone, representing 13.2%

of all patients from whom gallstones were removed during the corresponding period. The ratio of females to males was 2.2 to 1. The youngest patient was 5 months and a fourth of the patients were more than 60 years of age.

In this large series of cases pain was the most common symptom. 80% had had definite biliary colic and only 2.4% had been entirely free from pain. There was a history of jaundice in 73.4% and symptoms of sepsis with chills and fever were present in 37%. (Lahey found chills and fever in only 4.2% of 221 cases.) Nausea and vomiting occurred in 68% of the cases and gastro-intestinal disturbances of some kind were present in almost all of the cases. External biliary fistula was present in 2.4%.

The intermittent nature of the symptoms in the presence of common duct stone is well known. A stone may lie silent in the duct for many years.

Lahey, Walters, and others have emphasized the fact that the possible presence of unsuspected stones in the common duct should always be considered during the conduct of gall bladder operations. Lahey reports that he now opens and explores the common duct for stones in 44% of cases operated upon for gall bladder disease, and he has found stones in 18.9%. The indications for exploration of the common duct as given by Lahey and Swinton are:

1. The presence of jaundice or a history of recent jaundice.
2. The presence of a markedly thickened or contracted gall bladder.
3. The presence of dilatation of the common duct or thickening of its wall.
4. The discovery by palpation of any suspicious lump suggesting stone.
5. The presence of an induration of the head of the pancreas which makes palpation of the terminal portion of the duct unsatisfactory.
6. Alteration of the bile in the common duct (obtained by aspiration).

In the case of small stones, impaction in the duct may be transient and the calculus may later pass into the duodenum. Best and Hicken have advised the adminis-

tration of a choleric (sodium dehydrocholate) together with anti-spasmodic drugs in order to favor the passage of small stones. They suggest the use of nitroglycerine and atropine as drugs intended to relax the sphincter of Oddi. It would appear that nitroglycerine and amyl nitrite would be suitable drugs for this purpose, but in our experience atropine does not relax the sphincter in human subjects. We have found that Dr. Boyden's fatty meal of egg yolks and milk sometimes will cause relaxation of a spastic sphincter when drugs such as amyl nitrite and nitroglycerine have failed.

Larger stones lodge in the duct and cause cholangitis and dilatation of the duct. If the flow of bile is obstructed sufficiently, jaundice results. In the presence of inflammation the sphincter becomes irritable, and spasm readily occurs. The patient then suffers from biliary colic which may persist for hours or even for days. During these periods of spasm the bile flow is likely to be interrupted and jaundice develops with bilirubinuria and clay-colored stools.

Clinical differentiation between the jaundice due to stone and the jaundice due to malignant obstruction may be very difficult. Courvoisier's law is not infallible since the gall bladder may be distended in cases of choledocholithiasis and may be contracted in cases of malignant obstruction. Furthermore, colic may occur in cases of carcinoma (which we usually consider as producing an insidious, painless jaundice) and may be absent in cases of stone.

Watson, however, has been very successful in differentiating the two conditions by means of his quantitative estimation of urobilinogen in the urine and faeces. He has found that the faecal urobilinogen is almost never more than 5 mg. per day, and not more than a trace of urobilinogen is found in the urine in the presence of malignant obstruction. In cases of calculous obstruction, on the other hand, the value for faecal urobilinogen is rarely less than 10 mg. The amount in the urine varies with the degree of hepatic dysfunction, but may

be small even in the presence of a damaged liver if the amounts of bile permitted to enter the intestine are greatly reduced.

The reliability of the test is indicated by the fact that in 49 cases of calculous jaundice the per diem excretion of urobilinogen in the faeces was less than 5 mg. in only 3 cases; while in 56 cases of jaundice due to neoplasm the urobilinogen in the faeces exceeded 5 mg. per day in only 3 cases. (approximately 95% accurate).

The figures given by Watson for normal urobilinogen in the urine are 0-2 mg. per day and in faeces are 40-280 mg. per day.

In the case of choledocholithiasis without liver damage the values for the urine are 0-6 mg. and for the faeces are 10-250 mg.

In the case of stone with complications such as cholangitis, biliary cirrhosis, and anaemia the values for the urine are 4-50 mg. and for the faeces are 10-250 mg.

In the case of malignant biliary obstruction the values for the urine are 0-0.3 mg. and for the faeces are 0.5 mg.

Stones which lodge in the common duct and are too large to pass into the duodenum must be removed surgically. The operation is best done early, but in the presence of a fluctuating jaundice it is often advisable to wait for this to subside and operate in an interval when icterus is absent.

The common duct may be opened supraduodenally, retroduodenally, or transduodenally. The supraduodenal approach is the simplest and is satisfactory in most cases. After removal of the stones the duct is usually drained to the exterior, although some surgeons (Kirschner) suture it closed and simply place a drain down to the region of the duct. Drainage of the duct will be discussed more fully under a separate heading.

The mortality of operations for common duct stones is reported to be from 6 to 12%. It would seem that this mortality might be reduced by earlier operation, before severe liver damage has occurred, and by careful pre-operative preparation of the patient.

It is sometimes difficult to find all of the stones even with the duct opened. In the group reported by Lahey and Swinton there were probably recurrent or persisting common duct stones in 5.5% of cases.

If the patient has a choledochostomy tube in place, it may be possible to remove the persistent stone without secondary operation. Pribram reported several cases in which stones were removed by repeated injections of 2 to 3 cc. of ether through the choledochostomy tube. Ether is a solvent for cholesterol and permits fragmentation of the stone. It also increases the pressure behind the stone, tending to force the fragments into the duodenum. Disadvantages of this procedure are that the distention produced by vaporization causes intense pain, and Probst and Eckert have found that injection of ether into the biliary tract of animals may produce hepatic damage.

Walters and Wesson have used a similar method, injecting a mixture of 1 part ethyl alcohol and 2 parts ethyl ether through the tube. By using this mixture they were able to inject 5 cc. at a time. In addition to injecting this solvent, they administered amyl nitrite in order to cause relaxation of the sphincter of Oddi and thus favor passage of the stone.

Best and Hicken have recommended the administration of a choleric (sodium dehydrocholate) together with drugs intended to relax the sphincter in order to favor the passage of stones. They report a favorable effect from instillation of olive oil into the choledochostomy tube. Neuwirt also previously had observed that the injection of iodized oil into a biliary fistula might be followed by passage of persistent stones.

If these methods fail, secondary operation will be required. We have had occasion to try the method suggested by Walters and Wesson in one case, but were unsuccessful in removing the stone and had to resort to operation. The patient stated that in her opinion the operation was the less severe form of treatment.

F. Biliary Fistula

may be external or internal and may arise spontaneously, or as a result of injury, or may be established intentionally.

External fistula usually results from either an overlooked obstruction of the bile duct or an accidental obstruction created at operation or from the development of a stricture. Complete external drainage of bile produces a condition of rapid emaciation terminating fatally (acholic cachexia or cachexia cholepriva). The administration of minimal amounts of bile by mouth, or leakage of small amounts of bile into the intestine will maintain an individual in good health. Total loss of bile generally results in acute intestinal disturbances with rapid weight loss, general osteoporosis, diminution of bile salt formation, and a purpuric tendency. There is often an associated anaemia, and gastroduodenal ulceration may develop.

An internal biliary fistula may arise spontaneously or it may be established by operation to divert the bile around an irremovable obstruction of the bile duct.

Borman and Rigler point out that spontaneous internal biliary ulcers are the second most important cause, while neoplastic growths are only an occasional etiologic factor. Common duct obstruction is usually associated with such a fistula, and if the obstruction is relieved the fistula tends to close.

The clinical picture varies. There is usually a long history of gall bladder disease. If there has been jaundice, this subsides. Immediately following the perforation, there is a period of relief from the symptoms of gall bladder disease. Occasionally, when stones are passed into the intestine, gall stone obstruction will develop.

If the fistula remains open an ascending cholangitis and hepatitis always develop, because lack of a sphincter mechanism permits reflux into the biliary tract. The majority of these ascending infections are not sufficiently severe to produce clinical symptoms, but occasionally death will result from cholangitis and hepatitis.

Diagnosis may be aided by roentgenographic

studies. Borman and Rigler have emphasized the presence of gas or of barium in the biliary system and mucous membrane changes at the stoma of the fistula as valuable diagnostic signs in gastrointestinal-biliary fistulas.

Treatment of spontaneous internal biliary fistula consists of removing the biliary obstruction and taking down the fistula. A temporary drainage of the bile duct is usually instituted after such an operation.

An operative internal biliary fistula may be established in order to divert the bile around an irremovable obstruction at the lower end of the common duct. Since the protection of the sphincter of Oddi is lost following such an operation, an ascending infection develops, but this rarely gives rise to clinical symptoms. Occasionally, however, a fatal infection may ensue, especially if stasis of bile occurs. For this reason the operation should not be performed indiscriminately, but only in the presence of the proper indications.

G. Tumors

of the common duct.

Benign tumors of the duct (adenoma, papilloma, neurofibroma, Fibroma, etc.) are rare. Malignant tumors are more common, and these are almost always carcinoma. Sarcoma in this region is exceedingly rare.

Carcinoma may occur in any portion of the common duct, but, according to Rolleston and McNec, it is most frequent at the junction of the cystic and common duct and next most frequent at the terminal portion of the duct.

It may be difficult to ascertain the origin of a tumor in the ampullary region. Graham has pointed out that: "Within an area with a radius of not more than $\frac{1}{4}$ inch carcinoma may arise in any one of the following structures: (1) the ampulla of Vater; (2) the end of the common bile duct; (3) the end of the duct of Wirsung; (4) the glandular tissue of the head of the pancreas; (5) the duodenal mucous membrane covering the biliary papilla."

The clinical manifestations are variable. Usually the first symptom is the insidious development of jaundice which may or may not be associated with colic. The stools become acholic and bilirubin appears in the urine.

Watson's test for quantitative urobilinogen determination as an aid in the differentiation of obstructive jaundice due to stone from that due to neoplasm has already been discussed. Briefly, he has shown that the obstruction due to neoplasm is more nearly complete than that due to stone, the faecal urobilinogen with the former almost never being more than 5 mg. per day while the faecal urobilinogen in the case of calculous obstruction is rarely less than 10 mg. He has pointed out that "Absence of urobilinogen from the urine, although a regular finding in cases of jaundice due to neoplasm, cannot be considered peculiar to this group, since it is noted also at times with varying degrees of obstructive jaundice due to stone and rarely with high grade obstructive jaundice due to cirrhosis."

Apparently "the interval between the appearance of jaundice and the development of complete obstruction is short, since the onset of jaundice points to an already considerable narrowing of the common bile duct" (Watson).

The treatment of carcinoma of the bile duct is surgical. Lesions in the proximal portion may sometimes be excised. The duct may then be reconstructed by end-to-end anastomosis or by indirect anastomosis; the divided stumps of the duct may be ligated and cholecystoenterostomy performed; or the distal stump may be ligated and the proximal end implanted into the duodenum or stomach.

The anatomical situation makes removal of neoplasms of the terminal portion of the bile duct difficult, but successful radical removal has been carried out in stages, the first step being directed toward relief of the jaundice either by the establishment of an external or internal biliary fistula, and actual extirpation of the tumor being carried out at subsequent operations. Whipple, Parsons, and Mullins have stated that the risk from the operation can be diminished by ligating the pancreatic duct

rather than trying to reimplant it into the duodenum when radical excision of the tumor has been performed.

In 80 cases of radical operation for removal of carcinoma of the lower end of the bile duct which were collected by Whipple, Parsons, and Mullins there was an operative mortality of 35%, and among those who recovered from the operation 24.6% were known to have had recurrence, while in other cases the follow-up was inadequate.

When the tumor cannot be removed, an internal biliary fistula should be established as a palliative measure. While this may not prolong the life of the patient it will greatly increase comfort.

Results of irradiation therapy in this group of tumors have been discouraging.

H. Functional Disorders:

Oddi in 1877 suggested that biliary colic and jaundice might result from spasm of the sphincter mechanism. John Berg in 1922 found support for this suggestion by demonstrating hypertrophied muscle tissue around the ampulla in certain cases and this observation has been confirmed by others.

Ivy, Voegtlin, and Greengard have shown that motor dysfunction may cause biliary colic in normal human subjects with non-inflamed biliary passages. Observations made upon patients with choledochostomy also demonstrate clearly that spasm of the sphincter can produce pain.

Such a condition of dysfunction has been referred to as biliary dyskinesia or biliary dyssynergia, and has recently received considerable attention.

Strictly speaking, the term dyskinesia should be applied only to cases in which the origin is purely functional and in which organic disease is absent. However, spasm of the sphincter may be secondary to an organic lesion such as inflammation in the common duct, head of the pancreas, duodenum, or even in more distant organs, and it seems that such

spasm must be brought on through reflex mechanisms.

Obviously the clinical diagnosis of dyskinesia is difficult, and it can only be presumed when every effort has been made to rule out an organic lesion.

Treatment of spasm secondary to an organic lesion is directed, of course, toward removal of the primary lesion.

True dyskinesia is probably best treated by medical means such as dietary restrictions and the administration of drugs for the purpose of relaxing the spastic sphincter. "Non-surgical duodenal drainage" of the biliary tract by the Meltzer-Lyon technique has been used with considerable success by many clinicians.

Surgical measures have been resorted to in some cases. Procedures which have been suggested are: (1) simple dilatation of the terminal portion of the common duct by the passage of graduated sounds; (2) short-circuiting operations such as cholecystogastrostomy or choledochoduodenostomy; (3) actual section of the sphincter either transduodenally or by way of an endocholechochal approach using a special instrument designed by Colp and Doubilet; (4) cholecystectomy; and (5) splanchnic section.

Drainage of the common bile duct

A majority of surgeons believe that external drainage should be instituted when operative procedures have been carried out upon the common duct.

Three kinds of rubber drainage tubes may be used: (1) An ordinary urethral catheter of the Nelaton type; (2) the T-tube which was introduced by Deaver; and (3) the L-shaped rubber catheter introduced by Horgan.

The straight catheter has two chief disadvantages: the difficulty of anchoring it securely, and the fact that, although it supplies adequate external drainage, it does not supply a means of drainage through the bile duct into the intestine.

The T-tube supplies both internal and external drainage and is easily maintained in place. It has the disadvantage that it

might injure the duct when it is removed. This danger may be reduced by cutting a window in the tube directly opposite the vertical limb, or by cutting off the bottom half of the cross-piece of the tube, converting this portion into an open trough in order to facilitate removal. Instances in which the transverse portion of the tube has broken off and remained in the duct have been reported.

Horgan has recommended the use of an L-shaped catheter designed to provide adequate drainage, ease of fixation, and simplicity of removal without damage to the duct.

There is no unanimity of opinion as to how long drainage should be maintained. During the past few years we have used three criteria to assist us in determining when the tube should be removed: (1) cholangiographic evidence that the biliary tree is structurally normal, that no filling defects suggestive of stone are present, and that the contrast medium empties readily into the duodenum; (2) direct evidence that the sphincter resistance is normal and that the sphincter is not irritable. Measurements are made by the method of Elman and McMaster; and (3) subjective comfort of the patient and lack of drainage around the tube when the tube is clamped.

If cholangitis is present we maintain drainage for weeks or even for several months. We have found that this procedure not only permits the dilated ducts to return to a more nearly normal size, but it also allows an irritable sphincter to return to normal. This, we believe, is very important.

Catheters may be left in the duct for long periods of time without ill effect. One of Dr. Wangenstein's patients has carried such a tube for more than $5\frac{1}{2}$ years, coming to the clinic periodically for change of the catheter.

In addition to the criteria which we have used to help determine the time for removing the tube, chemical

and microscopic study of the bile have been advocated by Carter and by Payne.

Chemical studies consist of analyses for bile salts, chlorides, cholesterol, and pancreatic ferments. The value for chlorides is often high shortly after the operation and the tube should not be removed until the level has returned to normal. (450 to 550 mg.%) Payne states that this may require up to three months. The bile salt level and cholesterol level should also be normal.

If pancreatic ferments are found in the bile the inference is that the sphincter ampullae is spastic and that the pancreatic juice is forced back into the biliary tree.

Microscopic examination of the bile for pus, mucus, and crystals also gives information as to the condition of the extra-hepatic biliary tract.

X-ray Examination of the common duct

Although most common duct stones do not cast a shadow, occasional opaque stones in the duct may be visualized by X-ray examination.

Foote and Bell have reported that the ducts may sometimes be visualized in the presence of obstructive jaundice after administration of iodeikon and glucose in divided doses and they suggest this method as an aid in the differential diagnosis of jaundice.

The value of roentgen examination in the diagnosis of internal biliary fistula has already been mentioned. Borman and Rigler state that: "The presence of gas or barium in the biliary system, the demonstration of the barium-filled fistula itself, the absence of a normal gall bladder shadow on cholecystography, and the presence of mucous membrane changes in the gastrointestinal tract are the chief roentgenologic findings."

The visualization of the bile ducts during or after operation by the injection of a radio-opaque medium is referred to as cholangiography. The media used include lipiodol, thorotrast, hippuran, diodrast, brominol, and others.

In 1922 Patterson and Tenney made the first study of the biliary tract by this method when they injected a bismuth paste into the external opening of a biliary fistula. Since that time the method has been developed until at the present time it is the rule in most clinics never to remove a choledochostomy tube before cholangiographic studies have been made. Delayed cholangiography gives valuable information and is associated with practically no risk if properly carried out. One precaution should be emphasized - namely, that the contrast medium should be introduced very gently. We have seen flare-ups of cholangitis following forceful injection of the contrast medium.

Immediate cholangiography, or cholangiography at the time of operation has not attained the universal acceptance of the delayed procedure, since it is somewhat more difficult to obtain satisfactory results. It has been recommended especially by Mirizzi, by Best and Hicken, and by Mixer and Hermanson. The last authors state that the procedure is accurate in 94% of cases.

Impressions

1. Anatomical studies have established the presence of a sphincter at the terminal portion of the bile duct.
2. The functions of this sphincter are to prevent the regurgitation of duodenal contents into the common bile duct, to regulate the flow of bile into the intestine, and to make possible the filling of the gall bladder.
3. Peristaltic activity is not present in the human bile duct. The bile duct also differs from the gall bladder in that its secretory activity is greater than its absorptive activity.
4. Painful sensations identical with biliary colic can be produced in man by sudden distention of the bile ducts or by spasm at the sphincter of Oddi.
5. The evidence indicates that the gall

bladder and the sphincter constitute a functional unit, so that when the gall bladder contracts the sphincter relaxes. Whether this is governed by nervous or hormonal control is not established.

6. The "normal" sphincter resistance in man ranges from 9.0 to 25.0 cm. of water. The average is probably around 15.0 cm. of water. In the presence of a spastic sphincter the resistance may be much greater.

7. In the presence of inflammation of the duct the sphincter is irritable.

8. The ingestion of a fatty meal causes relaxation of the sphincter. A carbohydrate meal has no effect.

9. Morphine, codeine, pantopon, and dilaudid cause an increase in the sphincter resistance.

10. Amyl nitrite, nitroglycerine, magnesium sulphate, theophylline ethylenediamine, and cholecystokin cause a decrease in sphincter resistance.

11. Pilocarpine, atropine, benzedrine, caffeine, hyoscine, physostigmine, calcium chloride and gluconate, papaverine, erythrol tetranitrate, phenobarbital, prostigmine, ergotamine tartrate, and posterior pituitary extract have no significant effect upon the sphincter in human subjects.

12. Sodium dehydrocholate causes a slight transitory fall, and histamine causes an initial rise followed by a fall in sphincter resistance.

13. The common bile duct may become dilated following cholecystectomy. The mechanism of this is not understood but several theories attempting to explain it have been discussed.

14. Clinical differentiation between jaundice due to stone and jaundice due to malignant obstruction may be difficult. Watson, however, has been very successful in differentiating the two conditions by means of his quantitative estimations of urobilinogen in the urine and faeces.

15. Internal biliary fistulas are always

associated with ascending cholangitis and hepatitis because the protective action of the sphincter is lost. The infection is usually sub-clinical, but it may be severe. For this reason anastomotic operations should not be performed indiscriminately.

16. Motor dysfunction (biliary dyskinesia) may cause biliary colic in normal human subjects with non-inflamed biliary passages. This condition is best treated medically.

17. Spastic disorders of the sphincter may be secondary to organic lesions elsewhere.

18. External drainage should be instituted when operative procedures have been carried out upon the biliary tract. Drainage should be maintained until cholangiographic evidence indicates that the biliary passages are structurally normal, that no filling defects suggestive of stone are present, and that the contrast medium empties readily into the duodenum; until direct measurements indicate that the sphincter resistance is normal; and until the tube may be clamped without resultant leakage around it and without causing the patient discomfort.

19. Cholangiographic examination gives valuable information, but the contrast medium should be introduced gently in order to avoid stirring up latent cholangitis.

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V. CASE REPORTS

1. Female, age 34. History of recurrent attacks of R.U.Q. pain for 5 years; jaundice for 3 weeks. No fever. No R.U.Q. tenderness. Icterus index 62; van den Bergh prompt direct; urobilinogen in faeces 16.1 mg. per day. Cholecystogram showed no visualization. Clinical diagnosis: cholecystitis, cholelithiasis, and choledocholithiasis. Jaundice subsided and operation was deferred for a few weeks. Cholecystectomy and choledochostomy on 4-5-38. Operative diagnosis: chronic cholecystitis and cholelithiasis; no common duct stone was found. Recovery was satisfactory. Six weeks later a cholangiogram indicated that the biliary tree was normal. Patient was to return for measurement of sphincter resistance, but was delayed for several weeks. She returned 8-3-38 at which time the T-tube was removed. When the tube was withdrawn she complained of severe abdominal pain with radiation to the right shoulder. A catheter was inserted into the sinus, thorotrast was injected, and roentgenographic studies were made. These showed escape of the contrast medium into the free peritoneal cavity, indicating injury to the duct or sinus tract resulting from removal of the T-tube. The patient was again admitted to the hospital, duodenal suction was instituted, and massive hot packs were applied. The patient recovered from the low-grade peritonitis which developed and she has been apparently well since that time.

2. Female, age 48. Jaundice for 6 weeks, associated with high fever and severe R.U.Q. colic. Icterus index 172; Van den Bergh biphasic prompt; no urobilinogen in urine and a trace of urobilinogen in the faeces. Clinical diagnosis: obstructive jaundice due to neoplasm, and an associated cholangitis. Diagnosis was confirmed by operation and microscopic examination.

3. Female, age 71. Came to this hospital with symptoms of common duct stone after having had 3 previous operations upon the biliary tract. On 2-4-33 choledochostomy was performed and multiple stones were removed. A T-tube was left in place. Recovery was satisfactory. In view of the history of repeated recurrence of choledocholithiasis after operations by competent surgeons, it was considered advisable to maintain the choledochostomy tube permanently in place. The patient now returns periodically for change of the catheter. (The T-tube having been replaced by a straight catheter). She has carried a tube for more than 5½ years. She is well and the sphincter resistance measurements are normal.

4. Female, age 47. The patient had had a cholecystostomy 25 years ago, and had had a cholecystectomy 12 weeks before admission. Since 8 or 10 days after the last operation she had become deeply jaundiced. There was no biliary fistula. The icterus index was 50; the Van den Bergh was biphasic; the urine showed a trace of urobilinogen and the faeces urobilinogen was 1.2 mg. per day. The clinical diagnosis was biliary stricture with almost complete biliary obstruction. On 10-26-1937 the duct was reconstructed over a T-tube, using the omentum to secure a tight closure. Recovery was satisfactory except that the patient developed a rheumatoid arthritis. The T-tube has been replaced by a straight catheter. Sphincter resistance measurements are normal. A cholangiogram shows the ducts to empty well, but there is a slight narrowing of the duct in the region of the previous stricture. The patient feels well.

VI. GOSSIP

Skipper George Elmer McGeary, former ophthalmologist and otolaryngologist at the old Health Service in Pillsbury Hall has a house boat on the Minnesota River. It is the old story with a different ending, as during his boyhood days he wanted one. The other night we went for a cruise. Leaving the dock about 5:00 p.m. we headed up stream, pushed along at a merry clip by a 30-horse power motor. Although it was chilly, the crowd assembled on the front deck where the steering gear is located. Thousands of ducks flew overhead from the nearby game preserve. The rays of the setting sun cast a myriad of colors over the wooded banks of the stream, which is all preliminary to telling you that the good ladies were inside in the trim galley, preparing dinner. When all was ready, the motor was shut off and the craft anchored in mid-stream. The feast was thoroughly enjoyed by all, after which tales were told by the skipper with frequent reference to the log book detailing previous voyages. A most interesting incident was when he met the steamer Capitol and forgot to signal the side on which he intended to pass. During the summer, trips to the St. Croix by way of the Mississippi and St. Croix Rivers enable the skipper, his family and friends to enjoy cool, peaceful, sleep on hot nights. On our return trip a heavy fog settled, and as other crafts were on the stream, it was necessary to give a periodic blast on the fog horn, according to Federal Regulations. At a late hour the boat was docked, and all left with a unanimous vote that a house boat was the ultimate in different enjoyment.....On a recent trip to Worthington, Minnesota, Fritz "Babbit" Schade introduced yours truly at a Kiwanis luncheon. Little did I realize that

Fritz possessed such talents of an after-dinner speaker. It was Farmers' Day and each Kiwanian invited a farmer friend. Drs. Mork, Mork, Stanley, Harrison, and Schade at the Worthington Clinic are doing good scientific work. The Southwestern Medical Society of 60 members comprising the six counties in the extreme southwestern Minnesota has had an enviable record of attendance at the Center for Continuation Study. During the past year 12 members have attended 23 times. It seemed like Old Home Week at the meeting, as a large percentage of the membership is made up of recent Minnesota graduates.....
 ..Superintendent Ralph Rosen of the State Hospital at Hastings went coon hunting last night. A pack of dogs were sent ahead to find the animal and tree it. From time to time the hunters stopped to relate tales of previous hunting experiences. After many hours a noise was heard from the dogs indicating that an animal had been sighted. It proved to be a cat, after which all the hunters returned to tell the tale of previous hunting experiences.....
Radiologist Leo G. Rigler feels that we might have given the impression that Nettie Stenstrom did not help with the evening meal. In retelling the experience there is a definite tendency to give her more credit for her feminine contributions to the comfort of the party.....
 The course in Diseases of the Skin at the Center for Continuation Study this week has been very successful. A group of 18 physicians of Minnesota and the surrounding states have been loud in their praise of the arrangements and the excellence of the teaching.....
Former Intern Gordon A. Samuelson is running for coroner of Blue Earth County.....