Retained Calculi within the Biliary Ductal System

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A review of 16,700 patients with biliary tract disease from five centers showed that in 24% common duct exploration was performed. In 46% of the ducts explored, calculi were removed. The incidence of *residual* calculi was estimated to average 1.1% of patients operated upon for calculous biliary tract disease and 4.3% for those following common duct exploration. The incidence of residual calculi in the biliary ductal system may be reduced by two approaches. The first is to treat cholelithiasis by undelayed cholecystectomy once the diagnosis is established and/or choledocholithiasis has developed. The second is the efficient and meticulous utilization of currently available roentgenological facilities for preoperative intravenous cholangiography and intraoperative cholangiography, both pre- and postcholedochotomy. Demonstrable residual calculi that occlude the common duct and prevent the flow bile into the duodenum must be removed. It is desirable and recommended that calculi that appear free within the ductal system be removed. However, in the latter situation removal is not mandatory because the degree and extent of future obstruction they may cause is unpredictable.

RETAINED CALCULI in the common duct following cholecystectomy and/or common duct exploration, with or without demonstrating choledocholithiasis, is one of the problems that haunts the surgeon. It is estimated that 15–20% of the adult population of the United States has cholelithiasis. In recent years operations upon the biliary tract have become the most frequently performed operation within the abdomen. Approximately 500,000 operations on the biliary tract are done annually in the United States. The common duct is explored in 15–50% of those at the time cholecystectomy is done. Just as there is considerable variation in the reported frequency of common duct exploration so there is considerable difference in the reported incidence of choledocholithiasis (Table 1).

The majority of patients who have had an exploration of the common duct have a catheter or T tube drain inserted for decompression. Before it is removed 7–10 days later cholangiogram is done. This reveals the presence or absence of residual calculi. The incidence of retained or overlooked calculi in the common duct is estimated to range from 1.6 to 7% of patients subjected to common duct exploration. Among patients in whom cholecystectomy without common duct exploration is done, residual choledocholithiasis may remain undetected until they cause symptoms or an intravenous cholangiogram is done. Residual calculi, regardless of the reasons for their presence, constitute an added increment in the surgical treatment of calculous biliary tract disease. They merit critical consideration in an effort to reduce their incidence and stimulate and encourage innovations in their management.

There follows a discussion of the diagnosis of retained calculi and the clinical problems they give rise to. The approaches commonly employed to remove them are briefly described and evaluated. The many advancements of surgery of the biliary tract are providing a favorable trend toward a reduced incidence of residual calculi within the biliary ductal system.

Incidence

A review of statistical data in the vast number of clinical reports of biliary tract disease emphasizes a lack of uniformity of terms. This is particularly true concerning "residual calculi." Calculi that are demonstrated within the ductal system following primary operation of cholecystectomy, with or without exploration of the common duct, and after secondary choledochotomy are residual calculi.

Five clinics believed fairly representative of centers that have kept careful account of their operations upon the biliary tract, both in this country and abroad, are

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TABLE 1. *Estimated Incidence of Calculous Biliary Tract Disease and Number of Cholecystectomies Performed in 1973 in U.S.A.*

A. Estimated total population	210,157,000
B. Estimated adult population	130,297,340
C. Estimated incidence of cholelithiasis (15% of B)	19,544.601
D. Estimated cholecystectomies	500,000

the source of the material that is presented in Table 2. The total patients in this group number 16,700. Four thousand-and-eighty-seven patients (24%) underwent common duct exploration and in 1,884 (46%) of those explored, calculi were removed. From this review the incidence of residual calculi is estimated to average 1.1% of the 16,700 patients operated upon for calculous biliary tract disease and 4.3% for those following common duct exploration. Calculated upon the statistics above it is estimated that 5,500 patients will have been burdened by residual calculi in the biliary ductal system in 1973.

These figures indicate a considerable disparity in the wide range of proportion of common ducts explored by the individual centers. The higher the frequency of common duct explorations, the lower is the incidence of calculi removed from the common duct. Thus it is reasonable to suggest that routine operative cholangiography as soon as the abdomen is opened would both reduce the number of the common duct explorations that were negative for calculi and also reveal the unsuspected calculus in the ductal system.

Manifestations

During the immediate postoperative course, the patient with a T tube in place ordinarily drains varying amounts of bile depending upon a number of factors including occlusion of the choledochoduodenal junction due to spasm or stone, the state of hydration and indeed the stature of the patient. If the passage is free there will usually be about 300–500 cc of bile drained during the first 24 hours. Thereafter it diminishes to 200 cc or less within 3–4 days. If the amount of bile drainage increases and it becomes suggestive that the entire bile output is draining through the T tube, then one must consider that there is occlusion proximal to or at the choledochoduodenal junction.

If 50% or more of the bile is diverted from reaching the duodenum there is usually a failure for the appetite to be re-established in the immediate postoperative period. This is accompanied by a lack of sense of well-being. Prolonged diversion of the bile results in hypochloridemia unless replacement therapy is employed, a state that is readily recognized.

There are a number of conditions that may cause partial or complete occlusion of the distal common duct. One is pancreatitis sometimes associated with biliary tract disease and following in the wake of an operation upon the biliary tract. In instances where there is a history of jaundice prior to operation, and particularly if it has been associated with an elevation of temperature suggesting cholangitis, the possibility of intrahepatic lesions must be borne in mind. Subhepatic accumulation from leakage about the T tube in the common duct may result in increased spasm of the sphincter of Oddi and produce an obstruction.

The determination of the cause of these manifestations is readily accomplished by cholangiography after attaching the T tube to a burette and noting the elevation of the fluid level. If the obstruction is complete the level rises to 30 cm or more and is associated with R.U.Q. discomfort and pain.

Avoidance and Detection of Retained Calculi

The vast literature upon calculous biliary tract disease enables us to anticipate with some degree of accuracy those patients in whom calculi in the common duct are most likely to be found. In this mass of material there are several factors that are readily identified as being related to the incidence of choledocholithiasis. First of all there are those patients in the older aged category. The older the patient, the greater is the likelihood of choledocholithiasis in the presence of cholelithiasis. The duration of the disease parallels this as

TABLE 2. *Residual Calculi Reported from Five Representative Clinics Among 16,700 Patients*

	Total Operations	C. D. Expl.	C. D. Stones	Stones in Ductal System Following C. D. Expl.
Colcock & Perry*[6] 1954–1958	1754	503 (28%)	139 (28%)	8 (1.6%)
Bartlett[1] 1943–1963	4763	2066 (43%)	744 (36%)	86 (4.2%)
Dunphy[22] 1960–1969	952	200 (21%)	137 (68%)	14 (7.0%)
Moller & Santavirta[16] Univ. Hosp. Helsinki 1960–1969	1937	289 (15%)	250 (86%)	20 (6.9%)
NYH-CMC 1932–1967	6795	946 (14%)	567 (60%)	47 (5.0%)
1972†	499	83 (17%)	47 (56%)	3 (3.6%)
Total	16,700	4087 (24%)	1884 (46%)	178 (4.3%)

* 9 residual stones amongst a total of 1754 operations (0.5%)
† 4 residual stones amongst a total of 499 operations (0.8%)

TABLE 3. *Indications Emphasized for Common Duct Exploration*

1. History suggestive of obstruction
2. Age: 60+
3. IVC, direct and indirect evidence of calculi

well. The clinical manifestations of choledocholithiasis may be brought to light by meticulous history taking. Thus three facts, the age of the patient, the duration of calculous biliary tract disease, and the signs and symptoms compatible with common duct obstruction are a basis for anticipating choledocholithiasis (Table 3).

These patients prior to operation may be subjected to specific evaluation in an effort to determine direct and indirect evidence, for or against the presence of calculi in the ductal system. Intravenous cholangiography as is well known and documented is a very valuable procedure in the visualization of choledocholithiasis. Its value was emphasized by Glenn, Evans, Hill and McClenahan[9] in 1954 and further confirmed in 1957 by Glenn and Johnson.[10] Before operation is embarked upon, the surgeon should have rather clearly in mind the evidence to support his conclusions for the presence or absence of choledocholithiasis.

Today operative cholangiography is more readily available than previously. Patients suspected of choledocholithiasis may have the entire biliary tree visualized with opaque material in various ways. The introduction of opaque material and the taking of a single film has been employed with increasing frequency over the past 2–3 decades. Such equipment is available in most hospitals throughout the United States. Within the past decade there has been developed operative cholangiography using an image intensifier to enable the surgeon to observe the flow of opaque material throughout the ductal system.

The introduction of opaque material into the gallbladder visualizing, thereby the cystic and the entire ductal system, both extra- and intrahepatic, before molesting the other abdominal viscera, at present seems to be the most efficient method. If, however, the cystic duct is blocked and the gallbladder entirely filled with calcareous material, then the opaque substance may be introduced directly into the cystic duct or the common duct. When this is done prior to embarking upon the operative procedure, one gains an overall and actual concept of the status of the biliary tract. While calculi are by far the most common findings in the ductal system, congenital anomalies and other disease processes involving the duct wall of both a benign and malignant nature may be readily identified.

When a choledochotomy is done and the common duct explored with or without the removal of calculi, it should again be visualized before terminating the operation. The films should be compared with those taken prior to the operation. Thus a precholedochotomy visualization and a postcholedochotomy roentgenological record provides our most efficient means of avoiding overlooking calculi. It should be self-evident that careful scrutiny of films by both surgeon and radiologist are required to completely evaluate roentgenological records be they on film or viewed on the image intensifier. Mullen, Rosato and Sullivan[17] reported that of 121 patients who following common duct exploration had a cholangiogram repeated, abnormalities not previously noted in the precholedochotomy cholangiogram were observed in 32. Ten of these were due to common duct calculi.

Postoperative cholangiography introducing opaque material through the indwelling T tube 7–10 days after operation provides additional evidence of the status of the ductal system. Over the past decade there have been increasing reports of closing the choledochotomy wound without drainage of the ductal system with no complication. The accumulation of more data from this practice is needed before the author would recommend it. Postoperative T tube cholangiography is our most useful but not infallible method of determining the presence or absence of retained calculi. Displacement of opaque material is usually by a calculus. However, blood clot, mucus and serum agglutination as well as air bubbles may displace the opaque material. These may be very difficult to distinguish from calculi. Therefore without exception the cholangiogram revealing displacement of the opaque material should be repeated after ductal irrigations of saline or water. Air bubbles are most readily overcome by this method. Clot and/or serum agglutination may sometimes be irrigated through into the duodenum. They are also subject to decrease in size and change in shape with the lapse of time and repeated irrigations. Calculi almost invariably maintain the initial pattern outline in spite of irrigations with water or saline.

Calculi may be obscured by the use of highly concentrated opaque material. Fifty percent solutions of hypaque, or their equivalent, are adequate to outline the ductal system and permit visualization of relatively small calculi. The performance of postoperative T tube cholangiography should be done with fluoroscopy. Occluding substances are more specifically located and evaluated as the dye flows through the entire ductal system. The external ductal system filled with concentrated opaque material and being somewhat larger in diameter may easily obscure calculi. Visualization of the choledochoduodenal junction and specifically the am-

TABLE 4. *Added Criteria for Intraoperative Cholangiography*

1. Concentration of dye, 50%
2. Visualization of the intrahepatic radicles
3. Visualization of choledochoduodenal junction

TABLE 5. *Solvents for Residual Calculi*

Ether
Chloroform
Heparin
Bile acids
Total of 113 substances studied by Best *et al.**

* Best et al.: Ann. Surg., **138**:570, 1953

pulla of Vater is sometimes difficult and unsatisfactory (Table 4).

Upon demonstrating what is believed to be a calculus in the ductal system, the examination should be extended so that films may be taken with the patient in various positions in an effort to demonstrate the displaceability of the calculus. A calculus that is fixed in the ductal system presents a greater surgical problem than the one that is floating free in bile.

A recent advancement and one that offers an opportunity for preoperative evaluation is endoscopic cholangiography, i.e. catheterization of the ampulla of Vater and the injection of opaque material under fluoroscopic examination. Over 2,000 have been attempted with about 90% success since its introduction by Ogoshi and his associates.[19] This means of evaluating the entire ductal system may be employed to determine the presence or absence of choledocholithiasis prior to any operation. It should be particularly helpful to demonstrate the nature and location of residual calculi following cholecystectomy or common duct exploration. It may also afford an opportunity to attempt dissolving and/or fragmenting residual calculi in those patients who have had only a cholecystectomy performed and those in whom the T tube has been removed.

Use of Solvents for Retained Calculi

With the utilization of postoperative cholangiography and the ready demonstration of retained calculi, attempts to remove or dissolve these calculi by means of irrigation through the T tube has been revived over the past decade. There was encouragement from those patients in whom an air bubble had been considered a calculus. The continuous flow of water or saline, even for a short time, through the indwelling tube in the common duct removed these almost immediately. The defects that were actual stones have been occasionally reported to be reduced in size. Calculi of small size, granular and amorphous calcareous material are sometimes flushed through the choledochoduodenal junction facilitated by relaxants of the sphincter of Oddi. A combination, therefore, of erroneous diagnosis and the occasional removal of very small stones and calcareous material by the use of simple irrigation with innocuous solutions and relaxants has encouraged surgeons to pursue their search for a substance that either dissolves or renders the stone to be more readily passed through the choledochoduodenal junction into the duodenum.

Durante,[11] in 1782, discovered that gallstones were soluble in turpentine. Thereafter biliary calculi were subjected to all manner of solutions in an attempt to dissolve them. Solutions that were considered to be tolerated by body tissues, and particularly the common duct, were selected for clinical use. Two substances at the turn of the century were considered as having great promise for this purpose, chloroform and ether. Both substances are indeed volatile and when introduced into the ductal system at a normal room temperature the higher body temperature resulted in distension of the ductal system. For the most part this method was discarded because of the untoward reactions which were often immediate, severe, and sometimes rather long-lasting. These consisted of pain in the RUQ followed by vomiting, chills and fever, and jaundice sometimes gradually subsiding over several days.

The unsatisfactory results by the use of solvents popularized by Pribram[20] led Best and his associates[5] in Omaha to evaluate a long list of substances in the early 1950s. A total of 113 agents were studied to determine their value in dissolving or decreasing in size calcareous accumulations. They, too, concluded that chloroform and ether were by far the most effective. Bergman and his associates,[4] however, were concerned with the deleterious effects that had been reported in the literature by the use of these substances when introduced into the ductal system as well as their own experience. They proposed a number of innovations that had as their objective the removal of the hazard of the distension of the ductal system. This they reasoned would be best accomplished by using small amounts of these agents and either combining it or shortly thereafter following it with flushes of such liquids as saline solution and/or water combined with oily preparations that would act as lubricants. They reported considerable success. They also pointed out that there were a fair proportion of patients in whom these substances did not satisfactorily reduce either the size of the calculi or remove them from the ductal system. For these therefore they recommended a direct surgical approach (Table 5).

The non-surgical approach to removal of retained common duct stones was well reviewed by Leon Sasson[21]

TABLE 6. *Calculous Disease of the Biliary Tract and Residual Calculi Following Operation*
(The New York Hospital-Cornell Medical Center, 1972)

Cholecystectomy + Choledochotomy	83
Residual calculi	3(3.6%)
Other operations	416
Residual calculi	1(0.2%)
Total operations	499
Residual calculi	4(0.8%)

TABLE 7. *Four Examples of Residual Common Duct Calculi (The New York Hospital-Cornell Medical Center, 1972)*

Sex	Age	Operative Cholangiogram Taken	Read	Error	Stone Revealed By	Outcome 2nd Operation
F	81	+	Neg.	+	T tube chol.	Calculi Removed
M	79	0	–	+	IVC	Calculi Removed
M	69	+	Neg.*	+	T tube chol.	Calculi Removed
M	38	+	Neg.	+	T tube chol.	Calculi Removed

* Re-evaluation of cholangiogram taken at operation was considered suggestive of a calculus in the common duct.

in 1969. He selected 35 papers published between 1935 and 1964. From these he brought together reports of 207 patients treated by a number of clinical surgeons using a variety of dissolution and flushing techniques. He concluded these were successful in 149 (72%) and unsatisfactory in 58 (28%).

The use of heparin has been rather carefully investigated by Bernard Gardner.[8] Using a continuous infusion of heparinized saline through a T tube, he has observed fragmentation of calculi within the common duct and their eradication by this method. In several cases he has had no untoward reaction from the use of heparin in saline and concludes that it is a useful adjunct in the removal of calculi and precipitated sediment in the common duct. He recognized that small stones with a calcified surface within the common duct probably are not as effectively fragmented or dissolved as those of nearly pure cholesterol. The additional use of a solid tip catheter to further the fragmentation and possibly encourage their being carried into the duodenum through the choledochoduodenal junction is advocated by him.

Over the past two years there has been discussed at medical and surgical meetings the role of cholates and their conjugates of taurine and glycine as solvents for dissolving gallstones. Bile acids, chenodeoxycholic and deoxycholic, have been used in animals and man to increase and maintain cholesterol solubilizing in bile.[3] With the aid of fluoroscopy and the image intensifier irrigation of the ductal system with innocuous solvent solutions combined with radiopaque material has been of value in establishing the size and location of residual calculi. This information is of value to those who seek to use either solvents, instrumentation or direct surgical removal of residual calculi.

Instrumentation

As instrument that could be inserted into a common duct and engage a retained calculus firmly enough that

FIG. 1. T-tube cholangiogram 9 days postcholecystectomy and common duct exploration revealing calculus that was removed surgically.

it could be withdrawn or crushed so that its fragment might pass through the choledochoduodenal junction would indeed be the ultimate in the solution of this disturbing problem. Many instruments have been designed, some have been successfully used but save for the reports of Mazzariello[15] the total experience of any one individual or group has been very limited. Bean and Mahorner[2] in 1972 described the removal of residual common duct stones through a T tube with a ureteral basket catheter. In a recent communication from Dr. Harold Conn he reported three of four patients with residual calculi successfully removed by non-surgical means. He further stated that Dr. Bean had been successful in 83% of 44 cases.

In general, it may be said that no two authors adhere to any single technique or procedure so a common approach remains to be established. Lamis[12] and his group have endorsed the use of the suction catheter of soft rubber with irrigation of saline and relaxants. C. J. Magarey[14] has reported the combined use of Desjardins forceps with a Dormia stone dislodger in five patients. He has found catheter suction an aid. McBurney and Gardner[13] have also used the suction catheter technique aided by the image intensifier to secure the calculus in the open end of the catheter. A further development in this approach has been the employment of a catheter with an arteriographic guide wire described by Niloff and Palayew.[18]

Numerous catheters and bougies have been devised in an effort to break up calculi and dislodge "calcareous sludge." Wendth, Liberman and Alpert[23] used a Teflon coated safety J guide introduced through a T tube. Unfortunately injury can result from these procedures. Reports on such iatrogenic lesions are seldom published. In discussion of these, Coyle and Thompson[7] quite correctly said: "In the past few years, Radiology has undergone many changes, but the addition of the TV image intensifier has added tremendously to the diagnostic and therapeutic capability of the radiologist. He can now direct catheters into small selected vessels, aid surgeons in removal . . . of retained common duct stones."

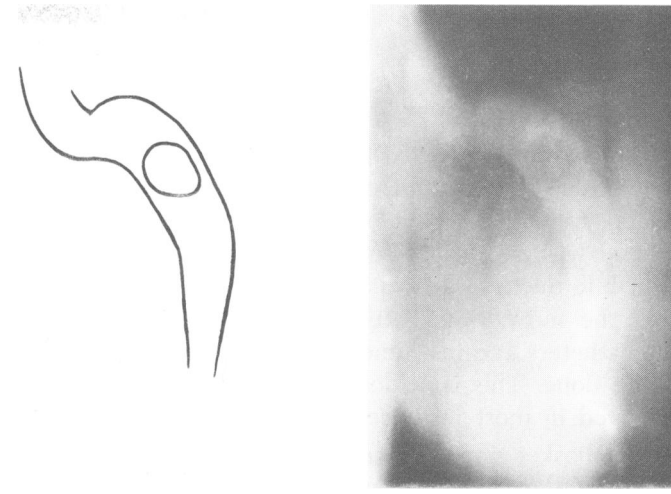


FIG. 2. Intravenous cholangiogram, postoperative, revealing large calculus within the common duct.

The most remarkable experience to be reported is

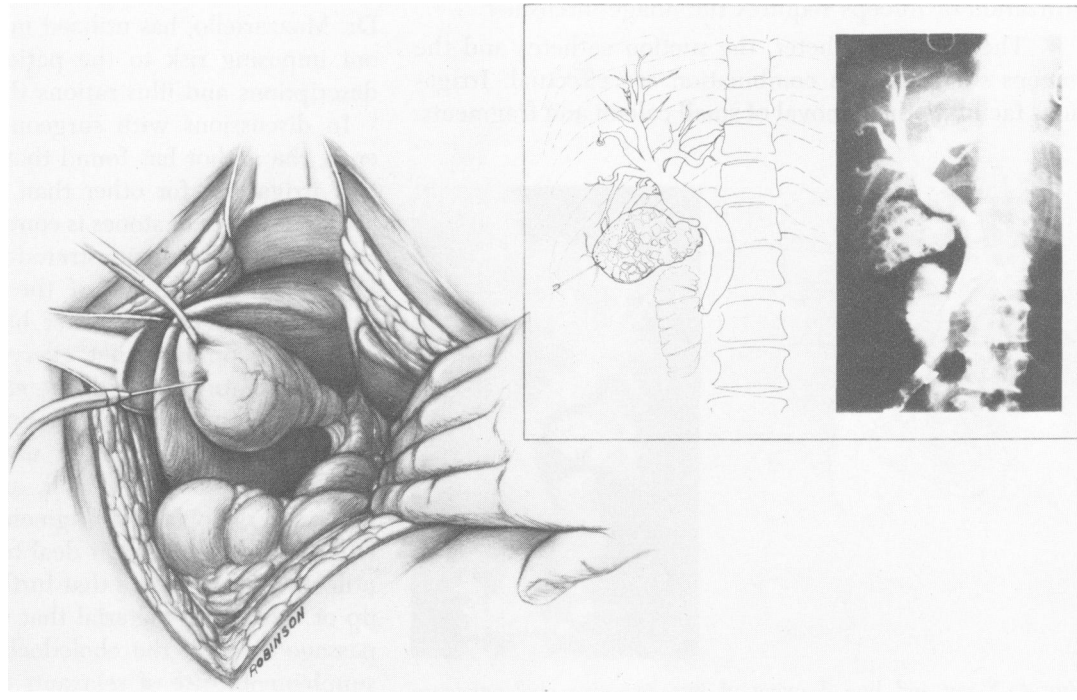


FIG. 3. Artist's sketch. At operation on all patients with calculous biliary tract disease an intraoperative cholangiogram is recommended unless there is a contraindication.

that of R. Mazzariello[15] of Buenos Aires, Argentina. Over a period from 1964 through 1972, he has attempted removal of residual calculi in 220 patients. He was successful in 204, or 92.7%. Over this period of eight years he has evolved the following approach.

1. After visualization of the fistulous tract and the ductal system, the skin orifice and the sinus tract are dilated with semi-rigid sounds up to and into the common bile duct.

If the indwelling T tube is large enough to admit the catheters and instruments he plans to use, dilatation is not done. This is seldom the case and the T tube is removed in most instances.

2. A basket tipped Dormia catheter is passed into the common duct through an open ended plastic sound. The distal and proximal segments of the common duct are thus explored under the fluoroscope and the calculus or calculi located. The Dormia catheter is then pushed past the calculus. It is then withdrawn so that the basket is immediately opposite and alongside the surface of the stone. The basket is opened to engage as much of the calculus as possible. The calculi may be fragmented and the duct irrigated and suction applied to the calculus through the catheter.

3. The utilization of forceps of varied curves and types are used as a first maneuver to locate and attempt dislocation of a calculus. These are also effectual in crushing or fragmenting calculi. Small calculi and fragments are usually most easily removed with forceps if they can be engaged in its tip portion or with a snare thread through perforations of the jaws of the instrument. The utilization of forceps requires the image intensifier.

4. The Dormia catheter, the suction catheter and the forceps singly and in combination are effectual. Irrigations facilitate the removal of small calculi and fragments.

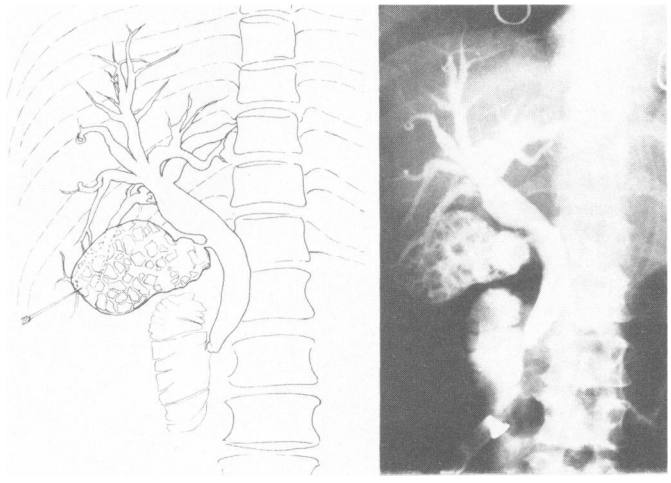


FIG. 4. X-ray and line drawing of intraoperative cholangiogram done by introducing opaque material into the gallbladder.

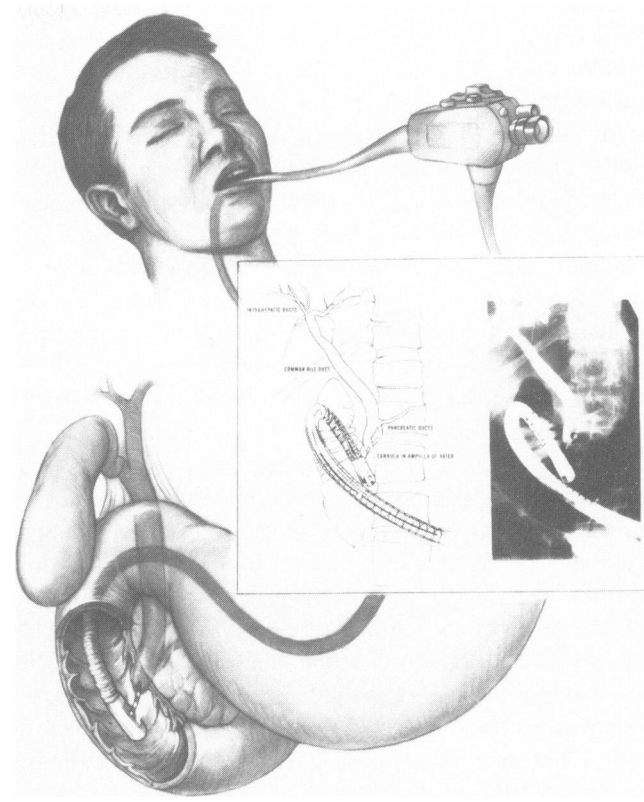


FIG. 5. Transduodenal endoscopic cholangiography.

Removal of a calculus, pushing it through the choledochoduodenal junction, engaging it in the end of a suction catheter or enveloping it in a wire basket or snare can be hazardous. The experienced user of these methods, Dr. Mazzariello, has utilized ingenious innovations without imposing risk to the patient as attested to by the descriptions and illustrations that he has published.

In discussions with surgeons of considerable experience, the author has found that there are those who feel that irrigations for other than the demonstration of the actual presence of stones is contraindicated, and that once stones have been demonstrated that the surgical approach for the direct removal of the calculi is indicated at a suitable time. On the other hand, there are those who are of the opinion that every known method of non-surgical treatment should be employed before a secondary operation is embarked upon. Beginning first with solutions of a non-solvent nature to remove the precipitous material, or calculi, and second by using substances to dissolve and fragment stones. This same group feel that there is a great deal to be accomplished by the utilization of catheters that further facilitate the breaking up of calcareous material that will permit facilitating its passage through the choledochoduodenal junction with supplemental use of relaxants of various kinds. In addition, those who advocate this latter approach feel that

instrumentation through indwelling tubes of one kind or another in the common duct is to be employed before embarking upon surgery. Surgery, in their opinion, is reserved for those intractable situations where calculi persist after all known non-surgical approaches have been employed without success.

A review of the reports of the five clinics listed in the table is indicative of the large number of patients that are operated upon annually, the frequency with which the common duct is explored, the incidence in which calculi are found, and how often retained calculi are demonstrated. Among 16,700 patients, 4,087 (24%) had common duct exploration that revealed calculi in the common duct in 1,884 (46%), an average incidence of retained calculi of 4.3%.

In an effort to determine a trend in the current incidence of retained calculi within the ductal system, the experience of the department of surgery of The New York Hospital-Cornell Medical Center for the year 1972 is presented. Admittedly this is a limited experience over one year, however, it happens that it is representative of the common course of events that precedes "residual calculi."

The New York Hospital Experience, 1972

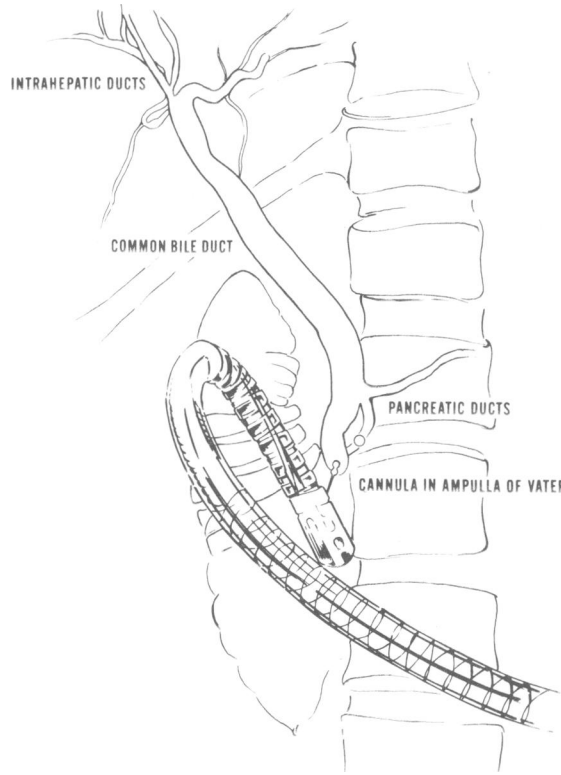
Four-hundred-and-ninety-nine patients were operated upon for calculous biliary tract disease in 1972. There were 360 females and 139 males. Three-hundred-and-two patients were 50 years of age or older and 197 under 50 years (Table 6).

Exploration of the common duct was done in 83 patients of the 499 at the time of cholecystectomy, or 16.6%; 47 (56%) had calculi removed. Four patients were demonstrated to have residual calculi by postoperative T tube cholangiogram or intravenous cholangiography. All were removed surgically.

Case Reports

M.K. 55 41 13 Sex F, Age 81: An elderly woman was admitted with a diagnosis of acute calculous cholecystitis. An intravenous cholangiogram showed moderate dilatation of the common bile duct, non-visualization of the gallbladder. Because of the patient's condition she was operated upon under local anesthesia and a cholecystostomy done. Numerous calculi were evacuated from the gallbladder and a Malecot catheter placed within it. She made a satisfactory recovery from this acute episode. Six weeks later she was readmitted for cholecystectomy and common duct exploration. An operative cholangiogram was negative for stones. A postoperative T tube cholangiogram was done eight days later and revealed a single lucent defect which was easily displaced and had a very smoothly rounded contour; it was believed to be an air bubble rather than a retained stone and she was discharged.

Thereafter the patient was followed in the out-patient department. She was readmitted to the medical service of the hospital several weeks later for cardiac decompensation that was corrected. At that time it was demonstrated that the alkaline phosphatase was elevated, being 315 on one occasion and two days later 277. There was also a slight elevation of bilirubin to 1.1 mg%. An



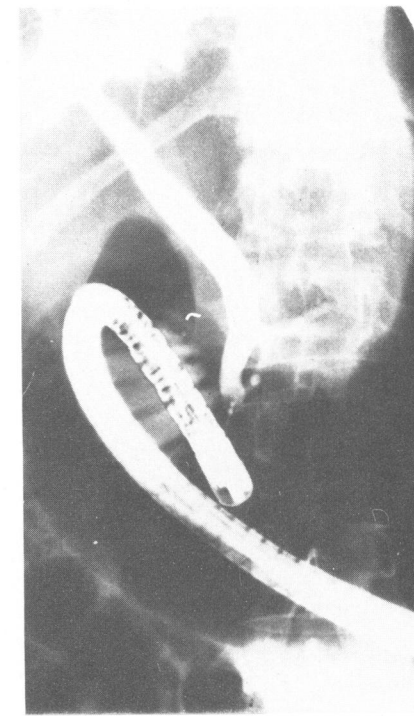


FIG. 6. Transduodenal endoscopic cholangiogram.

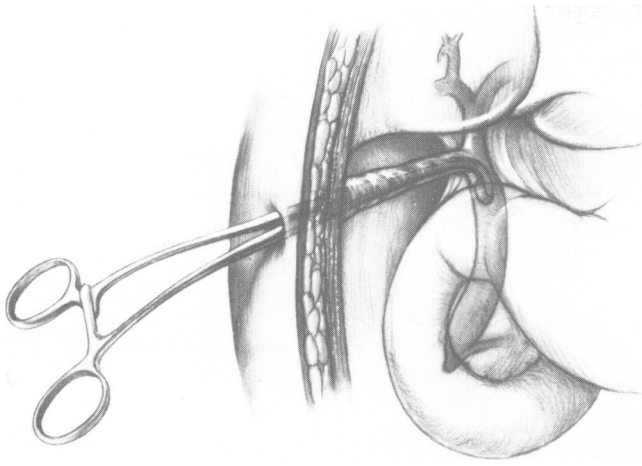


FIG. 7. An instrument is introduced through the sinus tract to crush a calculus located by fluoroscopic examination with opaque material as described by Mazzariello.

intravenous cholangiogram was reported as follows. "Dilated common duct with a large lucid filling defect identified on current study." The patient underwent surgery and a calculus was removed. Five days after operation a T tube cholangiogram demonstrated a negative biliary ductal system. The cholangiogram was repeated two weeks later and again read as negative. The patient was then discharged from her third hospitalization.

P.S. 67 93 19 Sex M, Age 79: At operation, cholecystectomy for chronic cholecystitis and cholelithiasis was done because the patient had been having attacks of RUQ and epigastric pain which radiated to the right scapula. An intravenous cholangiogram had not been done. At operation the size, thickness and nature of the wall of the common duct was not described. The patient was discharged from the hospital eight days following surgery with a statement that he had had a satisfactory postoperative course. He continued to have upper abdominal discomfort which was attributed to an umbilical hernia. He was therefore readmitted to the hospital four weeks following his discharge and an umbilical herniorrhaphy was done. The patient continued to complain of pain and was interviewed by psychiatrists. Seven months later an intravenous cholangiogram revealed a dilated common duct believed to contain many stones and the patient was operated upon a week later. Twelve days postoperative a T tube cholangiogram revealed a ductal system free of calculi. He was discharged free of abdominal pain.

W.M. 113 54 94 Sex M, Age 69: A patient was operated upon for chronic cholecystitis and cholelithiasis and probable choledocholithiasis. Calculi and calculus sludge were removed from the common duct. Before the abdomen was closed a T tube cholangiogram was done and considered to be free of calculi.

The postoperative course was satisfactory save that the total bile from the T tube ranged to 1000 cc/day and there was, in addition, bile leakage about the tube. Ten days after operation a T tube cholangiogram was done. "There was no flow from the common bile duct into the duodenum and a definite meniscus was seen at the most distal portion. There was some leakage about the T tube as it extended from the common duct." It was the impression of the radiologist that a calculus completely obstructed the distal common duct. A re-evaluation of the cholangiogram at the operation was very suggestive of a calculus in the common duct.

A few days later the common duct was re-explored and a single calculus and "calcareous sand" removed. The ductal system was decompressed with a T tube. A postoperative cholangiogram done 11 days after the second operation and 31 days after the primary procedure was negative for calculi.

J.K. 90 45 71 Sex M, Age 38: A young man with epigastric pain radiating to the back was admitted to the hospital with a diagnosis of cholelithiasis and a question of choledocholithiasis. The radiologist suggested that there was a lucency in the common duct on an intravenous cholangiogram. At operation the gallbladder was removed, the common duct explored and no common duct calculus found. Therefore a duodenotomy was done searching for presumed common duct stones. None was found. An operating room cholangiogram was obtained. This showed a normal ductal system, which was slightly dilated and no calculi were visualized. The patient's postoperative course was satisfactory. Twelve days after operation of T tube cholangiogram demonstrated a triangular filling defect proximal to the cephalad portion of the T tube. The patient was reoperated upon. A multi-faceted black stone, 5 × 4 × 3 mm, was easily extracted from the mid-portion of the duct. A #10 T tube was positioned in the common bile duct and the choledochotomy was closed. An operating room cholangiogram had been performed just prior to anesthetizing the patient in the operating room. The stone that was demonstrated prior to the initiation of surgery was not seen on postcholedochotomy x-ray. A T tube cholangiogram revealed a ductal system free of calculi nine days after the second operation.

Discussion

That the most frequently performed intra-abdominal operations are those upon the biliary tract is indicative of the high incidence of calculous biliary tract disease in this country. The evolution of the development of the surgery of the present has been continuous and gradual over the past century. Indeed it is the only effective therapy to interrupt its course and natural sequelae as well as a cure. This has been widely accepted by the profession and the patients chiefly because it has come to be accomplished with minimal risk and reasonable discomfort.

Residual calculi within the ductal system following operation is an increment that delays the surgical objective, namely cure and may prolong disability. The estimated incidence is upward from 0.5% of all patients operated upon for calculous biliary tract disease. It is anticipated that this is being currently reduced and it is hoped that they will be entirely eliminated some time in the future. There has accrued a vast literature of the experience of surgeons caring for those patients with biliary calculi. The information concerning those patients who are known to have had choledocholithiasis as well as cholelithiasis includes such specific data as age, duration of biliary tract disease, diet and habitus emphasizing that residual calculi may be anticipated in this group in particular.

In other words, choledocholithiasis is a prerequisite for residual calculi in the ductal system. The facilities for demonstrating calculi in the ductal system prior to

operation are good, providing both direct and indirect evidence. Intraoperative cholangiography is our most efficient means of definitive examination of the ductal system in determining the presence or absence of calculi. Equipment for operative cholangiography is being rapidly improved, but at present with rare exception it is adequate in most general hospitals to enable surgeons to detect the number, location and often the nature of calculi in the common duct when used with ordinary care. The recognition of all calculi within the ductal system at operation will surely reduce the number of patients with residual calculi to an all time low.

When residual calculi are suspected, relatively simple measures and roentgenological examinations can quickly settle the question. If residual stones are demonstrated the first question to be answered is: should they be removed or left unmolested? Both surgeons and patients are reluctant to leave them and await the development of untoward symptoms. The future course cannot be forecast with any accuracy. Obstruction of the flow of bile and its attendant symptoms can occur, but when is unpredictable.

Once demonstrated beyond a doubt, residual calculi become a target for a wide range of approaches directed at their removal. Solvents to dissolve them completely or sufficiently to permit their passage through the choledochoduodenal junction have long been utilized but with far from satisfactory results. Over the past two decades there has been introduced in addition and in combination with solvents and lubricants the use of instruments, forceps, crushing clamps, metal tipped catheters and suction apparatus. The success of Mazzariello of Buenos Aires has stimulated an intense wave of nonsurgical methods of removal of residual calculi. Success has been reported. Specific information regarding iatrogenic injuries has only occasionally been mentioned although certain hazards are recognized. The majority of surgeons with experience in the management favor direct surgical approach for the removal of residual calculi. When in relation to the previous surgery this should be done is dependent on the overall status of the patient and his convenience.

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Discussion

Dr. Warren H. Cole (Asheville): I certainly enjoyed this paper of Dr. Glenn's very much indeed. He has described the use of solvents and instruments in eradicating residual stones, and I agree with him heartily that some of them should be tried—not all, of course. But some of the instrumentations, and particularly those which he described, are very worthy of trial. He has presented a very low incidence, however, of residual stones, due to his vast experience and care.

Unfortunately, we are still encountering these residual stones, and I'm afraid we will continue to encounter them, no matter