Routine Operative Cholangiography:

An Evaluation

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Introduction

OPERATIVE cholangiography is a valuable diagnostic tool which does not increase the morbidity or mortality of gallbladder and bile duct surgery. Its accuracy as a guide to common duct exploration is considerably greater than the usual clinical indications. When it is done with regularity and precision, excellent diagnostic films are available. The added operating time does not exceed ten minutes. Good results necessitate close cooperation between the surgeon, radiologist and the anesthesiologist.

This report is an evaluation of our total experience with operative cholangiography. All of these operations were performed by the author or his partner between the years 1954 and 1960 inclusive. One-hundred seventy-nine consecutive cases of extrahepatic biliary disease with operative cholangiograms are reviewed to emphasize the value of the technic in:

1. Duct survey for stones; anomalies, tumors, dilations and stenosis;
2. Increasing the safety of biliary tract surgery;
3. Checking for residual stones after choledochostomy to avoid secondary operations;
4. Decreasing the incidence of unnecessary common duct explorations.

Equipment

Our first operative cholangiograms in 1954 and 1955 were made with a 40 ma., 90 KV. portable machine using a screen cassette with a five to one stationary grid in a wood cassette tunnel. The films were of relatively poor quality. The two cases with retained common duct stones occurred early in this series when the technic was new, and the machine was of insufficient power capacity.

Four years ago one operating room was equipped with a 200 ma., 100 KV. rotating anode machine permanently installed on an overhead track. Five to one ratio Lysholm grid cassettes are used in a Franklin cassette tunnel. Average exposure is 0.1 second. Cholangiograms are now of good technical quality, and there have been no retained common duct stones in this four-year period.

Technic

The patient is positioned on the operating table in proper relationship to the cassette. A preliminary film is exposed prior to operation to check position and exposure.

The surgeon exposes the cystic and common bile ducts in the usual manner, except that wound towels are fixed to the subcutaneous tissues by silk sutures rather than metallic clips or clamps. The cystic duct is ligated adjacent to the gallbladder to prevent passage of stones into the ducts and reflux of opaque media into the gallbladder. Through a slit opening in the distal portion of the cystic duct, a small polyethylene or ureteral catheter is threaded so that the tip is one or two centimeters within the common bile duct (Fig. 1). Fixation is secured by a ligature around the cystic duct and catheter. A

syringe containing 20 ml. of iodopyracet (Diodrast) is then attached to the catheter with a needle of appropriate size. All air bubbles are eliminated before making this connection. The catheter is filled with bile by simple aspiration, and packs and instruments are removed from the field. Ten to 15 degrees of Trendelenburg position result in better fill of the hepatic ducts, and 20 degrees of tilt to the right facilitates projection of the common bile duct shadow to the right of the vertebral column.

The roentgen tube is now positioned, and two exposures are taken following fractional injection of iodopyracet. A state of apnea for these exposures is readily induced by the anesthesiologist in patients under general anesthesia; this is more difficult to attain in the heavily sedated patient under spinal anesthesia. Depending on the size of the common duct, 3.0 to 5.0 ml. of opaque medium is injected; and the first exposure is made. More medium may obliterate roentgenographic details of the lower end of the common duct because of rapid passage of the iodopyracet into the duodenum. A second exposure is made after slow injection of 10 to 20 ml. additional iodopyracet.

The contrast medium used throughout this study is iodopyracet (Diodrast). It is water-soluble and produces a good pattern of the biliary tree without untoward reactions. In our experience any abnormality in bile ducts of normal caliber is readily visualized with a 35 per cent concentration of the medium. Several observers[15, 17, 37] have recommended more dilute media. When the common duct is dilated, concentrations of 10 to 17.5 per cent iodopyracet are necessary to prevent obliteration of stone shadows.

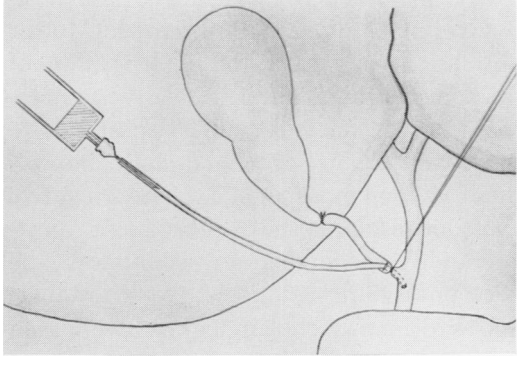

FIG. 1. Method of initial operative cholangiography using a polyethylene catheter.

TABLE 1. *Initial Operative Cholangiograms*

Number consecutive cases studied		179	
Number cases with operative cholangiograms		179	(100%)
Number initial operative cholangiograms		171	(95.5%)
A. Negative cholangiograms		142	(83%)
False negatives—stones removed	2		(1.2%)
B. Positive cholangiograms		29	(17%)
Suspected stones	8		(4.7%)
Unsuspected stones	7		(4.1%)
Dilated common duct—no stones	5		(3.0%)
Anomalous bilary ducts	2		(1.2%)
Fibrosis of sphincter of Oddi	2		(1.2%)
Tumor of the bile duct	1		(0.6%)
False positives	2		(1.2%)
Air bubbles	1		(0.6%)
Interposition of spine	1		(0.6%)
C. Unsatisfactory cholangiograms		6	(3.5%)
Duodenal injection	2		(1.2%)
Motion	2		(1.2%)
Spasm of the sphincter of Oddi	1		(0.6%)
Poor filling of the bile ducts	1		(0.6%)

The surgeon removes the gallbladder while the technician develops the cholangiograms. Examination of the processed roentgenograms is carried out in the operating room. If they are unsatisfactory, the process is repeated. This is rarely necessary after the technic becomes routine.

If the common duct is explored, completion cholangiograms are routinely obtained by injection of the opaque medium through the T-tube. To eliminate air bubbles in the bile ducts following choledochostomy, a closed system irrigation with isotonic saline has been most helpful.[13] The Trendelenburg position during this process facilitates passage of air bubbles into the duodenum.

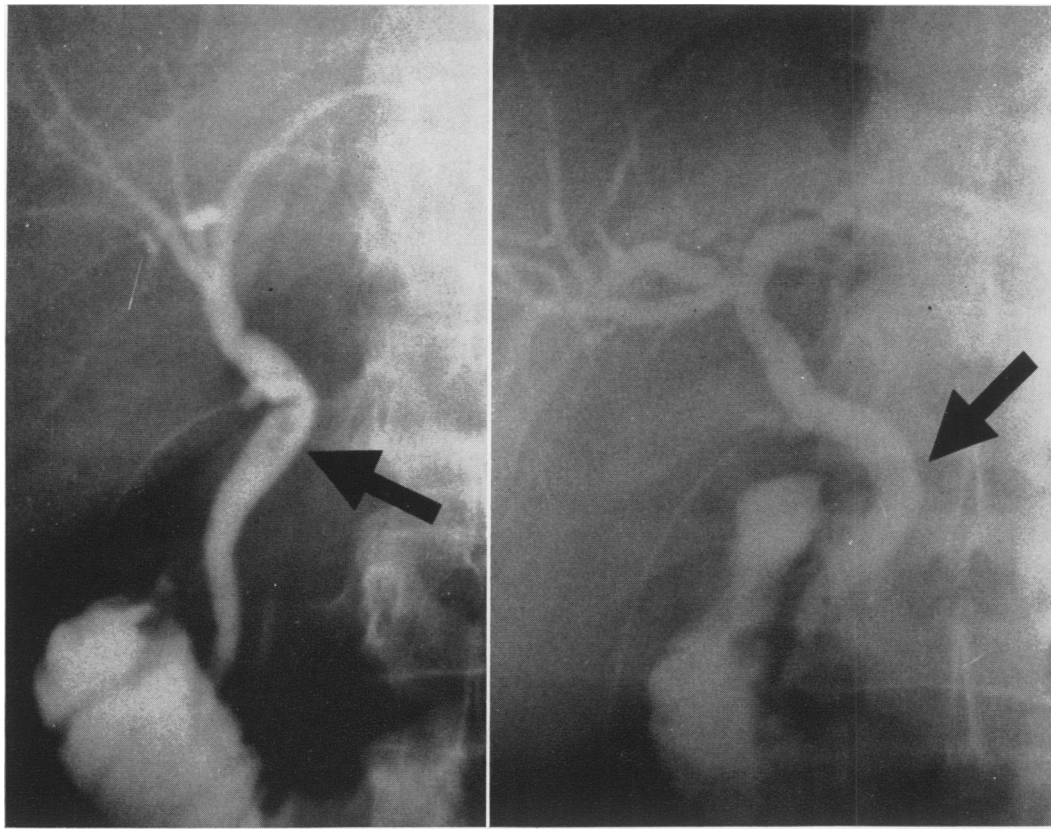

FIG. 2. False positive initial operative cholangiograms. *A.* (left) Air bubbles in the common bile duct. *B.* Interposition of the spine. Radiolucency of nucleus pulposis created a false impression of common duct stone.

Results

Initial operative cholangiograms were performed in 171 of 179 consecutive cases or 95.5 per cent of those patients undergoing operation for extrahepatic biliary disease. A summary of the findings is recorded on Table 1. Cholangiograms were negative in 83 per cent (142 patients). Two of these were false negatives. In each case small stones were palpated in the common duct and removed during the initial operation. None of the other negative cases have returned with symptoms suggesting an overlooked stone.

In 17 per cent of the patients the initial cholangiograms were positive. There were stones present in 52 per cent of the positive group (15 cases). Unsuspected stones were found in seven instances or 4.1 per cent of those having initial cholangiography. Other positive results and their relative occurrence are shown in Table 1. The bile duct tumor was a metastatic neoplasm from a hypernephroma of the right kidney which had been treated by nephrectomy five years previously. The two false positive results (Fig. 2A, B) were due to air bubbles in one case and interposition of the spine in the other. The relative radiolucency of the nucleus pulposis posterior to the common duct created a false impression of common duct stone. Negative choledochostomy and subsequent postoperative cholangiogram confirmed the false positive designation in each instance.

Unsatisfactory cholangiograms were seen on six occasions or 3.5 per cent. Duodenal injection, motion, spasm of the sphincter

of Oddi and poor filling of the bile ducts were the reasons for the unsatisfactory studies.

The common duct was explored in 39 patients or 21.8 per cent of the 179 consecutive cases with extraphepatic biliary operations under operative cholangiographic control (Table 2). Stones were removed from the ducts in 23 instances (59%). Choledochostomy was negative for stones in 41 per cent (16 cases), but half of these individuals had noncalcareous common duct disease including dilatation, carcinoma, anomalous ducts and fibrosis of the sphincter of Oddi.

Despite meticulous common bile duct exploration, completion operative cholangiograms through the T-tube revealed three cases out of the 36 so studied (8.3%) with shadows suggestive of stones. In each instance the common duct was re-explored immediately, and the calculi removed. A second surgical procedure was thus avoided in these patients.

Postoperative cholangiograms were done on 38 individuals prior to removal of the T-tube (Table 3). Radiolucencies indicative of retained common duct stones were observed in two patients (5.3%). The stones were removed successfully by chemolysis in both cases.

In this series there were 23 choledocholithotomies; a retained calculus was found in one case by postoperative cholangiography (4.3%). The second instance of retained stone reported above followed a negative common duct exploration.

TABLE 2. *Common Duct Explorations*

Number of common duct explorations		39	
A. Stones		23	(59%)
Suspected	16		(41%)
Unsuspected	7		(18%)
B. No stones		16	(41%)
Normal bile ducts	8		(20.5%)
Dilated bile ducts	5		(12.8%)
Fibrosis of sphincter of Oddi	2		(5.1%)
Carcinoma of common bile duct	1		(2.6%)

TABLE 3. *Postoperative Cholangiograms*

Number postoperative cholangiograms		38	
A. No stones		36	(94.7%)
B. Retained stones		2	(5.3%)
Stones removed by chemolysis	2		(100%)
Secondary operation	0		

There were no deaths among the 140 patients subjected to cholecystectomy and operative cholangiography. One death occurred postoperatively, in the 39 choledochostomies with or without cholecystectomy. This was a 78-year-old white woman who had a cholecystectomy and choledochostomy for acute cholecystitis, cholelithiasis and choledocholithiasis. She died on the fifth postoperative day due to an anterior myocardial infarction which occurred two days previously.

Discussion

Unsuspected Common Duct Stones. Much has been written about the problem of the overlooked, retained and unsuspected common duct stone.[2, 5-8, 10, 13, 16, 18-20, 23, 24, 28-36] 10 to 20 per cent of all patients with stones in the gall bladder will also harbor calculi in the common bile duct.[2, 4, 9, 20, 29, 36] The constant problem is that of identification of these patients at the time of cholecystectomy. In the past this has been accomplished by the appraisal of the symptoms and findings at operation.

The fallibility of these indications is exemplified by a study conducted by Glenn.[16] A detailed analysis of 100 consecutive cases of cholecystectomy without choledochostomy revealed that within a ten-year period 4.0 per cent required secondary operations for choledocholithiasis. Ferris[12] reported seven cases of unsuspected common duct stones among 185 primary operative cholangiograms. Mehn[28] found 10 per cent unsuspected common duct stones in 113 analogous studies. Thomson[35] reported a similar experience. Seven of the 87 operative cholangiograms recorded by Isaacs and Daves[23] showed un-

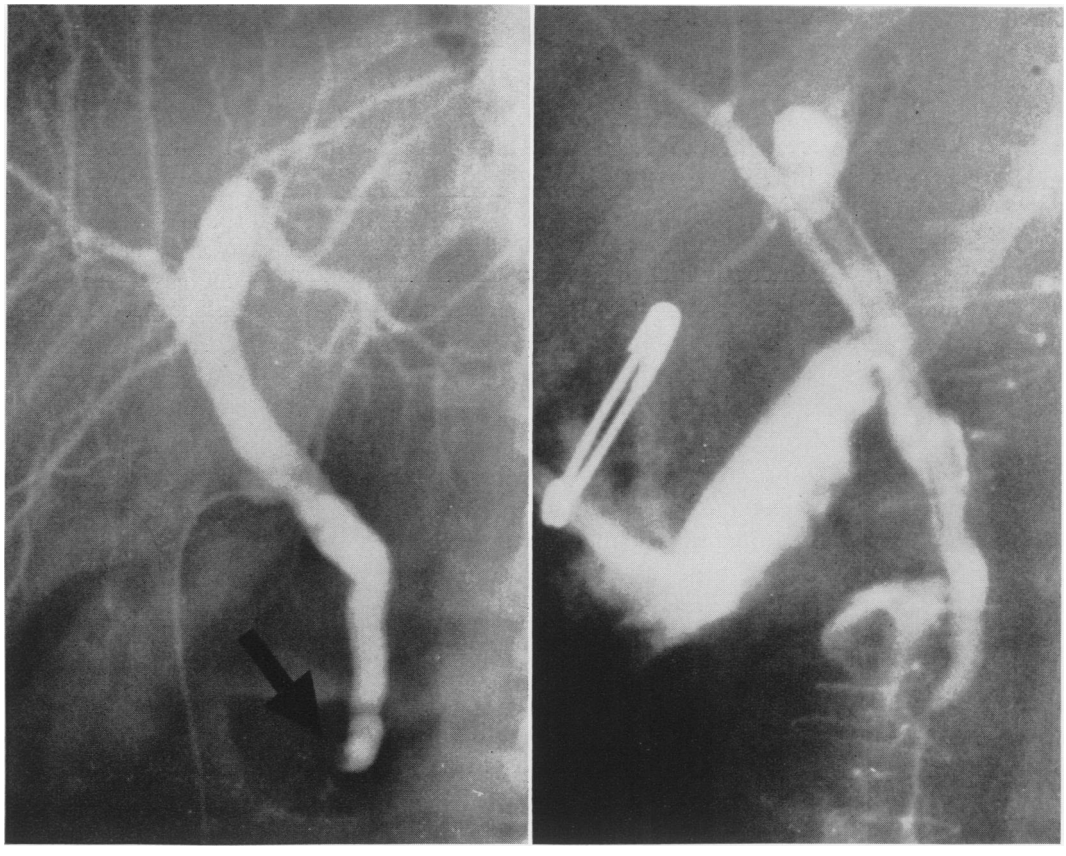

FIG. 3. *A.* Unsuspected common duct stone on initial operative cholangiogram. Impacted calculus was removed transduodenally. *B.* Negative postoperative cholangiogram.

suspected common duct stones. Our clinical evaluation (seven unsuspected stones in 171 cases) is comparable in a general way to the others. The most recent case of unsuspected common duct calculus in this series is illustrated in Figure 3.

Retained Common Duct Stones. Retained common duct stones occur with distressing frequency following choledocholithotomy. Buxton and Burk[8] reported residual calculi in 8.3 per cent of 190 choledocholithotomies. In 249 cases of negative common duct explorations for stones, postoperative cholangiograms demonstrated retained stones in 3.6 per cent. Smith, *et al.*[34] performed 224 cholecystectomies with choledocholithotomies and found that all stones had not been removed in 24 patients, an incidence of 10.7 per cent. Thomson[35] found 11.6 per cent residual stones after re-exploration of the common bile duct of 106 patients. Johnson, Waugh and Good[24] recorded 8.0 per cent overlooked common duct stones in 153 choledocholithotomies. Glenn[16] related a 9.7 per cent incidence of residual stones. Pribram[31] stated that stones are left behind by even the most experienced surgeons in 16 to 25 per cent of choledocholithotomies. Calculi were retained in 27 per cent of 206 choledocholithotomies reported by Paine and Firme.[30]

Several recent reports have included information concerning the incidence of retained stones under operative cholangiographic control. Hicken, McAllister and Walker[19] recorded 3.5 per cent overlooked stones in 105 choledocholithotomies. Prior

to the use of operative cholangiography, Isaacs and Daves [23] reported retained calculi in 10.5 per cent of 57 choledocholithotomies. With cholangiographic control, they failed to demonstrate an overlooked stone in 24 cases. Ferris [13] related an identical experience in 22 patients with surgical removal of common duct stones. Retained calculi were noted in 4.6 per cent of 146 negative completion cholangiograms studied by Mixter, Hermanson and Segel.[29] Our incidence of retained stones in those patients subjected to choledocholithotomy (4.3%) parallels these reports.

Though completion cholangiograms were considered negative for stones by the surgeon and the radiologist in both of our cases of overlooked calculi, the stone shadows were obvious in retrospect (Fig. 4, 5). These cases occurred early in this series when the x-ray equipment was relatively poor and the technic new. Motion is seen in Figure 5A. This is due in part to the long exposure necessary with the low power portable machine. It was easy for us to call these radiolucencies artifacts, rather than the less acceptable, incomplete common duct exploration. The added time to re-explore the ducts would have been well spent, although the hepatic duct stone may have been inaccessible. These failures are considered primarily human error, rather than failure of the method.

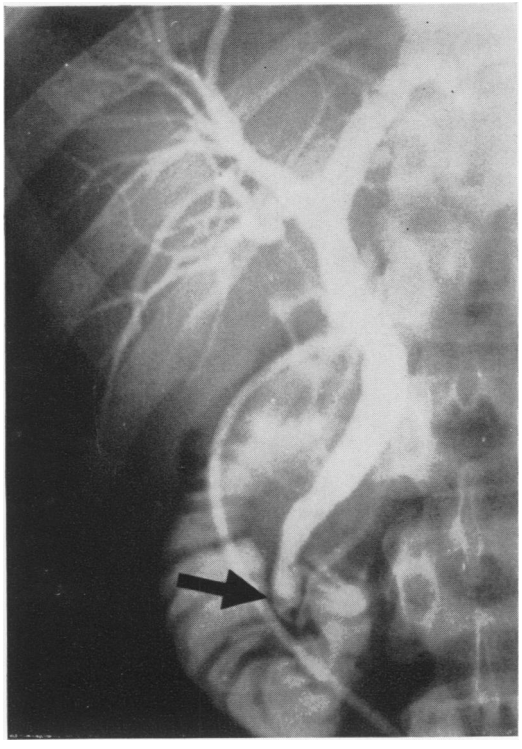

FIG. 4. A. Retained common duct calculi on completion operative cholangiogram.

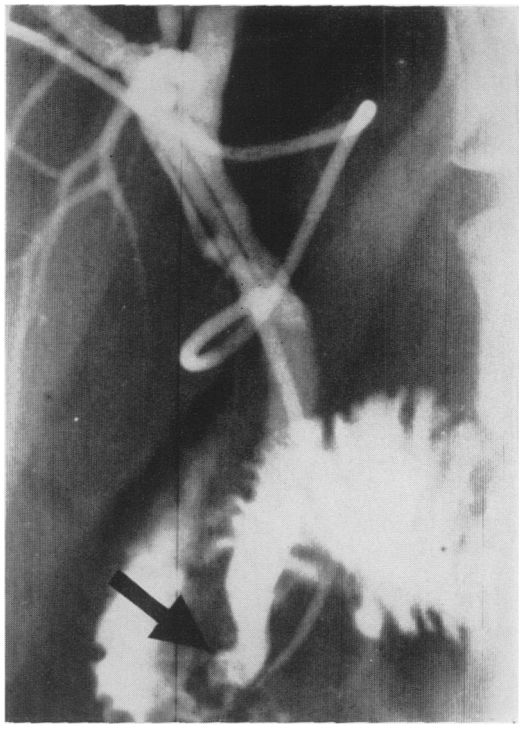

FIG. 4. B. Cholangiogram on eighth postoperative day showing the residual stones.

Fortunately secondary operations were successfully avoided. The calculi were removed by chemolysis in both cases. The patient with several small stones in the distal portion of the common duct (Fig. 4) had an excellent response to a single instillation of 5.0 ml. ether. The case demonstrating the large stone descending from the intrahepatic ducts postoperatively (Fig. 5) presented a greater problem. The T-tube was a mechanical barrier preventing passage of this calculus to the distal

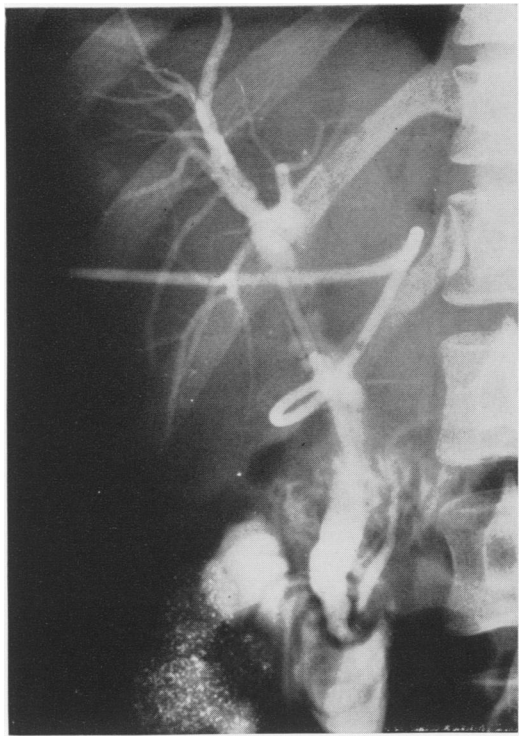

FIG. 4. C. Normal cholangiogram on tenth postoperative day after one treatment with ether intraductally.

portion of the common duct. Nine stones of similar size had been removed from the choledochus during the primary operation, and these cholesterol and bile salt calculi fragmented within ten minutes when subjected to ether and agitation. Their solubility in chloroform was similar. Under fluoroscopic control using 2.0 ml. iodopyracet injected into the T-tube, the extent of Trendelenburg position necessary to bathe the retained stone in ether was determined. This position was used for each subsequent ether instillation. Ten ml. of 1.5 per cent Metycaine injected into the tube produced adequate local analgesia and sphincter relaxation. After aspiration of all bile and Metycaine, ether was introduced via the T-tube using the drop-by-drop method with agitation and periodic release of pressure as advised by Best, *et al.* and Singleton and Coleman.[33] Almost three months later and two hours after her thirteenth treatment with 5.0 ml. ether injected intraductally, she experienced an episode of typical biliary colic of short duration. Cholangiograms on the following day were negative for stones.

The willingness of the patient to be subjected to continued medical insults and her negative attitude toward a secondary operation, were the factors responsible for this good result. I recommended operation after four weeks of chemotherapeutic failure. She has been symptom free during the five year period since chemical dissolution of her calculus.

Pribram[31] reported 51 cases of ether dissolution of retained stones without a failure. He stated, "It is a slow, conservative method which requires patience and time. Its greatest advantage is that it is entirely safe and harmless." Best, Rasmussen and Wilson[7] are also advocates of the safety

FIG. 5. A. Retained hepatic duct calculus on completion operative cholangiogram after nine faceted stones had been removed from the common duct.

and efficacy of chemolysis. They report 80 per cent success in 14 cases of overlooked calculi. Singleton and Coleman[33] also favor the chemical treatment and they believe that many residual stones can be safely removed by this method. Ether and alcohol were used with success in six of 20 cases reported by Behrend and Steppacher.[6] Retained calculi were removed in two other cases by the Best medical flush regimen and in one additional instance by belladonna and olive oil orally after unsuccessful treatment with ether and alcohol. Thus, favorable results were attained in nine of 20 cases using only medical therapy. Since secondary choledocholithotomy is associated with a mortality approaching 10 per cent,[35] every available method should be used to avoid it.

Physiologic flushing of the bile ducts using hydrocholeretic agents is another conservative method which we use routinely after all operations on the gallbladder or bile ducts. It probably helps to rid the bile ducts of retained cellular and calcareous debris. Lutton and Large[25] showed that the low cholesterol content in dog bile successfully dissolved human gallstones by absorption of cholesterol. Cole and Harridge[10] used 3.0 or 4.0 Gm. of bile salts daily on nine patients with retained common duct stones after choledochostomy. The T-tubes were clamped in all cases. The stone vanished in seven of the nine patients within eight to 36 weeks. Only two patients needed reoperation.

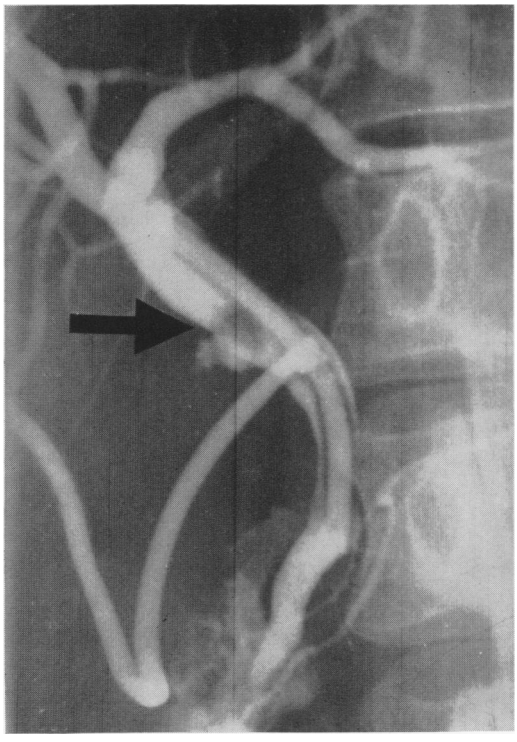

FIG. 5. B. Cholangiogram on the ninth postoperative day showing residual stone after its descent into the common duct.

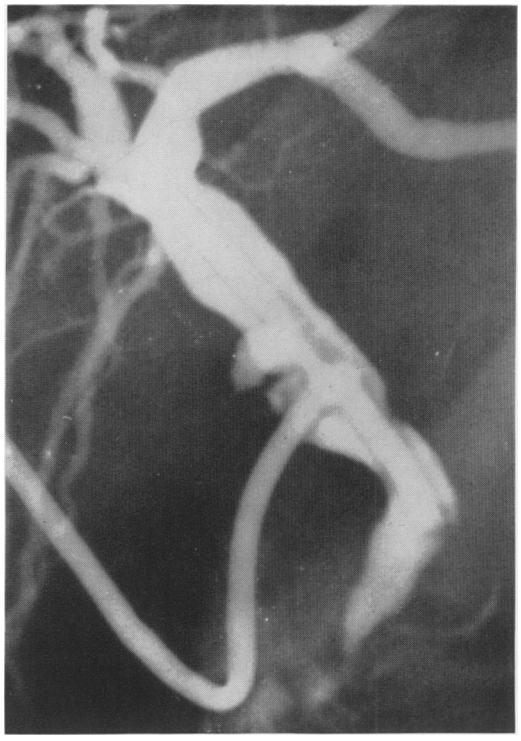

FIG. 5. C. Cholangiogram 12 weeks later. Stone successfully removed by ether dissolution.

Unnecessary Common Duct Explorations. The indications for common bile duct exploration have been fairly well standardized. Buxton and Burk[8] listed these criteria:

1. Palpable stones in the hepatic or common bile ducts;

2. Jaundice on admission or recently;
3. Dilatation or thickening of the ducts;
4. Clinical evidence of cholangitis;
5. Small stones in the gallbladder;
6. Thickening or induration of the head of the pancreas;
7. Biliary colic without stones in the gallbladder.

The presence of sludge or muddy bile in the common duct is another indication worthy of inclusion in a list such as this. The presence of sludge in the duct is readily apparent upon aspiration of bile through the polyethylene catheter during operative cholangiography.

A great number of unnecessary common duct explorations are performed when only criteria similar to those listed above are used. This was the situation before operative cholangiography became a popular procedure. The scholarly study of 2,243 cases of gallstones by Bartlett and Waddell[4] illustrates this well. Choledochostomies were performed in 43 per cent of this group to recover the stones harbored by 16 per cent. Others,[2,9,23,29] report a similar experience.

Using routine operative cholangiograms, we explored the common ducts of 21.8 per cent of our cases. Stones were present in the ducts of 13 per cent. This is only about 60 per cent of the incidence of choledochostomy prior to operative cholangiography. Mixter, Hermanson and Segel[29] stated that before they used cholangiography with operation 50 per cent of their common duct explorations were unnecessary. Hight, Lingley and Hurtubise,[20] Baker,[2] Isaacs and Daves,[23] Thomson,[35] MacCarty and Crickard,[26] and Hicken, McAllister and Walker[19] also emphasize its value in the reduction of the number of needless common duct explorations.

Merit of Completion Operative Cholangiography. After choledochostomy we do completion operative cholangiograms routinely to prove that all calculi have been removed before closure of the abdomen. In three of our 36 cases or 8.3 per cent, the common duct had to be re-explored because of overlooked stones. The incidence of retained calculi on completion operative cholangiograms was 25 per cent of 39 cases reported by Thomson,[35] 13 per cent of 146 studies by Mixter, Hermanson and Segel,[29] and 13 per cent of 109 cases evaluated by Hight, Lingley and Hurtubise.[20] Wall and Peartree[36] found common duct stones by initial operative cholangiograms in 63 patients. After the common ducts were explored and judged to be free of calculi, completion operative cholangiograms revealed overlooked stones in 36 of the 63 patients. These factual analyses extol the merit of the procedure.

Relation of Operative Cholangiography to Morbidity and Mortality. The mortality of cholecystectomy with choledochostomy appears to be about five times as great as that with cholecystectomy alone.[4,16,29] Any procedure which decreases the incidence of common duct exploration will reduce the risk of biliary tract surgery to an even greater degree. We can depend upon operative cholangiography to do this, when it is used routinely.

The duration of hospitalization after cholecystectomy is 8.5 days. When choledochostomy is added to this procedure, the hospital confinement increases to an average of almost 14 days. A 30 to 40 per cent reduction in the incidence of common duct exploration results in a great saving of time and expense.

General Considerations. The time tested indications for common duct exploration can be modified to some degree with opertive cholangiography. There is no need to explore the minimally dilated duct when cholangiograms are normal. However, common ducts over one centimeter in diameter are opened regardless of the roentgenographic findings. A normal cholangiogram is not a contraindication for choledochostomy when adequate clinical indications

warrant it. Muddy bile or particulate matter in the bile on common duct aspiration indicates the necessity for choledochostomy even though the cholangiograms are normal. The procedure is a reliable aid, but it is not a substitute for clinical judgment.

Like any diagnostic method, operative cholangiography has limitations and pitfalls. False positive, false negative and unsatisfactory studies are reported in all surveys. Accuracy depends upon good diagnostic films. There is no contraindication to repetition of the examination if the x-rays are of poor quality. Experience, interest and skill do much to reduce the incidence of errors.

Summary

Operative cholangiography is a valuable diagnostic procedure worthy of continued use. Accuracy depends upon good diagnostic films which are the products of interest, skill and cooperation. Best results are obtained when the method is performed routinely in all operations for extrahepatic biliary disease. It is safe, easy and not time consuming. Though its accuracy as a guide to common duct exploration exceeds that of the usual clinical indications, cholangiography is not a substitute for surgical judgment.

The incidence of unsuspected common duct stones at the time of cholecystectomy exceeds 4.0 per cent. The average incidence of retained stones after choledocholithotomy is greater than 10 per cent. Routine operative cholangiography facilitates the detection of unsuspected stones during the primary operation, and it reduces the average occurrence of retained stones to approximately 4.0 per cent.

The two cases of retained common duct stones in this report were treated by chemolysis with excellent results. In no instance was secondary operation necessary. The ether method of stone dissolution is described. Since the risk of secondary choledocholithotomy is great, every available conservative method should be used to avoid it.

Completion cholangiograms demonstrate 8.0 to 25 per cent overlooked common duct stones after choledochostomy. The procedure gives us the opportunity to remove these calculi during the primary operation.

When the time tested criteria for choledochostomy are used, with the benefit of cholangiography, the incidence of common duct exploration is diminished nearly 40 per cent. Many patients are thus spared the morbidity, mortality and expense of unnecessary common duct exploration.

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