OPERATIVE CHOLANGIOGRAPHY*

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Operative cholangiography was first described by Mirizzi[10] in 1932. The present status of operative cholangiography is typically expressed by the following divergent views, as found on successive pages in the *Archives of Surgery*, 1956: M. D. Sachs,[11] of Cleveland, states 'There is universal agreement as to the value of postoperative cholangiography. The equivalent results are obtainable with operative cholangiography. There should be no question as to the value of the procedure'. On the next page, Arthur Allen,[1] of Boston, says: 'It is apparent that the routine use of operative cholangiography is a cumbersome and impracticable solution to the problem of diagnosis and treatment of stones in the biliary ducts'.

I drew attention to the use of operative cholangiography in South Africa in 1956,[12] and in 1957[13] published my observations on 140 consecutive cases of biliary surgery

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in which routine use was made of cholangiography at operation.

Up to 31 January 1960, a further 213 biliary tract operations with operative cholangiography were performed, making a total of 353 for review since I commenced this procedure in October 1955. Although it is not infallible, we have shown that this is a valuable addition to our standard techniques of biliary surgery. It is however, only an *additional* procedure, and under no circumstances should the accepted clinical indications for exploration of the common bile duct be ignored.

Technique

It is obvious that X-ray plates of the highest quality should be obtained if we want reliable information. Therefore, the technique of introducing the dye must be meticulous, the standard of radiography should be excellent, and a radiologist should be present at the operation.

STEPS IN THE PROCEDURE

1. *Tunnel and Casettes*

Arrangements are made for the insertion of the casettes containing the X-ray plates. The most satisfactory is the apparatus devised by Eric Samuel[14-16] (Fig. 1). This consists of a full-length wooden tunnel, which is leadlined except for a space corresponding to the position of the upper abdomen. This space is closed in by a perspex plate with a stationary Potter-Bucky grid built in. The casettes are contained in pockets in a canvas 'bag' which can be extracted to the required spot by a helper at the head of the table. In this way a series of 3 - 5 plates may be taken without disturbing the operating team.

If this apparatus is not available, a suitable tunnel may be constructed of wood, and a casette, together with grid, may be slipped in and out from the sides (Fig 2). Modern operating tables have a suitable tunnel built in.

2. *Position of Patient*

The radiographer checks that the right subcostal area over the midclavicular line corresponds to the centre of the X-ray casette.

The patient is now rotated slightly to the right by placing sandbags behind his left buttock and left lower ribs. This is essential in order to project the common duct clear of the spine. Note that the *patient* should be rotated, not the table; tilting the table will interfere with the vertical projection of the X-rays through the Bucky grid, leading to linear disturbing shadows on the plate.

3. *Laparotomy*

Laparotomy is performed, all abdominal and pelvic organs examined, and biliary pathology confirmed.

4. *Dissection*

This begins at the gallbladder neck, and the cystic duct is positively identified. The cystic artery is tied and divided at this stage if it can be identified.

Two silk ligatures are passed around the cystic duct. The one nearer the gallbladder is tied and held long. The other is kept loose. A lateral opening is cut into the cystic duct between the ligatures. (Note: If there is any difficulty in identifying the cystic duct, cholecystectomy proceeds from the fundus, and only when the cystic duct is finally identified, is cholangiography carried out.)

Meanwhile 35% 'pyelosil' has been drawn into a syringe, and an 8-inch length of No. 2 polythene tubing is attached to the syringe with a well-fitting needle. Airbubbles are excluded, the end of the polythene tube is threaded into the cystic duct for only 1 cm. and the silk ligature is firmly tied over it.

5. *Injection of Dye*

The X-ray apparatus is wheeled into position and serial injections and exposures are now made. When the common duct is not widened, the amounts used are small, 1 ml., 2 ml. and 5 ml. If the common duct appears dilated, we use 2 ml., 5 ml. and 10 ml. Before each injection a new casette is slipped into position.

6. *Cholecystectomy*

This operation is now completed, and appendicectomy and other procedures may also be performed at this stage.

7. *Decision on Duct Exploration*

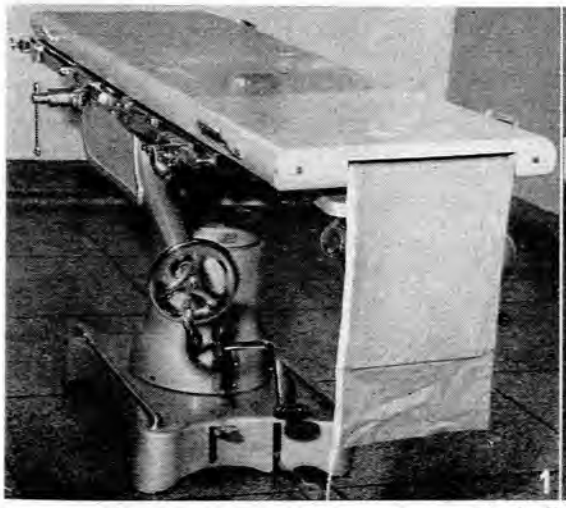
The common duct and the head of the pancreas are now inspected and palpated, and a clinical decision is made regarding the necessity for duct exploration. The X-ray plates are now back for inspection and a final decision is made.

8. *Points to Examine on the X-ray Plate*

(*a*) Width of common duct, (*b*) length and abnormalities of direction of cystic duct, (*c*) exact site of entry of cystic duct into hepatic duct, (*d*) low junction of left and right hepatic ducts, (*e*) accessory hepatic duct, (*f*) stones in common duct, (*g*) other filling defects, (*h*) stricture of common duct, (*i*) flow of dye into duodenum, and (*j*) filling of main pancreatic duct.

9. *Cystic Duct*

Only now, when the anatomy of the biliary tree has been positively demonstrated, is the remnant of the cystic duct dissected out and tied close to the common duct.



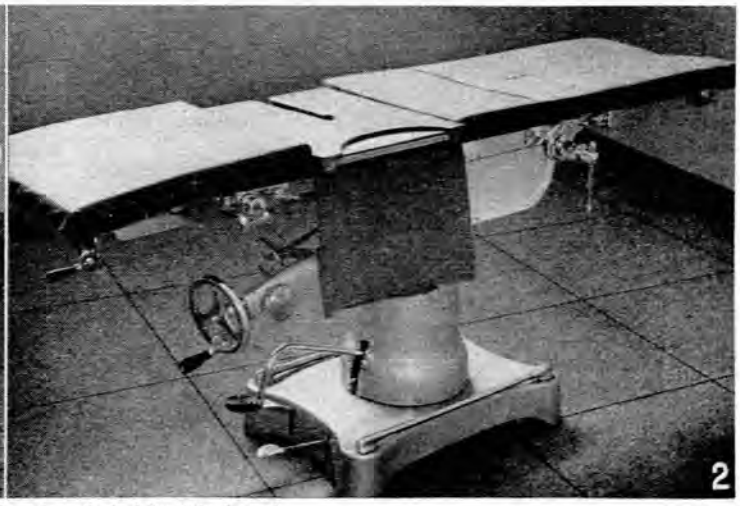


Fig. 1. Tunnel as devised by Eric Samuel.
Fig. 2. Simple wooden tunnel for insertion of X-ray casettes from the side.

10. *Common-duct Exploration*

If an indication for exploration exists, the common duct is opened, stones are removed, the ducts are irrigated, the ampulla is dilated with Bakes' dilators, and choledochoscopy is performed.

A No. 16 Bardex T-tube is cut so that the transverse portion is about 2·5 cm. long. It is cut in the form of a gutter, inserted into the common duct, and sewn in, so that it is watertight, with 00 catgut (plain) sutures. The T-tube should be inserted without trapping airbubbles. To achieve this the tube is filled with saline and clamped. The common duct is also filled with saline. The area around the opening in the duct is flooded, and the T-tube is now inserted 'under saline'. In this manner, airbubbles are eliminated completely from the tube and duct system.

11. *Control Cholangiogram*

A further series of 3 plates is taken as before to check on residual stones, before completing the operation. (Note: Frequently no dye will flow past the sphincter of Oddi at this stage even though a 10 mm. Bakes' dilator had been passed. This is due to spasm and should not cause concern.)

12. *Completion of Operation*

Closure of abdomen, with insertion of Penrose drain, completes the operation.

13. *Postoperative Cholangiogram*

If a T-tube has been inserted, the vertical limb is clamped from the 8th day, and a cholangiogram is done under fluoroscopic control on the 10th - 12th day.

VARIATIONS IN TECHNIQUE

1. *Cholecysto-cholangiography* may be done through a Foley catheter in the gallbladder, or dye is injected directly into the gallbladder by needle in some cases, e.g. in suspected carcinoma of the head of the pancreas.

2. *Direct injection into the common duct* is performed by syringe and needle in cases where the gallbladder had been removed, in cases where the ductal anatomy cannot be identified, and in cases of common duct stricture.

3. *Retrograde removal* of the gallbladder (from the fundus down) may often be necessary before the cystic duct can be identified for cannulation.

4. When stones in the common bile duct are palpable, the operative cholangiogram may be dispensed with, but a *control cholangiogram* at the end of the operation is essential.

5. *Trans-hepatic injection* into a bile duct through a long needle is useful in cases of common-duct stricture.

DANGERS AND COMPLICATIONS

The following have been described, although we have encountered none of them:

1. Pancreatitis.
2. Cholangitis or liver damage.
3. Iodine sensitivity.
4. Bile leakage from needle puncture (drainage should always be provided).
5. Radiation hazards to personnel. We have made measurements and have established that if all personnel stand back 5 feet from the X-ray tube during exposure, they are in no danger.

RESULTS

The results of the operative cholangiography carried out on the series of 353 patients are given in tabular form in this section.

Table I analyses the whole series (353), while Tables II, III and IV deal only with the 326 cases of 'benign biliary-tract disease', the 2 failures mentioned in Table I having been excluded.

Table II indicates that in an appreciable number of cases stones might have been missed but for operative cholangiograms.

Table III is self-explanatory, showing the low incidence of error in this series.

Table IV gives a comparison of unselected reports from the literature of the incidence of residual stones, i.e. stones which were overlooked at the times of the choledochotomy. The low figure in the present series is to be noted.

Table V gives the incidence of ductal anomalies encountered in the present series.

TABLE I. OPERATIVE CHOLANGIOGRAMS

Condition	*No.*	
Benign biliary-tract disease:		
Primary gall-bladder disease	295	
Post-cholecystectomy syndrome	23	328
Benign stricture	10	
Carcinoma	17	
Miscellaneous	8	
Total	353	

Of the 353 cholangiograms, 253 were normal, 98 showed abnormalities and 2 were failures. The pancreatic duct was shown in 35 cases (9·9%).

TABLE II. OPERATIVE CHOLANGIOGRAMS IN BENIGN BILIARY-TRACT DISEASE (326 CASES)

	Cases	*%*
Stones not palpable, but shown on X-ray	23	7
No stones palpable, no history of jaundice, common bile duct not dilated, but stones shown on X-ray	7	2
No history of jaundice, stones shown on X-ray	19	6
History of jaundice, but common duct not explored	22	7

TABLE III. LOW INCIDENCE OF ERROR IN OPERATIVE CHOLANGIOGRAMS IN BENIGN BILIARY-TRACT DISEASE (326 CASES)

	Cases	
Common ducts explored	113	
Stones shown on X-ray	71	8 false negatives (2·5%)
Stones found in common bile duct	79	
Shadow on X-ray, no stones in common bile duct	2	2 false positives (0·6%)
Residual stones on control (terminal) X-ray	0	
Residual stones on postoperative cholangiogram	2	(in 104 explorations — 1·9%)

TABLE IV. RESIDUAL STONES AFTER CHOLEDOCHOTOMY ACCORDING TO VARIOUS AUTHORS

	%		*%*
Hughes *et al.*[6]	24	Buxton *et al.*[2]	9
Corff *et al.*[3]	18	Johnston *et al.*[5]	8
Hicken *et al.*[7]	12	Sullens *et al.*[17]	7·7
Thomson[19]	11	Hight *et al.*[5]	5
Smith *et al.*[18]	10·7	McKittrick *et al.*[9]	2
Glenn[4]	9·7	Present series	1·9

TABLE V. ANATOMICAL ABNORMALITIES FOUND IN 351 OPERATIVE CHOLANGIOGRAMS

Abnormal ducts	*Cases*	*%*
Cystic duct	24	6·8
Hepatic ducts and common bile duct	4	1·1
Accesory hepatic ducts	7	1·9
Total	35	9·8

DISCUSSION

Objections

The following objections to the procedure have been raised:

1. *It is unnecessary*. Some surgeons state that stones in the common bile duct can always be palpated. This is not true. We have been able to demonstrate on 23 occasions that a stone, which was not palpated, could be shown on an X-ray plate, frequently in the presence of an undilated common duct. Some authorities state that they can dissect the anatomy of the biliary tree without difficulty. This is not true, and to attempt it is dangerous. An operative cholangiogram gives us a perfect picture of any anatomical variation in the ductal anatomy, and with this picture before us subsequent dissection becomes quite safe (Fig. 3).

Fig. 3. Accessory hepatic duct (*a*), and stone in common duct (*b*).

2. *It wastes time*. This also is not true. We estimate that the whole procedure takes about 3 - 5 minutes. The operation proceeds in the usual manner while the plates are being processed.

3. *There is fumbling under sterile towels*. This is eliminated by the use of Eric Samuel's tunnel.[14-16]

4. *It is dangerous*. We have encountered no complications following the use of this procedure. Radiation danger to personnel is eliminated if all of them stand back 5 feet from the X-ray tube. At this distance a person will receive a dose of about 1mr. per exposure. The safety margin of radiation is 100 mr. per week.

5. *False positives may occur*. Airbubbles in the biliary tract may simulate stones. This condition will be eliminated simply by ensuring that no airbubbles are introduced. Other filling defects in the ducts may be due to hepatic artery compression, a kink in the common bile duct, overlying gas, etc. A radiologist will be able to diagnose these. In this series there were 2 false positives in 326 cases (0·6%) — see Table III.

6. *False negatives may occur*. This is a real criticism. Dye may surround and totally obscure a small stone. We have practically eliminated this trouble by using a more dilute dye, by taking a series of 3 or 4 plates, by injecting small amounts, e.g. 1 ml., 2 ml. and 5 ml. in a series of 3 exposures, and by insisting on expert radiographic technique (Fig. 4). In this series there were 8 false negatives in 326 cases (2·5%) — see Table III.

7. *Stones may be left after choledochotomy*. We insist on a control cholangiogram by injecting dye through the T-tube at the end of the operation. Care should be taken not to introduce airbubbles. This is done by filling the bile duct and T-tube with saline and inserting the T-tube under a water seal. Numerous reports mention stones discovered in this way in 2 - 24% of cases.[2-9,17-19] In the present series 2 out of 104 cases of duct explorations showed residual stone (1·9%) — see Table IV.

8. *Operative cholangiography might be done only if required, not as a routine*. We cannot see how an accurate selection of cases for operative cholangiography can be made. We have repeatedly demonstrated stones in cases where there were none of the clinical indications for common-duct exploration. We have established that, although not infallible, operative cholangiography can be of very great help indeed. With films of excellent quality and the help of an experienced radiologist in interpretation, a high degree of accuracy can be obtained. I have used the procedure as a routine in 353 cases up to 31 January 1960, and consider that it should be so used. I believe that attempts to use it only in 'selected' cases are wrong, and that much pathology will be missed.

Duct Anomalies

It is noteworthy that in all papers on operative cholangiography, attention is paid almost exclusively to the question of stones in the common duct.

A plea is made here for more attention to anomalies of the cystic, hepatic and common bile ducts. We have found a duct anomaly in 35 out of 351 cases (9·8%) — see Table V. It has been of the greatest help to demonstrate the presence of an accessory hepatic duct, a low junction of the left and right hepatic ducts, the cystic duct entering an accessory hepatic duct, the cystic duct entering the right hepatic duct, the cystic duct entering to the left of the common duct, and the ampulla of Vater situated in the third part of the duodenum (Figs. 5 - 7).

With the anatomy of the biliary tree perfectly outlined on the X-ray plate, it has been possible to plan dissection accurately and to avoid injury to anomalous or normal ducts.

Common-duct Stricture

If dye can be injected above the stricture, the X-ray photograph shows the exact location of the narrowing, the presence of stones above, and frequently the condition of the duct below (Fig. 8).

Fig. 4. Serial X-rays, showing how a common-duct stone may be obscured by overfilling. Stone (*a*) seen only on the '2 c.c.' plate.

Carcinoma of the Pancreas

Usually there is no difficulty in identifying the blunt obstruction of a malignant lesion, and it is a great help when a decision has to be made concerning pancreatoduodenal resection (Fig. 9).

Post-cholecystectomy Syndrome

Dye injected directly into the common duct, the gall-

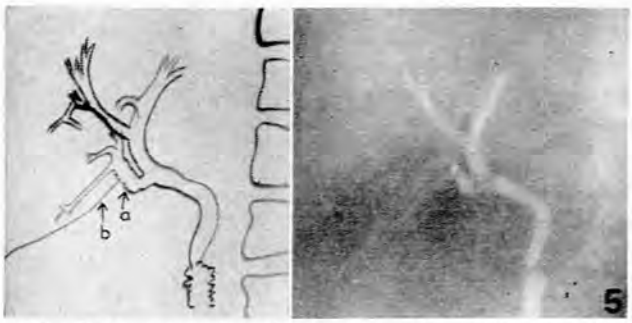


Fig. 5. Accessory hepatic duct (*a*), with cystic duct (*b*) entering it.

Fig. 6. Low junction of left and right hepatic ducts (*a*).

bladder having been previously removed, is usually of great help in showing residual or recurrent common-duct stones, a cystic-duct stump with or without a stone, a gallbladder remnant, common-duct strictures, and stenosis of the sphincter of Oddi (Fig. 10).

CONCLUSION

It is seen, therefore, that operative cholangiography is helpful in identifying stones and obstructions, and is also of the greatest importance in providing an accurate picture

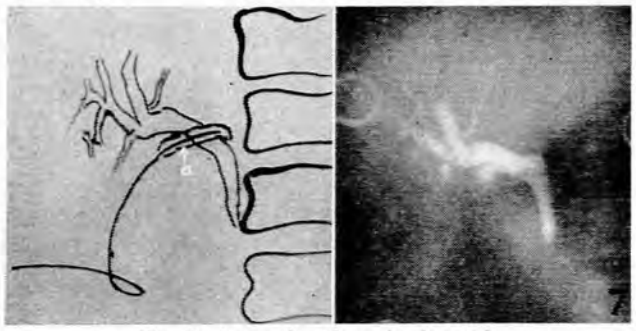


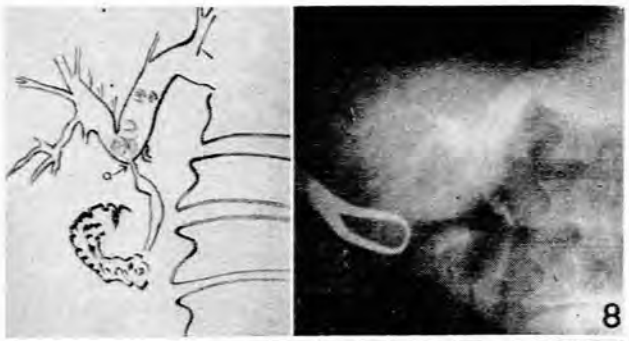
Fig. 7. Anomaly of cystic duct (*a*).

of the anatomy of the bile ducts and in directing the surgeon's attention to abnormal anatomy.

THE FUTURE

Having established the fact that operative cholangiography is not only useful but essential during biliary tract operations, it remains for us to improve the present technique.

1. We should insist on expert radiographic and radiological help.
2. A built-in overhead X-ray tube, and a specially constructed table with a tunnel and movable Bucky grid, may give better X-ray photographs.
3. An image intensifier may be used.
4. Television X-ray: With this technique, a television screen in the theatre visible to the operator demonstrates



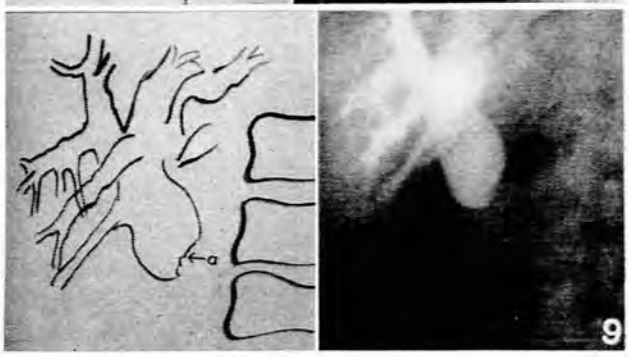


Fig. 8. Common-duct stricture (*a*).

Fig. 9. Carcinoma of head of pancreas, showing blunt obstruction (*a*) of common bile duct.

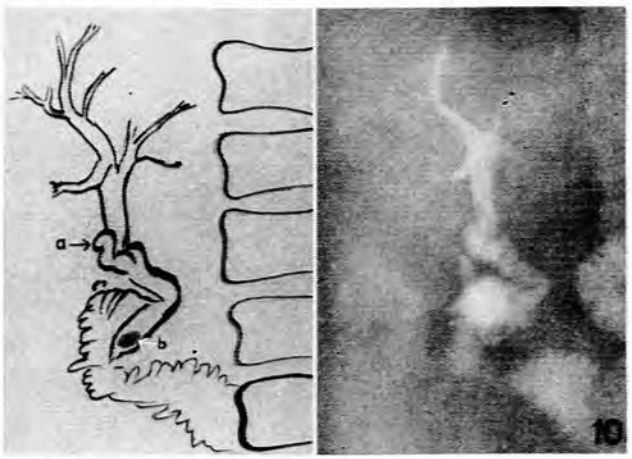


Fig. 10. Post-cholecystectomy syndrome, showing cystic duct remnant (*a*), and stone in common duct (*b*).

the radiographic picture of the common duct continuously while the dye is being injected. Viewing takes place under daylight conditions. Although it is outside the scope of this paper, it is suggested that a choledochoscope be used whenever the common duct is opened.

SUMMARY

1. A detailed analysis of 353 biliary operations, where operative cholangiography was used, is given.
2. The technique of the procedure is described, and stress is laid on the necessity for meticulous attention to detail in the injection of the dye, as well as on the need for the highest standard of radiography.
3. Complications and criticisms of the procedure are

discussed. It is shown how false positive and false negative readings have almost been eliminated by improvements in technique. A low incidence of residual common-duct stones is reported.

4. Stress is laid on the use of cholangiography at operations to demonstrate anatomical anomalies such as an accessory hepatic duct, a low junction of the hepatic ducts, anomalies of the cystic duct, etc. Operative trauma to such ducts is then easily avoided.

OPSOMMING

1. 353 persoonlike gevalle van operatiewe cholangiografie word ontleed en resultate word bespreek.

2. Die tegniek van die prosedure word breedvoerig beskryf. Klem word gelê op die belangrike punte van die tegniek, en 'n hoë standaard van röntgenologie word vereis.

3. Die nadele van operatiewe cholangiografie word bespreek. Deur verbeteringe in die tegniek het dit moontlik geword om vals negatiewe en vals positiewe bevindings feitlik uit te skakel. 'n Baie lae voorkoms van agtergeblewe choledochus-stene word gerapporteer.

4. Operatiewe cholangiografie is belangrik om abnormale anatomie aan te toon soos bv. bykomstige lewerbuise, afwykings van die ductus cysticus, ens. Operatiewe skade aan die buise word dus vermy.

I should like to thank Drs. A. v. B. Smith, F. W. McLachlan and A. C. McDonald, radiologists, for their help and advice in this work.

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