majority of surgeons still pursue the well-tried and conventional method of T-tube drainage.

The remaining common duct stone: With T-tube drainage a cholangiogram can be done ten days after operation and may reveal a remaining common bile duct stone (even in spite of cholangiography during operation). In elderly and unfit patients a stone free in the duct may never give further trouble and stones of up to 7 mm have been known to pass spontaneously; in such patients a waiting policy can be adopted. In younger fit patients it is better to explain matters to the patient and advise reoperation provided the environment and experience of the surgeon is right (*see* second principle above).

Dissolving stones: While stones may pass spontaneously it is doubtful if they can be dissolved by the introduction into the ducts of stone-dissolving substances via a T-tube. To dissolve cholesterol in the stones, Pribram (1935) advocated injections of ether in very small amounts (1–2 ml); as ether increases in volume two hundred times when vaporized, the tube should not be clamped. Olive oil has also been used to encourage the passage of sludge. Bile salts solutions have been employed, since bile salts dissolve cholesterol and human gall-stones will dissolve *in vitro* if placed in the bile of a dog or an ox: I have used the method three times with uncertain results – certainly it is expensive in terms of the cost of a hospital bed and does not deserve any special advocacy.

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Mr Rodney Smith
(*London*)

Strictures of the Bile Ducts

In this paper I shall mainly discuss operative traumatic strictures for, regrettably, operative trauma is in fact the most common cause of a stricture. However, there are other causes and I shall deal briefly also with malignant strictures of the bile ducts and nonmalignant strictures arising from causes other than operative trauma.

Malignant Strictures
Carcinoma of the common hepatic duct is not a common lesion but is not particularly rare. It presents clinically as a progressively deepening jaundice of an obstructive pattern and on exploration the bile ducts below the liver are found to be contracted and empty of bile. Quite often the tumour itself at this stage is small and the diagnosis is missed, an incorrect diagnosis of sclerosing cholangitis being made. Even if a biopsy is taken from the porta hepatis the fragment removed often does not contain a piece of
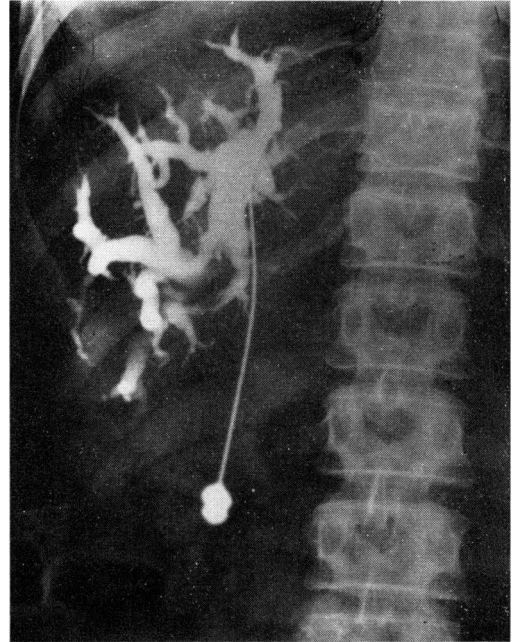

Fig 1 *Percutaneous transhepatic cholangiogram showing dilated intrahepatic ducts with total obstruction at the porta hepatis characteristic of a carcinoma of the common hepatic duct*

the carcinoma and this is later held to confirm the belief that the cause of the jaundice is non-malignant. If pre-operative percutaneous transhepatic cholangiography is used and operative cholangiography via the small common bile duct is added, then the visualization of very large dilated bile ducts in the liver together with contracted empty bile ducts below the liver should allow a correct diagnosis to be made (Fig 1).

Treatment: Resection of a carcinoma of the common hepatic duct is occasionally possible (Fig 2), followed by anastomosis of the divided right and left hepatic ducts to a Roux loop of jejunum. Most tumours, however, are inoperable

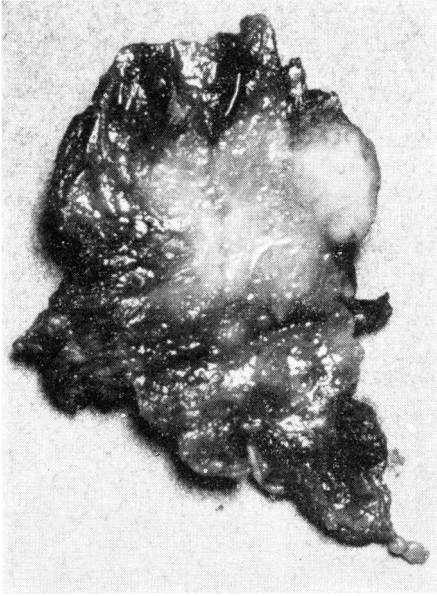132 *Proc. roy. Soc. Med. Volume 62 February 1969*

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Fig 2 *Resected specimen of a carcinoma of the common hepatic duct. The divided right and left hepatic ducts can be seen on the upper surface of the specimen and the divided common bile duct on the lower. A scirrhous carcinoma in the middle has an associated metastatic lymph node attached*

and the surgeon in this case can aim only at palliation. Relief of the jaundice can be effected by dilating forcibly the malignant stricture after which the largest sized T-tube that can be used is placed with the long upper end through the carcinoma into the dilated intrahepatic bile passages, the lower end in the common bile duct. This T-tube is left in permanently and kept clear from deposited pigment by daily wash-outs. Relief of the jaundice may also occasionally be effected by some form of biliary short circuit. This is the aim of the Longmire operation, the

principle of which is to amputate part of the left lobe of the liver, thus entering a dilated branch of the left hepatic duct, this latter being anastomosed to a Roux loop of jejunum. A different variety of short circuit can sometimes be effected if the gall-bladder is normal and if the cystic duct is normal and enters a normal common bile duct low down well away from the porta hepatis. In such a case the gall-bladder may be dislocated from its fossa after division of the peritoneal attachment, an intrahepatic dilated bile radical may be sought with a needle and syringe and then exposed by dissection through the liver substance, after which this dilated bile radical is anastomosed to the gall-bladder which is itself thus used as a bile duct (Fig 3) (Smith 1964a).

It is well worth while persevering in the attempt to relieve jaundice in a patient with a carcinoma of the common hepatic duct for these tumours are frequently late in metastasizing and the patient may survive for several years.

Diffuse Sclerosing
Cholangitis
This interesting and uncommon variety of bile duct stricture presents with obstructive jaundice, often mild and intermittent to begin with and complicated by attacks of cholangitis, increasing in severity as the years go by. Various theories have been put forward from time to time as regards the ætiology and it is interesting, for instance, that a higher proportion of patients have or have had ulcerative colitis than coincidence would seem to allow. Investigations, including pre-operative percutaneous transhepatic cholangiography, laparotomy and operative cholangiography, should demonstrate the diffuse nature of the lesion and there should not be confusion between the appearances in diffuse cholangitis and carcinoma of the common hepatic duct (Fig 4). Since intrahepatic as well as
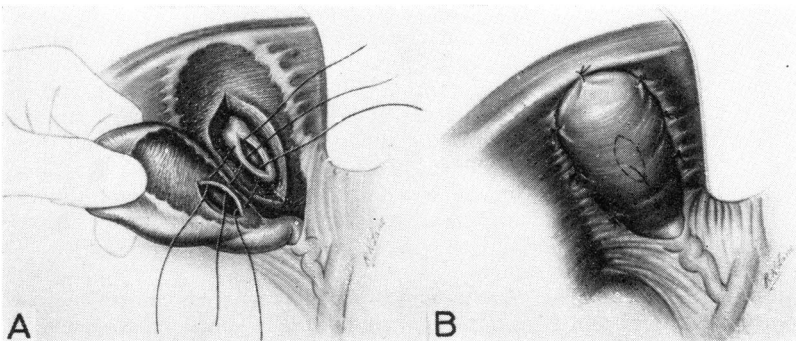

Fig 3 A, B *Short circuit of a carcinoma of the common hepatic duct can occasionally be effected by anastomosis of a dilated intrahepatic duct to the gall-bladder*
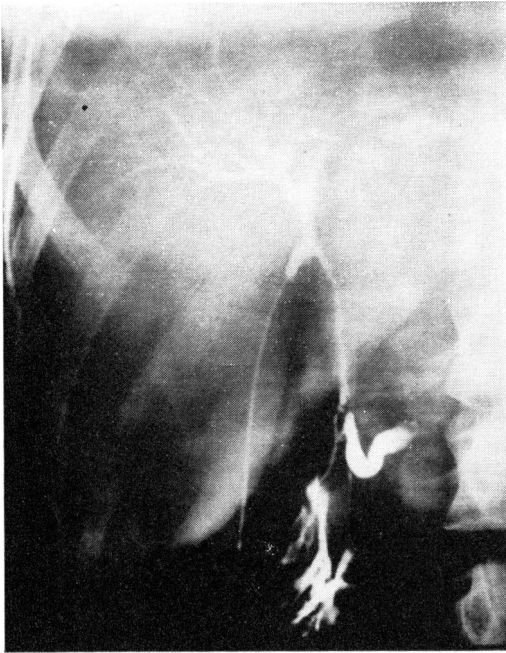
Fig 4 *Operative cholangiogram via the cystic duct in a case of diffuse sclerosing cholangitis. The widespread stricturing of both intra- and extra-hepatic ducts is well shown. This fibrosis extended right down to the papilla of Vater causing partial obstruction of the pancreatic duct which is seen here to be dilated*

extrahepatic bile ducts are usually extensively involved in the sclerosing, stricturing process, surgical short circuit is not an effective method of treatment. The long-term use of steroids has proved of benefit in some cases and it is possible that long-term drainage of the common bile duct with a T-tube may also play some part in treatment although there are differing views on this.

Traumatic Strictures
Any severe abdominal trauma may injure the bile ducts and cause the later development of a stricture but the great majority of traumatic strictures result from operative trauma during the operation of cholecystectomy. I shall not go into details as to how this accident happens except to comment that the belief, apparent from the content of some articles on this subject, that the bile duct is commonly injured at the point where the common duct and cystic duct join is not borne out by the experiences of most surgeons interested in this problem. When there has been an injury to part of the extrahepatic biliary system and a stricture later develops it is nearly always found that this is high up in the porta hepatis at a point only a short distance below the junction of the right and left hepatic ducts.

I shall confine my remarks to the treatment of this troublesome lesion. Probably the most skilful operator in this field was Dr Richard Cattell in Boston and the operation he selected was usually an end-to-end anastomosis of the damaged bile duct after excision of the stricture (Cattell 1947, Cattell & Braasch 1959). I feel that he obtained successes with this operation more from the very skilful way he did it than from the intrinsic merit of the operation itself, for very few other surgeons have obtained a high percentage of successes with this very difficult procedure.

Most surgeons would today agree that some form of hepaticojejunostomy should be selected in most cases. The trouble is that after hepaticojejunostomy there is a high incidence of restenosis at the anastomosis and it is a very common story that a patient who has sustained an injury of this kind embarks upon a series of operations, each one apparently successful for a while but each one later followed by further obstructive jaundice and cholangitis rendering a further procedure necessary.

The whole basis of the problem can therefore be stated quite simply. What steps can be taken in doing the operation of hepaticojejunostomy to avoid restenosis at the biliary-intestinal anastomosis? Certain principles will be accepted by all. The anastomosis should be as large as possible; the apposition of the lining of the duct system to the jejunal mucosa should be accurate all the way round the stoma and there should be no tension upon the anastomosis. It is very easy to set this out as one's aim and indeed if one were to achieve this in every case there would be no problem and restenosis would be rare. Unfortunately it is always difficult and sometimes impossible to satisfy these criteria for the duct injury may be such a high one that the lining of the hepatic duct system, which we wish to appose accurately to the jejunal mucosa, may lie at such a high level and so encased in scar tissue that this apposition becomes impracticable.

Various ways have been sought to get over the difficulty. One way is to construct as accurate an anastomosis as possible and then, recognizing that this is not in fact accurate all the way round the circumference of the stoma, to provide splintage of the anastomosis by means of an indwelling tube. Probably the most effective way of providing intubation of this kind is to use a transhepatic tube (Smith 1964b). This method works very well provided that there is apposition of duct lining to jejunal mucosa at some 40-50% of the circumference of the stoma. It does appear that if this is so and if one uses intubation for 4-6
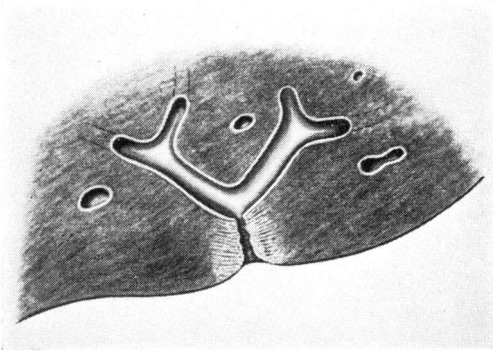
Fig 5 *A high duct injury does not allow adequate access to the obstructed biliary system*
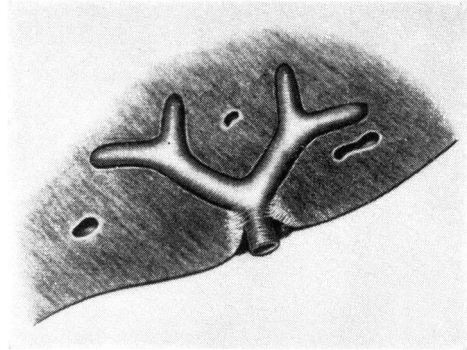

Fig 6 *'Coring out' the 'hepatic duct' may mean merely dissecting out a cylinder of scar tissue*

months (although some surgeons prefer 12 months) then when the tube is removed a stricture will not form. However, if after a difficult operation there is really no effective apposition of duct lining to jejunal mucosa at all, and if in fact what has been done is to anastomose a cylinder of scar tissue to the jejunum, then the patient will remain free from jaundice whilst the tube is in place but a stricture will rapidly return once the tube is removed.

For the last two years, in an attempt to solve this problem of the stricture so high in the porta hepatis and so obscured by scar tissue that apposition of duct lining to jejunal mucosa cannot be achieved, an entirely new principle has been observed. I first reported the operation described below, which I call the 'jejunal mucosal graft' operation, to the Association of Surgeons

at the meeting in Dublin in April 1967 and the results have so far been encouraging. The principle is as follows:

(1) Dissection in the porta hepatis shows the granulating tract through dense scar tissue through which bile is trickling and above which lies the dilated hepatic duct system the lining of which is not yet in view (Fig 5).

(2) The previous standard method of procedure was to 'core out' the 'hepatic duct' as shown in order to anastomose this to the Roux loop of jejunum (Fig 6). If in fact this is carried out on the type of case illustrated here a cylinder of scar tissue will be anastomosed to the jejunum. This has no lining and even if it is splinted with an indwelling tube, as soon as the tube is removed a further stricture will form (Fig 7).
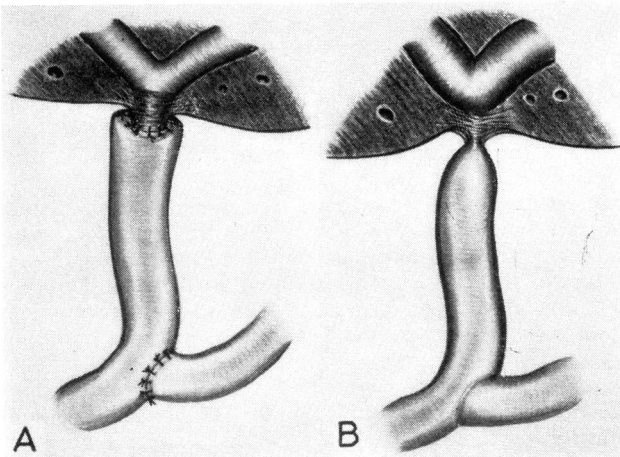

Fig 7 A, B *If a cylinder of scar tissue is joined to the jejunum it is certain to contract and form another stricture*
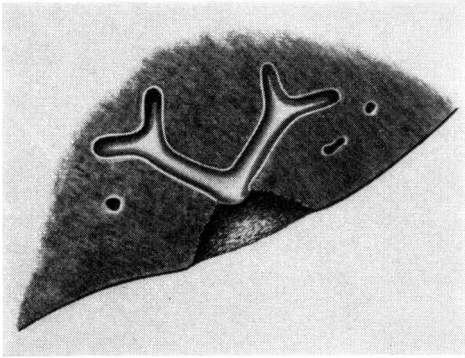
Fig 8 *Removal of the scar tissue or incision and dilatation will give access to the dilated bile ducts above it*

Fig 9 *Preparation of the 'mucosal graft'*

(3) The principle to be adopted therefore is a different one. The scar tissue obscuring the lining of the hepatic duct system is either cut away as shown in Fig 8 or more simply and more easily split and dilated until the duct system can be clearly seen and the right and left hepatic ducts identified.

(4) The Roux loop is now prepared so as to provide the 'mucosal graft'. With the open end of the Roux loop not yet closed a disc of the seromuscular coat is removed as shown in Fig 9.

(5) A Y-tube of a special shape is placed inside the Roux loop and the two ends of this are made to protrude through two small holes in the exposed jejunal mucosa. The end of the Roux loop is now closed (Fig 10).

(6) The Y-tube carrying the mucosal graft is introduced into the position shown in Fig 11. There are several ways of facilitating this. One
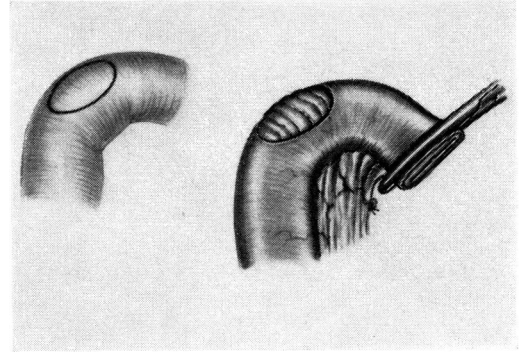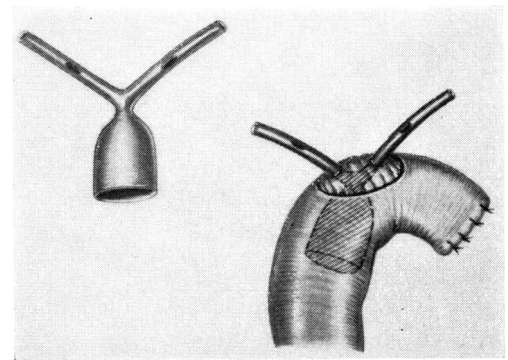

Fig 10 *Siting of the Y-tube inside the Roux loop and mucosal graft*

way is to make a small puncture into the Roux loop distal to the tube, inserting a Bakes dilator into the bell-shaped end of it and using the dilator to exert a little gentle pressure as the limbs of the Y-tube are inserted (Fig 12).
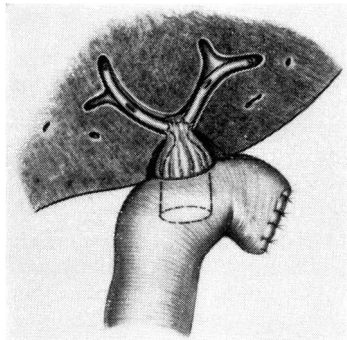

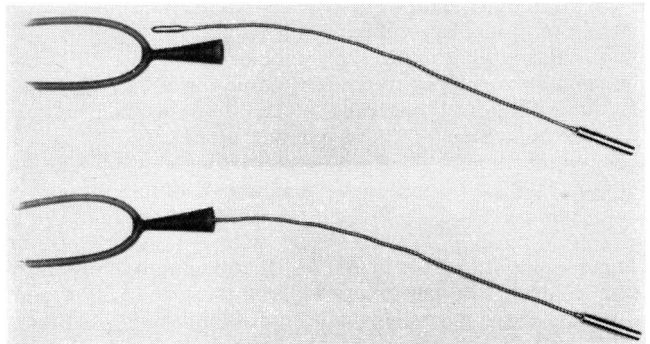Fig 11 *Introduction of Y-tube and graft into hepatic duct system*

Fig 12 *One method of introducing the Y-tube is to employ a Bakes dilator as shown (the end of the dilator and the tube are of course inside the Roux loop which has been omitted from the diagram for simplicity)*
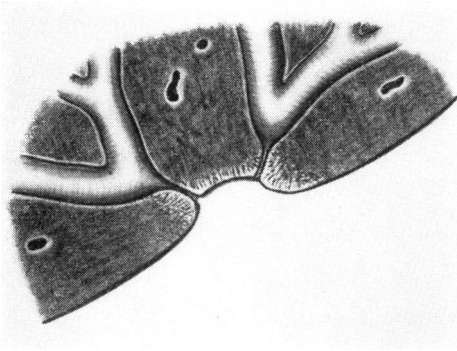
Fig 13 *If there has been complete obstruction of the common hepatic duct the right and left hepatic ducts must be sought*
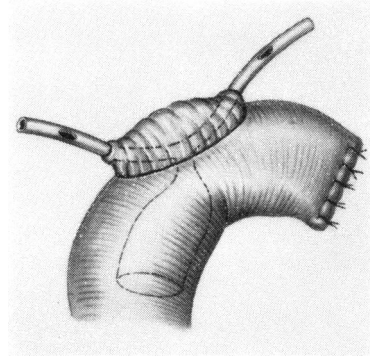

Fig 15 *Long mucosal graft suitable for replacement of the common hepatic duct*
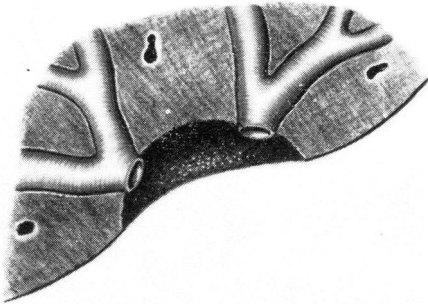

Fig 14 *Excision or splitting of the scar tissue must display fully the lining of the right and left hepatic ducts*
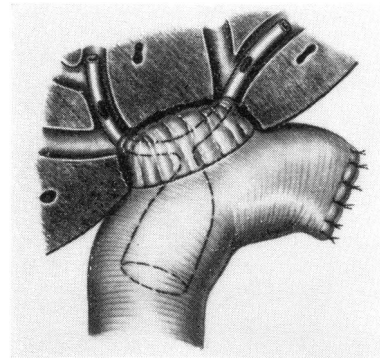

Fig 16 *When in place the mucosal graft should lie between the right and left hepatic ducts as shown*

Another way is to pass a fine probe up the right and left hepatic ducts, through the liver to the exterior in order to attach pull-down threads which can be attached to the limbs of the tube and used to pull the tube into place. With the tube held steadily in place either by these threads or by the Bakes dilator the seromuscular layer of the jejunum is sutured to the scar tissue forming the much-thickened liver capsule. The tube stays in place by virtue of its shape but eventually loosens after a period of a few weeks to a few months, and is dislodged by the jejunal peristalsis and is passed.

(7) In some high duct injuries the common hepatic duct has been totally destroyed and dissection in the porta hepatis brings to light two tracts leading through the scar tissue into the right and left hepatic ducts respectively (Fig 13).

(8) If this is the case the scar tissue, as before, is either dissected away or incised, split and dilated so that the duct lining of the right and left hepatic ducts can be clearly seen (Fig 14).

(9) A rather longer mucosal graft is constructed (Fig 15).

(10) This when placed in position provides a large mucosal pocket which acts as a new common hepatic duct (Fig 16).

As to the results of this method, I have now done nearly 50 since the first in 1966. This is too short a period to be sure how effective it is likely to be in reducing the number of cases where restenosis occurs. The immediate results, however, have been more satisfactory than other methods which I have hitherto used.

I would not, however, disagree with Dick Cattell's well-known expression of opinion about traumatic strictures of the bile duct when he said that in his experience the only certain method of treating them was not to have one!

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Miss Phyllis George
(*Royal Free Hospital, London*)

Cholangiography

The biliary tree is not normally visible on plain X-ray of the abdomen but may be seen after biliary surgery – a sphincterotomy, a sphinctero-plasty or an anastomosis, particularly if partially or recurrently obstructed – air is trapped in the ducts and will show on plain X-ray; where no air is visible, it is sometimes feasible to give the patient a gassy drink, when gas will enter the tree.

Gas in the biliary tree may be due to a spontaneous or post-operative biliary fistula and may be regurgitated through an incompetent sphincter of Oddi – usually when there is a coexistent disease of the biliary tract such as cholecystitis or gall-stones.

Oral Cholecystogram
Provided the gall-bladder concentrates the opaque medium adequately in oral cholecysto-graphy, the administration of a fatty meal or of cholecystokinin will cause it to empty and show the bile duct in part but this is seldom a satisfactory method; it may show that the common bile duct is normal or possibly or probably abnormal – rarely do the right and left hepatic ducts show well.

Intravenous Cholangiography
If liver function is normal, then the ducts may be shown after approximately 15 minutes or up to 2 hours. This method is especially useful in the nonjaundiced 'post-cholecystectomy syndrome' patient; it is contraindicated if the serum bilirubin is greater than 2–3 mg/100 ml, unless the level is falling; if the bilirubin is more than 1·5 mg/100 ml, oral cholecystography will usually be useless; if more than 2·5–3 mg/100 ml, intravenous cholangiography will most probably be ineffective; the continuous infusion method with iopanoic acid (Telepaque) may show the ducts with a bilirubin up to 4·5 mg/100 ml.

Percutaneous Cholangiography
Percutaneous transhepatic cholangiography (PTC) is of use in the obscure case of jaundice of at least six weeks' standing, where a definite diagnosis has not been made between 'medical' and 'surgical' jaundice or where the patient is known to have obstructive jaundice but exact delineation of the site and probable cause will be an advantage to the surgeon and thereby also to the patient. Thus it can differentiate between jaundice caused by drugs, hepatitis, biliary cirrhosis or cholangitis. If no duct is entered after four or five attempts by an experienced person, then the duct system is assumed to be undilated and the patient is spared an unnecessary or possibly hazardous operation. Occasionally an undilated duct system is entered and here, too, it will be seen that operation is not indicated.

Surgically, percutaneous cholangiography is most helpful in the case of stricture of the ducts, when multiple previous operations may have been carried out and the patient is still jaundiced: in these cases there are likely to be many and dense adhesions, when dissection in the area without the benefit of percutaneous cholangiography may be both time consuming and hazardous of damage to otherwise normal structures. If the site of the obstruction is demonstrated, then the surgeon can plan the operation and will know precisely where to dissect to find dilated duct suitable for anastomosis. In other cases there may be a history of a previous 'negative' laparotomy (without an operative cholangiogram) with a still-jaundiced patient. The patient may naturally be loath to undergo another operation but will usually agree when told that an X-ray will show whether his jaundice should be relieved by surgery or whether he is better treated medically. The diagnosis usually proves to be carcinoma high in the ducts.

Whenever a 'positive' percutaneous cholangiogram is obtained (that is, when the duct system is entered) then it is essential to operate within four hours; we usually take the patient straight from the X-ray department to the theatre because there is a risk of biliary peritonitis or hæmorrhage if a distended duct system is punctured and the peritoneal cavity is not drained; the polythene tube is left in place to prevent leakage while the patient is being transported to the theatre.

Sometimes the procedure is 'negative' because the ducts are infiltrated by growth or are full of stones or the liver itself is fibrotic and the needle will not readily penetrate its substance. In these patients operation is required because the patient is known to have an obstructive lesion; operative cholangiography is then indicated.

*Cholangiography
at Operation*
Sometimes a transhepatic cholangiogram may be done at operation after the abdomen is opened,