THE RADIOLOGICAL ANATOMY OF THE BILIARY PASSAGES WITH ESPECIAL REFERENCE TO THE POST-CHOLECYSTECTOMY SYNDROME

Hunterian Lecture delivered at the Royal College of Surgeons of England
on
31st May 1956
by

Eric Samuel, F.R.C.S.
Johannesburg, South Africa

THE SCIENTIFIC DETACHMENT with which John Hunter approached all his medical problems conjures a deep sense of inadequacy in those of us who are fortunate enough to have the honour and privilege of addressing this College and more especially, when the care and deliberation that he exercised before making known his findings are considered.

In every new field, and even to-day, radiology must be regarded as a relative newcomer, enthusiasm frequently clouds judgment and the advice of John Hunter, to " keep your records carefully, criticise your results and deliberate long before you present them to the public " passes unheeded. I feel sure that it will appear to you that I may be guilty of such a fault but I ask for your indulgence in the belief that a new interest brought to any problem is worth-while, not necessarily from the new information it provides, but from the fresh stimulus it may provide to other investigators.

My thesis to-day is that the newer methods of radiological investigation have given an opportunity hitherto denied us of studying the extra-hepatic biliary passages in life. As a consequence a better understanding of the changes that occur in these structures after cholecystectomy has greatly assisted in evaluating symptoms when they appear after that operation.

The material I have studied consists of 112 consecutive cases (1953 to 1956) of symptoms occurring at varying periods after removal of the gall bladder and clinically regarded as post-cholecystectomy syndromes. The group is unselected and does not represent the surgical results of any individual surgeon or team of surgeons, and here I must pay generous thanks to my colleagues who so readily put their cases at my disposal. I have not had the opportunity of performing routine cholangiograms on post-cholecystectomy subjects who had no symptoms but have only studied those in whom symptoms appeared or persisted after removal of the gall bladder.

It is fortunate that McClenahan (1955) has provided us with a study of the normal appearances after cholecystectomy in asymptomatic patients. Consideration, however, must be given to the fact that in McClenahan's

series the cholangiograms were made relatively early after removal of the gall bladder and that studies of the same subjects at a later date may not necessarily show the same results.

Much information as regards the living anatomy of the hepatic and common bile duct has become available from the investigation of cholecystectomised patients and also from an examination of the bile ducts pre-operatively by this new method.

Before passing to consider these anatomical findings I would briefly like to explain various radiological methods that have been used to outline the bile ducts and to discuss in more detail the method used in this series.

Briefly they may be grouped into pre- and post-operative methods.

Pre-operative demonstration of the biliary passages may be attained by stimulating the dye-filled gall bladder to contract after a fatty meal when the Sphincter of Oddi has been closed by the use of a morphine derivative. The technique of this method has been described by Twiss and others (1954), but even under optimum conditions a relatively high degree of failure makes the oral method in my opinion too uncertain for general use.

Opaque medium has been introduced directly into the gall bladder with the aid of a peritoneoscope (Lee, 1942 ; Royer, *et al.*, 1947) and more recently direct puncture of the dilated bile duct with a long needle has been performed by others (Nurick, Patey, and Whiteside, 1953 ; Kidd, 1956). Both these methods are, however, too complex for everyday use.

Post-operative cholangiography is performed through a T tube inserted into the common bile duct and may be immediate (Hufford, 1937, and Schulenberg, 1956), that is, done during the operation, or a few days later (delayed) (Macdonald, 1944 and 1950 ; Wapshaw, 1955) before the tube is removed. The limitations of these post-operative methods are mainly associated with the necessity of surgical exploration before they can be performed, but it must be admitted that the degree of contrast and the clarity of the structures demonstrated is highest in this method. However the injection of contrast medium even of the water soluble type post-operatively is however not entirely free of danger, and Herschey (1955) has reported a case of fatal pancreatic necrosis after post-operative cholangiography.

Transduodenal cholangiography (Gaylis and Gunn, 1955) has utilised an ingenious double lumen double balloon tube inserted into the duodenum to occlude a segment of doudenum whilst dye injected along the tube fills the enclosed duodenal loop and regurgitates along the common bile duct. Whilst this procedure cannot be utilised in those cases where the Sphincter of Oddi is intact, the method may be useful in assessing cases after transduodenal sphincterotomy.

Intravenous cholangiography using sodium iodipamide, the method used in this series, has few of the disadvantages of these other methods

and furthermore it is applicable to both pre- and post-operative cases with no more discomfort than attendant on any intravenous injection (Hornykiewytsch and Stender, 1953 ; Berk, *et al.*, 1954 ; Glenn, *et al.*, 1954 ; Frommhoch, 1953).

I will describe the method used for intravenous cholangiography in some detail as only by meticulous attention to technique can satisfactory results be obtained.

The original contrast medium used was sodium iodipamide, which is a 20 per cent. solution containing as its essential agent di-sodium salt of N. Nadipyl-bis (3 amino) 2 :4 :6 triododobenzioc acid. Its iodine content is 64·32 per cent. and the preparation is commercially known as Biligrafin or Cholografin. The first fifty cases were investigated using this substance. Subsequently the manufacturers changed the sodium salt for the methyl glucamine salt and increased the concentration to 30 per cent. and 50 per cent. (Biligrafin Forte). In this series I found that the visualisation of the ducts as judged by the radiograph was not improved by the use of the more concentrated solution as with the latter a greater quantity of dye was excreted via the kidney. The manufacturers claim that 90 per cent. of the dye is excreted under normal circumstances by the liver, the remainder via the kidney. It would appear that the liver can only take up a given quantity of dye from the circulation and that any excess is excreted by the kidneys. Together with other co-workers I found that some correlation existed between liver function and the rate of excretion of the dye and that a rough estimate of liver function could be made from the density of the shadow produced on the radiograph (Samuel, Gluckman, Barlow, 1955).

The rate of injection of the contrast medium also had a definite relationship to the visualisation of the bile ducts. Forty ccs., the quantity routinely used in this series, was injected at the rate of approximately 5ccs. per minute, the whole injection taking between eight and ten minutes.

Reactions to the dye were infrequent and consisted of either a local or general reaction. Local reaction consisted of arm pain, but it was unusual and was only met with in 3 per cent. of cases. General reactions, reputed to be less frequent in jaundiced patients (Theander, 1955), were slight and no severe reaction was seen. Six per cent. of cases complained of nausea and 2 per cent. actually vomited. These figures are comparable to those seen in intravenous urography. Severe reactions have only been noted occasionally (McClenahan, *et al.*, 1955 ; Ward, 1954 ; Theander, 1955). Aggravation of symptoms were, however, noted in occasional cases and in one case in this series an attack of biliary colic was precipitated, and it was associated with collapse and some degree of shock.

A total 12 per cent. of cases therefore showed some reaction, either local or general, but not more than three could be described as more than extremely mild.

The preparation of the patient was important and a high colonic wash-out prior to examination was administered routinely. A thorough cleansing of the bowel to exclude intestinal gas shadows is important.

Fifteen minutes after the injection films of the right hypochondrium are then taken in the prone and in the prone oblique positions. I need not emphasize that the full advantage must be taken of modern radiographic advances, high ratiogrids, rotating anode tubes, &c., being used to obtain radiographs showing the finest detail. These films are immediately developed and inspected, and depending on the rate at which the dye is excreted further films at thirty minutes or one hour are taken. At this time an assessment is made as to whether the duct is best seen in the oblique or in the prone oblique position.

Tomographic films are then taken in the position most clearly showing the duct (Samuel, 1955 ; Orloff, 1954). Some authors (Hornykiewytsch and Stender, 1953) have found that tomographic films do not materially help but in this series in 82 per cent. of cases the duct was more clearly seen in tomographs than in the routine films. Indeed, I would hesitate to diagnose a negative shadow in the duct as a stone unless tomographic sections through the duct had conclusively proved that the shadow lay within the duct and did not represent a superimposed intestinal gas bubble.

In some instances serial views with compression of the common duct taken in the erect position have helped to clarify the diagnosis, but in the main tomography has supplied all the additional information that has been needed.

Radiological anatomy

In this series good concentration of dye and a clear demonstration of the ducts was obtained in 83 per cent. (Sandweiss and Fulton, 1955) of cases, in another 14 per cent. faint visualisation of the ducts occurred, and in 3 per cent. the ducts were not visualised.

The first and second intrahepatic divisions of the bile ducts were clearly demonstrated in most cases whilst in others where an obstruction was present the finer terminal intrahepatic branches could be seen.

Intravenous cholangiograms demonstrate that the intrahepatic branches form a constant and definite pattern. The common hepatic duct is formed by the union of three major intrahepatic ducts. The left hepatic duct which runs downwards and forwards from the left lobe is, surprisingly enough, the largest of the branches (Norman, 1951), and joins the others at an acute angle. The two branches arising from the right lobe unite virtually at the same level as they are joined by the left hepatic duct. The dorsal branch which appears as the direct continuation of the hepatic duct runs cranially and to the right to drain the dorsal subdivision of the right lobe of the liver. The ventral branch of the right hepatic duct pursues an angular course to drain the intermediate and ventral subdivisions of the right lobe. It can be recognised on the radiograph by its

looped course but it is often superimposed on the right dorsal branch and a prone oblique film is needed to separate these ducts (Fig. 1).

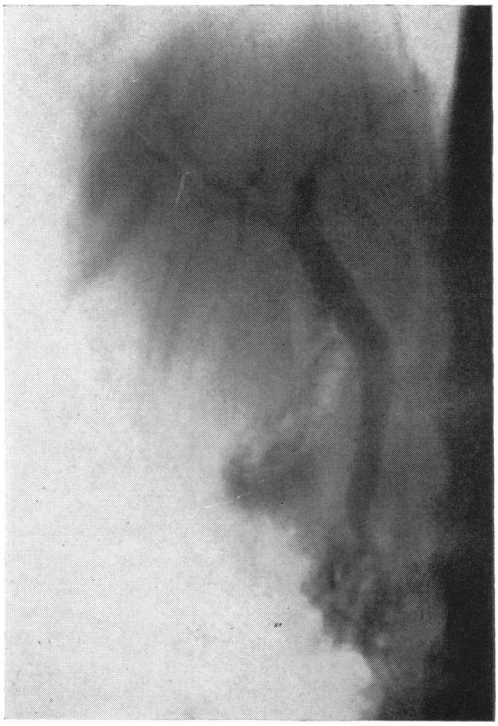

Fig. 1. Demonstrating the anatomical features seen in the post-operative intravenous cholangiogram. The left hepatic duct is larger than the right which subdivides soon after its origin. The gentle medial curve of the hepatic and common bile duct is seen. The cystic duct stump with a negative shadow (due to a stone in the cystic duct stump) is seen. The normal anatomical narrowing present at the lower end of the common bile duct is demonstrated.

Union of the three major intrahepatic branches usually occurs at the porta hepatis, but perhaps one of the major advances that intravenous cholangiography has made, has been the recognition of anomalies of union of the hepatic ducts described by Hjörtsjö, 1948 ; Norman, 1951, and others. The most frequent variation noted has been the low position at which the right and left hepatic ducts join. In some instances the right dorsal branch may join the fused left and right ventral branches only at the level of union of the cystic duct, an anomaly which may readily result in surgical injury to the common bile duct. In other instances the ventral branch from the right lobe may only unite with the joined dorsal right and left hepatic ducts at a low level. Sometimes more than one right hepatic branch was present and these duplicated branches always arose from the dorsal portion of the right lobe, the anomalous branch almost invariably emptied low down into the common hepatic duct.

Norman (1951) found that 7·5 per cent. of his series showed anomalous variations of the hepatic ducts. Thorek (1943) was of the opinion that the accessory hepatic ducts are always right hepatic ducts and that they are present in 18 per cent. of individuals. Flint (1923) had many years previously described four sites where the accessory duct may join, namely (i) into the hepatic duct high up, (ii) near the union of the cystic and hepatic ducts, (iii) in the actual angle between the cystic and hepatic ducts, (iv) where the accessory duct entered the cystic duct. Kehr (1913) also noted that the accessory duct might on occasions empty directly into the gall bladder. These findings of Thorek, Flint, Osler and Kehr and others, however, merely refer to the extrahepatic ducts, and as Norman (1951) has pointed out cholangiography in addition reveals the origin of the duct and usually it can be shown to represent an anomalous rather than a true accessory duct. It can be re-emphasised again that to be forewarned by the knowledge of anatomical variations must constitute a major advance in the efforts for safe biliary surgery.

Intravenous cholangiograms cannot demonstrate the relationship of the ducts to the porta hepatis as this anatomical site cannot be demonstrated radiologically, consequently an assessment of a high or low union is all that can be made. At the origin of the common hepatic duct a linear filling defect is frequently visualised caused by the vessels running to the right lobe of the liver. This defect may simulate a stricture or on occasions a stone lodged in the origin of the common hepatic duct. The common hepatic duct runs in a downward and medial direction and its actual length depends on the site at which it is joined by the cystic duct to form the common bile duct. Its average width is slightly less than the common bile duct.

The cystic duct in almost every case runs parallel to the hepatic duct for some distance before actually uniting with it to form the common bile duct. Usually it joins the hepatic duct on its lateral wall, more rarely on its anterior or posterior wall and still less frequently on its medial wall (Fig. 2). These anatomical variations are of the utmost importance as traction on the cystic duct at operation deforms and rotates the common bile duct and as a consequence the distorted anatomy renders the common duct more liable to injury. The recognition of these anatomical variants in the insertion of the cystic duct pre-operatively represents another major advance from intravenous cholangiography. The long parallel course of the cystic duct closely bound to the hepatic duct readily explains why stones lodged in this portion of the cystic duct may sometimes produce obstruction of the hepatic duct. It is readily understandable, too, why relatively long stumps of cystic ducts are so frequently found after cholecystectomy.

Common bile duct

The average length of the common bile duct as measured on the radiographs in this series was between 4 to 6 cm. In the post-operative series

the measurements of width of the ducts varied between 3 and 22 mm., those measuring more than 10 mm. being regarded as pathologically dilated. Sandweiss and Fulton (1955) following Royer (1950) and others, have regarded 8 mm. as an arbitrary upper limit of normal. In this series a width of 10 mm. was taken as the upper limit of normal, as in

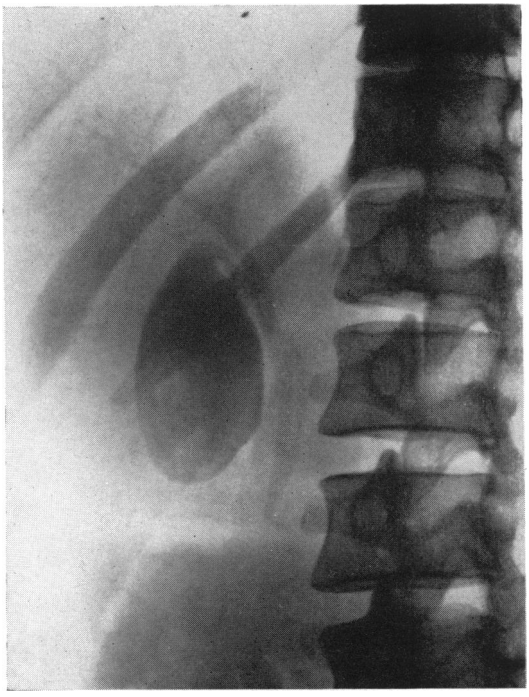

Fig. 2. Low implantation of the cystic duct. The cystic duct can be seen to cross the hepatic duct and be implanted in its medial aspect near its lower end.

unoperated cases common bile ducts of this width were noted. It may, however, be argued that such pre-operative measurements indicate pathological dilation of the common bile duct and that the smaller measurement should be accepted as the upper limits of normal (Figs. 3 and 4).

The common bile duct as depicted in the radiograph runs a distinct angled course, its upper portion runs downwards and medially towards the spine, and then forming a relatively wide bend it turns in a downward and in a slightly outward direction, runs to the second portion of the duodenum. Immediately above the site of angulation, the duct attains its maximum width, the lowermost portion of the duct gradually narrows to a funnel-shaped appearance terminating in a thin filiform thread which represents the trans-duodenal (pars intestinalis—Sterling, *et al.,* 1949) portion of the duct. The narrowed portion immediately proximal representing the trans-pancreatic part of the common bile duct.

To translate these radiographic appearances to those of surgical anatomy the portion proximal to the angular bend corresponds to the supra-duodenal portion of the duct, while the narrower and lower portion, the infra-duodenal, represents that portion of the duct passing behind the first part of the duodenum and its lowermost portion is that embedded in the head of the pancreas.

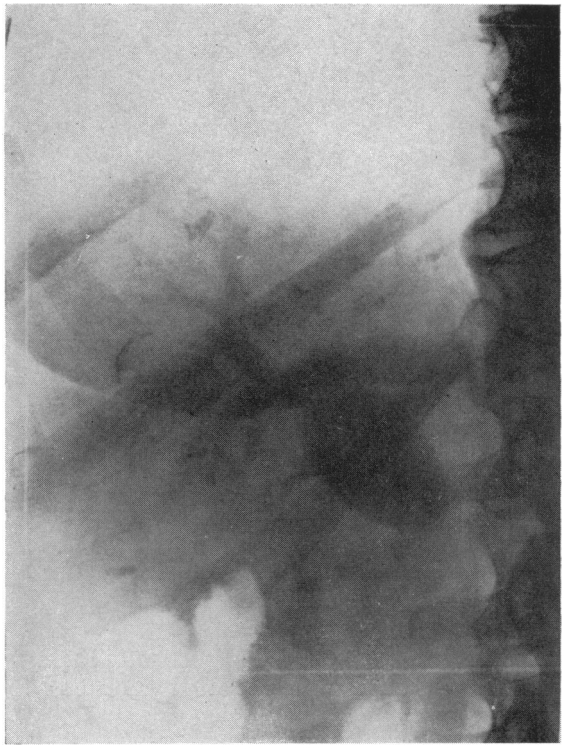

Fig. 3. Post-operative stone formation. The gross dilatation of the common bile duct is associated with a considerable degree of shortening of the duct. A small funnel-shaped projection arises from the lower end of the duct.

This angulation of the common duct may be of considerable surgical significance as stones in the common duct may become lodged at this site of angulation as well as at the lower end. The clinical picture of duct stones lodged at this site is quite distinct from those lodged at the lower end (Fig. 5).

The angulation of the common bile duct at this point between its free and fixed portion may be exaggerated by respiratory movements, and cases showing ptosis of the abdominal viscera may increase this kinked appearance. It is important not to regard this normal angulation as

pathological kinking (Conway and Campbell, 1956) and to attribute symptoms occurring post-operatively to this finding.

The common bile duct at its lower end joins with the pancreatic duct, and according to Hughes and Kernutt (1954) this occurs at a point from 2 to 10 mms. outside the duodenal wall. These authors found from their anatomical dissections that after union the ducts were separated by a

Fig. 4. Post-operative stone formation. The dilated common hepatic and common bile duct with extensive filling defects due to stones is demonstrated.

thin septum. Wapshaw (1955) in a radiographic study of the common bile duct found that contrast medium injected via a catheter refluxed into the pancreatic duct in 14 per cent. of cases. An analysis by the same author of 1,521 cases reported, revealed that pancreatic reflux occurred in 33·5 per cent. of cases. These findings substantiate the anatomical dissections of Rienhoff and Pickrell (1945) who found a true ampulla measuring from 3 to 14 mms. in 32 per cent. of cases. In these cases showing a common ampulla some additional factor, such as obstruction, temporary or otherwise, must develop at the Sphincter of Oddi to allow reflux into the pancreatic duct. Furthermore, it must be remembered that the pressures developed in the ducts when a post-operative cholangiogram is performed must also play a considerable part, as in only two cases in

this series by intravenous methods was such a pancreatic reflux detected even when the common bile duct was grossly dilated. Undoubtedly these cases with a common stem are prone to the development of attacks of pancreatitis.

The frequent lack of clarity of the termination of the common bile duct on intravenous cholangiography has been the source of criticism by various authors (Berk, *et al.*, 1954). I have, however, regarded this funnel-like termination of the lower end of the common bile duct as a

Fig. 5. Recurrent stone formation. The gross dilatation of the duct again associated with shortening of the duct is demonstrated.

normal finding. If thought is given to the rigid anatomical structures such as the head of the pancreas surrounding the duct, the thinness of the duct in the duodenal wall (pars intestinalis), the tapering appearance of the duct at its termination seen as a normal finding, is readily appreciated.

This tapering appearance was noted in 75 per cent. of cases in this series and in these cases the hepatic and common bile ducts were radiographically normal.

In other instances where the common hepatic and common bile ducts are dilated, the lower end has a rounded cigar-shaped appearance and far less frequently a nipple-like projection extends from this blunt termination. In this series 20 per cent. showed a rounded blunt termination

and in all these cases mensuration of the hepatic and common bile ducts revealed that they were pathologically dilated. In the remainder, the function of the liver was insufficient clearly to outline the duct.

It is of interest that the rounded terminal appearance of the common bile duct closely approximates to the appearances seen in the bile duct after the injection of morphia. By analogy it would appear that some obstruction or spasm at the Sphincter of Oddi is responsible for this type of appearance when it is seen post-operatively.

Duodenal diverticulae arising from the second part of the duodenum near the ampulla (Vaterian diverticulae) may press on and obstruct the common bile duct.

Fig. 6. Demonstrating pre-operative dilatation of the ducts with stone formation within the ducts. The demonstration of significant degrees of dilatation pre-operatively must be taken into account when assessing post-operative dilatation of the ducts.

If we may now pass on to a consideration of these anatomical findings as applied to an investigation of the post-cholecystectomy syndrome it is found that the cases fall into four groups based on cholangiographic findings (Table I).

TABLE I

POST-CHOLECYSTECTOMY CASES

GROUP 1 :—66 per cent.	
No radiological changes in the biliary ducts.	
55 per cent. of cases, no definitive diagnosis.	
11 per cent. Alimentary causes :	
i Duodenal Ulcer	6 per cent.
ii Gastric Ulcer	1 per cent.
iii Achlorhydria	2 per cent.
iv Hiatus Hernia	2 per cent.
GROUP 2 :—27 per cent.	
Radiological changes and causes evident on radiograph.	
i Recurrent stone formation	12 per cent.
ii Cystic duct stump syndrome	12 per cent.
iii Chronic pancreatitis	2 per cent.
iv Bile duct strictures	1 per cent.
GROUP 3 :	
Radiological changes evident but nature obscure.	
i Obstruction at Sphincter of Oddi	6 per cent.
GROUP 4 :	
Failure of visualisation of ducts.	
i Liver Cirrhosis .. .. }	3 per cent.
ii Obstructive Jaundice .. .. }	

Group I

Those where there are no radiographic changes in the biliary tract (66 per cent.) when the symptoms are considered not to be associated with changes in the biliary tree. In 55 per cent. of cases a definite diagnosis could not be made, but in 11 per cent. of cases some lesion of the alimentary canal, such as hiatus hernia, peptic ulcer, achlorhydria, was thought to be responsible for the symptoms.

Group II

Where the biliary tract is found to show pathological changes and where the nature of these changes are evident. Recurrent stone formation, cystic duct stump, chronic pancreatitis and duct strictures are examples.

Group III

This embraces those cases which show pathological dilation of the bile ducts but where no cause is evident on the radiograph. This group forms the most difficult to assess and is the greatest source of controversy both as regards aetiology and treatment.

Group IV

Where the ducts were not visualised due to liver failure or obstruction.

To deal with each group separately :

Group I

In this group approximately 11 per cent. of cases had symptoms which had persisted unchanged after operation. Such cases must be regarded as an incorrect assessment of the cause of symptoms pre-operatively. Two per cent. of cases in this group showed a hiatus hernia and this was

considered to be responsible for the symptoms, whilst another 2 per cent. showed a complete achlorhydria. It is possible, however, that the achlorhydria may be a sequel of a gastritis associated with the previous chronic cholecystitis. A duodenal ulcer was found in 6 per cent. of cases and in 1 per cent. a gastric ulcer. In some of these cases the symptoms prior to cholecystectomy had almost certainly been due to the undiagnosed peptic ulceration.

The high percentage of cases falling into this group certainly merits some serious thought, as although this analysis may be biased as only cases who showed symptoms were examined, it nevertheless is an alarmingly high proportion which must reflect on pre-operative assessment of the cause of the symptoms.

Group II

This forms the most satisfactory group both from a diagnostic and therapeutic standpoint. The aetiological causes will be considered individually ; to deal first with stone formation :

Stone formation

The demonstration of stones in the common bile duct represents the most significant advance made by intravenous cholecystography. The demonstration of such stones readily explains the cause of symptoms and at the same time indicates the treatment (Hughes, 1955 ; Millbourn, 1950).

Appreciation of the frequency with which recurrent stone formation causes symptoms after cholecystectomy has been radically altered following the advent of this intravenous cholangiogram. In this series twelve cases showed recurrent stone formation as the cause of symptoms. Of these twelve cases, nine showed stones lodged in the common duct, one in the left hepatic duct, and two stone formation in the stump of the cystic duct (Fig. 7).

Two main types of symptoms are associated with the presence of stones in the common bile duct after cholecystectomy. The first group are associated with the smaller type of stone and consist of colicky pain similar to biliary colic and may or may not be associated with obstructive jaundice. When obstructive jaundice was present, or when biochemical tests revealed a serum bilirubin of more than 4·0 mgs. per cent. or a bromsulphalein retention of more than 40 per cent. (McDonnagh and Wise), the findings of intravenous cholecystography have proved disappointing as the degree of liver damage associated with the obstruction prevents sufficient concentration of dye adequately to outline the biliary passages. This poor concentration of dye in the bile ducts probably accounts for the 16 per cent. error in intravenous cholangiography reported by Walters and others (1956), a figure which in my opinion could be considerably reduced by careful technique. Nevertheless it is considered that those patients who suffer from colicky pain after cholecystectomy and who fail to concentrate the dye after intravenous cholangiography can be, by inference, adduced to have a small stone obstructing

the common bile duct even though such a stone is not demonstrable radiologically. Two such cases were noticed in this series. Another possible source of error was considered, namely that the negative shadow caused by a small stone might be obscured by a large quantity of dye in a dilated duct. The following experiment carried out proved that this was not the case and that even a small stone of 5 mm. in diameter showed recognisable negative shadows. Biligrafin was diluted with saline to varying

Fig. 7. Cystic duct stump stones. The dilated cystic duct stump with negative shadows due to stones has to be differentiated from folds of the spiral valve remaining in the cystic duct stump.

concentrations from 1/64 to 1/16 and polythene tubes of 0·75 and 1·5 cm. diameter were filled with dye in these concentrations. Beads made of density one wax 5 mm. and 10 mm. in diameter were inserted into the polythene tubes and these tubes were strapped onto a normal subject and radiographed. The radiographs showed that in tubes with shadows of density approximating to the bile ducts the negative shadows of even the smaller wax pellets are clearly visible. I am certain that a failure to demonstrate such stones depends largely on the poor concentration of dye rather than on the smallness of the stone.

The second group of symptoms associated with recurrent stone formation is that of a flatulent dyspepsia and vague right hypochondrial pain similar to those of a chronic cholecystitis. Severe colicky pain or jaundice, indicating migration of the stones, are rarely complained of. In this series 7 per cent. of stones were in this relatively silent group. The stones were demonstrated as negative shadows varying from $\frac{1}{2}$ to 1 cm. in diameter occurring in a dilated common bile duct. In three instances the stones

Fig. 8. Generalised massive dilatation of the hepatic and common bile ducts occur post-operatively without any evidence of hold up. Kinking of the duct at the site where it passes under the duodenum is clearly illustrated.

were lodged in the supra-duodenal portion of the common bile duct and the duct below was relatively normal in size. It is easy to understand why in such cases obstructive jaundice, biliary colic, &c., do not occur.

Stones in the common duct appear as negative shadows and it is important not to confuse overlying gas shadows with those caused by stones. The only absolute method of determining that these shadows actually lie within the duct is by tomography. A tomographic section through the duct readily determines the exact site of the shadow. Small stones in the hepatic ducts, however, are seldom demonstrated by radiography and probably prove the nidus for recurrent stone formation at a later date.

To summarise, therefore, small stones like their fellows in the gall bladder are more likely to migrate and cause signs of obstructive jaundice. These stones are more difficult to detect radiographically, but clinically offer an easier diagnostic problem as they present with the picture of biliary colic, obstructive jaundice, &c. Larger stones present with symptoms of vague right hypochondrial pain and radiologically the demonstration of this type of stone is relatively simple. In this series approximately one out of every nine cases showed recurrent stone formation as the cause of symptoms after cholecystectomy.

Cystic duct stump syndrome

It was found in this series that 30 per cent. of cases showed a demonstrable cystic duct stump. These cystic duct stumps were measured and were arbitrarily grouped into small, moderate or large, according to whether the stump measured less than 1 cm., between 1 to 2 cm., or more than 2 cm. in length. Forty-two per cent. of cases were grouped as small stumps, 16 per cent. as moderate, and 42 per cent. as large cystic duct stumps.

Glenn and Johnson (1955) in their series of more than 3,862 cholecystectomies report that nineteen per cent. showed cystic duct stumps and in a more recent series of 121 cholecystectomies subjected to routine cholangiography, twenty-four showed cystic duct stumps. Of these twenty-four, only in six cases was the cystic duct remnant thought to be responsible for symptoms.

From these figures, the problem therefore arises as to whether the mere presence of the duct stump in itself is sufficient to cause symptoms. From the findings of McClenahan (1955) who showed twenty-four examples in 121 consecutive cholangiograms performed routinely post-operatively, it is obvious that careful consideration is needed before attributing symptoms to a cystic duct stump.

The persistence of the cystic duct stump when its function has been removed means that the lumen remains patent owing to the high pressure which normally occurs in the biliary passages.

Of more importance is the part played by the cystic duct stump acting as a diverticulum from the main bile passages as a potential source of infection or of stone formation. Glenn and Johnson (1955) found stone formation in the cystic duct remnants in ten out of thirty-five cases. In the present series stones were demonstrated in the cystic duct in two cases. In those nine cases where stones were demonstrated in the common bile duct, cystic duct remnants were seen on two occasions. Whether or not the common duct stones had originated from the cystic duct stumps in these cases is problematical.

In my series only one case was reoperated on for removal of the stump with apparent relief of symptoms. As this latter case has only been followed

for less than a year the final assessment of the part played by the cystic duct stump in the production of symptoms has still to be made.

The majority of cystic duct stumps were not dilated but occasionally the stump may dilate to the size of a full bladder—the reformed gall bladder. In this series a single case was met with where the duct remnant showed a marked degree of dilation approximating to a " re-formed " gall bladder.

A radiological appearance closely mimicking a gall bladder shadow may appear when the dye excreted into the duodenum fills the duodenal cap and this structure overlies the cystic stump or bile duct. The appearances may be of the utmost importance when the nature of a previous operation on the gall bladder is not known.

From this series it appears that the significance of a demonstrable cystic duct stump has to be carefully assessed as it can be expected to be seen in approximately thirty per cent. of all patients who have been submitted to cholecystectomy.

Symptoms can only be attributed to duct stumps when all other possible causes have been excluded, or when radiography has demonstrated stone formation, dilatation or other abnormality actually occurring in the duct stump. Symptoms originating in the cystic duct stump are in the nature of flatulent dyspepsia and vague right hypochondrial pain, although Glenn and Johnson (1955) maintain that severe colicky pain can occur.

No cases of severe symptoms attributable to a cystic duct stump were met with in this series.

When recurrent fevers, rigors and jaundice point to a cholangitis, the significance of an enlarged cystic duct stump becomes doubly important and it should then be regarded as the probable source of the recurring infection.

Strictures of the bile ducts

In the majority of cases of strictures of the common bile duct, the clinical features are sufficiently dramatic to warrant exploration without recourse to intravenous cholangiography. Furthermore, the liver dysfunction in the vast majority of strictures renders intravenous cholangiography of little value.

McDonough and Wise (1955) found that in a group of eleven cases of strictures occurring post-operatively, in six intravenous cholangiography failed to visualise the duct, but in three intravenous cholangiography was considered essential in the diagnosis as the strictures were not suspected.

Two cases of post-operative strictures of the bile ducts were seen in this group and in both intravenous cholangiography indicated the site and degree of the stricture. In both these cases there was no evidence of jaundice at the time of examination, although one case had suffered from repeated attacks of jaundice.

Chronic pancreatitis

Undoubtedly chronic pancreatitis or attacks of recurrent sub-acute pancreatitis may contribute to the development of symptoms after removal of the gall bladder, and it is probable that many cases labelled as post-cholecystectomy syndromes are in actual fact due to chronic pancreatitis. Perhaps the infrequency with which this diagnosis is made reflects on the inadequacy of our diagnostic methods.

In this series only one confirmed case of chronic pancreatitis was seen and it was regarded as an obstruction at the Sphincter of Oddi until review laparotomy revealed a hard fibrotic head of the pancreas.

When bio-chemical assays reveal an elevation of the blood amylase or of the urinary diastase, or when analysis of the stools reveals a disturbance of fat or protein metabolism, a fairly confident diagnosis of chronic pancreatitis can be made. Likewise, if radiographs reveal evidence of pancreatic calculi, enlargement of the pancreatic head, or disturbance of the mucosal pattern in the second part of the duodenum, the diagnosis may be confidently made. It must be admitted, however, that the diagnosis in the vast majority of cases is only made at laparotomy.

The bile ducts in the case of proved chronic pancreatitis showed a gross dilatation of the ducts.

It is of some importance in the diagnosis of chronic pancreatitis that the termination of the duct tends to be funnel- rather than cigar-shaped in appearance and this feature persists despite the enormous dilatation of the common bile duct.

Calcification in the pancreas does not necessarily lead to fibrosis and extensive calcification may be associated with few symptoms. Likewise, cholangiography may show ducts relatively unaffected by the calcification in the pancreas and showing no significant dilatation.

Sphincter of Oddi obstruction

The most unsatisfactory group of cases both from a diagnostic and therapeutic standpoint are those which show dilatation of the ducts without obvious cause and which are adjudged to be due to some obstruction at the Sphincter of Oddi.

The obstruction is usually incomplete unless stone formation or other causes are present and these patients seldom show any evidence of obstructive jaundice. The radiographs indicate that emptying of the ducts, which usually commences at fifteen minutes, is delayed and dye may not appear in the duodenum until forty to sixty minutes later.

McDonough and Wise lay considerable stress on the delay in the emptying of the ducts but the possibility of dye being absorbed and entering the enterohepatic circulation cannot be wholly excluded.

These cases are thought to be due to some dysfunction in the mechanism of the Sphincter of Oddi. Dyskinesia, spasm, fibrous structures and

sclerosing odditis (Mirizzi, 1942 ; Moreno, 1950 ; Urrutia and Lavezzo, 1951 ; McNeill Love, 1952 and Walters, 1956) have all been suggested as the cause of the obstruction. In this series only two examples of gross dilatation of the hepatic and common bile duct (without any apparent cause for the obstruction) were noted.

The radiological changes noted in the cholangiogram in these cases of dysfunction or partial obstruction of the Sphincter of Oddi are :

(*a*) A gross dilatation of the common and hepatic ducts, the width of the ducts measuring more than 10 mms.

(*b*) The termination of the common duct was cigar-shaped and the dye filled duct appeared to terminate at some distance from the medial wall of the duodenum.

(*c*) The appearance of the dye in the duodenum was considerably delayed.

If we consider each of these individually :

(*a*) Dilatation of the ducts

It has already been stated that chronic pancreatitis, stricture and recurrent stone formation may cause dilatation of the ducts indistinguishable from each other. Furthermore, dilatation of the ducts noted post-operatively may in fact represent a pre-operative change and associated with infective changes in the duct. Due care must, therefore, be taken in regarding minor degrees of dilatation as necessarily due to post-operative changes.

(*b*) Cigar-shaped termination of the duct

This may also occur when dilatation is due to other causes and in itself does not indicate that spasm or dyskinesia of the Sphincter of Oddi is necessarily the cause of the radiological appearances.

(*c*) Delay in the appearance of the dye in the duodenum

Under normal circumstances dye appears in the duodenum between fifteen to thirty minutes after the injection. This finding can be readily confirmed by the coating of the mucosal folds in the duodenum.

In the two cases in this series which are thought to be due to spasm of the Sphincter of Oddi, no dye appeared in the duodenum for as long as two hours after the injection. In both these cases inhalation of octyl and amyl nitrite had no effect in altering the so-called " spasm," and neither of these cases showed a regurgitation of contrast medium into the pancreatic ducts, a feature which has been noted by some authors. The rarity of this condition in this post-cholecystectomy series makes it difficult to assess whether drainage or opening of the common bile duct at the time of operation played any part in the later development of dyskinesia of the biliary sphincter. The similarity in the radiological appearances in this type of case to the changes noted after the administration of morphia suggests, however, that some alteration in the mechanism of the Sphincter

of Oddi may be a determining factor in producing these radiological features.

In conclusion, it can be stated that an extension of the use of intravenous cholangiography pre-operatively and its use in conjunction with drugs which influence the Sphincter of Oddi will do much to add to our knowledge of the changes that occur in the bile ducts after removal of the gall bladder, and certainly it will give a better understanding of the indications for cholecystectomy and a better appreciation of the changes that may be expected after removal of that viscus.

REFERENCES

BERK, J. E., KARNOFSKYRE, R. E., SHAY, H., and STAUFFER, H. M. (1954) *J. Amer. med. Ass.* **127,** 361.
BLER, G. F., and DOW, R. S. (1945) *West J. Surg.* **53,** 316.
CONWAY, D. M., and CAMPBELL, H. (1956) *J. Fac. Radiol. (Lond.)* **7,** 197.
FLINT, E. R. (1923) *Brit. J. Surg.* **10,** 509.
FROMMHOCH, W. (1953) *Fortschr. Röntgenstr.* **79,** 283.
GAYLIS, H., and GUNN, K. (1955) *Surg. Gynec. Obstet.* **100,** 249.
GLENN, F., and JOHNSON, G. (1955) *Surg. Gynec. Obstet.* **101,** 381.
————, EVANS, J., HILL, M., and MCLENAHAN, J. (1954) *Arch. Surg. (Chicago)* **140,** 600.
HERSCHEY, J. E. (1955) *Arch. Surg. (Chicago)* **71,** 885.
HJÖRTSJÖ, C. H. (1948) *Die Anatomie der intrahepatischen Gallengange beim Menschen mittels Röntgen und Injektionstechnik.* Studier, Lund.
HUFFORD, C. (1937) *Amer. J. Roentgenol.* **37,** 154.
HORNYKIEWYTSCH, T., and STENDER, H. S. (1953) (*a*) *Fortschr. Röntgenstr.* **79,** 292. (*b*) *Ärtzl. Wschr.* **9,** 24.
HUGHES, E. S. R., and KERNUTT, R. H. (1954) *Aust. N.Z. J. Surg.* **23,** 223.
————(1955) *Brit. J. Surg.* **43,** 198.
KEHR, H. (1913) *Die Praxis der Gallenwege-Chirurgie* **1-2,** Munich.
KIDD, H. A. (1956) *Arch. Surg. (Chicago)* **72,** 262.
KLEITSCH, W. P. (1955) *Arch. Surg. (Chicago)* **71,** 795.
LEE, W. J. (1942) cited by Royer H. and Solari, A. V.
LOVE, R. J. MCN. (1952) *Brit. J. Surg.* **40,** 214.
MCCLENAHAN, L., EVANS, J. A., BRAUNSTEIN, P. W. (1955) *J. Amer. med. Ass.* **159,** 1353.
MACDONALD D. (1944) *Canad. med. Ass. J.* **50,** 349.
———— (1950) *Amer. J. Surg.* **80,** 349.
MILLBOURN, Z. (1950) *Congr. Soc. int. Chir.* **8,** 73.
MIRIZZI, P. (1942) *Surg. Gynec. Obstet.* **74,** 300.
MORENO, I. G. (1950) *Amer. J. Surg.* **79,** 436.
NORMAN, O. (1951) *Acta radiol. (Stockh.)* Supp. 84.
NURICK, A. W., PATEY, D. H., and WHITESIDE, C. E. (1953) *Brit. J. Surg.* **41,** 27.
ORLOFF, T. L. (1954) *Amer. J. Roentgenol.* **72,** 5.
RIENHOFF, W. F., Jr., and PICKRELL, K. L. (1945) *Arch. Surg. (Chicago)* **51,** 205.
ROYER, H., and SOLARI, A. V. (1947) *Gastroenterology* **8,** 586.
————, MAZURE, P., and KOHAN, S. (1950) *Gastroenterology* **16,** 83.
SAMUEL, E. (1955) *Brit. J. Radiol.* **27,** 482.
————, GLUCKMAN, J., and BARLOW, J. (1955) *Lancet* **1,** 13.
SANDWEISS, D. J., and FULTON, H. (1955) *J. Amer. med. Ass.* **159,** 998.
SCHULENBERG, C. A. R. (1956) *S. Afr. med. J.* **30,** 186.
STERLING, J., *et al.* (1949) *Surg. Gynec. Obstet.* **89,** 292.
THEANDER, G. (1955) *Acta radiol. (Stockh.)* **43,** 369.
THOREK, M. (1943) *Surgical Errors and Safeguards.* 4th edition. Philadelphia, Lippincott.
TWISS, J. R., BERENBAUM, S. A., GILLETTE, L., and POPPEL, M. H. (1954) *Amer. J. med. Sci.* **227,** 372.
URRUTIA, J. M., and LAVEZZO, P. (1951) *Radiology* **56,** 80.
WALTERS, W. (1956) *Arch. Surg. (Chicago)* **72,** 199.
WAPSHAW, H. (1955) *Brit. J. Surg.* **43,** 132.
WARD, W. M. P. (1954) *Lancet* **2,** 887.