smoking to cause symptoms. One approach to the problem of tobacco addiction might be to try to persuade cigarette smokers to change to a pipe. Apart from other considerations, those persuaded would probably smoke less.

Summary

The relation between smoking and respiratory symptoms and disability has been studied in 734 men between the ages of 25 and 64 who were randomly selected from urban and rural populations, defined by private census during the course of community surveys into the prevalence of common diseases.

A questionary was used to record respiratory symptoms and smoking habits; the ventilatory capacity was assessed using the indirect maximum breathing capacity test.

A clear relation between smoking and persistent cough and sputum has invariably been found, and smokers also tended to record more chest illness, wheezing, breathlessness, and "chronic bronchitis" (defined as persistent sputum and at least one chest illness during the past three years) than non-smokers.

Non-smokers recorded a higher mean M.B.C. than smokers, the best estimate of the difference, allowing for the size of the various groups studied, being 9 litres a minute. There was, however, no significant downward trend with increasing tobacco consumption among the smokers.

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THE COMMON BILE DUCT AFTER CHOLECYSTECTOMY

BY

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In 1887 Oddi (see Boyden, 1936) stated that the common bile duct becomes dilated after removal of the gall-bladder. This statement, which since then has often been quoted, has apparently little evidence in its support. Indeed, Don and Campbell (1956), on the basis of intravenous cholangiographic studies, concluded "that it seems justifiable to assume that physiological dilatation of the duct (i.e., after cholecystectomy) is not the usual course of events in man," but they had no direct evidence in support of this view. With the introduction of intravenous cholangiography, allowing visualization of the extrahepatic bile ducts, definite evidence on this point becomes essential if such an examination is to be interpreted correctly in a person whose gall-bladder has been removed. This report records the results of an investigation into the problem, based on a comparison of the diameter of the duct as seen at operative cholangiography and at post-operative intravenous cholangiography in a series of patients in whom both these examinations were performed.

Methods and Material

Observations were made on 73 unselected patients (58 women, 15 men) admitted for cholecystectomy. Their average age was 51.8 years (range 21–79). All but one of the patients had stones in the gall-bladder, and in 18 (25%) stones were removed from the common bile duct.

Operative cholangiography was performed before removal of the gall-bladder or exploration of the common bile duct, by injecting 35% diodrast down a fine catheter inserted into the common duct via the cystic duct. Three films were exposed after the slow injection of approximately 3 ml., 6–8 ml., and 12–15 ml. of the contrast medium, using an overcouch tube with the film in a special box beneath the patient.

All the patients were seen for clinical assessment and further radiological examination not less than 12 months after operation. The average interval between operation and this review was 19.5 months (range 13–33). Patients attended for interview between 9 and 10 a.m., having taken only a light breakfast. A test dose of 1 ml. of a 30% solution of iodipamide methylglucamine ("biligrafin") was given intravenously: 30 minutes later, with the patients supine, 20 ml. was injected intravenously, and the patient remained supine for 30 minutes, when a film was exposed using an overcouch tube. On rare occasions a further exposure 10 to 20 minutes later was required to obtain clear visualization of the common bile duct.

The diameter of the duct on each examination was measured by the use of callipers. This measurement was made in the suprapancreatic portion of the duct, as this is usually the widest part. On the operative

cholangiogram this portion of the duct could be identified easily, and by comparison the same portion was measured on the post-operative film. In the few cases in which the cystic duct entered the bile duct low down near its termination measurements were made at a similar level, despite the fact that under these circumstances the duct measured was, strictly speaking, not the common bile but the common hepatic duct.

On the basis of their symptoms at the time of the post-operative review the patients were placed in one of four categories: group 0, those with no digestive symptoms; group 1, those with mild digestive symptoms not thought to be related to the biliary system; group 2, those with mild symptoms possibly or probably due to some disorder of the biliary system; group 3, those with more severe symptoms, definitely thought to be related to the biliary system.

In a further series of 15 patients intravenous cholangiography was performed before operation and the diameter compared with that of the duct as shown on operative cholangiography.

Results

The diameter of the common bile duct as measured in the operative and post-operative cholangiogram in each case in the main series of 73 patients is shown in Fig. 1. It will be seen that the pattern of distribution

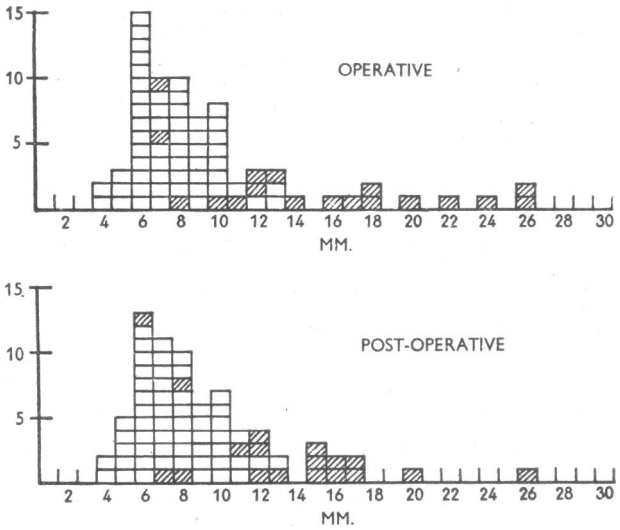

FIG. 1.—Diagram showing the diameter of the common bile duct in all 73 cases, as measured on the operative and post-operative cholangiograms. Each rectangle represents one case, and hatching indicates that a calculus was found in the duct concerned.

of duct diameters is similar in each series, with no evidence of a general tendency to dilatation after cholecystectomy. For reasons set out below, a duct diameter of 10 mm. as measured under these circumstances is considered to represent the upper limit of normal. In the entire series there was no instance of a duct of normal calibre on the operative cholangiogram increasing in diameter by 2 mm. or more. It is to be noted that 14 of the 18 patients with stones in the common bile duct had a duct diameter of 11 mm. or greater at the time of operation, and, furthermore, that only four patients had ducts of this diameter not containing a calculus. In two of these four patients there was strong clinical evidence (jaundice, severe pain) that there had recently been a stone in the duct, whilst a further patient spoke so little English that no clear evidence was obtainable on this point.

In cases with dilated ducts at the time of operation there is the possibility not only of increase but also of diminution in size after operation. The measurements at both examinations of the 16 patients with a duct diameter of 12 mm. or more on operative cholangiography are set out in Fig. 2, each case being designated with a serial

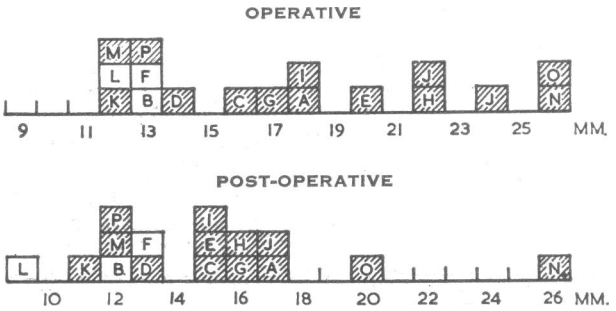

FIG. 2.—Details of the 16 cases with bile ducts of 12 mm. or greater diameter on operative cholangiography. Each case is designated by an initial. For details of Case J see text. Hatching indicates presence of a calculus.

letter. In only five cases was there definite evidence of diminution in duct size after operation, and in this respect Case J is of particular interest. At his first operation this man had a cholecystectomy with removal of a calculus from the common bile duct, which at this time had a diameter of 24 mm. Eighteen months later he was readmitted with recurrent rigors, jaundice, and pancreatitis. At a second operation sludge and grit were removed from his bile duct, which on this occasion measured 22 mm. in diameter. When seen two years later this man was placed in symptom grade 1, and on intravenous cholangiography his bile duct was found to measure 17 mm. in diameter. This was the only case in the entire series in which there was any evidence of a residual calculus in the common duct after the initial operation.

The clinical categories of the patients were as follows: 37 (50%) were grade 0, 18 grade 1, and 18 grade 2. None had symptoms severe enough for them to be placed in grade 3. Most of those in grade 2 were placed there because of some degree of fat intolerance. There is no clear evidence that this was due to any abnormality, structural or functional, of the biliary system, and in most of these cases the common duct was of normal calibre (Fig. 3). If this relationship between symptomatology and duct size is considered in the reverse way, all those patients with a duct diameter of 12 mm. or greater, as measured on the post-operative cholangiogram, were graded as follows: seven in grade 0, seven in grade 1, and one in grade 2.

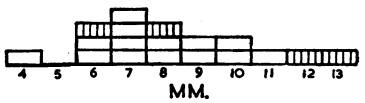

FIG. 3.—Diagram showing the duct diameter, on post-operative cholangiography, of the 18 cases in symptom grade 2. Hatching rectangles represent ducts from which stones had been removed.

The Table shows the results obtained in the 15 patients in whom an intravenous cholangiogram was performed before operation, for comparison with the diameter of the duct as measured on an operative cholangiogram. It is to be noted that the series contains ducts of widely varying calibre, and that in seven of the patients stones were present in the common duct.

Diameter of Common Bile Duct in the Second, Smaller Series of Patients Investigated by Pre-operative Intravenous and Operative Cholangiography

No.	Stones in C.B.D.	Diameter of C.B.D. in mm.	
		Pre-operative	Operative
1	Yes	13	14
2	,,	28	31
3	,,	9	10
4	,,	13	16
5	No	14	15
6	,,	6	7
7	Yes	16	16
8	No	7	8
9	,,	11	12
10	,,	4	4
11	Yes	16	16
12	No	7	8
13	Yes	6	7
14	No	10	11
15	,,	5	5

Discussion

The investigation reported is based upon the measurement of the image of the common bile duct on an *x*-ray film and its comparison with a similar measurement from a film exposed under different circumstances. Inherent in this method are several potential inaccuracies and discrepancies which might impair the validity of the results and conclusions. Accordingly several technical points require specific consideration.

Both the radiological examinations were performed with an overcouch tube, giving a magnification factor of 1.1–1.2. In the operative cholangiogram, carried out with a portable machine, the tube–film distance was slightly less than in the post-operative, tending to give a somewhat greater magnification, but calculations showed that this never increased the apparent diameter of the duct by more than 1 mm. Further, the distance between the duct and the film varied slightly according to the build of the patient, but again calculations showed that this introduced a negligible inaccuracy.

Three possible inaccuracies arose in the actual measurement of the duct diameter. First, the duct is not of uniform calibre throughout its length, but, as explained above, measurements were, so far as possible, made in the same portion of the duct. Secondly, the common bile duct is not a rigid tube of fixed calibre, but is undoubtedly capable of distension. This might particularly occur as a result of injection of fluid into the duct during the operative cholangiography. To avoid this danger the fluid was injected slowly, and measurements from all three films showed no evidence that significant distension of the duct took place, except possibly in obstructed ducts—that is, those containing calculi (see below). Thirdly, the image of the duct on the *x*-ray plate was not always clear-cut, and geometric blurr at times made it difficult to decide exactly where to place the points of the callipers, though we do not believe that this led to any significant abnormality. However, taking all these points into account, it is felt that no significance can be attached to any apparent alteration in diameter of the duct unless this alteration exceeds 2 mm.

Operative cholangiography was, of necessity, performed whilst the patient was under the influence of pethidine or morphine and of anaesthetic agents. By affecting the musculature surrounding the lower end of the bile duct these drugs might cause distension of the duct and so invalidate a comparison of measurements made at this time with others made under different circumstances. The results in the series of 15 patients investigated by pre-operative intravenous cholangiography to elucidate this point suggest that this factor does not significantly affect the validity of the comparison. None of the eight patients without stones in the common bile duct had a difference of 2 mm. or more in the size of the duct between the pre-operative intravenous cholangiogram and the operative cholangiogram. In two of the seven patients with stones in the duct the diameter of the duct on the operative film was 3 mm. greater than on the pre-operative film; in the others there was no significant alteration. Presumably in some cases the stone in the duct causes some obstruction to the flow of the injected medium, resulting in some distension. The findings in this series confirm that no significance can be attached to apparent alterations in duct size of 2 mm. or less, and suggest that no real significance should be attached to an apparent decrease in size of a duct containing a calculus unless this decrease exceeds 3 mm.

Owing to the magnification factor of 1.1–1.2, the image of the duct as measured on the *x*-ray film was some 10–20% larger than the actual duct itself. Benson (1940) measured the calibre of the duct in patients coming to necropsy, and in 47 cases with no evidence of biliary disease the greatest diameter was 6.5 mm., corresponding to a shadow on cholangiography, by the technique used here, of 8 mm. There is, however, considerable disagreement over the upper limit of normality of the diameter of the common bile duct as seen radiologically. Sullens and Sexton (1955) place the upper limit at 7 mm. and Samuel (1957) at 10 mm., whilst others (Cole and Harridge, 1956; Wise and O'Brien, 1956) accept a diameter up to 15 mm. as being normal.

In the present series 14 of the 18 patients with a duct of 11 mm. or greater on operative cholangiography had stones in the common duct, while there were eight patients with a duct 10 mm. in diameter, and in only one of these was there a stone in the duct. In view of this and of the general shape of the distribution curve, 10 mm. has been taken as the upper limit of normal corresponding to a duct with an actual internal diameter of 7.5–8 mm. It is apparent that there is a considerable range in diameter of the normal common bile duct, but in the interpretation of cholangiograms it is essential to have some figures for guidance, and on the basis of the evidence presented here it is suggested that 10 mm. diameter represents the usual upper limit of normal, and that no duct should be regarded as definitely dilated unless its image measures 12 mm. or more.

The results of this investigation show no tendency for the bile duct to dilate following cholecystectomy, at least in the period covered by this review. The general pattern of duct size distribution was the same on post-operative cholangiography as on operative cholangiography, and there was no single example of a duct of normal calibre increasing in size by 2 mm. or more.

There was no evidence that the ducts that were dilated at the time of operation tended to decrease in calibre after removal of the gall-bladder. In five of the 16 patients with a dilated duct on operative cholangiography (12 mm. or greater) the duct on post-operative examination had diminished in diameter by over 2 mm. (5, 6, 7, 3, and 3 mm. respectively). But, in the light of the findings in the small series in which a

pre-operative cholangiogram was performed, it seems probable that in part the difference in measurement in these cases was due to some mechanical dilatation of the duct when taking the operative cholangiogram, and that the diminution in size of the duct was more apparent than real. Certainly the results obtained provide no evidence that there is a clear tendency for a dilated duct to diminish in size after removal of calculi.

There was no evidence of any correlation between the continuation of symptoms after cholecystectomy and the size of the bile duct. Of the 15 patients with a bile duct of 12 mm. diameter or greater on post-operative cholangiography, 14 had either no symptoms or only mild ones not considered to be related to the biliary system. Similarly, of the 18 patients with symptoms possibly or probably due to some disorder of the biliary system, 15 had a common duct measuring 10 mm. or less on post-operative cholangiography. It is clear that the finding of a dilated common duct on cholangiography in a patient who has previously had a cholecystectomy is in itself of no significance. If there is evidence that at the time of operation the duct was definitely smaller, the enlargement presumably indicates obstruction to the duct, but this investigation provides no direct evidence on this point.

Summary and Conclusions

In a series of 73 patients undergoing cholecystectomy measurements were made of the diameter of the common bile duct as revealed on operative cholangiography, and on intravenous cholangiography performed 12 months or more after operation. At the time of this latter examination the patients were interviewed and placed in one of four categories according to their clinical symptoms.

There is a wide variation in the calibre of the normal common bile duct. It is suggested that, as seen on radiology, an image of 10 mm. diameter represents the usual upper limit of normal, and that an image of 12 mm. or greater is evidence of dilatation of the duct.

There is no evidence that the common bile duct becomes dilated after cholecystectomy.

There is no evidence that a dilated common bile duct diminishes significantly in calibre after cholecystectomy and removal of stones from the duct.

There is no correlation between the continuance of symptoms after cholecystectomy and the calibre of the common bile duct.

The finding of a dilated bile duct on intravenous cholangiography performed after cholecystectomy is of no significance in itself in the absence of information about the size of the duct at the time of operation.

All the patients in this investigation were admitted to the wards of the department of surgical studies, under the care of the director, Mr. D. H. Patey, or one of us (L. P. LeQ.). The operations were performed by members of the staff of the department. We are grateful to Mr. D. H. Patey for allowing us to review his patients and to include them in this report.

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NEW TECHNIQUE WITH HYDROXYDIONE

EXPERIENCES WITH "PRESUREN"

BY

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During his initial experiments to establish the existence of the "adaptation syndrome," Selye (1941a, 1941b) discovered that steroids had anaesthetic properties. He also reported that, while many steroids were hormones, pregnanedione could be regarded as a steroid anaesthetic without hormonal activity (Selye, 1941a, 1941b, 1942a, 1942b, 1943). Laubach *et al.* (1955) synthesized a soluble derivative of pregnanedione: 21-hydroxypregnane-3,20-dione sodium hemisuccinate ("viadril," "presuren"), which has become known by the contracted name of hydroxydione. Thus, for the first time, an anaesthetic became available which was chemically related to the heart tonics, the saponins, and certain substances manufactured in the body, such as the bile acids, corticosteroids, and the sex hormones. The first clinical trials of hydroxydione were conducted in the U.S.A. by Gordan *et al.* (1955), Murphy *et al.* (1955), and Howland *et al.* (1956), and these were followed by many others (Dauri, 1955; Burstein, 1956; Deligné and David, 1956; Dent *et al.*, 1956; Galley and Rooms, 1956; Gordan *et al.*, 1956; Harbord and Wild, 1956; Laborit *et al.*, 1956; Lerman, 1956).

The advantages claimed for this type of anaesthesia were: a high therapeutic index (wide safety margin); lack of respiratory depression if doses were kept within average clinical limits; quiescence of pharyngeal, laryngeal, and bronchial reflexes; the facility with which controlled respiration could be effected; and a less unpleasant recovery period for the patient (Galley and Rooms, 1956; Lerman, 1956). The disadvantages were the slow rate at which hydroxydione dissolved; a marked tendency to thrombophlebitis unless very weak solutions were used; the slowness of the induction resulting from the administration of such solutions by intravenous drip; and rises in pulse rate and occasional falls in blood pressure, particularly in elderly patients.

Recent Developments

Until recently the incidence of thrombophlebitis was minimized either by injecting 2.5% solutions into an exceedingly fast running drip (Murphy *et al.*, 1955) or by administering the substance in very weak solutions —for example, 0.5%—by means of an intravenous drip (Burstein, 1956; Galley and Rooms, 1956). Stedtfeld (1957) and Opderbecke (1957) reassessed the situation. Stedtfeld thought that post-operative vein reaction might be caused by chemical irritation, osmotic irritation, irritation due to solutions being at temperatures less than blood heat, the rate of injection (that is, the prolonged time during which weak solutions of hydroxydione remained in contact with the veins), or the large volumes necessitated by using an intravenous drip. After experiments on animals and a human volunteer he suggested warm physiological saline as the