habits might considerably influence the national exposure to any carcinogen in cigarette smoke.

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TOBACCO SMOKING, RESPIRATORY SYMPTOMS, AND VENTILATORY CAPACITY

STUDIES IN RANDOM SAMPLES OF THE POPULATION

BY

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Evidence is accumulating that tobacco smoking is an important factor in the aetiology of chronic bronchitis and emphysema. In a prospective study of mortality of medical practitioners Doll and Hill (1956) found a statistically significant gradient from non-smokers to heavy smokers in the mortality rates due to chronic bronchitis. Investigations of bronchitis morbidity in hospital patients, working groups, and representative samples of the general community support the hypothesis. Abbott *et al.* (1953) presented their findings in 294 patients suffering from various types of emphysema. They noted an almost constant history of protracted cough or so-called "chronic bronchitis" in these cases and considered that tobacco irritability was an important aetiological factor in 214.

Palmer (1954), in a study of 422 male hospital patients, found that chronic bronchitis was significantly commoner in smokers than in non-smokers. Greene and Berkowitz (1954) recorded a very high prevalence of "smokers' bronchitis" in patients smoking 20 cigarettes or more daily. These findings were supported by Leese (1956), who compared 100 patients with bronchitis with 100 controls and showed that the controls smoked less. Lowell *et al.* (1956) studied 34 patients (28 males and 6 females) aged 50–81 years and concluded that in New England smoking was the major cause of emphysema in this age group. Oswald and Medvei (1955) investigated the records of 6,245 clerical Civil Service employees and compared smokers with non-smokers. They found a higher prevalence of bronchitis in both sexes among the smokers. Clifton (1956) compared respiratory symptoms in a group of workers in heavy industry in Sheffield with those recorded in males in a rural general practice and noted a close association between tobacco smoking and persistent cough and sputum.

Phillips *et al.* (1956) observed a close correlation between cigarette smoking and chronic cough, and

stressed the importance of standardizing for smoking habits in assessing the other factors considered important in the aetiology of chronic bronchitis. Ogilvie and Newell (1957) carried out an investigation of bronchitis in a sample of 3,866 inhabitants of Newcastle upon Tyne. They compared 464 bronchitics with 485 non-bronchitic controls and showed that in both sexes the bronchitics were the heavier smokers, and among the men included a higher proportion of cigarette smokers. There was, however, no significant association between the number of cigarettes smoked and the disease. In a recent investigation of 1,062 men aged 60–69 living in Birmingham (Brown *et al.*, 1957) chronic bronchitis was found to be more frequent in cigarette smokers than in non-smokers.

Our own investigations at the Pneumoconiosis Research Unit of random samples of geographically defined communities have supported these findings. Thus in men aged 55–64 studied in Leigh (Lancs) tobacco smokers had significantly more "chronic bronchitis," defined as persistent sputum and a history of one bronchitic chest illness during the past three years, than non-smokers (Higgins *et al.*, 1956). In the Vale of Glamorgan, in South Wales, the prevalence of persistent cough and sputum was significantly higher in smokers than non-smokers, and smokers also appeared more liable to chest illness, breathlessness, and "chronic bronchitis" as previously defined, though for none of these symptoms did the difference reach the conventional level of statistical significance (Higgins, 1957). Finally, in Annandale, in South-west Scotland, a similar trend was observed in a sample of men and women aged 55–64 (Higgins and Cochran, 1958).

Surprisingly few attempts have been made to correlate smoking with changes in lung function. Whitfield *et al.* (1951) studied the effect of tobacco smoking on lung volume in 58 healthy men, and concluded that smoking produced a slight diminution in the vital capacity and a more pronounced increase in the ratio of residual air to total lung volume. These conclusions were criticized by Oldham (1951), who pointed out that they could not be drawn with certainty from the results presented.

Bickerman and Barach (1954) studied the acute effects of smoking three cigarettes in 91 patients with emphysema and 27 normal subjects. Although they observed no consistent trend, they noted a fall in the maximum breathing capacity in 10 subjects and suggested that this might have indicated increased bronchospasm. More recently Eich *et al.* (1957) investigated the acute effects of smoking on the mechanics of respiration in chronic obstructive emphysema. They showed an immediate statistically significant increase in the airway's resistance in 14 out of 15 emphysematous patients after smoking one cigarette, but no change in a control group. Franklin (1958) has reported the results of an investigation of the effect of smoking habits on lung function in a working population aged 40–65. Analysing kymographic tracings of the maximal forced expiration, he found that the flow rate was significantly lower in heavy smokers compared with light smokers or non-smokers. There is clearly a need for further studies assessing the long-term effect of smoking habits on lung function, using an objective physiological test. Our investigations of bronchitis in different communities have always included detailed smoking histories and also an assessment of the ventilatory capacity. The purpose of this paper is to consider the relation of smoking to

symptoms and to the ventilatory capacity as assessed by the indirect maximum breathing capacity test.

Methods and Procedure

Assessment of Ventilatory Capacity.—We record the three-quarters-second forced expiratory volume (F.E.V.), using a Gaensler type spirometer with electronic timer. The first measurement is rejected and the mean of three subsequent ones is multiplied by 40 and expressed as the indirect maximum breathing capacity (M.B.C.). The validation of this test as an objective measure of respiratory disability and the reasons for preferring it to the M.B.C. measured directly have been considered previously (Carpenter *et al.*, 1956). Its accuracy, simplicity, and repeatability are characteristics admirably suited to field investigations, particularly when these are continued over a number of years.

Smoking Habits.—In each investigation a questionnaire has been used to record respiratory symptoms and smoking habits. Present smoking habits and major changes of habit over the past 10 to 15 years have been noted. To reduce the error due to observer variability to a minimum (Cochrane *et al.*, 1951) all the interviews were carried out by one observer. The symptoms have always been recorded before asking about smoking habits. Smokers have been classified after the manner suggested by Doll and Hill (1950) according to the quantity of tobacco smoked. A smoker is defined as one who at any period of his life has smoked 1 g. of tobacco or more a day for one year. One cigarette is equivalent to 1 g. of tobacco a day; 1 oz. (28 g.) of tobacco a week is equivalent to 4 g. of tobacco daily. The subjects were classified into non-smokers, ex-smokers, and smokers of 1–4, 5–14, 15–24, 25–49, and 50 g. and over a day. For most purposes a simple classification of smokers into light (1–14 g.) and heavy (15 g. a day and over) was used. The classification was based on the stated average consumption over the previous 10 years. The separate classification of ex-smokers explains certain discrepancies between the

figures in this paper and those published previously (Higgins *et al.*, 1956) in which ex-smokers were included in their appropriate group when their tobacco consumption was averaged over 10 years.

The Samples Studied.—Detailed accounts of the methods used to obtain our random samples have been published previously (Thomas *et al.*, 1956; Higgins *et al.*, 1956; Higgins, 1957). The samples were drawn from the Rhondda Fach and Vale of Glamorgan, in South Wales, Leigh in Lancashire (England), and Annandale in South-west Scotland. The Vale of Glamorgan and Annandale are rural areas and the Rhondda Fach and Leigh are urban areas. In the Rhondda two samples were studied. The first was stratified by age, occupation, and, in the case of the miners and ex-miners, x-ray category of simple pneumoconiosis; the second was drawn from all miners and ex-miners aged 55–64 living in the area, irrespective of x-ray category. In Leigh, again, a random sample of men aged 55–64, including non-miners, miners, and ex-miners with and without pneumoconiosis, was seen. In both the Vale of Glamorgan and in Annandale the samples considered here consisted of non-miners. Over 90% of those drawn in the various samples were seen.

Results

Table I shows the numbers and mean indirect M.B.C., according to their smoking habits, in each age and occupation group. The miners and ex-miners seen in Leigh and the Rhondda have been subdivided on the basis of their chest x-ray category into those with and those without pneumoconiosis. In the second Rhondda sample and in Leigh there were a few miners with progressive massive fibrosis (P.M.F.), and these too are shown separately.

Smoking Habits

The proportion of non-smokers in the 55–64 age groups was between 5 and 10% of the samples. The proportion of non-smokers was somewhat higher in the

TABLE I.—Mean Indirect M.B.C. According to Age, Occupation, and Smoking Habits in 734 Men seen in Five Random Samples. Percentages in Parentheses

Area	Age Group	Occupation and X-ray Category	Smoking Habits (g./Tobacco/Day)								Total No.
			Non-smokers		1-14 g./Day		15 g./Day and Over		Ex-smokers		
			No.	M.B.C.	No.	M.B.C.	No.	M.B.C.	No.	M.B.C.	
Rhondda Fach (1st sample)	25-34	1. Non-miners	3 (13.6)	145.7	9 (40.9)	134.2	9 (40.9)	135.6	1 (4.5)	153.0	22 (99.9)
		2. Miners and ex-miners category 0	2 (4.3)	143.0	20 (42.6)	121.0	17 (36.2)	123.9	8 (17.0)	132.1	47 (100.1)
		3. Miners and ex-miners category 3	12 (25.5)	114.1	26 (55.3)	123.4	9 (19.1)	129.3	0	—	47 (99.9)
	35-54	4. Non-miners	5 (14.7)	130.4	16 (47.1)	95.2	10 (29.4)	115.5	3 (8.8)	98.3	34 (100.0)
		5. Non-miners	3 (6.0)	93.0	21 (42.0)	88.9	17 (34.0)	98.6	9 (18.0)	91.4	50 (100.0)
	55-64	6. Miners and ex-miners category 0	2 (4.2)	82.0	28 (58.3)	71.8	14 (29.2)	57.0	4 (8.3)	75.3	48 (100.0)
		7. Miners and ex-miners category 3	4 (8.7)	93.3	27 (58.7)	77.8	11 (23.9)	62.2	4 (8.7)	97.0	46 (100.0)
		8. Miners and ex-miners category 0	0	—	8 (42.1)	74.6	10 (52.6)	74.9	1 (5.3)	81.0	19 (100.0)
		9. Miners and ex-miners with simple pneumoconiosis	1 (5.9)	98.0	10 (58.8)	71.5	6 (35.3)	80.1	0	—	17 (100.0)
		10. Miners and ex-miners with P.M.F.	0	—	7 (63.6)	64.3	3 (27.3)	71.0	1 (9.1)	36.0	11 (100.0)
Leigh	55-64	11. Non-miners	8 (9.5)	92.0	39 (46.4)	87.4	29 (34.5)	83.0	8 (9.5)	73.9	84 (99.9)
		12. Miners and ex-miners category 0	11 (10.9)	80.9	49 (48.5)	76.0	36 (35.6)	73.0	5 (5.0)	86.4	101 (100.0)
		13. Miners and ex-miners with simple pneumoconiosis	2 (9.5)	90.5	10 (47.6)	79.2	7 (33.3)	91.6	2 (9.5)	87.5	21 (99.9)
		14. Miners and ex-miners with P.M.F.	1 (10.0)	84.0	8 (80.0)	76.3	1 (10.0)	42.0	0	—	10 (100.0)
Vale of Glamorgan	55-64	15. Non-miners	5 (5.8)	101.2	30 (34.9)	98.1	34 (39.5)	82.6	17 (19.8)	82.8	86 (100.0)
Annandale	55-64	16. Non-miners	6 (6.6)	114.3	37 (40.7)	89.1	35 (38.5)	95.7	13 (14.3)	99.9	91 (100.1)

younger men in the Rhondda, being highest in the group of miners and ex-miners with category 3 simple pneumoconiosis. The differences in smoking habits between urban and rural communities are not striking. There was a slightly higher proportion both of heavy smokers and of ex-smokers in the two rural areas.

It is widely believed that miners, since they are not allowed to smoke while underground, smoke less than non-miners. This view is supported by the recent findings of Cross *et al.* (1958) in the case of Stoke miners. In the present study the results in the Rhondda also supported this view; there was a slightly higher proportion of heavy smokers in the non-mining group. But in Leigh the smoking habits of miners and non-miners were strikingly similar, which suggests the likelihood of regional differences.

Ventilatory Capacity

Table II compares the mean indirect M.B.C. of non-smokers with that found in smokers in each of the 16 groups studied. There were no non-smokers in two of the groups; but in 13 of the remaining 14 groups which

TABLE II.—Comparison of Smokers and Non-smokers. Mean Indirect M.B.C. in Litres/Minute in Each of the 16 Groups Shown in Table I

Group No.	Non-smokers	Smokers	Difference
1	146	135	11
2	143	122	21
3	114	125	-11
4	130	103	27
5	93	93	0
6	82	67	15
7	93	73	20
8	—	75	—
9	98	76	22
10	—	66	—
11	92	86	6
12	81	75	6
13	91	84	7
14	84	72	12
15	101	90	11
16	114	92	22
Mean	104	89	
Difference of means 15			
Mean of differences 11			
Weighted difference 9			

can be compared non-smokers recorded a higher mean M.B.C. than smokers. The overall difference in means between smokers and non-smokers was 15 litres/minute, which is significant at the 1% level. Allowance must, however, be made for the numbers in the different groups. The best estimate of the average effect of smoking when due weight is given to the different sizes of the groups is that it caused a reduction of 9 litres/minute in the M.B.C. This difference is not explained by small differences in age between the groups.

When the various groups of smokers were compared there was, rather surprisingly, no consistent trend in the M.B.C. with increasing tobacco consumption. In only two groups—namely, the elderly miners with and without simple pneumoconiosis seen in the Rhondda—did heavy smokers appear materially worse than light smokers. Nor can any firm statement be made about the mean values for ex-smokers. In the non-miners their mean was about the same as that for the smokers; in the mining groups it tended to be higher.

The statistical analysis of the results indicates that the findings in the different areas are sufficiently homogeneous for pooling. Table III shows, for men aged 55–64, the mean values for the M.B.C. according to the

amount smoked, after grouping by occupation and x-ray category of pneumoconiosis. The difference between the smokers and non-smokers is well seen, and the trend within the smoking groups, though statistically insignificant, suggests that in this age group the amount

TABLE III.—Mean Indirect M.B.C. According to Occupation, X-ray Category, and Smoking Habits in Five Random Samples. (Men Aged 55–64)

Occupation and X-ray Category	Non- smokers		Smokers				Ex- smokers		Total
			1-14 g./Day		15 g./Day and Over				
	No.	M.B.C	No.	M.B.C	No.	M.B.C	No.	M.B.C	
Non-miners ..	22	100.3	127	90.6	115	89.1	47	87.6	311
Miners and ex- miners category 0 ..	13	81.1	85	74.5	60	69.6	10	81.4	168
Miners and ex- miners with simple pneumo- coniosis ..	7	93.1	47	76.7	24	75.8	6	93.8	84
Miners and ex- miners with P.M.F. ..	1	84.0	15	70.7	4	63.8	1	36.0	21

smoked may have an effect in some people. The distributions of the M.B.C. values for the 55–64 age groups supported the conclusions reached from considering the means. In each group the proportion of men with values less than 50 litres/minute, indicating fairly severe impairment of the ventilatory capacity, was higher among smokers than among non-smokers.

Respiratory Symptoms and "Chronic Bronchitis"

The questionnaire about respiratory symptoms used in the Rhondda surveys was not strictly comparable with that used subsequently in Leigh, the Vale of Glamorgan, and Annandale. It seems better, therefore, to restrict the symptom analysis to the 393 men studied in these three surveys. The results are given in Table IV. The smoking habits of the whole group are given first and then the number of men in each smoking category reporting the various symptoms.

The main difference is between smokers and non-smokers, the former reporting consistently more symptoms than the latter. There was a marked trend

TABLE IV.—Prevalence of Respiratory Symptoms and "Chronic Bronchitis" According to Smoking Habits in Men Aged 55–64 Seen in Leigh, the Vale of Glamorgan, and Annandale. Percentages in Parentheses

	Non-smokers	Smokers		Ex-smokers	Total
		Light (1–14 g./Day)	Heavy (15 g./Day and Over)		
No. seen ..	33	173	142	45	393
No. with:					
Persistent cough and sputum*	2 (6.1)	34 (19.7)	60 (42.3)	4 (8.9)	100 (25.4)
Wheezing in the chest†	5 (15.2)	91 (52.6)	74 (52.1)	19 (42.2)	189 (48.1)
Chest illness‡	1 (3.0)	41 (23.7)	34 (23.9)	11 (24.4)	87 (22.1)
Breathlessness§	6 (18.2)	52 (30.1)	48 (33.8)	13 (28.9)	119 (30.3)
"Chronic bronchitis"	0	24 (13.9)	25 (17.6)	2 (4.4)	51 (13.0)

* Cough and sputum for some part of the day most days for at least three months in the year.

† Answer "yes" to the question, "Do you ever have wheezing in the chest?"

‡ At least one bronchitic chest illness during the past three years severe enough to keep a man off work for a week or more.

§ Unable to keep up with other men of own age on hills or stairs or hurrying.

|| Persistent sputum and at least one chest illness during the past three years.

of increasing cough and sputum with increasing tobacco consumption; but for the other symptoms the difference between the light and heavy smokers was not striking. The evidence also suggests that the ex-smokers had less cough and sputum and "chronic bronchitis" than would be expected.

The analysis of the results so far has been confined to total smoking habits and has ignored any differences that may exist between pure pipe and cigarette smokers. It is usually assumed that pipe smokers are little affected by their indulgence and that they can therefore be included with the non-smokers. Among the 393 men whose symptoms are under discussion there were 77 pure pipe smokers—64 smoked 1–14 g. of tobacco daily and 13 smoked 15 g. or more a day. Table V shows

TABLE V.—Prevalence of Respiratory Symptoms and "Chronic Bronchitis" in 77 Pure Pipe Smokers Seen in Leigh, the Vale of Glamorgan, and Annandale. (Men Aged 55–64)

No. with persistent cough and sputum	..	10 (13.0%)
" wheezing in the chest	..	32 (41.6%)
" chest illness	..	14 (18.2%)
" breathlessness	..	19 (24.7%)
" "chronic bronchitis"	..	8 (10.4%)

their prevalence of symptoms and "chronic bronchitis." It will be seen that these pure pipe smokers had fewer symptoms than the cigarette smokers; but that they were not as free from them as the non-smokers. They form, in fact, an intermediate group, possibly closer to the smokers than is usually believed.

Cigar smoking is so rare in this country that separate analysis of pure cigar smokers is not possible.

Discussion

Smoking histories are liable to certain obvious errors. It is, for example, unlikely that the histories of those with frequent changes of habit will be accurately obtained. In the present series of investigations this did not appear to be an important source of error, since a surprisingly high proportion of those questioned maintained that they had not changed their tobacco consumption during the 10 years of review. It must be recognized, however, that there may be discrepancies between the amount people say they were smoking 10 years ago and the amount they actually smoked. It is impossible to assess the accuracy of statements about present tobacco consumption, and it is not unusual to find that in his wife's view a man tends to underestimate the amount he smokes. Deliberate misstatements might possibly be made when compensation issues are involved; but there is no evidence to suggest that such falsification occurred.

Hilding (1956) has investigated smoke intake in smokers. He studied the length of the cigarette butt left unsmoked, the number of puffs per cigarette, the duration of each puff, and the duration of glow. He estimated the amount of smoke taken into the mouth by 17 smokers in 24 hours and noted a poor correlation with the number of cigarettes stated to be smoked.

In our investigations no attempt was made to assess the importance of inhaling. The validity of the claim that a smoker "always inhales" or "never inhales" is an open question, and the difficulty of securing accurate information on this point appeared prohibitive.

Certain difficulties in classification arise as a result of major changes in smoking habits. A heavy smoker may give up smoking because of symptoms, which may then

improve, cease altogether, or persist unchanged. In the present study he would be classified as an ex-smoker and present no problem. But if instead of giving up altogether he continues smoking a few cigarettes a day he must be included in his appropriate group when his tobacco consumption is averaged over 10 years. A man might have been a light smoker for 10 years, but have symptoms persisting from his heavy-smoking days, which will tend to obscure any correlation of symptoms with amount smoked. Possibly men with such gross changes in habit should have been excluded and with them the similar case of the heavy cigarette smoker who changes over to a pipe, in whom also symptoms may persist. The problem is not, however, a large one and the few men in each category have been included.

Berkson (1958) has advanced the hypothesis that non-smokers, or relatively light smokers, are endowed with a specially resilient constitution, which is biologically disposed to self-protective habits, and that this is correlated with resistance to disease. While there is some recent evidence suggesting personality differences between smokers and non-smokers (Heath, 1958) it seems more likely that non-smokers comprise mainly those who fail to obtain from tobacco the soothing gratification enjoyed by the majority.

The importance of selection among smokers is difficult to evaluate. It seems possible, for example, that some low M.B.C.s in non-smokers could be due to people with bad chests never starting to smoke. More important than such initial selection is, however, the likelihood that the heavier smokers will contain a high proportion of men who are able to smoke without developing respiratory symptoms and disability. This form of selection could explain the high M.B.C. values observed in some of the heaviest-smoking groups.

The absence of a significant trend in the ventilatory capacity with increasing tobacco consumption is in contrast to the well-marked trend in the prevalence of persistent cough and sputum. A possible explanation of the difference might be that, while smokers generally ignore what they refer to as "only a smoker's cough," they are more likely to take action once their lung efficiency becomes impaired and either give up smoking or reduce the amount smoked.

It is interesting to compare this trend in the prevalence of persistent cough and sputum with that which occurs in the mortality rates from cancer of the lung (Doll and Hill, 1956). In both conditions there is a steady rise with increasing amount smoked, and it is perhaps legitimate to speculate on an association between them. In an interesting paper on mustard-gas poisoning, relevant to the present discussion, Case and Lea (1955) found a significant excess of deaths from cancer of the lung in men pensioned from the first world war with chronic bronchitis. Their evidence suggested a possible association between chronic bronchitis and the subsequent development of cancer of the lung. It may be that the persistent chronic cough that the cigarette addict comes to believe is normal can similarly lead to the development of lung cancer.

There were differences in the proportion of pipe smokers in the different areas. Pipe smoking was commoner in Lancashire and Scotland than in South Wales. An interesting finding was that the majority of pipe smokers smoked under 15 g. of tobacco a day. Though pipe smoking did not appear to be entirely harmless it did seem to be much less apt than cigarette

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 questionnaire 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