PLACE OF MASS RADIOGRAPHY IN RELATION TO LUNG CANCER IN MEN

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The value of miniature radiography for the detection of "early" or resectable lung cancer is a subject of considerable and persistent controversy. The problem was viewed optimistically in the earlier days in the United States (Overholt and Schmidt, 1949; Guiss, 1952; Rigler, O'Loughlin, and Tucker, 1953), but even then few authors shared Overholt's (1953) opinion: "This common cancer is the most detectable of all internal cancers. With the use of chest screening and present treatment methods, it can be the most curable of all internal cancers." In contrast, Bignall (1959) concluded that the majority of lung cancers are undetectable by any kind of radiography when they are small or so-called "early," and Shanks and Kerley (1962) cast doubts on the justification of large-scale mass-radiography surveys for the detection of lung cancer.

In a previous paper we have shown that there is a higher resectability rate in cases found by unselective radiography than in those detected by other means, but the small numbers discovered at routine surveys, and in some instances the lack of adequate control groups, made statistical evaluation very difficult (Posner, McDowell, and Cross, 1959). Our work has been confirmed by others (Brett, 1959; Young, 1959; Cuthbert, 1959; Höst, 1960). Furthermore, some of the studies here and in the United States (Posner *et al.*, 1959; Boucot, Horie, and Sokoloff, 1959; Boucot, Cooper, and Weiss, 1961) showed that only a small proportion of cases detected by routine radiography were truly asymptomatic or "silent."

An analysis of the contribution of miniature radiography to case-finding generally, and especially to the detection of "early cases," must take into account that during the past decade the emphasis of mass radiography in England and Wales has shifted from the conventional periodical routine surveys in factories and areas to selective radiography of special groups. The most important of these groups is the one in which patients, the majority of whom have symptoms, are referred to the x-ray units by their general practitioners. Consequently, the majority of lung-cancer cases detected by miniature radiography in recent years originated from this group. During the past two years 55% of the 4,300 malignant pulmonary neoplasms in men came from general practitioners' referrals (Ministry of Health, 1961, 1962).

Birmingham Region Investigation

Heasman (1961) believes that only 10% of all new cases are diagnosed with the help of miniature radiography and only half of that proportion at routine surveys. In the area of the Birmingham Regional Hospital Board the registration of cancer mortality and morbidity is now of a very high standard (Ministry of Health, 1961), and it is known that in 1959 miniature-radiography units contributed 394

(23.9%) to the total of 1,649 newly registered male cases. Between July 1, 1955, and June 30, 1960, 1,699 cases were classified by the physicians in charge of the regional mass radiography units as primary lung cancer. Sufficient information was collected at first attendance from 1,550 cases (89%) to justify analysis. Inadequate initial documentation prohibited the follow-up in 149 cases, but these have been included in the case-finding rates, shown in Table I. Of

TABLE I.—Cases of Carcinoma of Lung Discovered in Men by Mass Radiography in Birmingham Region. July, 1955, to June, 1960

Years	G.P. Patients			Routine Surveys			Totals		
	No. Examined	Cases		No. Examined	Cases		No. Examined	Cases	
		No.	%		No.	%		No.	%
1955-7	65,079	542	8.3	429,346	147	0.3	494,425	689	1.4
1958-60	86,070	847	9.8	411,348	163	0.4	497,418	1,010	2.0
Total	151,149	1,389	9.2	840,694	310	0.4	991,843	1,699	1.7

the 1,550 cases only 27 had incomplete follow-up. Thus the follow-up series of 1,523 cases includes only those which were confirmed by surgical or cytological means or by necropsy, or where, in the absence of such evidence, the further course of the disease left no reasonable doubt about the diagnosis in the opinion of at least two independent observers. Numerically, our series is now comparable with the largest analyses of hospital cases reported in this country in recent years (United Birmingham Hospitals, 1954; Bignall, 1958; Flavell, 1962).

Methods of Investigation.—These have been described in some detail before (Posner *et al.*, 1959). At the beginning of the investigation all units used basically the 35-mm. film, but, with the exception of two, all others converted to the 70-mm. and 100-mm. technique after 1957. We collected our cases between July 1, 1955, and June 30, 1960. Our analysis was restricted to men and our findings were divided into two main periods: mid-1955 to mid-1957 and mid-1957 to mid-1960. These periods are shown on most tables as 1955-7 and 1958-60.

Results of the Investigation

Case-finding Rates

Despite the steadily rising mortality from bronchogenic cancer between 1955 and 1960 (Ministry of Health, 1956-61) and the change-over to more efficient radiographic technique during the last three years, only a small increase in case-finding rates at routine surveys was observed during the later part of this investigation (Table I). The yield of 0.4 per thousand was the same as for the country as a whole (Heasman, 1961), but, not unexpectedly, it was lower than the case-finding rates originating from intensive mass-radiography campaigns in Glasgow, Edinburgh, and Liver-

pool, where over 70% of the male population were x-rayed in the course of a few weeks, resulting in cancer-detection rates between 0.5 and 0.8 per thousand (Cowan, Horne, Geddes, Tait, and MacGregor, 1958; Seiler, Welstead, and Williamson, 1958; Waddington, 1960; Semple and Hughes, 1960).

The case-finding rates in the *General practitioners' group* (9.2 per thousand) for the whole period of the investigation were 23 times higher than for routine surveys, and somewhat higher than those shown by Heasman (1961) for general practitioners' referrals in England and Wales (7.9 per thousand). The higher detection rate in general practitioners' patients during the later period of the investigation corresponded with the increased number of referrals (Table I).

Age Distribution

The percentage age distributions of general practitioners' referrals and routine survey cases, diagnosed over the whole of the period of the investigation, are shown in the Chart and compared with the age distribution of patients

Percentage age distribution of male lung-cancer cases. Mass-radiography cases, Birmingham region 1955-60; Birmingham Cancer Registry 1955-9.

registered from all sources with the Birmingham Regional Cancer Registry during the years 1955-9. As would have been expected, the proportion of men in the oldest age-group of Registry patients (30%) is greater than in the two mass-radiography groups and consequently the proportions referable to the other three age-groups are less. Furthermore, the proportion of routine survey patients aged 65 years and over (15.4%) is noticeably less than the corresponding proportion for general practitioners' patients (21.5%). This deficiency is balanced by the proportionate excess of routine survey cases in the 55-64 age-group. Generally, proportions for individual age-groups for G.P.s' referrals agreed more closely with those obtained from the Regional Cancer Registry than those of routine survey cases.

During the later period of investigation (1958-60) the proportion of men above the age of 65 in the G.P. referrals group was higher than during the earlier years, whereas the proportion for the routine survey group decreased slightly (Table II).

TABLE II.—Age Distribution During Earlier and Later Period of Investigation

Years	-45		45-54		55-64		65+		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%
General Practitioners' Patients										
1955-7	36	8.9	124	30.9	172	42.8	70	17.4	402	100
1958-60	72	8.2	228	26.1	369	42.2	205	23.5	874	100
Routine Survey Cases										
1955-7	9	9.7	28	30.1	41	44.1	15	16.1	93	100
1958-60	7	4.6	43	27.9	81	52.6	23	14.9	154	100

Histological Cell Type

A histological diagnosis became available in 908 (59.6%) of all cases. This percentage is regarded as very satisfactory in view of the fact that units used different laboratories throughout the region to carry out the histological examinations. It also corresponds closely to the histological confirmation rate (62%) in Bignall's (1958) large hospital series, and to other mass-radiography reports from this country, with the exception of the high confirmation rate (85%) after the Liverpool Campaign (Waddington, 1960). The specimens were reported on by a considerable number of pathologists, which resulted quite naturally in a lack of uniform classification, and we therefore used on Table III a very broad classification into adenocarcinoma, and squamous-celled and undifferentiated neoplasms, the latter including the oatcell type. Table III shows a

TABLE III.—Distribution of Cases According to Predominant Cell Type

Group	Squamous		Undifferentiated		Adenocarcinoma		Others		All Cases with Known Type	
	No.	%	No.	%	No.	%	No.	%	No.	%
G.P. referrals	400	53.0	274	36.3	45	6.0	36	4.8	755	100
Routine surveys	74	48.4	53	34.6	9	5.9	17	11.1	153	100
All sources	474	52.2	327	36.0	54	6.0	53	5.8	908	100

similar cell-type distribution in routine survey cases and general practitioners' referrals, and the pattern, with its predominance of squamous-cell tumours and only small numbers of adenocarcinomas, is in accordance with general experience in male patients. It should, however, be stressed that most histological reports in this series originated from resection specimens, and the distribution is therefore likely to be biased in favour of the squamous-type tumour (Hinson, 1958; Walter and Pryce, 1955).

Smoking Habits

The close association between the smoking of cigarettes and bronchogenic carcinoma is now firmly established, and has recently been comprehensively summed up (Royal College of Physicians, 1962). We therefore thought it unnecessary to show an analysis of our cases, especially as the smoking habits of the first 240 patients in this series have already been shown (Posner *et al.*, 1959).

Resectability

Like most other authors we found it impossible to make always a clear distinction between "operable" and "resectable" cases, and Table IV therefore includes an unknown

TABLE IV.—Resectability

Group	Pneumonectomies		Lobectomies		All Resections	
	No.	% of Total	No.	% of Total	No.	% of Total
G.P. referrals	246	19.3	180	14.1	426	33.4
Routine surveys	49	19.8	66	26.7	115	46.5
Total	295	19.4	246	16.2	541	35.6

number of resections which are likely to have been of a purely palliative nature. There is, however, no evidence to suggest that the higher resectability rates in routine survey cases compared with those of general practitioners' referrals were due to a larger proportion of palliative

operations in either group. Table IV clearly shows that the higher resection rates in routine survey cases were due to a larger proportion of lobectomies, whereas the proportion of pneumonectomies was the same for both groups. During the course of the investigation the proportion of lobectomies rose from 37% in 1955 to 52% of all resected cases during the last two years, a proportion which is very close to that reported by Flavell (1962), and higher than in most other surgical series. We have, however, no statistical proof whether the thoracic surgeons who dealt with our cases were performing lobectomies on an increasing scale because they were finding less widespread lesions at operation, or whether they were becoming more in favour of "conservatism" in the surgical treatment of lung cancer than in earlier years. It is generally accepted (Bignall and Moon, 1955; Belcher, 1956; Cleland, 1958; Flavell, 1962) that the post-operative consequences of lobectomy are more favourable than those of pneumonectomy, and the larger proportion of lobectomies in routine survey cases seems to us of some importance.

A true comparison of resection rates between various regions and centres is, of course, impossible because of many varying factors, but it appears that the rates not only of our routine survey cases but also of the general practitioners' referrals were much higher than those of the large hospital series (Bignall, 1958; Taylor, 1960). The rates for routine survey cases were only slightly lower than those reported after the Glasgow and Edinburgh Mass Radiography Campaigns (Seiler *et al.*, 1958; Cuthbert, 1959) but considerably below Waddington's (1960) rates after the community survey in Liverpool.

Age and Resection.—Up to the age of 65 years the resection rates by age-group for routine survey cases were much higher than for general practitioners' patients; in men above that age they agreed very closely. In each group the resection rate remained remarkably constant with respect to age up to the 65 years-and-over group (Table V).

Resection and Histological Cell Type.—For all three main histological types the resection rates were higher in routine survey cases than in general practitioners' referrals (Table VI). The higher percentage of resection in cases with squamous carcinoma in general practitioners' patients is in accord with the findings of most published series (Nicholson, Fox, and Bryce, 1957; Bignall, 1958; Brett, 1959; Höst, 1960). On the other hand, the resectability rate of undifferentiated tumours in routine survey cases—70%—contrasts sharply with common experience, with the exception of a routine survey group reported by Waddington

(1960) in Liverpool. We find it difficult to attribute any significance to this unexpected result.

Survival

The very marked differences in survival rates between resected and non-resected cases (Table VII) indicate that at

TABLE VII.—*Survival After X-ray Examination—With and Without Resection (Percentage Distribution)*

	Resected Cases				Non-resected Cases			
	1955-7		1958-60		1955-7		1958-60	
	G.P.	R.S.	G.P.	R.S.	G.P.	R.S.	G.P.	R.S.
No. at risk:	138	44	288	71	264	49	586	83
Percentage surviving:								
0 years	100	100	100	100	100	100	100	100
1 "	61	71	56	66	22	33	13	27
2 "	46	50	36	49	6	14	3	10
3 "	35	48	27	47	4	8	2	7
4 "	29	41			3	6		
5 "	27	38			3	6		

G.P. = G.P. referrals. R.S. = Routine survey.

the present time only surgery offers reasonable chances of survival for more than two years. In both our groups less than one-third of the men who had no resection were alive after the first year of follow-up. Non-resected routine survey cases fared somewhat better than the corresponding group of general practitioners' patients, but the two-year survival rate for the former group was only 12%.

Survival of Resected Cases

A five-year follow-up has been possible for cases detected during the first two years of the investigation. Survival rates for the routine survey group were somewhat higher than those for general practitioners' referrals: 38% of men in the former group survived five years as compared with 27% of general practitioners' cases (Table VII). The rates for our routine survey cases were generally higher than those of the large hospital series (Bignall, 1958; Thompson, 1960; Flavell, 1962), whereas the rates of our general practitioners' patients broadly compare with the rates for patients who were referred to these hospitals from all sources.

It soon became evident, however, that the post-resection experience of men detected and operated on after 1957 would be less favourable than that of men in the earlier period of the survey. Table VIII gives two-year survival

TABLE VIII.—*Two-year Survival of Resected Cases During Earlier and Later Period of Investigation (From Date of Operation)*

	No. Resected	No. Alive after 2 Years	2-year Survival Rate (%)
1955-7 { G.P. referrals ..	138	58	42
Routine surveys ..	44	22	50
1958-9 { G.P. referrals ..	196	67	34
Routine surveys ..	43	18	41
1955-9 { G.P. referrals ..	334	125	37
Routine surveys ..	87	40	46

rates for the periods 1955-7 and 1958-9. A decrease in the rates took place for each group. Although the difference for the two groups combined was not significant statistically, this decrease reduced the two-year survival rate (39%) for all 421 resected cases during the period 1955-9 below the level of Sellors's (1955), Gifford and Waddington's (1957), and Bignall's (1958) results, although their resections were carried out before the start of our investigation.

TABLE V.—*Resectability by Age*

Age	G.P. Referrals			Routine Survey		
	All Cases	Resected		All Cases	Resected	
		No.	%		No.	%
—45	108	45	41.7	16	8	50.0
45-54	352	140	39.8	71	39	54.9
55-64	541	200	37.0	122	62	50.8
65+	275	41	14.9	38	6	15.8
Total ..	1,276	426	33.4	247	115	35.6

TABLE VI.—*Resectability by Histological Cell Type*

Group	Squamous			Undifferentiated			Adenocarcinoma		
	No. of Cases	Resected		No. of Cases	Resected		No. of Cases	Resected	
		No.	%		No.	%		No.	%
G.P. referrals	400	259	64.8	274	107	39.1	45	27	60.0
Routine survey	74	54	73.0	53	37	69.8	9	8	88.9
Total ..	474	313	66.0	327	144	44.0	54	35	64.8

The less favourable post-resection survival rates during the later part of our study were due to an increase in the *post-operative mortality rates* (death within two months of operation), from 8% during the years 1955-7 to 17% during 1958-60 (Table IX). This increase mainly occurred in the general practitioners' group, who showed a higher immediate post-resection mortality from both lobectomies and pneumonectomies. In the later period the post-resection mortality of this group was significantly greater

TABLE IX.—*Post-operative Mortality (Death Within Two Months After Resection) by Type of Operation*

Group	Lobectomy			Pneumonectomy			Both Operations		
	No. of Cases	Deaths		No. of Cases	Deaths		No. of Cases	Deaths	
		No.	%		No.	%		No.	%
1955-7:									
G.P. referrals	50	3	6.0	88	8	9.1	138	11	8.0
Routine surveys	26	1	3.8	18	2	11.1	44	3	6.8
All cases	76	4	5.3	106	10	9.4	182	14	7.7
1958-60:									
G.P. referrals	130	19	14.6	158	37	23.4	288	56	19.4
Routine surveys	40	2	5.0	31	4	12.9	71	6	8.5
All cases	170	21	12.3	189	41	21.7	359	62	17.3

than that of routine survey cases. The increased mortality does not seem to be related to a change in the age composition of resected cases.

Discussion

Almost 20 years ago mass miniature radiography was introduced into this country as a tuberculosis case-finding agency (Clark, Hart, Kerley, and Thompson, 1945). When we embarked on this investigation in 1955 conventional routine or *laissez faire* mass radiography (F. A. Nash, personal communication, 1962) had started to yield decreasing tuberculosis case-finding rates, although even to-day its contribution in the field of tuberculosis is by no means negligible (Ministry of Health, 1961). At about the same time the still growing "epidemic" of lung cancer made its first full impact on the public mind, and, quite naturally, many people who had become accustomed to the slogan "early discovery means early recovery" believed mass radiography to be as powerful a weapon in the combat of cancer as it has proved to be for tuberculosis.

From the start it was clear that we were faced with an entirely different problem. Not only has the detection of a presumably non-communicable disease such as cancer quite different implications for the community than tuberculosis, but it has to this day remained one of the most fatal forms of malignant disease, whereas tuberculosis, even in its advanced stages, has become eminently curable. Nevertheless, it seemed to us worth while to clarify the place and value of a highly organized radiological organization in the detection of such cases of lung cancer the timely diagnosis of which could hold out hopes of reasonably long survival or even cure.

This analysis of 1,523 miniature radiography cases, to our knowledge the largest published so far, clearly shows that only resection offers reasonable chances of survival, and the problem of the value of this medium resolves, therefore, into the issue whether it can find sufficient numbers of tumours the resection of which would have some impact on the unfavourable therapeutical position of present days. It shows, like others previously referred to, that resectability was higher for cases picked up at routine surveys than for patients referred to us by their doctors, and that even the

poorer resectability rates of the latter were higher than those of patients referred to hospitals from other sources. The more favourable resectability rates in the routine survey group were neither due to a surplus of old men in general practitioners' referrals nor to a different histological pattern of tumours in the two groups. The investigation has, however, failed to show any increase in resectability rates over the period under review. They were, for both groups combined, 37% in 1955-7 and 34% in 1958-60. Furthermore, the post-resection survival rates have declined in recent years because of an increase in post-operative mortality among general practitioners' cases.

To our disappointment, the larger size of films used during the second half of our investigation and—if only because of this exercise—the lowered threshold of suspicion of those who interpreted them did not produce a significant increase in the discovery rates at routine surveys. Consequently, of the 541 resected cases in this series only 115 originated from routine radiography. We must therefore agree with Rosenblatt and Lisa (1956) that "the number of non-invasive cases diagnosed at routine screening is too small to affect the total result" and that "the hope that improved methods of diagnosis in recent years would result in a larger number of early cases has not been realised."

Although the resectability rates for general practitioners' patients were lower than in the routine survey cases, it must be stressed that this group contributed almost three-quarters of resections during the period under review and that the case-finding rates were 92 per 10,000 men referred to us. With regard to survival after resection, there is some evidence that the routine survey group did somewhat better; but again it must be stressed that of those who were followed up for two years after operation 125 resected doctors' cases and only 40 of the corresponding routine survey group were still alive.

The cost of finding these cases must not be overlooked. From information available we calculated that it took almost £1,000 to find a case of lung cancer at routine mass radiography, whereas the cost of detecting a case referred to us by general practitioners was only £41. It is of some interest that during the same period the cost of active cases of tuberculosis found at general practitioners' sessions and routine surveys was £20 and £124 respectively.

For all these reasons we believe that orthodox, unselective routine mass radiography—that is, periodical visits to factories and localities at three- to four-yearly intervals—has little to offer in the way of finding lung cancer with favourable prognosis. More frequent visits to factories, offering x-ray examination only to men above the age of 40, have been suggested. Although these are likely to increase the yield of lung cancer and, incidentally, also of tuberculosis (Joint Tuberculosis Council, 1962; Geddes, 1963) such age-restricted routine surveys are notoriously difficult to organize and are often resented by the younger workmen.

There are, however, other possibilities of introducing serial and selective schemes. In London, six-monthly x-ray examinations are offered to all men above the age of 40 who attend routine M.M.R. sessions, and Nash, Morgan, and Tomkins (1961) believe that by this method almost two-thirds of male cases of lung cancer in a defined population can be found. They quote resection rates of 56% for those who entered their scheme and 52% for those found at subsequent examinations. However, their survival rates have not yet been shown, and the defaulter rate at the first repeat examination was 27% (Nash, personal communication 1962).

It would appear that, in present conditions, the most economic and valuable method of finding resectable lung-cancer cases is through the general practitioners. In most regions during the past few years family doctors have been making increasing use of the readily available chest x-ray sessions of static and mobile x-ray units, but the large majority of men referred to us have respiratory symptoms and only a few are being sent for routine or serial x-ray examination.

With central and local authorities and local executive committees providing the necessary funds for clerical help, a scheme whereby general practitioners send all their male patients above the age of 40, whether they have respiratory symptoms or not, for at least annual chest x-ray examination should be administratively and financially feasible. Some regions have now sufficient 70-mm. and 100-mm. facilities to deal with such schemes; the others should be provided with them at clinics, out-patient departments of hospitals, or mass-radiography centres. In making these suggestions we are fully aware that, at the present state of diagnosis and therapy, serial selective radiography, however comprehensive, cannot be the answer to the lung cancer problem. Nevertheless, we believe that, for little cost and effort, it can provide the thoracic surgeons with larger numbers of prognostically favourable cases.

Summary

A series of 1,523 cases of lung cancer in men, found by miniature radiography in the Midlands during a five-year period, are reviewed. The investigation deals with cases found at routine surveys and cases referred by general practitioners, and the results are shown for two main periods, 1955-7 and 1958-60.

Resectability rates and post-resection survival rates were higher in the group of routine cases than in patients referred by family doctors, but, despite more efficient radiological facilities, the case-finding rates at routine surveys did not increase during the course of the investigation. The case-finding rates of the general practitioners' group were 23 times higher than at routine surveys and showed an increase over the years.

A significantly higher proportion of routine survey cases had lobectomies than general practitioners' patients, but the post-operative mortality of the whole series rose from 8% to 17%, and consequently the two-year post-resection survival rates fell for both groups during the later period of the investigation.

It is suggested that orthodox routine mass radiography cannot improve the finding of cases with favourable prognosis to any significant extent, but that serial chest x-ray examination of men in the critical age-groups should be introduced on a large scale. This should be done with the help of general practitioners, who should be provided by the authorities with the necessary clerical assistance. Sufficient miniature—70-mm. and 100-mm.—x-ray sets should be available at mass-radiography centres, chest clinics, and hospital out-patient departments.

We are most grateful to the chest physicians, thoracic surgeons, and pathologists in the region for providing information of patients referred to them. We are indebted to the staff of the Birmingham Follow-up Department for the most efficient follow-up of our patients, to the Birmingham Cancer Registry for the age distribution of cases, to Mrs. M. Hampton for clerical assistance, and to Mrs. M. Sheldon for help with processing the material.

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"As always the National Association for Mental Health has been concerned with watching progress at the national level and with providing services to support and supplement it. During this period the 'ten-year plan' for local authority services has appeared to complement the 'ten-year hospital plan,' and both nationally and at local association level these two policy documents have provided a frame of reference for the association's work. They have provoked discussion in committee of the effectiveness of training programmes to meet these new plans. Where are the wardens and matrons for the new hostels so largely proclaimed to come from? Where is employment to be found for patients leaving hospital and adolescents leaving special schools? Are the adult training centres, of which there are to be many, sufficiently closely linked with Ministry of Labour provisions? Do the financial incentives which are available in them make sense, both as training objectives and as payment for work done? How much do we really know about what is happening to the sub-normal and the severely subnormal in the community? Are we sure that the hospital plan's guesses about provision for sub-normality are accurate? Where psychiatric hospitals are being run down, are the interests of the staff in every case safeguarded, given a system which provides payment for staff on the number of beds manned? What about the psychotic child, who, during this year, has emerged from conference after conference as requiring special provisions?" (National Association for Mental Health, *Annual Report*, 1962-3).