- 1 was transferred to a mental hospital with a psychosis, in the second month (10 PH);
- 6 had severe toxic reactions attributed to P.A.S. (4 20 PH, 2 10 PH);
- 1 had a severe toxic reaction attributed to streptomycin (SH);
- 2 stopped treatment in the second month—one because of acute nephritis, the other because of persistent haemoptysis believed to be related to treatment (2 SH);
- 2 had a change of treatment in the first month: for one 10 PH patient streptomycin was added after eight days, and the dosage of P.A.S. was doubled, because of the serious clinical condition: for one 20 PH patient streptomycin was added after 18 days because of radiographic deterioration; this patient had 1-minus deterioration at one month, and the deterioration at three months was still classed as 1-minus;
- 2 had a change of treatment in the second month (2 20 PH): one patient had deteriorated both clinically and radiographically and the treatment was changed to SH at six weeks; at ten weeks a radiograph showed 1-plus improvement compared with the condition on admission: the other patient deteriorated radiographically and streptomycin was added at six weeks, but there was 2-minus deterioration at three months.

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RESULTS OF SURGICAL TREATMENT
OF CARCINOMA OF THE LUNG*

BY

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In the treatment of cancer of the lung it is generally accepted that surgery alone offers any real hope of success. Up to the present time radiotherapy has played a part that is largely palliative, and the experiences gained by the combined use of radiotherapy and surgery are too limited to be of value. There are now large enough numbers of surgically treated cases on which a rough estimate of long-term results can be based, and in this article an analysis of personal cases operated on between the years 1940 and 1950 is made. The follow-up was carried out up to the end of 1953, which gives a five-year survival figure for cases operated on prior to 1948 and three-year survival figures for those treated in the subsequent two years.

Excision of a tumour of the lung is a practicable proposition so long as the mass can be actually removed and so long as the patient can sustain the inevitable loss of lung tissue. Pneumonectomy is regarded as the standard operation in the treatment of pulmonary cancer, though a more limited resection in the form of lobectomy can be carried out in certain circumstances. Improvements in all branches of thoracic medicine and surgery have been responsible for making lung resection a relatively safe technical procedure and in reducing the post-operative mortality and complications to reasonable limits. The lapse of time has now been long enough to permit evaluation of the results of operation.

Incidence

The steady annual ascent of the recorded death rate in relation to carcinoma of the lung is indicated by the Registrar-General's figures given in Table I, and, even allowing for a much greater awareness of the disease and for

*Based on a paper given at the Sectional Meeting of the American College of Surgeons, London, May, 1954.

improved methods of diagnosis, these give some idea of the magnitude of the problem. Stocks (1947) believes that the incidence shows a true increase during the past two or three decades, and gives the standardized death rate in males as having increased from 1.1 in 1910 to 10.6 in 1938. More recently the crude mortality rate per million living has doubled in ten years.

TABLE I.—*Mortality Per Million Living (Registrar-General's Figures)*

	1938	1943	1948	1953
Carcinoma bronchus	113	162	238	343
" stomach	311	337	337	323

Figures for carcinoma of the stomach are added for comparison.

The proportion of patients suitable for surgery is depressingly small; figures have been given for an operability rate of as high as 15 to 25%, but these figures come from surgical centres where there has been a considerable measure of pre-selection, and in all probability obviously inoperable patients have been excluded. Reasons for declining operation lie in the size and position of the growth, metastasis, and in the age and general condition of the patient. The figures produced by Brian Taylor and Waterhouse (1950) showed that in over 1,500 patients not treated by surgery the average expectation of life was four months. In consequence, if surgery can produce results which allow survival beyond the average expectation of the untreated case it will have performed some service. For this reason, in analysing the figures we have classified the follow-up into deaths that occurred up to two years after operation and then considered the survivals for a period of five years.

Factors Influencing Operability

General Condition of the Patient.—The most obvious contraindication is the inability of the patient's respiratory function to withstand removal of part or whole of a lung. A rigid chest, gross emphysema, and chronic bronchitis are examples, and the presence of persistent bronchospasm is a potent factor in rendering the post-operative course hazardous. Cardiac disability, unless severe, is not such a serious hazard to surgery as might be supposed, and many patients whose hearts have been suspect have supported the operation well. Straightforward clinical observation has been found to be the most satisfactory guide in assessing cardio-respiratory function.

Age.—As measured in years age is not important (see Fig. 1); many men of 70 and over have had younger tissues than their fellows in lower age groups and have supported the operation well.

FIG. 1.—Age incidence in 200 pneumonectomies.

Site of Growth.—A mass placed in the centre of the lung field is a better immediate risk for surgery than one located close to the mediastinum. Growths at the apex are more likely to invade pleura and traverse it than those at the base, where the tumour may spread along the pleural layers for a considerable distance without invading the chest wall. When a pleural effusion is caused by spread of growth over the membrane the chances of a radical excision are small, but a clear effusion or even empyema does not necessarily preclude operation. Involvement of mediastinal structures by the growth itself or by glands is one of the most frequent causes of inoperability. Practically no case which has developed a vocal cord paralysis can be excised completely; the same applies to involvement of the phrenic nerve. Obstruction of the superior vena cava and invasion of the left auricle with the development of fibrillation are further contraindications, though a number of these cases have been explored on the faint hope that excision will prove practicable. Oesophageal obstruction resulting from pressure of enlarged glands is suggestive of inoperability, but not always. Invasion of the pericardium is often associated with a considerable amount of effusion into that sac, which, when incised, shows bulging of the tumour into the pericardium without actual penetration of that membrane. Spread of the actual growth along the pulmonary veins is well recognized, and the risk of embolism of fragments of growth as a result of manipulation have been pointed out by Aylwin (1951).

Size of Growth.—It is not always the largest growth that gives the worst prognosis. Many large breaking-down tumours have been removed successfully, with good later results. Most of these tumours have an expanding rather than an infiltrative character, and, with a well-defined oval or circular outline, may easily be mistaken for benign growths.

Type of Growth.—In the present series no case of so-called adenoma of the lung or bronchus has been included. I regard these tumours as entities requiring separate consideration. The histological character of the tumour has a considerable bearing on the surgical selection and on the prognosis. D. M. Pryce and J. B. Walter (personal communication, 1954) have investigated the cell types in two consecutive series of cases; the one was taken from necropsies and the other from operation specimens, many of which are included in the material for this article. In the necropsy series squamous-cell tumours were recognized in 20.1%, adenocarcinomata in 28.3%, oat cell in 37.1%, and polygonal in 10.7%. In the pneumonectomy or excision series squamous-cell tumours were 60.4% of the total, adenocarcinomata 15.5%, oat cell 15.9%, and polygonal 7.7%. If the necropsy series is regarded as representative of all cases of lung cancer then the operability rate for squamous-cell carcinoma is infinitely superior to that for the other cell types—a feature that is well recognized; but it is not so well appreciated that adenocarcinoma is almost as common as oat-cell tumours. In the follow-up by Pryce and Walter the end-results of operation for squamous-cell growths are superior to those of the other types. An interesting commentary on the prognosis of adenocarcinoma and oat-cell tumours is that, while it is commonly supposed that the latter give consistently bad results and that adenocarcinoma is a less sinister type, an analysis of their figures suggests that both these growths are equally unfavourable for surgery.

Regional Metastasis.—The existence of secondary deposits in the regional glands has a considerable influence on prognosis. In the first place, they may have infiltrated adjacent mediastinal structures: this is particularly the case when the subaortic group of glands have invaded the aorta or main pulmonary artery, or when glands have infiltrated the main bronchial bifurcation. Such a circumstance may well preclude operation. Secondly, there may be enlarged glands which can be removed, but in which a full surgical clearance is unlikely. In this group of cases the operation is more of a palliative than of a radical nature. In a third

group of cases the glands may be grossly enlarged, but on histological examination they are found to be of a secondary inflammatory character without metastases.

Type of Operation

The accepted operation is a dissection pneumonectomy with removal of the lung and glands *en bloc*. In the earlier cases in this series the pulmonary arteries and veins were secured individually as they emerged from the pericardium. More recently incision into the pericardium has allowed these vessels to be taken closer to the heart and has enlarged the scope of the operation and even allowed excision of part of the left auricle if necessary. In all cases the division of the bronchus was made as close to the carina as possible and the closure carried out by interrupted non-absorbable sutures. Various methods have been used from time to time to cover the bronchial stump and reduce the incidence of bronchial fistula, which has now fortunately become a less serious complication than it was in former years. Excision of the parietal pleura is carried out over the mediastinum in all cases and over areas where lung is adherent.

Lobectomy, though a less radical operation, has produced excellent results, sometimes apparently superior to pneumonectomy. The operative mortality is lower and the loss of lung function less, but the cases chosen for this operation are carefully selected and largely consist of small central tumours without gross glandular involvement.

Segmental resection is an operation that is not often performed deliberately, but is sometimes carried out under the mistaken impression that the condition is tuberculous or that the tumour is benign.

In no case was a simultaneous or post-operative thoracoplasty performed unless the presence of an empyema required some measure of chest-wall collapse. The fate of the phrenic nerve was problematical; in most cases the nerve was divided, though in some instances, particularly on the left side, it was left intact.

In discussing the results of surgery over a period of years some points in the development of thoracic surgery should be recalled. Pneumonectomy was practised successfully on occasions in the late 1930's, but it did not become a common routine or established procedure until some years later. Towards the end of the recent war the introduction of penicillin coincided with a number of improvements in technique and experience, all of which contributed to a decrease in mortality and morbidity even though more extensive operations were being undertaken. The volume of material has also increased with the greater realization of the frequency of the disease and the wider application of chest radiology, including mass radiography. In spite of many endeavours to achieve an earlier diagnosis and consequently to improve the surgical results, the average delay in 1950 between the early symptoms and operation was six months. This contrasts more favourably than the nine months which was the period of delay in 1940, but still leaves much to be desired.

Results

In an analysis of the operations performed between 1940 and 1950 a total of 689 thoracotomies were recorded and

TABLE II.—Type of Operation

	1940-8	1949-50	Total
Thoracotomy only	155	88	243
Pneumonectomy	227	137	364
Lobectomy	46	36	82

243 thoracotomies; 446 resections.

excision was undertaken on 446 occasions (Table II); this gives an approximate figure of two cases out of every three explored being operable. The "operative mortality" was taken to cover all patients who died in hospital or within

four months of operation. Of those who were submitted to resection 81 (18%) died: the figure for the period 1940-8 was 24%, but this fell in the subsequent two years to 9% (Table III, Fig. 2). There was one death in the lobectomy

FIG. 2.—Survival rate.

TABLE III.—Results of Resection

	Resections	Deaths			Survivals			
		Following Operation	4-12 Months	1-2 Years	At End of 2 Yrs.	At End of 3 Yrs.	At End of 4 Yrs.	At End of 5 Yrs.
1940-48	273	66 (24%)	78 (28.5%)	36 (13%)	93 (34%)	81 (30%)	65 (23.5%)	57 (21%)
1949-50	173	15 (9%)	53 (31%)	35 (20%)	70 (40%)	59 (34%)	—	—

series, which consisted of 82 cases. A number of the patients included under the heading operative mortality had indeed recovered from the actual operation, but succumbed from respiratory complications or from distant metastases which were not recognized at the time of operation. In an analysis of a number of these early deaths it can be mentioned that death occurring within a week was largely caused by heart failure, pneumonitis, or respiratory insufficiency. A later complication sometimes leading to fatality, particularly in the earlier cases, was empyema consequent on a bronchial fistula.

Deaths which occurred within 4 to 12 months of the operation amounted to 131 (29%). The majority of these deaths followed early local recurrence or a distant secondary. Brain and suprarenal glands were common sites for these metastases, and there is little doubt that some of the former were caused by direct embolism of growth as a result of operative manipulation. In all, 47.5% of the patients who had the growth excised did not survive a year, and a further 16% were dead before a further two years had lapsed.

When dealing with survival figures two analyses have to be made; the period 1940-8 gives survival up to the end of five years, but the 1949-50 group can only give a three-year figure. It will be noted from Table III and Fig. 2 that the figures from this more recent group are superior to the earlier ones, largely as a result of the reduction of operative mortality; but as more advanced cases were undertaken there is a percentage increase in the deaths occurring before two years had passed. In the 1940-8 group 34% of the patients were alive at the end of two years, 30% at the end of three years, 23.5% at the end of four years, and 21% at the end of five years. At one time it was thought that if a patient survived operation without recurrence for two years his chances of long-term survival were good, but it would appear that three years must elapse

before there is any feeling of security. In the 1949-50 series 40% of the patients were alive at the end of two years and 34% at the end of three years. If these figures follow the pattern of the other group it would seem reasonable to suggest that a 25% survival at five years might be expected.

Many of those who have died are known to have died from causes other than recurrence of cancer of the lung; suicide, accident, and old age have all played some part in reducing the number of survivors. A number of those who have exceeded the five-year period are known to have lived longer than this arbitrary limit. My longest survivor is 15 years (a case not included in this analysis), and there are four who have lived 10 years, and a greater number who have passed the seven-year mark.

An analysis of any surgical results in the treatment of cancer is bound to be disappointing, and there would seem to be an impression that the results of treatment in lung cancer are so poor that surgery is not worth while. This is suggested by the number of patients who are treated conservatively or are referred for radiotherapy without being seen by a thoracic surgeon, who alone can give the best advice regarding the chances of operation in an individual case. In spite of the many disappointments there is a kernel of success and satisfaction in that at least 21% of the patients operated on survive the five-year period, and indeed in the more recent cases there is every reason to expect that this figure may be appreciably raised.

Summary

An analysis of personal cases of cancer of the lung operated on between 1940 and 1950 is made.

Of a total of 689 thoracotomies, 446 were found suitable for excision—an operability rate of about two-thirds of the cases explored.

A follow-up to the end of 1953 gave for cases operated on prior to 1948 a survival rate of 34% at the end of two years, 30% at three years, 23.5% at four years, and 21% at five years. In the 1949-50 series 40% were alive at the end of two years and 34% at three years.

It is thought that there is some satisfaction that at least 20% of these patients survived the five-year period. Moreover, the more recent cases suggest that this figure may be improved upon.

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Stocks, P. (1947). *Studies on Medical and Population Subjects*, No. 1. H.M.S.O., London.
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According to the Annual Report for 1952 of the Chief Inspector of Mines, recently published, the number of persons killed in 1952 was a new low record, being 420, comparing with 487 in 1951 and an average of 583 in the previous ten years. Much of the improvement in 1952 was due to the absence of any great disasters. Deaths due to falls of ground were fewer than in the previous year's, but deaths due to haulage increased by 22 over the previous year's. "The numbers of fatalities in shafts and on the surface have shown no improvement in the last ten years or so—a state of stagnation which constitutes both a reproach and a challenge." The number of accidents required by law to be immediately reported involved 2,109 injured people, as compared with the 1951 figure of 1,942. People injured in accidents not immediately reportable but causing disablement for more than three days numbered 238,100, as compared with 234,400 in the previous year. But as more people were employed there was little change in the accident rate, which was one accident for every three employees. In the last decade fatal mining accidents have fallen by 52% and non-fatal by 25%. The safety organization of the National Coal Board continued to grow, but there were 33 vacancies in the mining inspectorate.

INTERMITTENT POSITIVE-PRESSURE RESPIRATION IN BULBO-SPINAL POLIOMYELITIS

USE OF THE RADCLIFFE RESPIRATION PUMP

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The use of positive-pressure respirators driven either by hand or by machines has been described by Lassen (1953). Smith *et al.* (1954), and Macrae *et al.* (1954) in the treatment of bulbo-spinal poliomyelitis, where postural drainage combined with some form of tank respirator is not sufficient to prevent inhalation of secretions. Recently we have treated three such cases in the poliomyelitis unit at Nairobi, Kenya, all in male adults, and the Radcliffe respiration pump (Russell and Schuster, 1953) was used. One patient died from shock and hyperpyrexia; one died suddenly on the twenty-fifth day of illness, no cause

Recent modifications in the Radcliffe respiration pump (P), and accessories. The pump has alternative motors—one for 230 volts A.C. and the other for 12 volts D.C. The latter is very suitable for transporting patients by air or road. The gas meter (M) replaces the cumbersome spirometer. H=Humidifier. V=Expiration flutter valve. G=Gauge. T=Cuffed tracheotomy tube.

being found at necropsy; while the other was flown to Oxford, still using the Radcliffe pump, at the end of the eighth week and is making satisfactory progress.

Christie (1954) has pointed out the difficulty of clinical assessment and has emphasized the importance of being able to call on the services of the physiologist, the biochemist, the clinical pathologist, and the pharmacologist. Such assistance is generally available only at the larger medical centres, and the aim of this article is to point out to those working in more remote centres that simple clinical methods can be passably successful.

For a general description of the machine and method the reader is referred to the article by Smith *et al.* (1954). This machine has since been modified as shown in the accompanying illustration (Ritchie Russell, 1954, personal communication).