Eventual surgical drainage of the boil area was required in 20% of the first group, while an even greater number (34%) developed fresh lesions within the observation period of six weeks. It is interesting that antibiotic therapy in the other group did not appear to influence the tendency of some patients to recurrent furunculosis.

Various systemic complications were observed in the placebo-treated group; these included fever in 36% of cases, usually lasting about three days.

Although most of the untreated boils showed only a slightly slower rate of disappearance of positive cultures, 8% of the tests still yielded a positive result even after 14 days.

Clinical Comparison of the Results of Treatment with Erythromycin and E 129

Both antibiotics showed approximately the same ability to arrest the progress of the boil—about 50% controlled within two days, and only 2% uncontrolled after four days. The development of the boil appeared to be halted slightly more rapidly with E 129.

The boils treated with E 129 healed more rapidly than those given erythromycin; 44% healed within the first week, in contrast to only 29% of those in the latter group. It can be shown, using the χ^2 test for a trend (Armitage, 1955), that the difference in rates of healing is statistically significant at the 5% level ($\chi_0^2=5.7$; $0.01<P<0.05$).

Tissue damage was not marked in either of the two groups—over 80% of the E 129 group and 72% of the erythromycin group could be placed in stage 1, although three patients in the latter group did show sufficient damage to be classified as grade 3.

Surgical drainage was necessary in slightly more (8) of the erythromycin group, while the incidence of fresh lesions was about equal.

Diarrhoea associated with the presence of *Candida* in the stools followed erythromycin therapy in four patients. No such complication was observed with E 129.

Bacteriological Findings

Coagulase-positive staphylococci were found in the initial culture from 159 of the 165 patients: the few negative cultures are attributable to the fact that the lesion was sometimes still closed when the first swab was taken. Although 37 (23.3%) of these strains were resistant to penicillin and 3 (1.1%) to tetracycline, they were uniformly sensitive to both erythromycin and E 129, the respective minimum inhibitory concentrations almost invariably found, using the method of Garrod and Waterworth (1956), being 0.12 and 0.25 µg./ml.: no strain differed from this figure by more than one (doubled) dilution.

Negative cultures were obtained after about the same time in both groups—within four days in 47% of the erythromycin group and 53% of the E 129 group. All strains of coagulase-positive staphylococci recovered from the original boil after the seven-days period of treatment (8 in the erythromycin group and 7 in the E 129), and those from fresh lesions developing during or after treatment (13 and 10 respectively) were retested and found to have undergone no change in sensitivity to either antibiotic.

Discussion

The apparent lack of effect that antibiotics had on less severe boils is in keeping with our knowledge of the adequacy of the body's natural defences against such infections. In the treatment of more severe infections it is clear that the use of antibiotics promotes more rapid recovery with fewer sequelae such as post-necrotic scarring, although the better results appear to depend not so much on the rapid elimination of the infecting organisms as on limitation of their destructive activity.

By each of the criteria used the effect of E 129 was slightly superior to that of erythromycin, and by one of these—the rate of healing—the difference has a statistical significance. Against this advantage has to be set the fact that a larger dose of E 129 was given. Reasons for adopting this dose have been stated, and, allowing for the impurity of the E 129 and its less complete absorption, the effective doses of the two antibiotics must have been approximately equivalent. It would be unwise, however, to base any final conclusion about the relative merits of these two antibiotics on these findings.

It was thought possible that a difference between them might be found in another direction. Staphylococci acquire resistance to erythromycin rather readily and to E 129 less so (Garrod and Waterworth, 1956). It has been a common practice to restrict the use of erythromycin severely for fear of breeding resistant strains, and it would not have been surprising if in some of these patients with persisting or recurrent infections increased resistance to the antibiotic had been found. In fact, no instance of increased bacterial resistance to either antibiotic was seen in the whole series. Whether this is to be credited to strict limitation of the treatment to seven days, or whether the nature of the lesion is unfavourable to change in bacterial resistance, is uncertain. It is nevertheless encouraging to know that this form of staphylococcal infection can be treated in this way apparently without serious risk of producing such a change.

Summary

Patients with severe boils were treated with erythromycin (1 g. daily) and E 129 (3 g. daily) each for one week, or by the local application of mercury perchloride only. There were 55 patients in each group.

As judged by each of four criteria, patients in both antibiotic-treated groups recovered more rapidly and more satisfactorily than the controls. Slight differences between the treated groups were in favour of E 129.

All strains of staphylococci found in these patients were normally sensitive to both antibiotics, and none cultivated again after seven days' treatment had acquired resistance to either of them.

The advice of Dr. R. M. B. MacKenna and Professor L. P. Garrod on the clinical and bacteriological aspects respectively of this work is gratefully acknowledged. Mr. M. P. Curwen kindly made the statistical calculation referred to in "Results." Antibiotic E 129 was kindly supplied by Glaxo Laboratories Limited.

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EFFECT OF ABDOMINAL OPERATIONS ON TOTAL LUNG CAPACITY AND ITS SUBDIVISIONS

BY

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Although serious pulmonary complications of an inflammatory nature are becoming less frequent after abdominal operations, atelectasis and bronchitis still occur. One of the main factors is the interference with the mechanical efficiency of the lungs. The effect of laparotomy on vital capacity has been extensively studied (Churchill and McNeil, 1927; Powers, 1928; Overholt, 1930; Anscombe, 1957) and reductions of up to 80% of the preoperative figure may occur after an upper abdominal operation.

Other effects on pulmonary function have not been examined in such detail. Beecher (1933) measured the total lung capacity and its subdivisions in 35 patients before and after abdominal operations. He found that reductions occurred in the total lung capacity and functional residual capacity. As the decreases in the vital capacity may be due to the effect of the operative trauma on the efficiency of the respiratory musculature, he argued that the total lung capacity and vital capacity readings were not indications of the "real state" of the lungs. The functional residual capacity, which did not depend on the voluntary efforts of the patient, was a better guide, and Beecher found that this was reduced to 20%.

More accurate methods are now available for the measurement of the gas volume of the lungs, and it was thought that a further investigation would be of interest. In this series a modification (Buxton and D'Silva, 1956) was used of the helium dilution described by Bates and Christie (1950).

Procedure

A total of 26 male patients comprising three groups was investigated, the same procedure being adopted in each group. Group I consisted of 10 patients admitted to medical and surgical wards, none of whom suffered from conditions likely to affect the respiratory system in any way or who underwent any operation during the period of study. The selection of those patients depended upon their availability for the investigation, and they serve as a control group. Group II consisted of 13 patients upon whom abdominal operations were performed. The operations consisted of seven inguinal herniorrhaphies and six upper abdominal operations (five partial gastrectomies and one cholecystectomy). Group III contained three patients only, and in each case an operation of similar severity was performed upon an extremity.

Two measurements were made on each patient. In groups II and III the first measurement was made within the 24 hours preceding the operation, the second within the first 48 hours post-operatively, depending upon the general condition and availability for study of the patient. In the control group two measurements were made within a period of 48 hours. The surgical patients were ambulant before operation, and then confined to bed in the period between the two measurements. As it has been shown that recumbency reduces the residual capacity (Whitfield, Waterhouse, and Arnott, 1950) the same regime was followed so far as was possible in the control group, and all measurements were made with the patients in this position.

The patients were brought by wheel-chair or in their beds to the apparatus, which was housed in an adjacent side ward. They then assumed the recumbent position, and after a brief explanation the mouth-piece was inserted and the nose clipped. The patient then breathed oxygen for 10 minutes in order to replace the nitrogen of the functional residual capacity. This period also allowed the state of the pulmonary circulation to become stabilized. At the end of a normal expiration the patient was admitted to the circuit, which contained pure oxygen and about 10% helium. The fall in helium concentration was followed on a katharometer until no further change was apparent.

Finally, two measurements of the vital capacity were made, and the results calculated and corrected to 37° C. at saturated water-vapour pressure. Assessment of the findings was made by use of the analysis of variance, or Student's t test.

Results

The first or pre-operative examination values for groups I and II were studied. The difference between the means of the subdivisions of the total lung capacity was not significant, but the total lung capacity showed a significant difference ($P=0.02$) (columns a and c, Table I). The changes in the three groups are shown in Fig. 1.

TABLE I.—*Total Lung Capacity and its Subdivisions (in litres) in Control Group and Patients with an Abdominal Incision*

	Group I (Control)			Group II (Abdominal)			
	a	b	Dif.	c	d	Dif.	
Functional residual capacity	3·3	3·4	0·1	3·8	3·2	0·6	0·05>P>0·02
Inspiratory capacity.. ..	2·9	3·0	0·1	3·2	2·3	0·9	P>0·01
Expiratory reserve volume..	0·8	0·7	0·1	0·9	0·6	0·3	0·05>P>0·02
Vital capacity	3·7	3·8	0·1	4·1	2·9	1·2	P>0·001
Residual capacity	2·5	2·7	0·2	2·9	2·6	0·3	0·2>P>0·1
Total lung capacity	6·2	6·4	0·2	7·1	5·5	1·6	P>0·001
Residual capacity × 100 / Total lung capacity ..	40	41	1	42	48	6	0·3>P>0·2

a and b represent the observed values in Group I at the first and second measurements, while c and d were the figures noted before and after operation in group II.

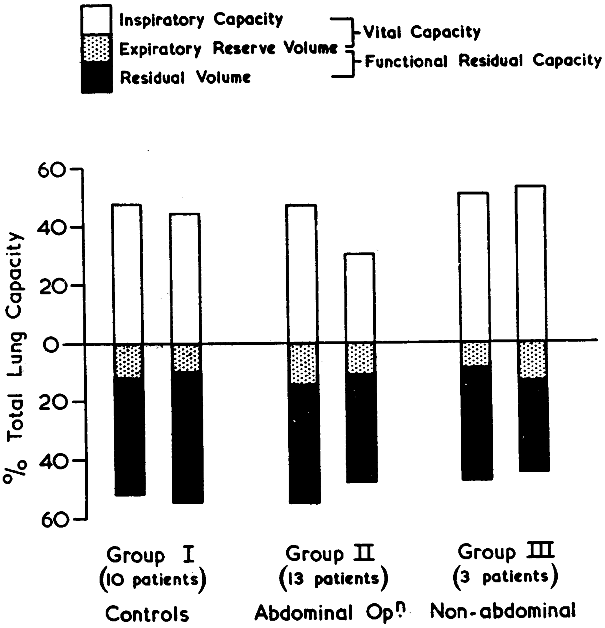

FIG. 1

It was found (Table I) that a small difference occurred between the first and second measurements in group I, depending on the reproducibility of the method, but that the corresponding pre-operative and post-operative figures in group II were grossly different. When these changes were investigated further, significant reductions were found to have occurred after laparotomy in the functional residual capacity, inspiratory capacity, expiratory reserve volume, vital capacity, and total lung capacity. This reduction was mainly due to a decrease in the vital capacity, although the functional residual capacity was reduced to a less extent.

The post-operative results in the three patients of group III showed no significant change compared with the pre-operative measurements (Table II). This is in accordance

TABLE II.—*Total Lung Capacity and its Subdivisions (in litres) in Control Group and Patients with an Operation on an Extremity*

	Group I			Group III			
	a	b	Dif.	e	f	Dif.	
Functional residual capacity	3·3	3·4	0·1	3·2	3·0	0·2	0·9>P>0·8
Inspiratory capacity.. ..	2·9	3·0	0·1	3·2	3·4	0·2	P>0·9
Expiratory reserve volume..	0·8	0·7	0·1	0·8	0·8	0·0	P>0·9
Vital capacity	3·7	3·8	0·1	4·0	4·2	0·2	P>0·9
Residual capacity	2·5	2·7	0·2	2·4	2·2	0·2	0·9>P>0·8
Total lung capacity	6·2	6·4	0·2	6·4	6·3	0·1	0·9>P>0·8
Residual capacity × 100 / Total lung capacity ..	40	41	1	37	35	2	P>0·9

a and b were the observed values in group I at the first and second measurements, and e and f were the figures noted before and after operation in group III.

with previous findings (Anscombe, 1957) that operation upon the extremities did not significantly affect the mechanical function of the lungs.

Table III.—*Total Lung Capacity and its Subdivisions (in Litres) in Patients with Upper and Lower Abdominal Operations*

	Upper Abdominal			Lower Abdominal			
	c′	d′	Dif.	c″	d″	Dif.	
Functional residual capacity	4·0	3·2	0·8	3·5	3·2	0·3	0·4 > P > 0·3
Inspiratory capacity.. ..	3·3	1·7	1·6	3·2	2·9	0·3	0·1 > P > 0·5
Expiratory reserve volume ..	1·1	0·6	0·5	0·8	0·6	0·2	0·02 > P > 0·01
Vital capacity	4·4	2·4	2·0	4·0	3·6	0·4	0·05 > P > 0·02
Residual capacity	2·9	2·6	0·3	2·7	2·6	0·1	0·8 > P > 0·7
Total lung capacity	7·3	4·9	2·4	6·7	6·1	0·6	0·05 > P > 0·02
Residual capacity × 100 / Total lung capacity ..	39	53	14	42	43	1	0·1 > P > 0·05

c′ and c″ were pre-operative measurements and d′ and d″ were post-operative values.

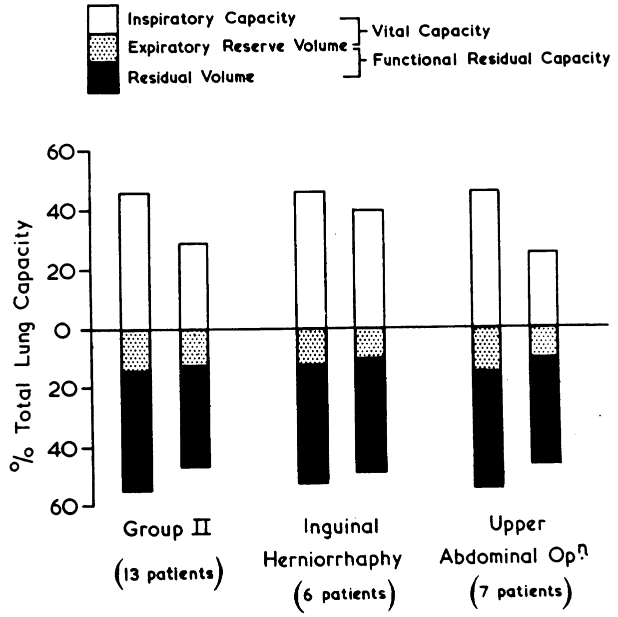

Fig. 2

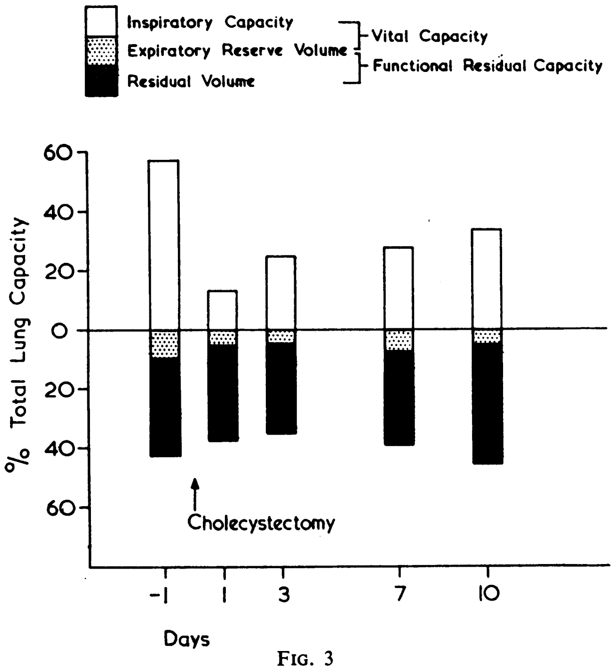

Fig. 3

By subdividing group II into those patients with inguinal herniorrhaphies and those with upper abdominal operations, the effect of the site of operation on these changes was studied (Table III and Fig. 2). The difference between the observations in these groups was significant only for the vital capacity ($0.05 > P > 0.02$) and the total lung capacity ($0.05 > P > 0.02$). This finding emphasizes further the importance of the decrease in vital capacity in reducing the total lung capacity and also stresses the fact that upper abdominal procedures cause a greater reduction than those of the lower abdomen. The findings in the subject who underwent cholecystectomy are illustrated in Fig. 3.

Discussion

A significant reduction in total lung capacity after laparotomy could be due to closure of part of the bronchial tree, to interference with the normal function of the muscles of respiration, or to a combination of these factors.

The bronchial tree may become obstructed actively by bronchospasm or passively by blockage with mucus or inflammatory exudate. The upper abdominal cases in group II showed an average reduction in total lung capacity of 2.4 litres. Passive obstruction of the air passages leading to atelectasis of this degree should be demonstrable on clinical and radiological examination, but there was no evidence to support this. In the present study, 0.25 g. of aminophylline was given intravenously to two patients before and after partial gastrectomy. No significant change was noticed pre-operatively or post-operatively in the total lung capacity and its subdivisions. It is likely that if any bronchospasm had been present after operation the exhibition of a bronchodilator would have caused some increase in at least one component of the total lung capacity.

Electromyographic studies (Campbell, 1952) have shown that the muscles of the anterior abdominal wall play no part in quiet breathing when the subject is lying supine. They do assist in the terminal portion of forced expiration, and their contraction is a limiting factor in maximal voluntary inspiration. We have confirmed with records from the rectus abdominis that no activity occurs during respiration at rest. But if the subject adopts a sitting posture or is inclined on a bed in such a way that his abdominal musculature is participating in maintaining his posture, then the recti will be involved more in expiration than in inspiration. Where respiration is forced against resistance then all the abdominal muscles are used in both phases of breathing. After laparotomy the potentials recorded were reduced, and this finding was more marked in those patients recovering from an upper abdominal operation.

Dysfunction of the muscles of the anterior abdominal wall may occur after operation as a reflex secondary to peritoneal inflammation or may be due to the local trauma of an incision. When the results obtained from patients after an abdominal operation (group II) are examined, reductions are seen to have occurred in both the inspiratory and the expiratory components. Impairment of the muscular power available to complete forced expiration will reduce the expiratory reserve volume. But the reduction in the vital capacity (mean 1.2 litres) was due mainly to a reduction of the inspiratory capacity (mean 0.9 litres). This is presumably due to the abnormal contraction of the abdominal muscles acting as a limit to the depth of maximum inspiration.

Those patients who had emphysema presented figures which followed the same general pattern as those not so affected, but the mean reduction in five emphysematous cases as compared with five without chest disease was 0.88 and 1.6 litres for the vital capacity, 0.5 and 1.3 litres for the inspiratory capacity, and 0.8 litre in both sets for the functional residual capacity.

Thus it appears that an abdominal operation, especially one in the upper abdomen, is followed by a reduction in the subdivisions of the lung volume, and that similar changes occur post-operatively in subjects with evidence of pre-existing lung disease. This effect occurring in a patient whose lung function is already impaired is more likely to cause respiratory insufficiency in the immediate post-operative period. It is suggested that any such patient should have the pulmonary function assessed before operation so that measures may be taken to combat any post-operative anoxia which may arise.

Summary

Measurements of the total lung capacity and its subdivisions were made on 26 male patients.

Significant reductions occurred in the total lung capacity, inspiratory capacity, expiratory reserve volume, vital capacity, and functional residual capacity after abdominal operations, and these changes were more marked after those on the upper abdomen.

Possible causes of these changes are briefly considered.

We thank Professor J. L. D'Silva for much helpful advice and criticism, and the surgical staff of the London Hospital for permission to study their patients. Figs. 1–3 are from *The Pulmonary Complications of Abdominal Surgery* by one of us (A. R. A.), and are printed by permission of Lloyd-Luke, London. This work was done during the tenure of one of us (R. St. J. B.) of a postgraduate Research Fellowship.

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OPEN HEALING OF TUBERCULOUS CAVITIES

RESULTS IN 40 PATIENTS TREATED CONSERVATIVELY

BY

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With the development of rational chemotherapy the phenomenon of open-cavity healing in pulmonary tuberculosis is becoming increasingly evident. From the extensive literature on the subject a few observations are summarized.

Auerbach and Small (1957) state: "For practical purposes it is the opinion of the writers that those cases should be accepted as open healing in which the lumen of the cavity is free of necrotic contents, the inner aspect contains no pyogenic membrane or necrotic lining, and the cavity wall contains no necrotic foci." The same writers comment that, although open healed cavities often appear cystic, the radiological appearances are deceptive in that a thin-walled cavity may present evidence of active disease and a thick-walled cavity may be healed. They believe that open-cavity healing is less common than might be supposed and point out that, despite the absence of tubercle bacilli from the sputum for many months, a resected cavity may show the presence of a necrotic lining. They admit, however, the increasing frequency of open healing after long-term chemotherapy and suggest that where the sputum has been negative for tubercle bacilli for more than seven months four out of five cyst-like cavities prove to be instances of open healing. In their experience isoniazid has not significantly increased the incidence of healing.

Corpe and Stergus (1957), on the other hand, believe that isoniazid is of great importance in this connexion. In their cases open healing was observed to occur most often when a triple-drug regime of streptomycin, P.A.S., and isoniazid had been used. They are not sanguine about the conservative management of such cavities, and state: "The possibilities of rupture, suppuration, haemorrhage, and reactivation of tuberculosis are well recognized. Accordingly, it is believed that when these openly healed or healing cavities are unilateral, or bilateral, they should be excised if the patient is otherwise fit for surgery." A similar opinion has been expressed by Chenebault (1954). Caffey (1950) explains the pathogenesis of pulmonary cysts during respiratory infections. Such cysts may develop during the course of treatment and may be indistinguishable radiologically from thin-walled cavities. Auerbach (1955) states: "After chemotherapy such healed cavities may be mistaken for lung cysts or emphysematous blebs. It is believed that such areas may be accepted as open healed cavities if they occupy the site of a cavity visualized in the roentgenograms, if bronchi communicate with them and if they do not surround an inspissated cavity or radial scar."

Most papers on the subject are concerned with the pathological findings in resection specimens. Little is known of the fate of patients who continue to receive drug therapy alone without resection therapy after they have achieved presumptive open healing of tuberculous cavities. Douglas and Horne (1956) have reported on six such patients. Corpe and Stergus (1957) indicate that they are in the process of making such a study. Raleigh and his co-workers (Raleigh 1957; Bell, Decker, and Raleigh, 1957) have reported unfavourably on the conservative treatment of patients in this category.

This paper records our own experience with indefinitely prolonged chemotherapy in 40 cases of advanced pulmonary tuberculosis with persistent cavitation. The cases recorded are the most grossly diseased of a large series of patients treated by prolonged chemotherapy in this unit over the past five years. They have been observed for periods ranging from one and a half to five years. The distribution of the patients is shown in Table I. Twenty-nine patients have been observed for more than two years and 17 for more than three years.

TABLE I.—*Distribution of 40 Cases Observed for One and a Half to Five Years*

	Period of Observation in Years				
	>5	4–5	3–4	2–3	1–2
No. of patients starting treatment ..	2	4	11	12	11
Total No. of patients under observation	2	6	17	29	40

Methods and Materials

By virtue of age, advanced disease, or poor respiratory function 37 of the patients were judged unsuitable for surgical treatment. A further three refused surgery. All were sputum-positive at the beginning of the study, the finding of a positive culture for *Mycobacterium tuberculosis* being considered obligatory to their inclusion in the