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PULMONARY RESECTION FOR TUBERCULOSIS IN CHILDREN

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The literature concerning resection for tuberculosis gives scattered references to resection in children, but as far as I know the only paper published on the subject has been that of Levitin and Zelman in 1950. These authors reported four cases of pneumonectomy in the age group 3 to 13 years. These operations were all performed in coloured patients, who had little natural immunity, and, of the four, three had done well. The fourth patient died of a contralateral activation of disease, which was present at the time of the operation. Pneumonectomy in the fatal case was performed before streptomycin was available as a cover for the procedure. The three successful cases were patients who had no evidence of contralateral disease. In two of the four the resection was performed for "destroyed lung." The other two were for basal cavities, one of which extended across the fissure to the upper lobe, and the other was confined to the lower lobe, but in this case lobectomy proved to be technically too difficult and a pneumonectomy was performed.

Seven lobectomies and six pneumonectomies have been done on 12 children by surgeons of the Northern Regional Thoracic Surgery Centre for Newcastle-upon-Tyne at Shotley Bridge Hospital and Poole Sanatorium. With the exception of one patient aged 16, all the patients have been under 15 years of age. Although 12 may be too small a series from which to draw conclusions, the results to date are favourable, and it is suggested that this may be the method of treatment for certain types of the disease in children.

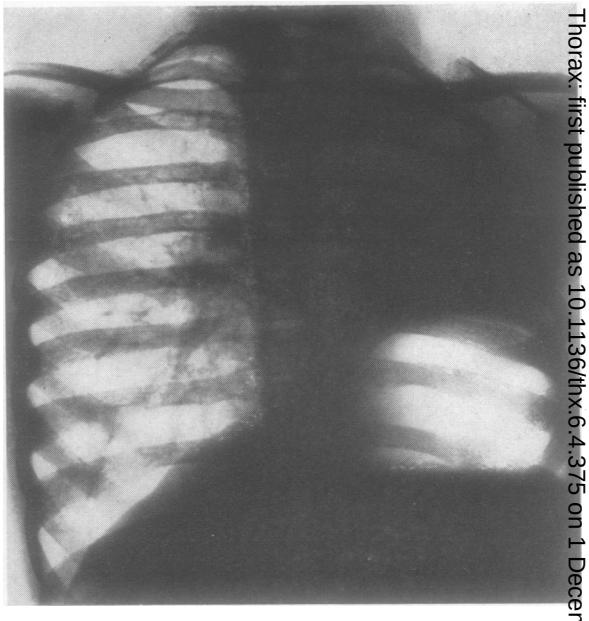
The pneumonectomies were performed for extensive unilateral disease, except in one case, where there was evidence of contralateral activity (Case 5). Of the lobectomies, three were performed where other methods were ineffective in controlling the disease; three were performed as a method of choice; and one was done as an emergency procedure to prevent the rupture of a cavity under artificial pneumothorax.

The radiographs illustrate the two series, pneumonectomies and lobectomies.

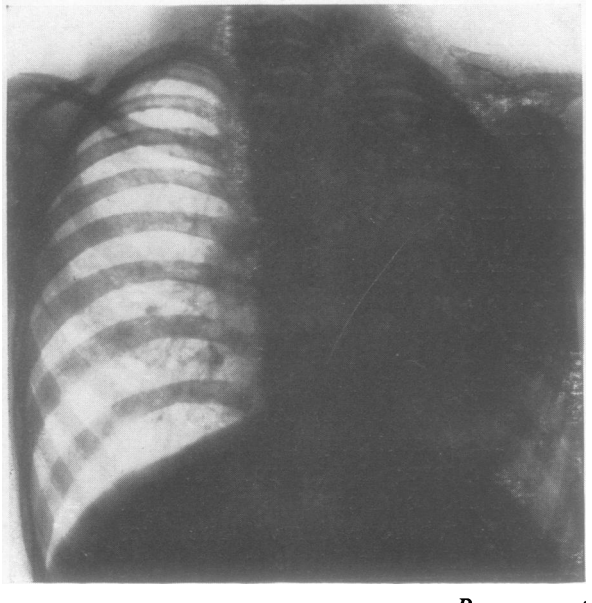
PRE-OPERATIVE TREATMENT

All patients, except two, were given a period of sanatorium treatment before resection was decided upon. Nine of the 12 patients received streptomycin, and some had P.A.S. in appropriate doses pre-operatively.

Every possible method was used to bring the patient into as good general condition as possible before operation. A high-protein diet, vitamins, iron, and, where necessary, blood transfusion were used. A patient was considered to be ideally fit for surgery if the temperature remained normal, the sedimentation rate was stable



Radiograph showing the collapsed and cavitated left lung, with contralateral infiltration.



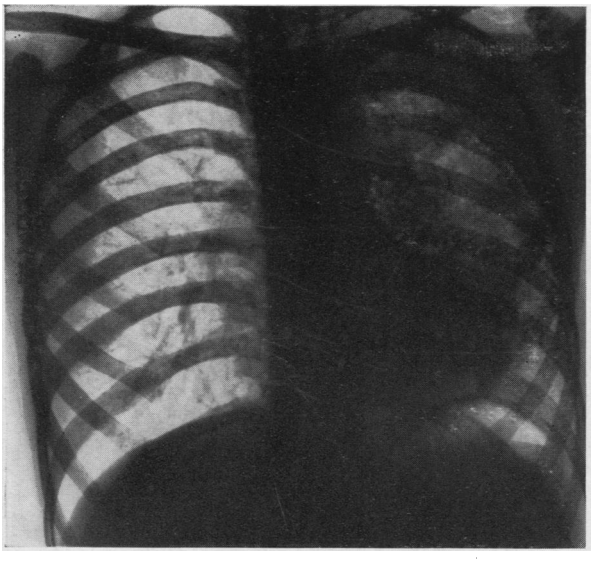
Radiograph two years later.

Pneumonectomy: Case 5

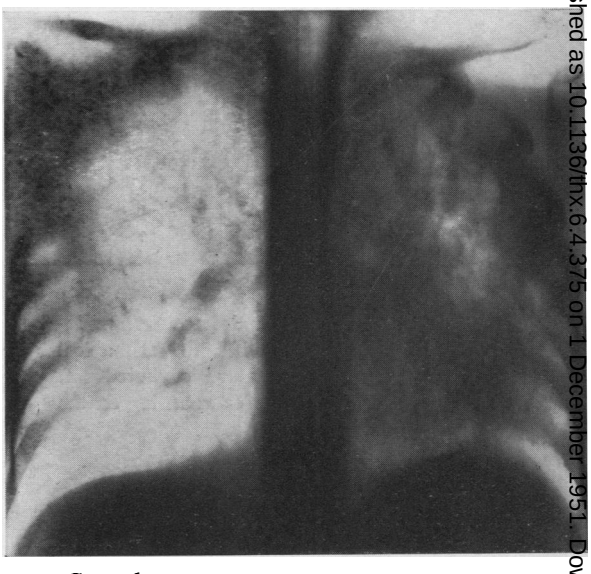
at a low level (relative to that in the acute phase of the disease), there was a good gain over the admission weight, and the radiological appearance suggested that the disease process was relatively stable.

OPERATIVE TECHNIQUE

The standard dissection operation was performed. If the disease process had extended into an adjacent segment, the whole of that segment or sub-segment was removed. It was thought to be better to remove more lung tissue than to cut across the inter-segmental plane. The pulmonary reserve in these children was adequate and persistent fistulae were less common if the dissection was in the inter-segmental plane. The bronchus was closed in all cases with a single layer of interrupted fine linen sutures. In the pneumonectomies, the bronchial stump was allowed to retract into the mediastinum and, where possible, the fascia was approximated over it. In some of the lobectomies the stump was covered with a pleural graft, but in others no cover was used. It was notable that, in spite of the fact that in several cases there was evidence of bronchial tuberculosis at the site of amputation of the bronchus, there were no post-operative bronchial fistulae in the group. Penicillin, streptomycin, and sulphathiazole powder was dusted into the pleural cavity at the close of the operation in all cases except the first. Closed (water seal) drainage was used in all the lobectomies. No drainage was used in the pneumonectomy cases, but an intercostal needle attached to a water seal was left in for 24 hours post-operatively to regulate intrapleural pressures.



Radiograph and tomograph showing collapsed, cavitated, and infiltrated left lung.



Pneumonectomy: Case 6

Post-operatively, intensive physiotherapy was employed from the first day to prevent post-operative atelectasis. Bronchoscopy was sometimes necessary to remove tenacious mucous plugs or bronchial casts. The post-operative course has, in general, been smooth, and the complication rate has been *nil* in this group if one excludes one case of " stitch abscess " (Case 1, lobectomy).

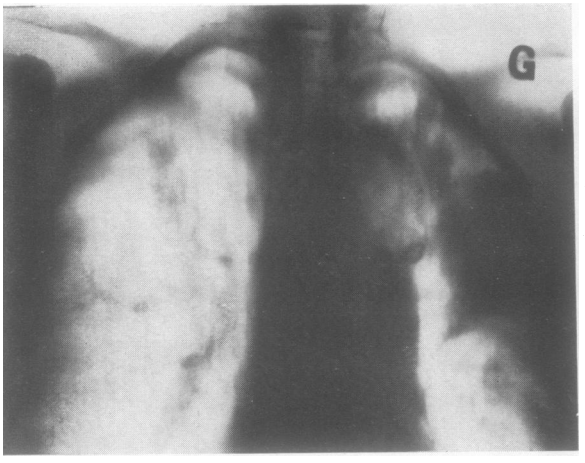
RESULTS

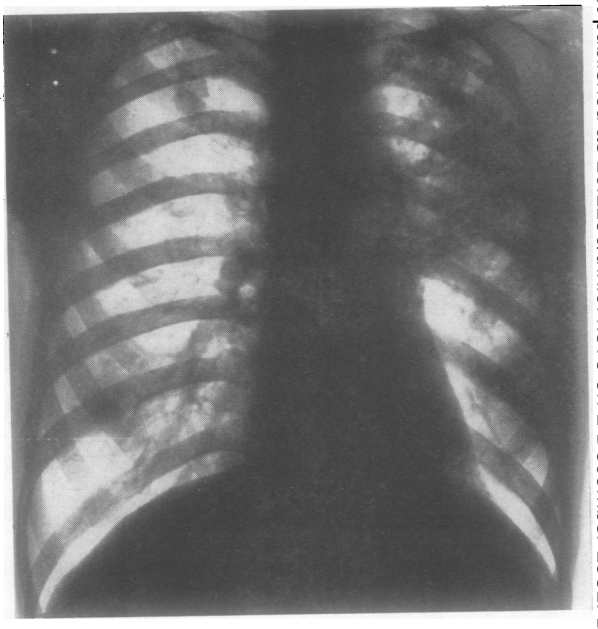
The patients have not been followed-up for sufficiently long periods of time to be sure that the present good results will be permanent, inasmuch as the post-operative periods vary from a few months to two years ; but it may be stated that the course of the disease has been changed for the better by the intervention. Ten had sputum or gastric washings positive for tubercle bacilli before the operation, and all positive cases had their sputum converted by the operation. There have been no deaths. One patient has had reactivation of a contralateral lesion (Case 6, lobectomy). The other 11 patients are alive and well.

CASE REPORTS

Pneumonectomies

Case 1.—This patient's father has silicosis and pulmonary tuberculosis. The patient, a girl aged 10 years, was admitted to Poole Sanatorium with a one-year history of productive cough, pain in the left chest, lassitude, and loss of weight. The sputum was positive for tubercle bacilli, and the sedimentation rate was 32 mm. Westergren. She was afebrile. Radiographs showed extensive cavitated and nodular disease of the left lung, and resection was decided upon. She received streptomycin and P.A.S. for 20 days, and



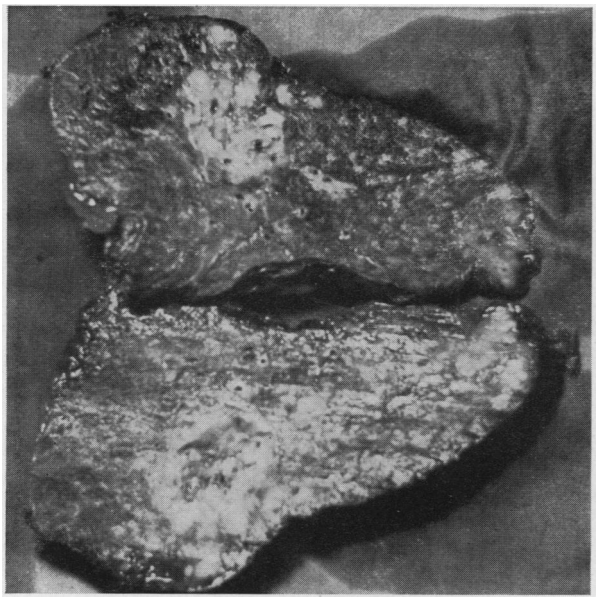


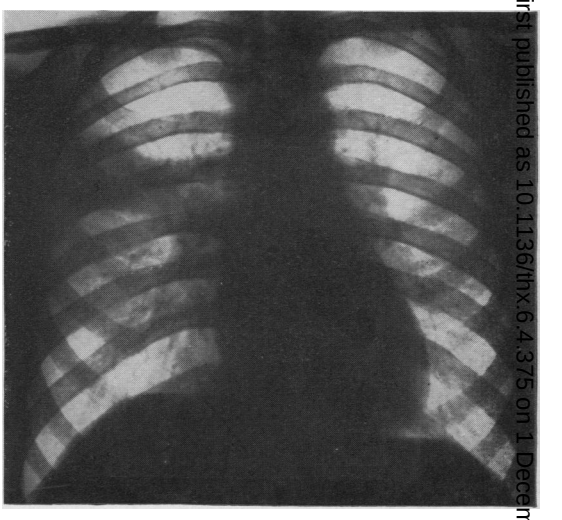
Tomograph and straight radiograph showing old right apical disease and extensive cavitated left upper lobe disease encroaching on the apex of the lower lobe.

Pneumonectomy: Case 3

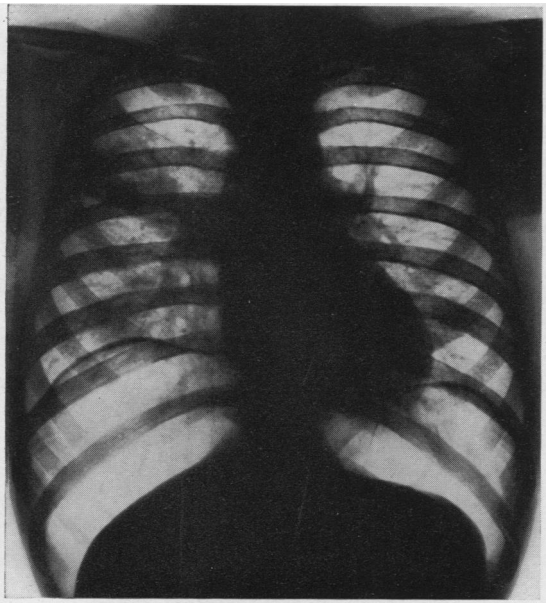
Left lung showing extensive caseous and cavitated disease of the upper lobe and caseous nodule in the apex of the lower lobe.

Pneumonectomy

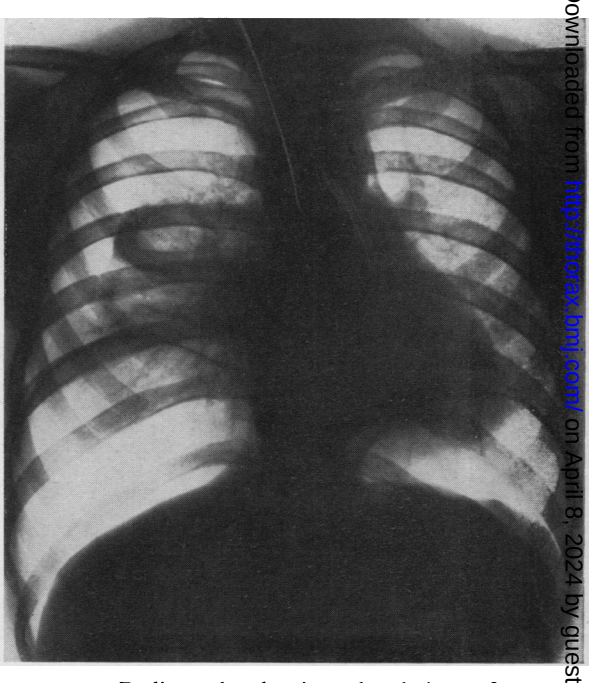




Radiograph showing, on admission, right upper lobe lesion, a cavitated area with a surrounding zone of acute exudative reaction.

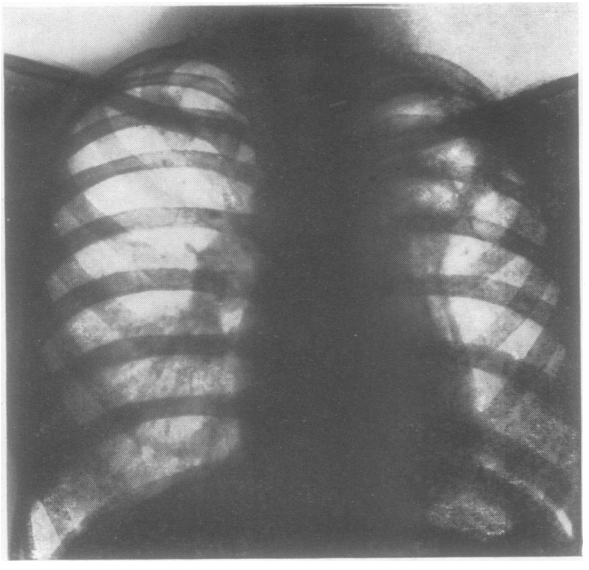


Radiograph showing lesion after the phrenic crush and induction of pneumoperitoneum. The acute exudative reaction has now subsided, but the cavity is not decreased in size.

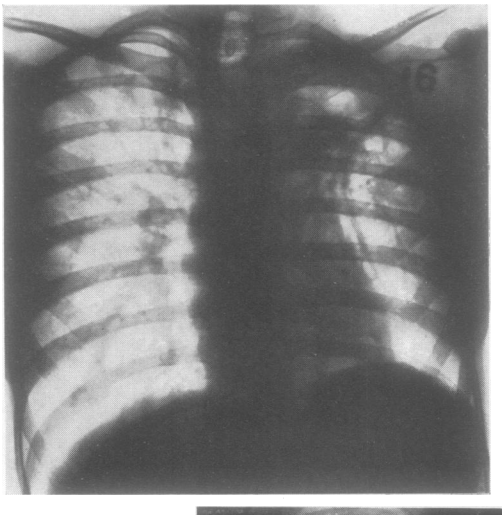


Radiograph showing the lesion after artificial pneumothorax has been induced. The cavity has enlarged, become rounded and tense in appearance, and has a surrounding zone of atelectasis.

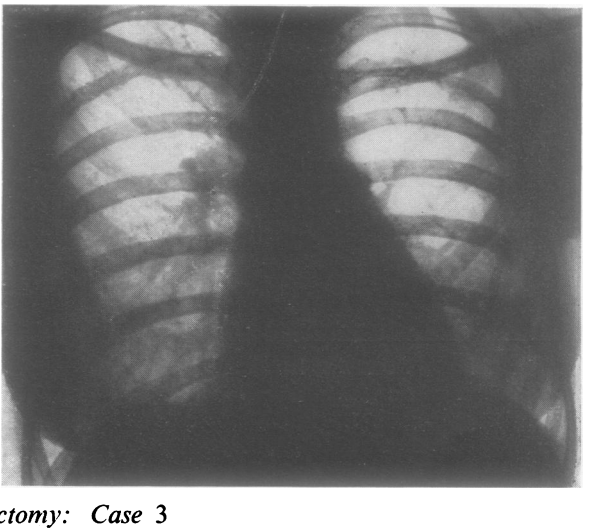
Lobectomy: Case 2



Radiograph showing bilateral apical cavitated disease.

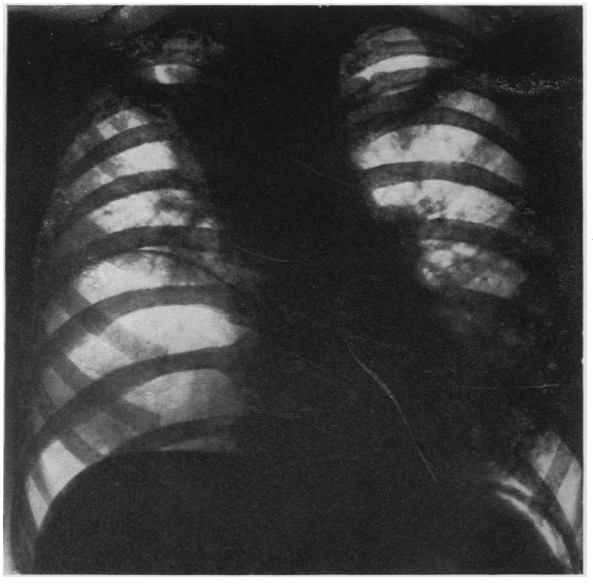


" Penetrating " radiograph showing the same as Fig. 1.

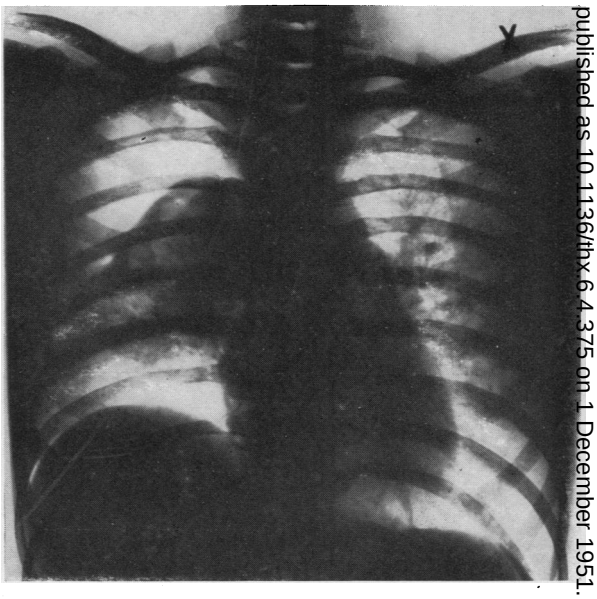


Recent radiograph showing appearance after bilateral resection.

Lobectomy: Case 3



Radiograph showing right upper lobe lesion uncontrolled after seven months' pneumoperitoneum.



Radiograph showing lesion after pneumoperitoneum and adhesion section:

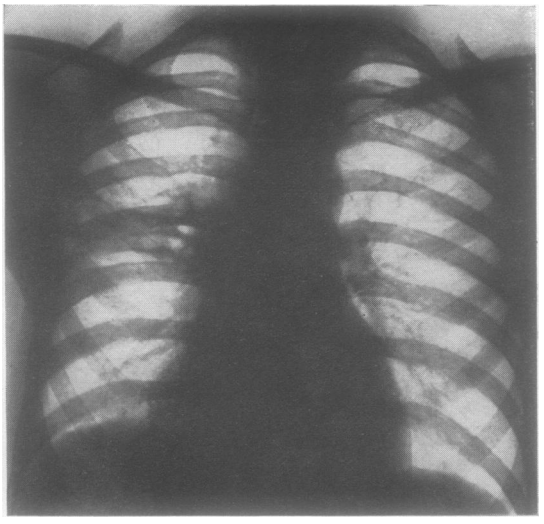
Lobectomy: Case 6

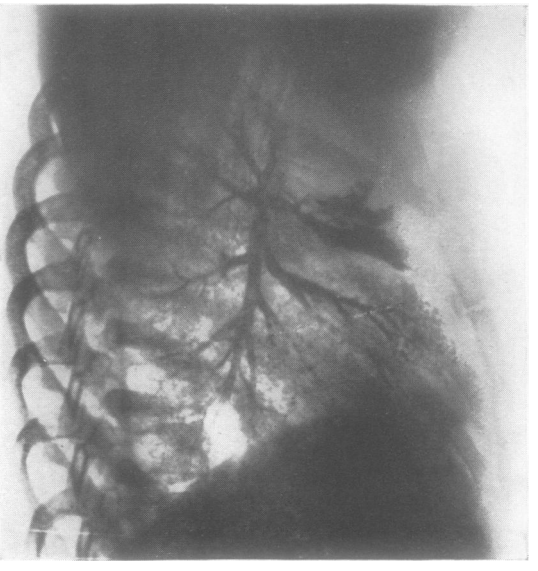
during this time was on strict bed-rest. Pre-operatively her blood sedimentation rate had been reduced to 15 mm. On July 25, 1950, a left pneumonectomy was performed. The post-operative course was uneventful. Streptomycin and P.A.S. were continued until August 2. Pathological examination of the resected specimen showed that there was endobronchial tuberculosis at the site of amputation of the bronchus.

Follow-up shows the patient well, radiologically "satisfactory," and able to return to school one year later.

Case 2.—This patient's mother died of pulmonary tuberculosis when the patient was 6 months old. The child, a girl now aged 11 years, was admitted to Poole Sanatorium with left upper lobe cavitation and diffuse mottling of the left lower lobe. Pulmonary tuberculosis with cavitation had been diagnosed in November, 1948, and she was treated with bed-rest until May, 1949, when she was discharged at the request of her guardian. She was readmitted two months later, critically ill, with an elevated temperature, dyspnoea, and cyanosis. On penicillin and postural drainage she improved considerably. On December 9, 1949, she began a 60 g. course of streptomycin, and at the same time was started on P.A.S. Left pneumonectomy was performed on June 11, 1950, under cover of more streptomycin. At the time of operation she was well; the sedimentation rate was 20 mm., but she had an occasional temperature of 100.4° F. She did very well post-operatively, and by October was well, afebrile, and had gained 3 lb. over her admission weight. Sections of the bronchus at the site of amputation showed the presence of submucosal tubercles. Follow-up six months post-operatively showed the patient to be well and the radiographs satisfactory.

Case 3.—This patient, a girl aged 12 years, was admitted to Poole Sanatorium on June 3, 1949, with a history of having developed left-sided pleurisy, lassitude, and cough approximately six months before. On admission she was pale, thin, toxic, and had a productive cough with a positive sputum. Her temperature was elevated, and her sedimentation rate was 32 mm.; radiographs showed what appeared to be old calcified and fibrotic disease of the right apex, old left apical disease, and a recent spread in the left



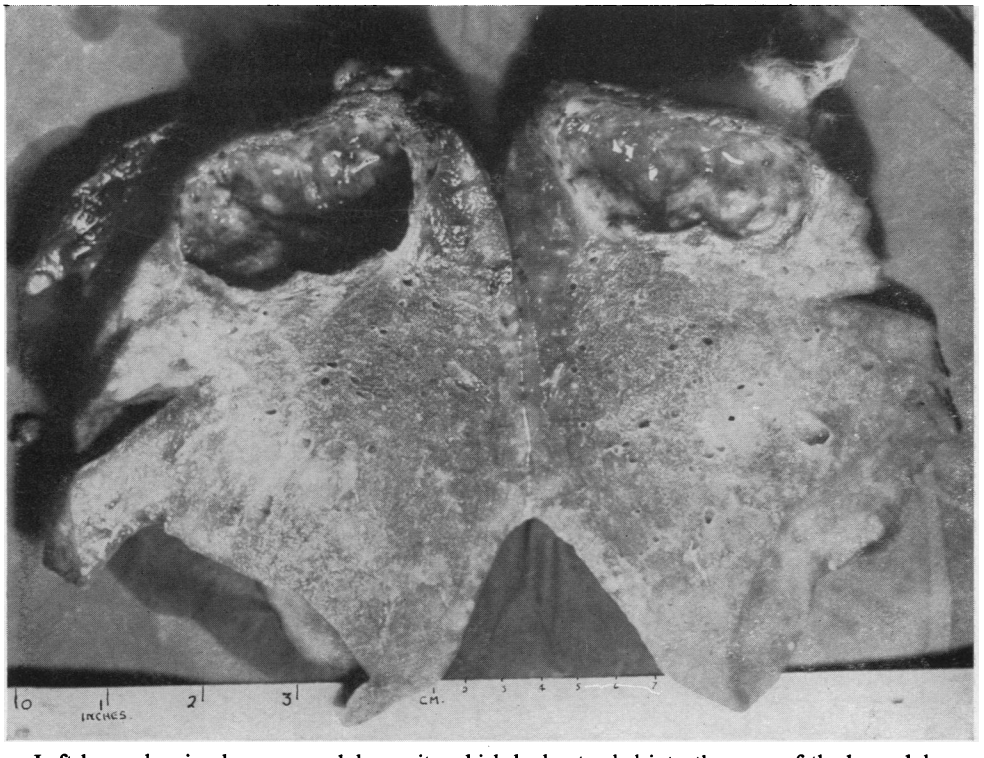


Straight radiograph and lateral bronchogram showing cavitated lesion in the pectoral segment of the left upper lobe having the appearance of bronchiectasis.

Lobectomy: Case 4

upper lobe. She was started on streptomycin on June 17, and by the end of the month the pyrexia was controlled. The radiographs remained unchanged and she was started on P.A.S. By October 13 she was generally much better, she was afebrile, and was 14 lb. heavier than she was on admission. Tomography at this time showed a large left upper lobe cavity, but no cavitation in the right lung. On November 15 she was operated on with the intention of doing a left upper lobectomy, but, as the apical segment of the lower lobe was also diseased, a pneumonectomy was performed. At the time of operation she was well, afebrile, with a sedimentation rate of 15 mm., and she was 20 lb. over her admission weight. Her post-operative course was uneventful, and at the time of writing she is well and her radiograph is satisfactory. The hilar lymph nodes showed the presence of tuberculosis, but the bronchus at the site of amputation showed only a non-specific inflammatory reaction.

Case 4.—The patient, a girl aged 13, was admitted to Poole Sanatorium on March 14, 1949, after having spent one and one half years under general sanatorium treatment for extensive disease of the left lung. Bronchoscopy on December 15, 1948, had shown hyperaemia of the left stem bronchus. On admission her general condition was fair. The sedimentation rate was 21 mm., and the sputum was negative for acid-fast bacilli. Radiographs showed extensive disease in the left lung, with upper lobe cavitation and some scattered nodularity of the right lung. In July, 1949, positive sputum was obtained. On November 15 a left pneumonectomy was performed, since the tomographs showed no evidence of cavitation in the right lung. At the time of operation she was well and afebrile ; the sedimentation rate was 4 mm. and the sputum was negative. The specimen showed the presence of extensive disease of both lobes, and the bronchus at the site of amputation showed submucosal tubercles.



Left lung, showing huge upper lobe cavity which had extended into the apex of the lower lobe.

Pneumonectomy: Case 3

Follow-up one and a half years later showed the patient to be well, and the radiographs showed no evidence of contralateral activation.

Case 5.—In this case, that of a girl aged 5, who was admitted to Shotley Bridge Hospital, one uncle and two grandparents were tuberculous, but neither the father nor the mother showed any evidence of infection. This little girl had "pneumonia" at the age of 6 months, and since that time had had a cough with thick white sputum and further attacks of "pneumonia" at frequent intervals. For the week before admission she had been coughing up bright red blood, was dyspnoeic on exertion, and showed marked lassitude. The radiographic appearance was that of a collapsed left lung. The sputum was positive for tubercle bacilli on two occasions. Bronchoscopy showed stenosis of the left main stem bronchus. Three months after admission, at which time pneumonectomy was being considered, she developed an elevated temperature and marked dyspnoea. There was clinical and radiological evidence of a contralateral spread of the disease. Penicillin and streptomycin therapy was begun, with fairly rapid improvement in her general condition. By March 4, 1949, she was afebrile and beginning to gain weight, but radiologically the lesion in the right lung was spreading. On March 7 a left pneumonectomy was performed. Streptomycin was continued for another month, and the post-operative course was uneventful. She was discharged to home one month

post-operatively at the request of her mother. At this time she was afebrile, sputum was negative for acid-fast bacilli, and radiologically the lesion in the left lung was regressing. Examination of the resected lung showed diffuse, caseous, and cavitated tuberculosis and endobronchial tuberculosis at the site of bronchial amputation. The regional lymph nodes showed tuberculous infiltration.

Follow-up two years later shows that the patient is well and attending school. There is no evidence of disease in the other lung or chest deformity. She is slightly smaller than average for her age, and she does get somewhat more short of breath on exertion than does the average child. Her activities are, however, only slightly limited by her pneumonectomy.

Case 6.—A girl, aged 8 years, was admitted to Poole Sanatorium. One brother died in 1940 of tuberculous meningitis, but there was no other family history of tuberculosis and no obvious contact.

In the early part of 1948 radiographs of the chest of this patient showed what appeared to be a primary complex, and films taken over the following year showed this to be improving until the lung fields appeared clear, and only the enlarged hilar nodes remained. On August 5, 1949, she was seen, as she was suffering from intermittent pyrexia and lassitude. Radiographs showed collapse and consolidation of the left lung. The sputum was negative on smear and culture for acid-fast bacilli. Bronchoscopy showed nothing abnormal, but after this procedure the sputum became positive on direct smear and remained so until after operation. Before admission she had received a total of 40 g. of streptomycin accompanied by the administration of P.A.S.

On February 27, 1951, her general condition was good, she was afebrile, she had gained 7 lb. over her admission weight, and the sedimentation rate had dropped from 58 mm. on admission to 14 mm. A left pneumonectomy was performed, and so far the post-operative course has been uneventful.

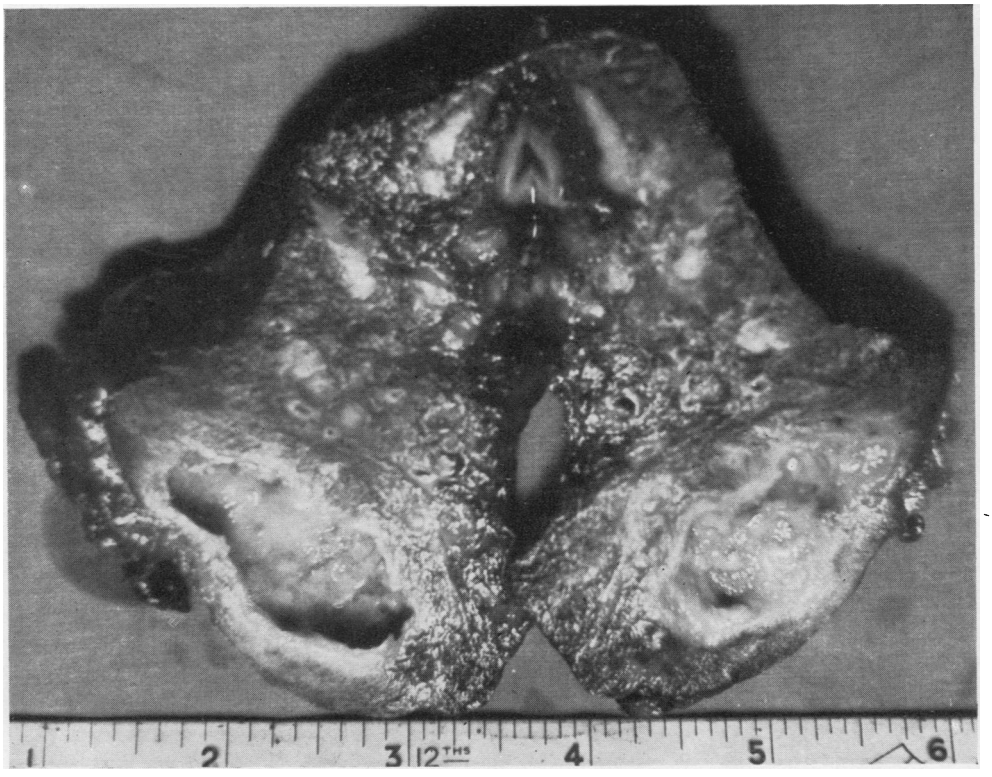
This is the most recent resection, and of course it is far too soon to make any predictions as to the result.

Lobectomies

Case 1.—There was no family history of tuberculosis. The patient, a girl aged 10, was admitted to Poole Sanatorium on June 3, 1949, with a seven-month history of cough, with copious sputum, and an occasional slight haemoptysis. The sputum was positive for acid-fast bacilli ; there was intermittent pyrexia ; and the patient was thin, pale, and appeared acutely ill. Radiographs showed the presence of a large right upper lobe cavity. Streptomycin was begun at once and continued for a course of 42 g. with marked improvement in her general condition. Serial radiographs showed retraction of the right upper lobe with diminution in the size of the cavity. On September 26, 1949, a pneumoperitoneum was induced, followed by a phrenic crush on October 6. Tomography in February, 1950, showed a small residual cavity in the dense, retracted upper lobe. On April 11, 1950, a right upper lobectomy was performed under cover of streptomycin and P.A.S. With the exception of some superficial wound infection, the post-operative course was uneventful. By June 29 she was well and afebrile ; the sedimentation rate was 14 mm., and she had gained 22 lb over her admission weight.

She is well one year later, with no evidence of further disease.

Case 2.—A girl aged 16 years was admitted to Poole Sanatorium on May 20, 1949, with a history of having had a moderate, recent haemoptysis. She was in fair general condition. The sedimentation rate was 12 mm. and she was afebrile. The radiographs showed right upper lobe cavitation. The sputum was positive for tubercle bacilli. Pneumoperitoneum was induced on June 26, and this was followed by phrenic crush on July 14 ; but this resulted in little change in the cavity, in spite of good elevation of the



Left upper lobe, showing large thick-walled cavity and multiple caseous nodules, involving the whole lobe.

Lobectomy

diaphragm. On September 13 a right artificial pneumothorax was induced, followed by adhesion section later. The resultant collapse was selective, but the cavity enlarged and developed "tension." Streptomycin was started on October 4, with a resultant decrease in the size of the cavity in about one month. By January, 1950, seven months after admission, she was afebrile, the sputum was negative, and she had gained 20 lb. over her admission weight, but the cavity in the right apical segment was still present. Upper lobectomy was decided on, but at operation it was found that the disease had extended into the medial segment of the middle lobe, and so this segment was resected also. The post-operative course was smooth, and by July 3 she was well and afebrile; the sputum was negative, the sedimentation rate 6 mm., and she had gained a further 5 lb.

These two cases were operated on because more conservative methods had failed to close the cavities. Of the next two cases, the first is remarkable because it is one of bilateral resection. In this patient resection was performed on one side because conservative methods had failed to control the disease, and on the other side the resection was the method of choice. In the second patient resection was adopted as the method of choice.

Case 3.—This girl, aged 13 years, was admitted to Poole Sanatorium in March, 1948, with left upper lobe cavitation, questionable right upper lobe cavitation, positive sputum, and fair general condition. In July, 1948, a left phrenic crush was performed and was followed by the induction of a pneumoperitoneum. The pneumoperitoneum was maintained for 14 months with no improvement. The left upper lobe cavity was increasing in size, the sedimentation rate was rising, and the child was irregularly febrile. The pneumoperitoneum was abandoned. By October her general condition was deteriorating and bilateral cavitation was confirmed. She was put on P.A.S. on October 19, and in one month had shown a definite improvement. By February 21, 1950, she was afebrile, the sedimentation rate was 14 mm., and she had gained 15 lb. By May of that year, although her general condition had markedly improved, there was little change in the radiographs. Conteban was started, and one month later she was placed on streptomycin. By June the radiographs showed marked regression of the lesion in the right lung, and resection of the left upper lobe and the apical segment of the lower lobe was carried out. Streptomycin and conteban were continued until August 3. At this time the sputum was negative for acid-fast bacilli, but on October 19 a positive sputum was obtained, and tomography showed that the right upper lobe cavity was still present. Under cover of further streptomycin the apical segment of the right upper lobe was resected. Except for transient post-operative atelectasis, which was treated with bronchoscopy and the removal of a bronchial cast, the recovery from both operations was quite satisfactory.

At the time of writing the child is well, gaining weight, and her radiograph is satisfactory.

Case 4.—This boy, aged 14 years, was admitted to Shotley Bridge Thoracic Surgery Clinic in September, 1950, with a history of having had a right-sided pleurisy in March, 1949, and since that time a slight productive cough and some weight loss. A radiograph showed a right basal collapse and cavitation of the pectoral segment of the upper lobe. This lesion was considered to be tuberculosis clinically, but it was not possible to find acid-fast bacilli on the sputum or in the fasting gastric juice either on direct smear or on culture. Guinea-pig inoculation of a bronchial aspirate gave a positive result. At bronchoscopy granulation tissue was seen on the medial wall of the right stem bronchus above the middle lobe orifice, but biopsy of this area was not positive for tuberculosis. Bronchography showed filling of the cavitated area in the right lung and no evidence of bronchiectasis in the remaining lung tissue. On November 28, 1949, the pectoral segment of the right upper lobe was resected. The post-operative course was uneventful, and he was discharged home on December 17, 1949, on a limited activity schedule. Pathological examination of the resected specimen showed bronchiectatic changes and tuberculous invasion.

The next case is one in which the operation was performed in the belief that the lesion was uncomplicated bronchiectasis. Examination of the specimen showed tuberculous invasion of a chronic fibrotic type.

Case 5.—This patient, a boy aged 4 years, was admitted to Shotley Bridge Hospital on July 5, 1950, after having been observed for some months as an out-patient. He had " pneumonia " at the age of 2, but he recovered satisfactorily on sulphonamide therapy and bed-rest. He had no symptoms apart from a slight unproductive cough. Radiographs showed collapse of the right middle and lower lobes and enlarged hilar lymph nodes. The tuberculin test was positive 1/10,000. Bronchoscopy showed obstruction of the right stem bronchus at the level of the middle lobe orifice by granulation tissue, of which a biopsy showed no evidence of tuberculosis. It was not possible to demonstrate tubercle bacilli in the sputum, gastric washings, or in the bronchial aspirate. Bronchography showed a normal right upper lobe, but no filling of the right middle or lower lobes.

On September 9, 1950, the right middle and lower lobes were resected. The dissection of the lung hilum was difficult due to the presence of enlarged and matted lymph nodes, one of which was caseating. For ten days post-operatively the patient was on streptomycin. The patient was discharged home on October 14, 1950.

In these two cases the association of tuberculosis and bronchiectasis is interesting. One might speculate that the bronchiectasis was secondary to the pressure of enlarged lymph nodes draining a primary focus in the affected segment, and that the resultant bronchiectatic changes made that segment more susceptible to a second tuberculous infection, or that the primary infection did not heal in the usual way but, in the bronchiectatic area, progressed to a fibrous type of lesion.

The next case had a pulmonary resection as an emergency procedure to prevent the rupture of a cavity under artificial pneumothorax.

Case 6.—A girl aged 15 years was admitted to Poole Sanatorium on April 7, 1949, with a history of chest pain, cough, and listlessness since December, 1948. On admission she was ill, febrile, had a productive cough, and was sputum-positive for tubercle bacilli. On May 5 a pneumoperitoneum was induced, and this was followed in a few days by a phrenic crush. By the end of that month her general condition had improved and her temperature was stable. On June 17 a course of streptomycin was begun, and by the end of that month her temperature was down to normal and the radiographic picture was improving. The acute pneumonic appearance of the right upper lobe had become much "harder." By December, however, the lesion in the right lung had progressed to cavitation, and on January 12, 1950, a right artificial pneumothorax was induced and an adhesion section was performed. After this procedure the right upper lobe became atelectatic, and the cavity enlarged and appeared to be under tension. Bronchoscopy at this time showed endobronchial tuberculosis of the right upper lobe bronchus. By February 14, since the cavity still retained its "tension" and the right upper lobe remained atelectatic, it was decided to resect the upper lobe to prevent the rupture of the cavity and the subsequent development of an empyema. At this time the patient was afebrile, the sedimentation rate was 9 mm., and she had gained 22 lb. over her weight on admission. Examination of the resected specimen showed the presence of tuberculosis in the bronchus at the site of amputation and also in the regional lymph nodes. A large cavity with a thin necrotic wall was present, virtually on the verge of rupture into the pleural cavity. When this patient was discharged a left-sided infiltration, which had been present on admission, appeared to be stable, and it was considered that the only further treatment necessary was rest. She did not follow instructions regarding this form of therapy, and on February 5, 1951, she was readmitted with cavitation of the lesion on the left side. The appearance of this lesion is now improving on bed-rest.

DISCUSSION

The treatment of "adult type" pulmonary tuberculosis in children is difficult because thoracoplasty probably results in severe deformity. If it is not possible to obtain a selective collapse with artificial pneumothorax, then one is left with the choice of pneumoperitoneum, with or without phrenic interruption, or of extrapleural pneumothorax. If wider experience shows that the results of resection are as uniformly favourable as this small series of cases suggests, then this form of treatment may be the one of choice.

It is difficult as yet to list criteria for pulmonary resection in children. The "destroyed lung," the patient with multiple cavities in more than one lobe, the patient who has a large cavity which involves both upper and lower lobes, and occupies more

lung tissue than it is feasible to remove segmentally, all point to pneumonectomy. This is particularly so if there is also an amount of nodular disease in the affected lung. Stenosis of the main stem bronchus is an indication for pneumonectomy.

In the selection of the cases for lobectomy, the following may qualify: (1) The patient who has unilateral cavitated disease confined to a small area in the affected lung, usually the upper lobe, and in whom more conservative methods have not been effective in controlling the disease. (2) The patient in whom artificial pneumothorax has been possible, but in whom the cavity has developed tension, or where the affected lobe has become atelectatic. (3) The patient who has a lower lobe cavity, particularly if the cavity be situated in the apical segment. (4) The patient who has a collapsed, bronchiectatic, infiltrated lobe, whose collapse may be secondary either to the pressure of tuberculous hilar nodes on the bronchus, to the obstruction of acute endobronchial tuberculosis, or to the stenosis resulting from the scar of a healed endobronchial lesion. (5) If the disease clearly involves only one or two segments of a lobe, then a segmental resection may be carried out. (6) In cases of bilateral disease, the contralateral lesion should, ideally, be stable at the time of operation, but each case must be considered as an individual problem.

A reasonable period of general sanatorium treatment with streptomycin and P.A.S. will be necessary in the acute cases to stabilize the patient before surgery. The patients who are toxic and febrile and have cavities with retained secretion and secondary infection will benefit from postural drainage and the appropriate chemotherapy.

The post-operative course may generally be expected to be smooth after pneumonectomy. The lobectomy cases are no more troublesome than are those who are operated on for lesions other than tuberculosis.

The obliteration of the dead space has not been a problem in our cases, and there has been no obvious deformity resulting from the removal of the lung.

Bed-rest is an essential part of post-operative treatment. Ambulation should be gradual, over a period of about three months. Activity should be restricted for about a further one or two years, and caution exercised for a similar length of time.

SUMMARY

A report has been made of six pneumonectomies and seven lobectomies performed for "adult type" pulmonary tuberculosis in children.

There have been no deaths in the series, post-operative complications have been practically negligible, and, in all but one case, the results to date have been favourable.

Further assessment of this form of therapy will depend on the examination of larger numbers of cases, but it may be the method of choice.

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