ARTIFICIAL PNEUMOPERITONEUM

An Ancillary Method of Treating Pulmonary Tuberculosis.

A critical Analysis of 40 Cases.

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C O N T E N T S

PART ONE
INTRODUCTION

PART TWO
GENERAL REVIEW OF COLLAPSE THERAPY

PART THREE
TECHNIQUE OF PNEUMOPERITONEUM

PART FOUR

THE RESULTS OF TREATMENT

PART FIVE

PART SIX

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ARTIFICIAL PNEUMOPERITONEUM
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PART ONE
OBJECTS OF THE PRESENT STUDY.

The work, which forms the foundation of this monograph, was executed in the City of Glasgow Hospital and Sanatorium at Robroyston. The institution was, until quite recently, wholly given over to the treatment of pulmonary and non-pulmonary tuberculosis and even in recent years provides accommodation for about 450 tuberculous persons, of whom close on 300 are under treatment for lesions which are mainly respiratory and tuberculous. In general the lesions found on admission are by no means early and an all too great proportion are frankly advanced. There is, however, a tendency manifest to admit patients with earlier lesions in greater numbers, a tendency which is presumably a result of the effects of the hospital administration to encourage to the maximum degree the employment of all reasonable methods of collapse therapy. Scrutiny of the Reports of the[103,104] Medical Officer of Health for Glasgow show that in 1936 the hospital staff utilised/

utilised collapse treatment in 94 instances, whereas in 1939 collapse in some form or another was the method of choice in treatment for 180 patients. The writer having been successively junior and, later, senior resident medical officer in the institution is fully aware that collapse therapy cannot be the sheet anchor of treatment in any but a very few patients, but he has been associated long enough with tuberculosis to realise that collapse of a diseased lung or parts of both lungs, where both are affected, is surely the greatest recent advance in the treatment of tuberculosis. Collapse cannot, as a statement of general opinion among phthisisologists, replace sanatorium regime, but as an ancillary method in a prolonged course of treatment it can utterly transform the outlook of numerous patients and greatly expedite their recovery.

Coincidental with the growing tendency to employ the numerous methods of collapse, there has been a widening of the views as to the indications for its employment. Time was when these valuable restorative operations were reserved for those fortunate few whose disease was strictly unilateral. For even such a simple measure as artificial pneumothorax, rules were laid down as to the extent and the activity of lesions in the better lung, which would permit or totally forbid the collapse of the more diseased organ. These/

These rules were proportionately more stringent for such major procedures as thoracoplastic operations. While such points will be referred to later, it seems that the widening indications for collapse of tuberculous lungs results from the realisation that a small active lesion in the better lung is often the result of the uncontrolled spread of mischief in the more extensively diseased organs; and that healing of the lesser cannot take place without rigorous control of the greater lesion. Further departure from the early rigid rules came from the realisation that relaxation or removal of tension was, in many instances, all that was necessary; and the earlier totally collapsed compressed lung gave way to the partially collapsed relaxed lung.

Even so regarding the tendencies as pointing to widening usefulness, there remains, and will remain, the large group of patients in whom there is neither a good nor a better lung, nor lesions in separate lungs which can be distinguished readily in age. These unfortunate people, most often suffering from not only extensive bilateral tuberculosis, but also showing all the signs and symptoms of actively spreading lesions, find themselves in wards where active measures are being applied to a majority of patients/

patients. They realise soon that they are more advanced in their lesions, more ill than the others, and psychologically, as well as physically, they deteriorate rapidly. It was for these people that artificial pneumoperitoneum was introduced into Robroyston Sanatorium by the author as a method of treatment. In the course of this thesis it will be argued that such a procedure is anatomically and physiologically correct, that it does attain relaxation of the thoracic contents and in consequence of that it is capable of ameliorating the condition of those patients who are treated by it; in short that the results given justify the writer in his hope that artificial pneumoperitoneum will take its place on the ladder to health, the steps of which are the forms of collapse therapy, the shafts of which are found in the established routine of a well conducted sanatorium.

HISTORICAL SKETCH.

Artificial pneumoperitoneum which is the deliberate introduction of air into the peritoneal cavity, is not a recent innovation into the field of medical science for it has been known and used for more than a third of a century, dating back, in fact, to the end of the 19th century. Since no study of artificial pneumoperitoneum would be complete, in the author's opinion, without some historical reference and as the important/

important phases in its chequered history are not devoid of interest, the writer proposes at this juncture to trace the history of pneumoperitoneum commencing with its introduction to the medical profession between 50 and 60 years ago.

It first came to notice in 1861, when Spencer Wells[130] unintentionally operated on a patient with tuberculous peritonitis with a prompt recovery. The fact that the patient's intestinal condition improved after the laparotomy inspired many people to investigate the possible relationship between the operation and the intestinal lesion, but it was not until 32 years later, that the first publication appeared. Thus it happened, in 1893, that Mosetig-Moorhof[88] sent an article to the press in which he called attention to a new line of treatment in tuberculous peritonitis. He reported a case with ascitic fluid, and with tuberculous epididymitis as a complication. The author stated that he excised the testis, evacuated the fluid, 1700 ccs. approximately, from the abdomen via the inguinal canal and then he passed aseptic air by this same route up into the abdomen. The child is said to have made a recovery in 5 months. This observation was confirmed in the same year by Nolen[89] in Germany. He reported 3 cases, with recovery/

recovery in 2 instances, the third patient dying with advanced abdominal tuberculosis.

In October 1910, Jacobaeus[68] in Stockholm published an article bringing to the notice of the medical profession the possibility of and diagnostic value of cystoscopic examination in serous cavities, including the peritoneal cavity. Cystoscopic examination of the latter, of course, was to be preceded by a pneumo-peritoneum. One month later, in the same year, Kelling[77] working in Dresden proved the value of Jacobaeus teachings by making use of pneumoperitoneum, for the first time, with a diagnostic objective.

In France Emile-Weil[44] and Loiseleur reported 6 cases of tuberculous peritonitis in which treatment was carried out by paracentesis followed by injections of air. Two of these six cases had nitrogen injected and in 3 cases a complete cure was effected. In Italy, Alessandrini[1] published an article in which he indicated the great possibilities and advantages of artificial pneumoperitoneum in radiological work as a means of diagnosing abdominal lesions.

About this period there began to appear series of observations on pneumoperitoneum and its beneficial effect on tuberculous peritonitis. Numerous authors began to contribute/

contribute and testify to its effectiveness. Thus Brown,[23] Rost,[108] Purvis and Bilcliffe[100] Stein[121] (A), were among the first to lay stress on the conservative treatment of the exudative form of tuberculous peritonitis by paracentesis with evacuation of the fluid and subsequent oxygen inflation. Others who reported similar findings were Mattrick,[84] Laney,[80] Hayes,[61] Garbat,[55] Jelks,[69] Girilbert,[56] Schwatt and Steinbach.[114] During the following four years the measure appears to have been applied mainly to radiological work as an aid in diagnosing pelvic lesions.[67] Jaches and Stein (I)[122,123] applied it as a means of diagnosing obscure gynaecological conditions. Other workers employed pneumoperitoneum as a means of investigating lesions of the abdominal organs outwith the pelvic region. Schieden[113] and Peiffer maintained that it was invaluable as a means of diagnosing suprarenal tumours, while Boller[19] and Pape asserted that pneumoperitoneum was very effective as a method of diagnosing abdominal tumours, as for example, cysts. The merit of the application of pneumoperitoneum in the treatment of intestinal tuberculosis, in America, belongs to Andrew L. Banyai,[10,11] who employed this method and who expatiated at length on its indications, its method of execution and its results.

What has been indicated hitherto gives some history of artificial pneumoperitoneum as a diagnostic procedure and/

and as a therapeutic measure in intestinal tuberculous lesions. It has been applied also with success in pulmonary tuberculosis. In 1930 Overholt,(92) experimenting on dogs, found that pneumoperitoneum elevated and limited the movement of the diaphragm. The first clinical reports of its application to disease in man were those of Ludwig Vajda(127) who applied this form of treatment to two cases of haemoptysis in pulmonary tuberculosis. In 1934 Banyai(12) reported his observations in 9 cases and in this publication he included for the first time in medical literature the combined use of phrenic nerve interruption and artificial pneumoperitoneum. In 1934 and 1936, Centoscudi(27,28) applied pneumoperitoneum to 19 cases of pulmonary tuberculosis. He, too, recommended the surgical paralysis of the diaphragm in combination with pneumoperitoneum, and in the same year Schlack(112) advised phrenic neurotomy and artificial pneumoperitoneum for collapse of an adherent lung. In 1936 Werwath(131) applied it to puerperal cases suffering from bilateral pulmonary tuberculosis and in the same year Rehberg(102) found its usefulness in arresting haemorrhage from the lung. The following year, 1937, Vajda(128) discussed the feasibility of pneumoperitoneum early in the puerperium. Other workers who have proved the efficacy of pneumoperitoneum in certain cases/

cases of pulmonary tuberculosis are Trimble (126) and Wardrip, Fremmel (51) and Bennett (17). In the same year Piaggio-Blancho (95) maintained that it was of some value in pulmonary emphysema and in the following year, 1938, Besta (18) and Dutrenit applied it to phthisis with results very much similar to those of the American writers, Trimble and Fremmel, et al. They paid, however, particular attention to the control of pulmonary haemorrhage by pneumoperitoneum and they observed also the favourable effects which pneumoperitoneum produced on the gastro-intestinal symptoms secondary to phrenic nerve paralysis.

Harper (60) and Levin illustrated rather an interesting case in which pneumoperitoneum was applied to a woman who had a left-sided phrenic nerve operation and a thoracoplasty in this same side. This patient appears to have complained of the characteristic syndrome which follows sometimes a left-sided (3) phrenic nerve operation, consisting of decreased appetite and a feeling of fullness associated with nausea and vomiting. Previous X-rays revealed in this case an acute angulation at the outlet of the stomach with resultant partial and intermittent obstruction. Pneumoperitoneum was induced and caused a marked improvement of the patient's symptoms and a great improvement in the anatomical position of the stomach. They reported that the stomach changed to

a/

a more transverse position, the pylorus and duodenum moved over to the right side of the vertebral column and no longer showed evidence of the tension and acute angulation which were previously seen.

More recent work in connection with pneumoperitoneum continued to show its progress in other countries. In 1940, for example, articles were published confirming the different therapeutic applications of this procedure. In June of that year, Barron (15) in Spain confirmed the findings of previous workers. He stated that pneumoperitoneum was very valuable in reinforcing the mechanical effects of phrenic evulsion or in checking pulmonary haemorrhage which cannot be controlled by other means. In December 1940, Jones (71) was able to cauterise adhesions between the liver and diaphragm. By this means the diaphragm became elevated to a much higher level when the restricting bands of adhesions were removed between the liver and the diaphragm, and as a result, the patient derived the full advantages of therapeutic artificial pneumoperitoneum. He stated that there were no complications, during or after this operation.

Since 1933 Continental and American workers have attempted to bring this form of collapse therapy to the notice of the medical profession but so far as the writer knows artificial pneumoperitoneum has not received any official/

official recognition in England, and, except for his own publications (182,183) in 1940, there have been no British contributions suggesting the inclusion of this form of treatment in the therapeutic armamentarium of pulmonary tuberculosis.

The term artificial pneumoperitoneum is used in contra-distinction to spontaneous pneumoperitoneum in which the latter is due to an existing pathological lesion in which air passes from an abdominal viscus into the peritoneal cavity, as e.g. rupture (134) of stomach (111) duodenum or bowel (36) or from the pleural space into the peritoneal cavity, as e.g. during a refill when the diaphragm has been elevated following on a phrenic crush. This type of pneumoperitoneum is sometimes called accidental pneumoperitoneum or indirect pneumoperitoneum (117) (53) (24) (93) (43), and in this thesis the term pneumoperitoneum will infer direct pneumoperitoneum in the more restricted sense of a deliberate insufflation of air into the peritoneal cavity effected with a therapeutic end.

THE DIAPHRAGM.

Anatomical, embryological and physiological features.

(a) ANATOMY: Since the diaphragm is intimately concerned with the mechanism of pneumoperitoneum it is fitting that a brief outline should be made of its anatomical characteristics/

characteristics. Several of the complications which have been reported e.g. mediastinal (13) emphysema, are understood more easily when the anatomical relations of the diaphragm are studied.

The diaphragm is a dome-shaped musculofibrous septum which separates the thoracic and abdominal cavities. Its convex upper surface forms the floor of the former, and its concave under surface is the upper limit of the latter. Its peripheral part consists of muscular fibres which take origin from the circumference of the thoracic outlet and converge to be inserted into a central tendon. The muscular elements may be grouped according to their origin into three parts, sternal, costal, lumbar. The sternal portion arises from the back of the xiphoid process by two fleshy slips. The costal bundles arise from the inner surfaces of the cartilages and adjacent portions of the lower six ribs on each side, interdigitating with the origins of the transversus abdominis, and the lumbar part takes origin from the lumbo-costal arches and from the lumbar vertebrae by two pillars or crura. There are two lumbo-costal arches formed by a medial or internal arcuate ligament and a lateral or sternal arcuate ligament, on each side. The crura are tendinous in structure at their origin and blend with/

with the anterior longitudinal ligament of the vertebral column. The right crus is larger and longer than the left and it arises from the anterior surfaces of the body and the fibrocartilages of the upper three lumbar vertebral; the left crus arises from the corresponding parts of the upper two vertebrae and discs only. The medial tendinous margins of the crura meet in the middle line to form an arch across the front of the aorta.

From these origins the fibres of the diaphragm converge to be inserted into the central tendon. The fibres from the xiphoid process are short and occasionally aponeurotic. Those from the medial and lateral lumbo-costal arches and from the ribs are longer and describe more curves as they ascend and converge to their insertion. The fibres from the crura diverge as they ascend, the most lateral being directed upwards and lateral to the central tendon. The medial fibres of the right crus ascend on the left side of the oesophageal hiatus. The central tendon is a thin but strong aponeurosis situated near the centre of the vault formed by the muscle, but situated more anteriorly than posteriorly, so that the posterior fibres are the longer. The tendinous central part is placed immediately below the pericardium, with which it is blended partially; as a result of this arrangement elevation of the diaphragm will/

will influence the hilar region of the lungs, indirectly, through the pericardium. It is also worthy of note that since there is a great aggregation of muscular fibre in the crura and that a considerable decussation of the right and left pillars of the crura occurs, there must be community of action.

The diaphragm is pierced by apertures for the passage of structure between the thorax and abdomen. There are three large openings for the aorta, oesophagus, and the vena cava; a number of smaller apertures are present. The aortic is the lowest and most posterior hiatus and lies about level of the 12th thoracic vertebra and allows passage to the aorta, the azygos vein and the thoracic duct. The oesophageal aperture is situated in the muscular part of the diaphragm at the level of the 10th dorsal vertebra and is formed by the splitting of the medial fibres of the right crus. The caval formen is the highest of the three large openings being situated between the 8th and 9th thoracic vertebrae. Through it passes the inferior vena cava, the walls of which are adherent to the margin of the opening, and some branches of the phrenic nerve. Of the lesser openings, two in the right crus transmit the greater and the lesser splanchnic nerves. Three in the left crus give passage to the greater and lesser splanchnic nerves and the/

the hemiazygos vein.

The diaphragm is innervated by the phrenic nerves and the lower six or seven pairs of intercostal nerves. These nerves are associated intimately with the distribution of pain which occurs during an initial insufflation of air into the peritoneal space.

The phrenic nerves are regarded as the main motor nerves to the diaphragm. Each arises chiefly from the fourth cervical segment of the spinal cord but the third and to a lesser extent the fifth segments contribute to it. On each side the nerve passes down from the neck through the thorax to the diaphragm, where it ends by supplying the motor fibres to the muscle of the diaphragm and sensory fibres to the peritoneum lining its under surface and the pleura lining its upper surfaces. Stimulation of these sensory nerves by pneumoperitoneum causes pain to be felt in both shoulder regions. The pain may be felt in either the whole or part of an area extending from an ill defined line just below clavicle and passing over the supraclavicular, across the upper surface of the acromion process and over the supra-scapular fossa. The cutaneous nerves of this region, in which this referred pain is felt, are the descending branches of the third and fourth cervical nerves which are finally/

finally distributed to the skin as the supra-sternal, supra-clavicular, supra-acromial branches. It will be noticed that these nerves arise from the same segments of the spinal cord as the phrenic nerve, and they may be regarded, morphologically, as the superficial branches of this nerve. The explanation for this apparent anomaly is provided by the developmental history of the diaphragm. This will be summarised in a later paragraph when the embryology of the diaphragm is studied. Briefly, it may be stated however, that originally the diaphragm formed in the neck, migrates in a caudal direction, at a very early period of intra-uterine life. This development of the diaphragm occurs simultaneously with the development of the lung buds from the primitive foregut, and the expanding lungs are said to push the diaphragm down below them to its permanent position at the lower end of the thorax. It can be seen, therefore, that the developmental history of the diaphragm is recalled when it receives a painful stimulus. The patient complains at once of pain in the shoulder as a result of such stimulation.

In 1922 Capps (26) and Coleman reported some interesting observations on the localisation of the pain sense of the diaphragmatic peritoneum. The method they adopted was to insert a trocar through the abdominal wall of patients/

patients who suffered from ascites or in whom they had induced an artificial pneumoperitoneum. Through this trocar a curved wire was passed which was made to impinge on various parts of the diaphragmatic peritoneum from within the abdomen and so cause pain originating from the various points stimulated. When the under surface of the diaphragm was stimulated in three patients, pain was felt solely in the area of the shoulder but when the extreme periphery of the diaphragm was stimulated, pain was felt solely in the superficial distribution of the lower intercostal nerves on the overlying costal margin.

The arterial supply of the diaphragmatic portions is quite distinct. The crura are supplied direct from the aorta; the costal portions from the comes nervi phrenici, a branch of the mammary artery, and the twigs proceeding from the lower six intercostal arteries.

(b) EMBRYOLOGY: Before commencing a discussion of the action of the diaphragm it is expedient to study the development of the diaphragm briefly, as its function is appreciated more easily when it is considered from a developmental view point.

The diaphragm very early in the life of the human embryo, is situated at the cephalic end but it shows soon evidence/

evidence of passing caudally, until finally it forms a partition which separates the intra-embryonic ceolom into the thoracic and abdominal cavities. The pericardium lies also at the headward end of the embryonic area and it communicates caudally on each side of the median plane, with the rest of the coelom. When the head fold becomes formed, the pericardium communicates dorsally with the pleural passages by means of two pleuro-pericardial canals, which open caudally into the peritoneal cavity, the former passages being themselves extrusions of the primary coelomic cavity. As the lung buds develop they grow into the pleural passages caudal to the duct of Cuvier and their caudal ends project into the peritoneal cavity. Sir A. Keith (54) states that the pleural cavities are analgous to the tunica vaginales since they are both extensions of the primary intra-embryonic coelom but the difference between the testicles and the lungs is simply that in the former all three layers of the hind gut are pushed in front, while in the latter only the inner of the three layers of the foregut of the cavity is perforated, and instead of being extruded into the beck, they push down the inner layer which goes to form the diaphragm. The pleuro-peritoneal apertures are simply the opening through which the lungs pass from the primitive abdominal cavity to the pleural cavities. They are situated on either side and divide each half of the diaphragm into a dorsal portion which arises from the/

the spine and arcuate ligaments and a ventro-lateral portion arising from the ribs and sternum. The closure of these openings complete a mesodermal partition which separates the thoracic from the abdominal viscerae and this same sputum occupies the position of the diaphragm in the adult. This partition has a composite origin. The central tendon is developed from the Septum Transversum. The dorsal portions are formed from that position of the body wall called the dorsal mesentery, which is inserted into the pericardium and Septum Transversum. The ventro-lateral parts are developed from the longitudinal muscular sheet from which the Rectus Abdominis is derived. So also the ribs which become formed in the chest wall. The ventro-lateral part takes origin from the six ribs posteriorly and is continuous at its insertion with the Septum Transversum.

Embryologically it would seem that the diaphragm is made up of two major parts which differ in their functions. One, the spinal parts, which act on the heart and pericardium and through them to the roots, elongating the thorax, and another the sterno-costal parts which act on the ribs.

(c) PHYSIOLOGY: Having outlined the embryology and the anatomy of the diaphragm it remains now to make reference/

reference to the action of the diaphragm as this function is of importance when the effect of pneumoperitoneum on the lung is considered.

Although the primary function of the diaphragm as Jones[70] says "is the elemental one of compressing the coelom" and "is most correctly regarded as an instrument for raising the general intra-coelomical pressure", it is as a respiratory organ with which the writer is concerned chiefly and its function as such will be discussed.

There is no doubt that the downward movement of the diaphragm, by increasing the intra-thoracic negative pressure, is concerned to some extent in the aeration of all areas of the lung. It was originally thought that palsy of the diaphragm only affected the basal lesions. In 1890 Pasteur[94] published an article in which he maintained that paralysis of the diaphragm was the cause of post-operative massive collapse of the lung. He stated that paralysis of the diaphragm tended to induce a loss of function of the subjacent lung, which, as he said, "is caeteris paribus, proportionate to the degree of paralysis". Whether it has a greater effect on one area than another is a debatable point. Sir Arthur Keith[74,75,76] has brought convincing evidence to show that the apex of the lung and particularly the posterior/

posterior part of the apex is largely dependent on the part of the diaphragmatic action for its proper aeration. Sir Charles Briscoe,(21) although differing from Keith in certain details, was of a similar opinion. The importance of the diaphragm in expanding the apex of the lungs has not been disputed to any extent. The lung below the apex is expanded by both costal and diaphragmatic action. Controversy has ranged chiefly round the question of what each part plays in their correlated actions. Briscoe, Keith and Dally(35) all agreed that the action of the diaphragm on the lower ribs was to assist the external intercostals in raising the ribs and widening the subcostal angle. Hoover(63) opposed this view. He held that the action of the diaphragm was antagonistic to the external intercostal muscles and that contraction of the diaphragm tended to pull the lower ribs forward towards the middle and lessen the subcostal angle. He produced a mass of experimental and clinical evidence to support his opinions.

The general conception of the functions of the diaphragm may be described as follows. It seems to have a piston like action during inspiration. It expands the basal parts directly and through them the apical areas. The muscular crura act on the pericardium and they have a direct/

direct action on the lung roots. The effect of the diaphragm on the lower ribs is very difficult to determine. It is generally believed that the diaphragm acts on the external and internal intercostal muscles causing them to produce an elevation of the ribs, at their anterior portions, and through the costo-chondral facets of the lower ribs push the sternum forwards thus resulting in a bending at the chondro-sternal articulation.

MECHANISM OF PNEUMOPERITONEUM.

Before discussing the technical and clinical aspects of artificial pneumoperitoneum, it will be necessary to discover what changes take place, in both the abdomen and the thorax, after air has been allowed to enter the peritoneal cavity. The bulk of the available literature has already been summarised and need not, with a few exceptions, be quoted again.

Artificial pneumoperitoneum, if it has those salutary effects in pulmonary tuberculosis which the writer claims for it, must have those effects as a result of changes in the abdomen, which in turn will affect the general intra-thoracic physiology considerably. Ideally it should be possible to quote authoritative literature on experimental pneumoperitoneum, but references are few and far between. The/

The writer has approached, therefore, the subject as he has viewed it from the study of his own patients and it can best be surveyed under the following headings:-

(1) The behaviour of the gas in the peritoneal cavity.

(2) (a) Changes in the intra-abdominal pressures.

(b) Changes in intra-pleural pressures.

(3) The influence of pneumoperitoneum on the diaphragm and on the lungs.

(4) (a) The effect of pneumoperitoneum on the abdominal parietes.

(b) Visceral changes.

(1) <u>The behaviour of the gas in the peritoneal cavity</u>.

It must be quite obvious that to have a considerable and therefore effective pneumoperitoneum, the coelom must be free of pathological adhesions over its main extent. Since, as will be shown later, pneumoperitoneum acts by virtue of an elevation of the diaphragm, any factor which prevents air coming into direct apposition with the diaphragmatic dome will seriously reduce the effectiveness of the operation. Even in the absence of limiting pre-existing adhesions, radiological examination shows that while even in the early period of treatment some air does appear above the liver and stomach, a larger proportion tends to remain localised in/

in the flanks where its influence is wholly misdirected. This wasteful spread of the injected air can, however, be overcome by the application of a tight deep abdominal binder, after which fluoroscopy usually shows a great increase of the air beneath the diaphragm and a proportional lessening of that in other parts of the coelom. The binder has the same usefulness whether or not the patient has a firm tonic abdominal wall, but obviously where as a result of previous distension, for example pregnancy, the parietes are lax, it must be reckoned as of primary importance in increasing the intra-abdominal pressure.

Certain elementary physical laws influence the disposition of the air. In relation to the physically fluid gut and gut contents the air will tend to rise. The author has taken advantage of this fact by performing the operation while the patient is in a sitting or at least a semi-recumbent position. In this position the air rises immediately to the dome of the diaphragm and the bowel of its own weight tends to fall to the lower half of the abdomen. Fluoroscopy proves this beyond question, and percussion of the area of liver dullness shows its rapid lessening or total disappearance. In the recumbent position, percussion reveals first of all an increase in the tympany of the mid-abdominal zone, only slowly followed by/

by a relatively slight lessening of the liver dullness.

(2) (a) Changes in the intra-abdominal pressure.

Whereas in artificial pneumothorax, the manometer gives practically all the essential information, in artificial pneumoperitoneum in the early stages, it is inadvisable to be guided solely by the manometric excursions. Where excursions are obtained they are small and result either in a mean reading of zero or a little more or less add up to a definite but small positive pressure reading. It is in fact difficult to place any reliance on them, and the absence of any excursion whatever need not be taken as indicating that the coelom and the apparatus for insufflation are not in communication. It must be remembered too that as opposed to therapeutic pneumothorax the readings are paradoxical, being positive during inspiration and less positive during expiration. The point is of some importance if certain sites are selected for the initial operation. Generally speaking the nearer the needle point is to the diaphragm the greater is the amplitude of the excursion. They are said to be larger when the induction is undertaken in the hypochondriac regions. It might appear, therefore, from what has been said, that there is little to inform an operator that the entering needle is in/

in such a position that air may safely be allowed to enter. Actually no such doubt need exist. When it is recalled how easy and harmless is the giving of an intra-peritoneal infusion to a child, a clue to a safe technique is immediately given. If, after the more superficial abdominal wall has been perforated, air be allowed free access to the abdomen, by opening the necessary clips on the apparatus, this air will flow after the coelom is entered. Of necessity using this method, pre-insufflation readings cannot be taken, but as has been pointed out they are of questionable reliability for clinical purposes. The air flow can be stopped at any stage during the insufflation and any desired readings taken. Apart from the ease with which air enters the free coelom additional evidence that the operation is proceeding smoothly can be obtained by noting (1) the absence of emphysema of the abdominal wall (2) the increasing fulness of the abdomen as a whole (3) the rapid lessening of the area of hepatic dullness (4) borborygmi, probably the result of increased neuromuscular activity of the gastro-intestinal tract produced by inflowing air, (3) and (5) the patient's statement, difficult to explain, that he or she can feel air going into the abdomen. (6) In a well established case, the easy entry of the needle into empty space is proof enough of the location of the point of the needle in the peritoneal space.

As/

As a result of the insufflation of air into the coelomic cavity, and more particularly since the insufflations are on the average large and about 1000 ccs., the intra-abdominal pressure would be expected to rise. In the 40 cases reviewed, in which the initial intra-abdominal mean pressure could be assessed, the average change in pressure showed a rise in eighteen cases, a fall in fourteen cases. In the remaining eight there was no appreciable change despite proof of the pneumoperitoneum having been successfully achieved. After the pneumoperitoneum had been established pressures became assessed more easily and after each refill the average rise was 12 cms. of spirit. Those in whom the pressure fell or remained as at the commencement of the induction are capable of simple explanation. This is dealt with more fully in a later section, but it will suffice meantime to state that as a result of the rise of the diaphragm and of a reflex relaxation of the abdominal musculature, the peritoneal cavity is enlarged after the insufflation and the pressure falls. Further, if the diaphragm had been previously paralysed by operation and where less active and more fibrotic as a result of pulmonary disease, manometric readings became of the "pneumothorax" type; the inactive diaphragm was drawn up into the thorax during/

during inspiration by the increased negativity of the intra-pleural pressures above and the positive intra-abdominal pressure exerted below. In this respect manometric oscillations at the end of the insufflations were paradoxical as compared with the average pneumoperitoneum. This happened in five instances.

The influence of an abdominal binder applied firmly after induction or a refill is best illustrated by one case record. While in the main it is inadvisable to depart from routine procedures in phthisical patients, this one girl was unusually co-operative. After an injection of 1500 ccs. the mean intra-abdominal pressure was 7 cms. of spirit. The needle was kept in situ and the connections to the manometer kept open, while a many tailed bandage was applied to the abdomen. It was found that as the binder was tightened so the pressure rose. When it was as tight as could comfortably be borne the intra-abdominal pressure had risen to 22 c.ms.. of spirit. The value of the tight abdominal binder in causing an increase in the intra-abdominal pressure with subsequent increase in elevation of the diaphragm has been appreciated by workers such as Gordon,[57,58,59] Foix[50] and Mattie.

(2) (b) Changes in the intra-pleural pressure.

Since, as will be shown later, the diaphragm rises considerably/

considerably under the influence of penumoperitoneum, it can reasonably be expected that the intra-pleural pressure will become less negative. Salkin (110) believes this to be the case. The author's series did not, however, offer scope sufficiently adequate to confirm or deny this observation. Either the patients' general condition was such as to contra-indicate any pneumothorax, or pneumothorax having been tried, the pleural spaces were found to be obliterated and so rendering a manometric reading impossible. In one case, however, it was thought advisable to supplement an existing artificial pneumothorax by artificial pneumoperitoneum. The average manometric readings for three entries into the pleural cavity before abdominal insufflation were - 9 cms - 12 cms. and -21 cms. - resulting in a mean intra-pleural pressure before refill of the pneumothorax of - 14 cms. of spirit. Similarly three pleural readings soon after the establishment of an artificial pneumoperitoneum were - 9 cms, - 9 cms. - 5 cms. averaging - 8 cms. of spirit. Comparison shows that the intra-pleural pressure would appear to have risen 6 cms., or in fact to have become less negative. Itself of no great importance, this lessened negativeness implies a proportionally lessened strain on both healthy and diseased lung tissues.

3./

3. <u>The influence of pneumoperitoneum on the diaphragm and on the lungs</u>.

A rise occurred in both diaphragmatic domes in each of the forty cases under discussion and this was confirmed by fluoroscopy and verified by measurements on X-ray plates taken before and after induction of the pneumoperitoneum. The comparative measurements of the positions of the domes of the diaphragm was obtained by dropping a vertical line to the diaphragmatic domes, and at right angles to a horizontal line drawn across the upper surface of the transverse process of the first thoracic vertebra. It was found that the average elevation was 2-3 ins. In six cases there was a greater rise in the right side when compared with the left side. The maximum elevation obtained in this side was four inches. In three cases the left side of the diaphragm was more elevated than the right side. These results differ slightly from those recorded by Banyai.(14) He found that there was a tendency for the left side of the diaphragm to be more often elevated than the right side. He believed this was due to a mobile stomach, which allowed a larger amount of air to collect beneath the dome of the diaphragm in the left side. In five cases a much greater rise in the hemi-diaphragm followed interruption of the phrenic nerve. While comparison is difficult/

difficult between the effects of any two phrenic nerve interruptions, there was little doubt in the author's mind that in these five cases the rise in the diaphragm was greatly accelerated by the pressure of air beneath it. (Cf. X-ray plate No. VII). But while a combination of pneumoperitoneum and phrenic nerve interruption gives a high rise in an immobile diaphragm, it was found that in fourteen cases the diaphragmatic movements were greatly reduced and as already mentioned, movement became paradoxical in five cases. Further the diaphragm became atonic in time and in appearances approximates to a diaphragm long unaccustomed to movement. To some extent this effect may be due to the diminished spasticity which follows adequate treatment of the lung lesions.

The changes in the volume of the lungs are difficult to assess on so few cases, and the literature of pneumoperitoneum makes scant reference to the subject. A study of the respiratory rates of the patients under review gives no conclusive result. A rise in the respiratory rate and a decrease in the respiratory excursion were noticed in about ten of the patients but it was referable only to a short period towards the completion of and immediately following a refill; and more particularly if the refill were large (1500 ccs.). The amplitude of the respiratory excursions/

excursions became greater in some during an equally large inflation, but a short time after the completion of the operation there was no visible departure from the normal depth of respiration. Changes in the vital capacity were equally indefinable. Individual changes covered a wide range, and while it would be expected that a fall in the vital capacity would occur as the pneumoperitoneum became effective, this was not always the writer's experience. The average vital capacity was about 1600 ccs. and of those showing a drop, the average drop was about 200 ccs. Nine cases showed no alteration whatever and nine cases demonstrated a rise in vital capacity averaging 130 ccs. This last finding is somewhat surprising but it must be remembered that the discrepancies in vital capacity already shown appear to be equally common after bilateral interruption of the phrenic nerve trunks. Cohen and Willauer (29) in their review of bilateral phrenic nerve paralysis have recorded a rise in some of their cases.

(4) (a) <u>The effect of pneumoperitoneum on the abdominal parietes</u>.

Almost as soon as air is allowed to enter the peritoneal cavity, one can make out a slight degree of rigidity of the abdominal musculature, fairly well localised to a small area surrounding the site of inflation. As already/

already mentioned there was a diminution of the respiratory movement generally and the abdominal movements were coincidentally reduced. Relative th the amount of air injected the abdomen distended, there being, as would be expected, a physiological relaxation of the abdominal wall. Salkin and Waggoner (110) (129) have done much work on this aspect of the subject and they point out that it represents a reflex attempt on the part of the abdominal wall to return the intra-abdominal pressure to atmospheric pressure. It must not be thought that this return of the pressure to normal in any way vitiates the value of pneumoperitoneum in the treatment of intra-pulmonary disease; it might in fact be put forward that the rise of the diaphragm, which is the essentially desired therapeutic effect, is in great measure a similar effedt to that already described for the abdominal wall, each of the two fibro-muscular sheets relaxing and bulging away from the centre of the abdominal cavity.-

(4) (b) Visceral changes.

(i) The liver: In every case there resulted a degree of ptosis and fluoroscopy revealed a liver suspended between gaseous bubbles. A degree of rotation of the organ is commonly seen, but only in one patient did this ptosis and/

and rotation become gross; it was remarkable that there were no concomitant symptoms. In such an example of course the ligaments became visibly stretched. While it cannot yet be said that in this case there was a complete return to normal, since the girl is still continuing with treatment, in others it was found that there was complete restitution after treatment had ceased some time.

(ii) The Stomach: Banyai and Jurgens (13) state that the stomach takes up a more transverse position during the course of a pneumoperitoneum. Probably for this reason Alexander (4) recommends artificial pneumoperitoneum to offset the dyspepsia which so often follows interruption of the left phrenic nerve. In one of the writer's patients it was found necessary to examine the gastrointestinal tract radiologically after a barium meal had been ingested. The opportunity was taken to investigate the statement already attributed to Banyai and Jurgens, but the radiologist and the writer saw little other than slight ptosis of the stomach.

(iii) The cardiovascular system: By reason of the central position which the heart occupies, and since the central tendon on which it rests moves but little, the heart was not found to be positionally altered in any patient. Similarly few changes of any nature could be observed in the blood vessels. It would be thought that the/

the abdominal distension of an artificial pneumoperitoneum coupled with the tight abdominal binder, mentioned in a previous chapter, might have caused interference with the venous return from the vessels joining the inferior vena cava, particularly in its lower extremities. The loss of, or at least the diminution in the pump-like suction or action of the diaphragm which would result from its lessened movement would be expected to aggravate this condition. Hughes (65,66) is of the opinion that in children, at least, diaphragmatic action is of great importance in the venous return and has shown that a tight binder applied over the abdomen and lower ribs caused a measurable and noticeable increase in the volume of the lower limbs. It would appear that neither of these factors play such an important part in the circulation of the adult at least under the conditions imposed by a pneumoperitoneum. The writer investigated the possibility in ten patients. The lower limbs were measured before, during and after a large refill, and in no instance was the measurement during or after insufflation greater than that recorded before the commencement of this investigation. A fixed point, 3 inches below the tibial tuberosity was selected to measure the alterations in the circumference of the leg. At the same time/

time pre-existing varices and haemorrhoids were made no worse by the abdominal distension and increased intra-abdominal pressure. (105) Ricci and Irelli in nine instances of pneumoperitoneous showed that the venous pressure dropped half an hour after an insufflation and remained at this low level for an interval of 24 hours.

PART TWO.

A GENERAL REVIEW OF COLLAPSE THERAPY.

THE AIMS OF COLLAPSE THERAPY.

In order to appreciate fully the peculiar though limited scope of pneumoperitoneum it is desirable to review in brief the aims and achievements of the treatment of pulmonary tuberculosis. First let it be said that the author's teaching and training have been augmented by considerable personal experience and all have confirmed that no form of collapse of diseased lung tissue can replace the generalised benefits of a sanatorium life for those who suffer from other than inactive pulmonary tuberculosis. Whenever there is the slightest tendency for tuberculous lesions to spread, collapse methods in ever increasing variety and ingenuity must be regarded as enhancing this routine of hygenic rest. Where, however, the intrapulmonary mischief is the late result of destructive tuberculous processes, it may be conceded that collapse alone of some form or other will to some extent restore the status quo ante; and in fact it is axiomatic that many of the late results of pulmonary tuberculosis would gain but little from the maximum of bed rest and the optimal nutritional and climatic circumstances. It is not out of place to state here, that pneumoperitoneum/

pneumoperitoneum shows its greatest value in the first class of patient and can confer practically no benefit for those in the second group. The specific indications will however be formulated later.

From what has been said it is obvious that pneumoperitoneum can never be a substitute for a well planned thoracoplasty either complete or apical, with or without fasciolysis. Thoracoplasties (37) are par excellence operations which aim at the obliteration of cavities, the relaxation of stressed fibrous tissue and the replacement of mediastia drawn over by old standing disease. They are operations which in general take their place late in the therapeutic programme of tuberculosis. Only rarely have they been done where the disease in the affected lung was yet wholly or very active, and significantly when so done, the end results are not good. Finally from their very permanence their success depends on the degree and activity of any disease in the contralateral lung. While the presence of some disease in the better lung is not a contraindication, it is still at least in a majority of opinion that when present it should be reasonably certain that it will either become rapidly quiescent or if already inactive remain so; and those who best know tuberculosis are the most cautious in giving such an/

an optimistic opinion. He would be rash who would say that bilateral lobectomy for persistent cavities will have no place in the advance of thoracic surgery, since it seems established already in America (40) as a reasonable measure where only one lobe is affected.

Extrapleural pneumothorax can probably be the most selective of all forms of collapse therapy. Its comparatively recent revival at the hands of Brock, (125) Roberts, (106) Sellars, (116) and others recalls the work of Tuffier in 1893, Baer (8) in 1913, and others, in their attempts to achieve localised adequate collapse or localised compression. Those workers in common with the present day thoracic surgeons realised the disadvantages of collapsing large areas of very vital healthy lung to achieve the adequate relaxation of those portions affected by disease; this realisation has greatly widened the scope of pulmonary collapse in tuberculosis. It is now a recognised procedure to combine two forms of localised collapse in the too frequent bilateral lesions provided that sufficient healthy tissue is left to maintain adequate respiration. Patients submitting to these combined procedures must of necessity have considerable powers of recuperation, and the rare mental attitude which either actively through their set purpose to recover, or passively allows them to survive psychically unscathed the strain of repeated operative interference. They are, on the average, people/

people who have gone a long way to stabilisation before seeking treatment, but who in the presence of gross toxaemia would have been poor operative risks for even such a relatively simple operation as extrapleural pneumothorax. Nevertheless this is an operation which, simple measures having failed, can and does so benefit a patient that the resultant improvement allows him to qualify for more radical and finite procedures at a later stage of his treatment; and while the late results of extrapleural pneumothorax are not so well established as those of the more common intrapleural variety, there are sound reasons for believing that in many instances it effects healing. The writer's innate caution suggests that its indications are only now becoming clarified, and the number and variety of its early complications yielding only now to growing experience.

Of artificially induced intrapleural pneumothorax relatively little need be said. Its worth in innumerable cases is proved. In its perfect form, the collapse that it produces, causes uniform concentric relaxation of the diseased lung, and so allows young fibrous tissue, formed as a result of the patient's inherent ability to heal, to mature to its safe permanent maximum contraction. Under its influence cavities diminish and with perseverance close and remain closed, and thereby removes the risk of secondary infection, homolateral/

homolateral on contralateral spread and haemoptysis and its sequelae. There can be few more satisfactory experiences than to induce and maintain a 90% collapse in a diseased lung when the remaining lung is radiologically and clinically free of microscopic disease. But the writer craves indulgence if he stresses what has been said represents an ideal all too seldom seen even in the ideal unilateral lesion. It is admitted that the number attaining effective collapse is greatly increased by section of adhesions and by combining intrapleural with extrapleural pneumothorax, but invariably in a large sanatorium a considerable number of the one time excellent pneumothoraces have eventually to submit to major surgery for one reason or another. If these results are so for the ideal patient, it follows that conditions are much worse for those in whom the ideal indications are not satisfied; and in the same dialetic vein one reaches a group of patients in whom, pneumothorax having been only partially successful, their condition has not been so improved as to warrant the putting into effect Alexander's (5) dictum that having decided on collapse it must be attained by progressive measures in inevitable sequence. Of the various forms of bilateral pneumothorax interval or simultaneous - volumes could be written of its indications and its failures. The people who show the theoretical indications/

indications for this line of treatment still form the bulk of the average tuberculous hospital population, together with those for whom even the most enthusiastic operator would hesitate to recommend any form of collapse therapy. It is from among those unfortunates that the writer feels that here and there some could be treated by pneumoperitoneum, who improved by it, would pass on to more radical and admittedly more satisfactory forms of collapse.

Nothing has so far been said of operations on the phrenic nerve, but in its effects on the lung above it, interruption of the phrenic nerve has many points of similarity to pneumoperitoneum. Phrenic interruption of a temporary nature is probably the safest primary operation in a programme aimed at the control of a tuberculous lesion. The minor character of the operation with its ¾" - 1" incision, about one finger's breadth above the sterno-clavicular joint, with the centre of the incision over the lateral border of the sterno-mastoid muscle, the absence of a general anaesthetic, and its non-repetitive character make it a less taxing introduction to the surgical treatment of surgical tuberculosis than possibly even pneumothorax, which can readily be induced later if temporary phrenic paralysis fails to achieve the desired results. However, phrenic paralysis can scarcely be thought suitable for the type/

type of patients who form the basis of this thesis, as will be shown later. For them any phrenic operation would require to have been bilateral and, if not permanent, at least effective for a very long period. The literature of bilateral phrenic paralysis is relatively small, and certainly some of the results have not been very encouraging. Fishberg (47) quoting Brauer states: "I know of patients who had thus been operated upon and who succumbed in great misery". Alexander (6) in his "Collapse Therapy" says "It seems to me that the indications for permanent bilateral paralysis must be very few; I have never seen a patient for whom I felt it was indicated". Cohen (29) and Willauer published their results in eleven cases, a number which constituted a larger group of cases than had been reported in the literature up till that time. Having crushed the first nerve they injected a small amount of novocain (0.5%) into the second nerve and observed the patient for at least twenty minutes before crushing the nerve. In two of the eleven cases there was sufficient dyspnoea to warrant discontinuing further attempts at diaphragmatic paralysis. O'Shaugnessy (91) published his results in four cases in which evulsion of both phrenic nerves had been performed. One patient became definitely worse but three patients began to show improvement. Dunner (41) reports a case of suffocation that/

that occurred when both diaphragms became elevated. Duryea (42) contributes a case in which he successfully performed this operation just after post-partum. By means of this operation he believed that he counteracted the harmful consequences which result from the sudden descent of the diaphragm. Eugenio Curti (32) performed bilateral operation at one sitting in five of his six cases and his results were:-

> One patient, the only one in whom exairesis was performed developed dyspnoea and tachycardia and died ten days after operation from cardiac failure.
>
> One patient died three months after operation with intestinal tuberculosis.
>
> One patient lost sputum one year after the operation and felt slightly dyspnoeiac on walking fast.

In two patients there was considerable improvement. Only one patient was slightly improved as a result of the operation. From the above results bilateral phrenic operation should not be hastily advised and the writer can only but conclude that such an operation attains its greatest and safest therapeutic results in conditions which are not essentially tuberculous in origin as, for example, in five cases of post-encephalitic spasm of the diaphragm (20,54,118,119,120) which appear to have been successfully treated by this operation/

operation. The writers state that none of the post-encephalitics suffered unusual dyspnoea, but this result is not surprising when it is remembered that they started with healthy lungs and had no atrophy of the accessory muscles of respiration which often accompanies tuberculosis.

THE INDICATIONS FOR PNEUMOPERITONEUM.

From what has already been said, in the short review of collapse therapy, it must be obvious that pneumoperitoneum must be considered only after other forms of collapse have been rejected. Those who live and work in a modern sanatorium will realise that while even in a rate maintained institution, such as Robroyston Sanatorium, the number of patients suitable for pneumothorax, thoracoplasty and allied procedures may reach 33%, yet there is left a great number who by reason of the extent of their disease, or of the failure of the originally planned procedures, are considered unsuitable for the unquestionable advantages of collapse therapy. For those too often the prospect degenerates into periods in and out of sanatoria, till the ultimate break up which results in permanent confinement to bed. It is no purpose of the writer to discuss their treatment; too often he feels that those people receive courses of gold, treatment with tuberculin and whatever may be the local enthusiasm of the period. No one working in a sanatorium can have failed to see that the/

the phthisical patient is on the whole an intelligent being, if perhaps his wit and increasing knowledge of his illness are often wholly selfishly arrested to his own benefit. Certainly there is ample evidence that those who do not receive collapse measures realise soon that their lot is a precarious one. No better are those in whom the simpler collapse measures have failed. It is from these people, the advanced and rejected, that one selects some whom the writer believes benefit from pneumoperitoneum.

The comparative immunity enjoyed by phthisical patients during pregnancy is a phenomenon familar to those who have observed a large number of cases. No less striking is the acute exacerbation of the disease which so frequently follows labour. Consequently the early workers in artificial pneumoperitoneum were induced to try this form of treatment in pulmonary tuberculosis when they observed the beneficial effects which a pregnant phthisical woman derived in the latter months of gestation. The problems of the reciprocal relations between pregnancy and tuberculous disease have been widely discussed, though some might say that they have not yet been satisfactorily studied. For many centuries, ever since the days of Hippocrates, physicians have stated that pregnancy ameliorates the disease in the female tuberculous patients, and some like Cullen/

Cullen (1712-1790) even recommend marriage for tuberculous girls. This view, of course, would not be tenable nowadays, but it illustrates the remarkable effect which pregnancy, especially in the latter months, has on a phthisical subject. There are many other writers who speak in a similar vein. Fishberg (48) states: "I have seen numerous pregnant women with progressive and far advanced lesions go through the long months of pregnancy and die soon after delivery, but I have not seen one die before delivery". The combined (78) writers state: "That pregnancy exerted a beneficial effect on women suffering from tuberculosis. The women seem to have a period of improved health throughout gestation. They put on weight and looked very well. It was realised that such women often succumbed to tuberculosis soon after the end of pregnancy". When one analyses both these quotations, one is struck forcibly by the fact that pregnancy in the latter months has not an aggravating influence on the tuberculous process in the lungs but that soon after the termination of a normal confinement diastrous exacerbations of active tuberculosis occur. How the pregnant uterus is able to influence beneficially the patient with phthisis is still a very difficult problem and why the same patient should become progressively worse at the end of pregnancy must, until further satisfactory data is provided, be/

be a very complex problem. A possible explanation for both these observations is offered in the suggestion that advancing pregnancy results in an elevation of the diaphragm similar to that following a phrenic nerve crush, while the deleterious effects that follow normal labour may be explained by the sudden removal of the beneficial effects due to the elevation of the diaphragm. Men like O'Shaugnessy (73) appear to be much of the same opinion for he states: "It is justifiable to assume that pregnancy in fair economic circumstances has no aggravating effect on tuberculous lesions; in fact, the elevation of the diaphragm in the later stages may be beneficial by causing some diminution in the volume of the lungs. But labour, owing to the great strain involved and the sudden descent of the diaphragm, probably does influence unfavourably the course of latent or progressive tuberculous lesions in the lung. A history of a recent confinement should therefore prejudice in favour of a diagnosis of progressive pulmonary tuberculosis". Crocket (30) lends support to this theory when he recorded the influence of the increased intra-abdominal pressure which occurred during pregnancy on the lung lesion. He states: "The increased pressure acts on the lung like an artificial pneumothorax, or a phrenic avulsion operation which causes the diaphragm to rise up into the thoracic cavity. The pressure/

pressure created is selective and is effected on the diseased areas; particularly, the elastic tissue of the healthy lung resists pressure until the non-elastic diseased tissue is fully compressed. When labour takes place, a change occurs of the utmost importance from the point of view of the lung lesion and the patient's health. The pressure relieved, the lung expands again fully and the fibrous tissue encpasulating the diseased areas is relaxed or ruptured. As a result tubercle bacilli are liberated from the various foci, and may be disseminated in the lung tissue or may be distributed to distant parts by the blood or lymph stream".

Pursuant to this opinion it was thought that support might be obtained by performing pneumoperitoneum on advanced bilateral disease. The aim of pneumo-peritoneum is to imitate the mechanical effects produced by the pregnant uterus in the latter month of gestation. Pneumoperitoneum can produce a similar but better elevation of the diaphragm with limitation of the amplitude of the diaphragmatic excursion, and if this treatment be supplemented by a phrenic crush on the worse side, then a greater and more valuable amount of pulmonary relaxation can be obtained. The diminution in lung volume must be greater than is usually appreciated as the elevation of the diaphragm occurs at the base/

base of the broad thoracic cone.

This volumemetric diminution must be a decided advantage for it tends to nullify the drag on the lung lesion which necessarily occurs during inspiration and, the ascent of the diaphragm, which is a natural result of pneumoperotineum, relaxes the pleuritic adhesions at the base, as well as any fibrous bands which are present, not only at the base but also extending upwards towards the apex of the lung. The gaseous interchange in the lungs becomes diminished, and the circulation of the blood and lymph retarded. By this stasis within and about the lesions the infection has a fair chance of remaining localised. The lung may be regarded as being in a state of partial rest. The diaphragm, which remains elevated as a result of the air pressing upwards on its peritoneal concave surface, becomes after some months thin and atrophic, and offers very little resistance to the intra-abdominal pressure.

This upward unimpeded force of the abdominal pressure makes coughing easier and more productive and as a result the patient coughs less frequent, the amount of sputum diminishes and changes in character with improvement of the lesion. As stated in a previous chapter, the writer in an attempt to increase the intra-abdominal pressure still further/

further has employed a tight abdominal binder as a co-adjuvant to pneumoperitoneum and pneumoperitoneum plus phrenic crush. On the basis suggested by the preceding paragraphs the writer would suggest that pneumoperitoneum would prove of value in the following conditions. It must be emphasised again that the operation in no way replaces adequate sanatorium treatment and does not prohibit the use of ancillary measures such as chrysotherapy.

(a) Extensive active pulmonary tuberculosis, bilateral with severe toxaemia.

The author doubts if many of the ardent advocates of artificial pneumothorax would consider this form of collapse therapy in this type of case. The application of pneumothorax to a lesion such as that envisaged in the above title is to be deprecated for when the disease is active and extensively bilateral, adequate collapse of both lungs is apt to produce so much dyspnoea that treatment has to be abandoned. In the chronic type of lesion, bilateral collapse is better borne because of the presence of adhesions which restrict the degree of lung deflation and the great danger of disseminating the disease to the remaining healthy lung tissue is greatly diminished. However the degree to which the lungs may be collapsed without gross signs of dyspnoea has always been a matter of great wonderment, and in view of/

of this experience many people would feel they were justified in advising a bilateral artificial pneumothorax even in the above type of lesion. The writer confesses, he fails to see what variety of bilateral pneumothorax could be administered to the patient with acute extensive bilateral pulmonary tuberculosis with much toxaemia without endangering life.

The term bilateral artificial pneumothorax is very often loosely employed to denote any one of three principles used when subjecting both lungs to collapse therapy by artificial pneumothorax. The essential difference in the principles is the stage reached in the treatment by collapse of the first lung before pneumothorax is commenced in the opposite pleural cavity. Thus an "initial simultaneous bilateral artificial pneumothorax" signifies that the second lung is induced a few days after the induction of the first lung. This type of bilateral pneumothorax would be reserved for the subacute type of bilateral lesion with not too considerable damage of the lung tissue. As a matter of fact, "initial simultaneous bilateral pneumothorax" appears to have fallen into disfavour. The more usual principle adopted is the "interval simultaneous bilateral artificial pneumpthorax", which is more widely used. By this method an interval of some months is allowed to elapse between/

between the induction of the first side and the second side. This type of bilateral pneumothorax, in the writer's opinion, is highly serviceable and often very effective but not in the acute extensive lesion with toxaemia, for, when the pneumothorax is induced and maintained on one side for many months, the other side will soon show the effects of strain. Pneumothorax of this variety is specially applicable to the subacute type of lesion in both lungs with healthy lung tissue left to maintain the respiratory function of the lungs. In an acute lesion, such as that described above, when a pneumothorax is induced on the one side there is initially in this homolateral side a generalised collapse affecting the whole surface of the lung, and as a result the patient becomes dyspnoeic since there is very little healthy lung parenchyma in the contra-lateral side. The lesion in this lung would tend to become aggravated and would endanger constitutional symptoms leading to a fatal issue. "Successive pneumothorax", the third principle, is not strictly speaking a bilateral pneumothorax for the lung collapsed is allowed to re-expand before pneumothorax treatment is begun on the opposite lung. This type of bilateral pneumothorax is reserved usually for the case in which there is some fibrosis in the contra-lateral lung, and this state of affairs naturally does/

does not exist in the acute bilateral lesion with toxaemia - a very definite contra-indication to a successive bilateral artificial pneumothorax.

The ideal in bilateral cases is to obtain a selective collapse in both sides so that the diseased portions of both lungs are collapsed and the healthy portions maintain their functions. Parry Morgan (86) was the first to suggest that a partial pneumothorax would produce the same results as a complete one by resting the diseased part. He pointed out that during inspiration the normal parts of the lung expand against the chest wall, so that a small quantity of air in the pleural cavity would tend to collect over the less expansive or diseased portions. This type of selective bilateral artificial pneumothorax is specially applicable to the local apical lesion, but it finds no application in a lesion which is widespread throughout both lungs as in the acute bilateral case of pulmonary tuberculosis with toxaemia.

The value of specific remedies, as an alternative method of treatment to pneumoperitoneum in an acute bilateral lesion, would find very few supporters. There are two preparations which have been widely used in tuberculosis, and which, the writer feels, deserve some recognition at this juncture. They are tuberculin and gold preparations. Workers/

Workers in tuberculosis are unanimous in their opinion that there is no specific drug for tuberculosis like quinine in malaria, sulphapyridine in pneumonia. On the value of tuberculin there are opposing schools of thought. There are those who regard it as useless; those who regard it as a panacea; and those who regard it as a placebo for their patients. The writers on the subject of tuberculin are innumerable, opinions and results regarding its place in treatment, prevention, and diagnosing are conflicting, but be that as it may, it is generally accepted that acute tuberulous lesions in the lungs with toxaemia are very definite contra-indications and that the vaccine has its most beneficial effect in the chronic type of lesion. Bandelier and Roepke[9], who did much of the early work in tuberculin, state that "definitely progressive forms of disease need not be considered for tuberculin treatment, nor is much to be expected in the cases of advanced processes where much destruction of lung tissue has taken place".

Gold therapy is much more popular than any of the other so-called specific drugs. It certainly does not produce the sterilisatio magna in man or animals that was claimed in the early days of its re-introduction by Mollgard[85]. It is toxic and can produce severe reactions and/

and complications and yet in some cases it appears to do good. In acute cases gold salts may aggravate the condition and if used at all should be given in very small doses. It is generally agreed that patients, who have chronic pulmonary tuberculosis and who are failing to improve or becoming slightly worse under simple routine treatment, do in many cases show a remarkable improvement as soon as they are given gold, (Burrell)[25]. In Robroyston Hospital gold therapy is mainly reserved for the above type of case and as a valuable adjunct to other methods of treatment as, for example, artificial pneumothorax on one side with disease on the other side. The gold is given with pneumothorax to treat the contra-lateral lesion, acute tuberculous lesions with gross fever being a very definite contra-indication. This seems to be in agreement with Holger Mollgard's[85] view for he states - "In more advanced cases sanocrysin treatment must, owing to its whole nature be perilous, while in the more seriously attacked patients it will offer only a slight chance of recovery."

Rest, hygiene and good food have been the time honoured and traditional therapeutic triad for a great many years. They have withstood the test of time, rest being the most important of them. No surgical procedure yet/

yet introduced in the treatment of tuberculosis has been able to dispense with this standard method of curing tuberculosis with rest. The application of the principle of rest remains the same. Pneumo-peritoneum is to be regarded simply as an extension of the principle of rest. Both must work together in order that the bodily defences are conserved and augmented.

A temporary phrenic nerve crush plus an artificial pneumothorax might appear on paper an excellent alternative to pneumoperitoneum, but when this form of treatment is suggested one must not lose sight of the fact that, in the type of case under consideration, both sides are actively and extensively involved and if a pneumothorax has to treat one of the diseased sides, it must be a very complete collapse on that side. The success of a phrenic nerve operation on the other side may be attended by some complications. In the first instance the surgeon may not be successful in crushing all the accessory fibres of the phrenic nerve in which case the effectiveness of the operation is greatly reduced. Again, a temporary phrenic crush may prove in the end to be a permanent crush in which case the vital capacity is permanently reduced in the homo-lateral side, and if the artificial pneumothorax proved to be ineffective after some months, any radical surgical procedure/

procedure at a later date, if the patient's condition improved sufficiently, would be influenced prejudicially by this form of treatment.

Rest alone in the acute bilateral lesion leaves too much to chance. These patients cannot afford to wait too long. It is quite true that in some instances improvement does occur, but again many of them go rapidly downhill. It is admitted that the prognosis in tuberculosis is most difficult to assess for one is dealing with a lesion which is subject to natural fluctuations in severity, and sometimes shows the strongest tendency to spontaneous healing under an ordinary hygienic regimen, but it seems a pity that when pneumoperitoneum disturbs the patient so little, and when there is a chance of the latter deriving some benefit from this therapeutic measure, that it should be denied the patient. One great advantage of pneumoperitoneum, which should be mentioned here, is its revocatory principle. Air can be given to the patient in gradual doses, e.g. 300 ccs., and if this is tolerated well by the patient, then this amount can be increased, but once there are signs that the air is not being borne well, it can be withdrawn from the abdomen or left, for small amounts are very quickly absorbed from the peritoneal cavity.

Pneumoperitoneum with complete rest, in the writer's opinion, offers the patient with the acute bilateral chest lesion, the best possible chance.

(b) Bilateral pulmonary tuberculosis, in which an artificial pneumothorax has been attempted, but for one reason or another has failed.

In theory at least there would appear to be many combinations possible to replace the failed pneumothorax and with the improving technique on chest surgery, it may be expected that the various combinations will be increasingly employed. The application of these double procedures is however limited firstly by the presumed amount of healthy lung left to function, - and frequently this would appear to be little; secondly it must not be forgotten that the results of the planned operations are influenced by the complications of each. Unquestionably properly chosen bilateral procedures will give better results in those patients in whom the disease is relatively limited, but in the type of lesion visualised by the writer and frequently encountered, there is often much granulamatous infiltration round and below the older lesions. Many there are who would suggest double phrenic interruption but from what has been already discussed in a previous chapter it is a procedure which can scarcely be regarded as encouraging.

Done/

Done as a unilateral operation, it goes only a very little way to solving half the problem. If the nerve be interrupted permanently, by section or exairesis, the chances of a successful thoracoplasty in the future are jeopardised,(38) and if done by crushing, the operation probably will have to be repeated, if, as sometimess happens the nerve recovers its conductivity.

In the writer's experience pneumoperitoneum should be considered in every bilateral case where there are present advanced lesions more or less equally distributed and unaccompanied by considerable activity either round them and below them. The lesions should be so extensive that effective collapse, and this does not of necessity infer complete collapse, of the lesion will be impossible by reason of the greatly reduced vital capacity that it would occasion. It is not suggested, and it has in fact already been denied in this thesis, that pneumoperitoneum will go a long way to closing cavities present. It will however do much to reduce to quiescence the exudative disease in either of both lungs, which offers such a handicap to the thoracic surgeon. Once this more recent soft mischief has been eliminated, it may be found that much less extensive thoracic collapse will be required to attain/

attain cavity closure. In some cases the performance of a closely selective extra-pleural pneumothorax will achieve this end, and in some small but locally drastic thoracoplastic operations will be necessary. Everything points to a revival of direct drainage (33) of cavities and the author visualises many cases in the future being treated by this procedure coupled with pneumoperitoneum. (707)

(c) Active pulmonary tuberculosis, artificial pneumothorax having been tried and failed.

The activity and distribution of the lesion in this group precludes any preference for the more radical measures; at least in the early stages. Surgical interference is reserved for a much later date when the achievements of the minor procedures have been successfully fulfilled. These attainments are (1) the restriction of the progress of the disease (2) the disappearance of much of the exudative process in the lung, and (3) a lessening of the activity of the infection. The least severe and revocable measures should be adopted first. No doubt the sanguine supporters of the doctrines of pneumothorax form of collapse therapy would recommend this procedure in the more extensively diseased lung. They would also supplement the pneumothorax with a phrenic operation on the contra-lateral side/

side. The writer most certainly agrees with these principles and from his own personal experiences could produce evidence to justify their value. While appreciating the advantages of this combined form of collapse therapy he is aware nevertheless of certain disadvantages associated with this procedure. The vital capacity, for example, is always in danger of being seriously reduced by (1) the pneumothorax causing an exacerbation to the contra-lateral lesion, especially in the hands of the inexperienced (2) the inability of the surgeon to assess and even control the rise in the diaphragmatic dome.

Theoretically a selective bilateral artificial pneumothorax would meet the demands of the lesion in question. This therapeutic recommendation is difficult to obtain. Air tends to rise and this physical property abrogates the clinical application of a selective pneumothorax to a basal lesion.

Despite the reluctance of the medical profession to accept departures from traditional therapeutic orthodoxy the writer feels justified in recommending artificial pneumoperitoneum as one method of treating the lung lesion under discussion; in assessing this procedure as an alternative method of treatment to artificial pneumothorax supplemented by/

by phrenic nerve operation the following points are worthy of consideration:-

1. The treatment is simple, revocable, less severe to the patient and the rise in the diaphragm is always under the operators control.

2. The procedure treats both lungs at the same time and besides helping to control a spread from the basal lesion it contributes towards the final arrestment of the disease by permitting more radical measures to be adopted at a future date.

3. The treatment combines well with other therapeutic measures.

4. In one instance the writer applied the principles of pneumoperitoneum to the type of lesion under discussion. The results were most satisfactory.

(d) Tuberculosis of the lungs in the puerperium.

These would seem ideal cases in which to advise pneumoperitoneum. The air in the peritoneal cavity would replace the mechanical benefits derived from the enlarged uterus during the latter months of pregnancy.

(e) Pneumoperitoneum used to stabilise and enhance the value of a phrenic crush.

Pneumoperitoneum can maintain and keep elevated, often at a higher level, the dome of the hemi-paralysed diaphragm, c.f. X-ray plate No. VI.

(f) Arrestment of haemorrhage.

The author has applied pneumoperitoneum to four cases of haemoptysis with definite success in one case; three of these patients died, indirectly as a result of the haemorrhage; a widespread broncho-pneumonic dissemination of the tubercle bacillus had occurred before the bleeding was arrested.

(g) Emphysema.

The relationship between the intra-pleural and intra-peritoneal pressures are reversed in emphysema. Pneumoperitoneum by causing an increased intraperitoneal pressure adjusts the disequilibrium between the intra-thoracic and intraperitoneal pressure and the patient obtains relief from his dyspnoea.

In emphysema, a condition exists in the chest in which the very voluminous lungs become too large for the bony thoracic cage. The lungs keep the diaphragm in a position of almost full inspiration and as a result the latter contracts very little, if at all. The chest expands to a barrel shape but a limit is reached when no further/

further distension occurs no matter how great the respiratory effort. Thus the lungs become imprisoned as it were in the bony cage; the vital capacity of the lungs becomes reduced; and finally, the respiratory demands of even slight exertion cannot be met without distress. Sudden relief from this constriction of the lungs is felt as a great relief. The Germans, about twenty years ago, gave much attention to devising operations which would overcome the mechanical defects, and at the same time, facilitate the patient's breathing. Thus, Freund (52) and Seidel (115) advocated an operation which included the severance of the costal cartilages. They hoped by this operation to relieve the highly positive intra-thoracic pressure. The popularity of this operation has now waned, for the severance of the cartilage is really illogical in that it permits the already stretched alveoli to stretch still further. The observations that patients with advanced emphysema assumed positions which compressed the abdomen as, for example, leaning forward, led to the development of belts, (2) which the patients could tighten and which would increase the intra-abdominal pressure and give the patient relief.

In the writer's opinion, pneumoperitoneum would suit this type of case admirably, for the intra-abdominal pressure/

pressure could be increased as desired, the patient would be more comfortable at night as well as during the day, and would not require to wear a very tight and irksome belt, whose power of increasing the intra-abdominal pressure was very limited. It would only be necessary for Pneumoperitoneum to be administered once per week or once a fortnight, and a greater diaphragmatic elevation would be obtained and more constantly maintained over longer periods of time.

The mechanism is quite simple and quite logical. The suddenly increased intra-abdominal pressure is directed upwards against the flattened diaphragm which is pushed up into the thorax towards the position of relaxation. The lungs become forcibly deflated in part, and as a result the diaphragm is no longer held down in the position of contraction or full inspiration. Piaggio,(95) Blancho and Ciammi claim excellent results from such treatment but the writer has not so far had the opportunity of treating emphysema on these apparently sound principles.

What has been written on the indications for pneumoperitoneum cannot cover all patients and all varieties of lesions; each patient must be treated as an individual.

On the rough indications given the writer's patients are divisible as follows:-

(a)/

(a) Extensive active tuberculosis, bilateral with severe toxaemia.

(b) Bilateral pulmonary tuberculosis, artificial bilateral pneumothorax having been tried and failed.

(c) Active pulmonary tuberculosis, one side extensively diseased and one side having mainly a basal lesion.

(d) Tuberculosis of the lungs in the puerperium.

(e) Pneumoperitoneum to stabilise or enhance phrenic paralysis.

(f) For the arrestment of pulmonary haemorrhage - other measures having failed or plainly contra-indicated.

(g) For severe pulmonary emphysema.

PART III

TECHNIQUE OF ARTIFICIAL PNEUMOPERITONEUM.

(1) PREREQUISITE FACILITIES.

If, as is usually the case, when pneumoperitoneum is instituted the patient has active bilateral pulmonary tuberculosis, bed rest with careful and skilled nursing should be prescribed. It is perhaps redundant to raise the question whether a patient should be treated in her own home or in an institution. Treatment in home is not to be recommended, for the intimate knowledge of the patient required by the physician for the successful application of treatment can be obtained only as a result of supervision in a well run sanatorium. The necessary discipline can seldom be effected in the family "circle" and contact infection must not be ignored. Yet there are patients who seem to raise strong objections to going into a sanatorium and in such cases the physician may be obliged to carry out pneumoperitoneum at home. If it were decided to perform the operation at home then the author sees no technical objections to the patient receiving this form of treatment. The question of X-ray control probably arises, but this is actually not an unsurmountable problem, as there are many portable X-ray sets on the market which/

which meet the requirements excellently.

(2) EQUIPMENT.

The pneumothorax apparatus is suited ideally for pneumoperitoneum. The writer used the Lillington Pearson apparatus, in which there is a manometer graduated empirically, the limbs of the U-tube containing methylated spirit. There are two adjustable bottles which can be raised or lowered to regulate the hydrostatic pressure. The rubber and glass tubing connecting the bottles are arranged so as to permit siphonage in either direction. Other accessories which make up the equipment are - hypodermic needles, serum needles, procaine 2%, sterile towels, surgeons' gloves and gowns, spirit and tincture of iodine.

(3) PRELIMINARY STEPS AND PREPARATION OF THE PATIENT.

Patients receiving this form of treatment are usually in bed and in a hospital or sanatorium. Aseptic precautions should be taken as for any other surgical procedure. The surgeon should scrub his hands under running water for 10-15 minutes, then rinse them through 1:60 carbolic acid lotion before drying them with a sterilised towel. Rubber gloves and sterile gown should be worn by the surgeon. There should be a small table or stand/

stand near the bed for the Lillington Pearson apparatus, and another covered with a sterile towel on which may be placed sterile hypodermic syringe, connecting tube with adaptor for needle, and any other sterile articles required. A package of sterile sheets should be at hand for draping the patient. An assistant to actuate the flow of air is a great advantage.

Preparation of Patient. The patient should be given a light breakfast, the bladder emptied, and an enema administered. If the patient should have a very troublesome cough a sedative may be given. Rehberg (102) quoting Werwath recommended that prior to insufflation of the peritoneal cavity the patient should be fasting and the intestine empty; an intestinal tube should be introduced one hour before the commencement of the pneumoperitoneum to remove intestinal gases if the procedure be thought to be effective.

(4) THE OPERATION.

In Robroyston Hospital the patients are given the treatment sitting up. This position according to Salkin (110) is about the only one that can produce elevation of the diaphragm. Steps are taken to remove, as far as possible, any feeling of apprehension on the part of the patient/

patient. The local anaesthetic must be adequate, so as to obviate reflex movement on the part of the patient and also to avoid unnecessary pain. Any site in the anterior abdominal wall would appear to be suitable for the introduction of air. Fremmel[51], for example, chose a site just lateral to left Rectus Abdominalis and immediately below costal margin. This area has the advantage of not overlying any particular vulnerable viscus, and the proximity of the ribs permits the skin to offer some resistance to the needle, thus preventing the former being pushed in front of the latter; this resistance is particularly welcome when the abdominal wall is flaccid such as one is apt to find in the thin multiparous woman. Other workers[13] in pneumoperitoneum enter the peritoneal cavity through the right lower thoracic region at the level of the ninth intercostal space in the mid axillary line. They maintain that, by choosing this site, the accident of perforating a hollow viscus would be avoided, as the liver would be a protection in this area. In the writer's opinion there is always the danger of piercing the pulmonary tissue in the costo-phrenic angle and so producing an air embolism. This danger, of course, could be obviated by screening the patient beforehand and marking the level of the diaphragm. Rubin[109] tried to avoid/

avoid the intra-abdominal route and suggested that in non-pregnant women the gas or air should be injected by the intra-uterine route. Lilienthal (81) chose the left lower quadrant of the abdomen. He made a minute incision in the abdominal wall under a local anaesthetic and passed a coarse needle slowly through the abdominal wall. A tube leading from an oxygen receptacle was fixed to the needle. The former had a cotton filtering chamber between it and the receptacle. This filtering chamber was merely a glass tube fitted with cotton wool.

In this series of cases the writer selected a spot midway between anterior superior spine and the umbilicus in the left side of the abdomen, in order to avoid the normal location of the large intestine. This area is cleansed with spirit and then iodine, and finally anaesthetised with two per cent procaine down to the peritoneum. Having annexed the rubber tubings to the glass connections in the Lillington Pearson apparatus, and joining an ordinary refill adaptor (135) to the rubber tubing and attaching a needle 2 ins. in length with a short bevel, and two terminal openings, to the adaptor, the surgeon is ready now to commence the induction of an artificial pneumoperitoneum. The needle is passed slowly through/

through the abdominal parietes, sudden and jerky movements being avoided. It happens sometimes that the skin in the abdomen is too lax over the left iliac fossa region and the needle seems to push the skin in front of it. This may be prevented by fixing the skin between the index and second fingers of the left hand and passing the needle, using the right hand, between the fingers of the left hand. The patient may be asked to grip the skin in the left flank and pinch it. This helps to make it more taut and facilitates the entrance of the needle through the skin and the abdominal wall. On account of the high negative pressure in the pleural space it is easier to gauge when the needle is in this space, than when it is in the abdominal cavity. The presence of the needle in the free peritoneal cavity, as stated in a previous chapter, can be recognised by:-

(1) The lack of resistance felt when the needle enters the coelom; (2) the ease with which the air passes along the needle; (3) the gurgling sound produced by the air in the cavity, exciting a wave of peristalsis in the bowel; (4) the patients may state that they feel the air going into the abdomen; (5) following the injection of 200 c.c. pain is felt often in the shoulder or in the epigastrium; (6) the manometric oscillations will be observed by the operator/

operator.

The manometer readings at the first insufflation give sometimes no indication of the position of the needle, for as often as not they are neutral. Even when readings are present they are not reliable. They are small and highly positive and they are pradoxical as compared with those noticed during the induction of a pneumothorax, in that during inspiration the pressure reading is more positive than during expiration. When the induction or refill is completed, it may be found that the final mean pressure is actually lower than that measured at the commencement, always provided that it had been possible to measure this at the outset. In these cases fluoroscopic examination may reveal an elevated atrophied atonic diaphragm, high up in the thorax. When the patient at the end of the insufflation inspires fully the high negative intrathoracic pressure causes the diaphragm to pass into the thorax, and as a result the peritoneal cavity increases in size and the pressures fall slightly. When the needle is passed just under the diaphragm into the peritoneal cavity, the manometer readings are often negative and large and they fluctuate with respirations, but inversely to those of the pleural cavity. This explains why/

why accidental pneumoperitoneum often occurs, especially if readings at the last refill were positive. The operator may inadvertently pass the needle through the diaphragm, and since the manometric readings are negative, or slightly positive, he may be under the impression that the needle is in the pleural space. A careful watch on the readings during inspiration and expiration might help in some cases to clear up any doubt in the mind of the operator. After inflations of large amounts of air into the coelom, the respiratory variations might differ by only 1-2 cms.(spirit) pressure. An atmospheric pressure might be recorded at the termination of such a refill. Salkin (110) has reported similar observations. He regarded this finding as being due to the physiological process called abdominal accommodation which has been discussed in the chapter entitled "Mechanism of Pneumoperitoneum". It may be asked wherein lies the value of pneumoperitoneum if the pressure in the abdomen is eventually atmospheric? This, however, does not influence the efficacy of pneumoperitoneum whatever. What is of concern is the elevation of the diaphragm and the limitation of the amplitude of the diaphragmatic excursion which occurs, and the benefits which a patient derives from such a procedure. Fluoroscopy reveals the splinting action which occurs as a result of the/

the upward pressure of the air on the diaphragm. In this series of cases it has been always a routine procedure to apply a very tight binder after the completion of an injection. This, besides tending to force the air up under the diaphragm helps to keep the intra-abdominal pressure positive. In those patients who have much subcutaneous fat in their abdominal wall it is usual to find higher positive end pressure readings, than among those patients with thin lax parietes. Occasionally the pressure readings are high at the beginning of an insufflation. This may be due to the presence of the needle in the peritoneal space or the irritative effect of the air on the peritoneum. Whatever the cause in the thin patient, the pressures fall towards the end of the inflation but in the case of the obese subject the pressure remains high throughout the operation.

(5) MAINTENANCE OF PNEUMOPERITONEUM.

Patients receiving pneumoperitoneum are given bi-weekly insufflations of air (500-700 c.cs.) for the first 2-3 weeks of their treatment. Since the peritoneum is a very large absorbing area large refills are necessary. It must be evident that the pressure readings give no idea how much air is present in the peritoneal cavity. The only method of gauging the effect of the air in the peritoneal/

peritoneal cavity is obtained by frequent fluoroscopic examination. The elevation of the diaphragm is the only guide. Some authorities have attempted to give rough estimates; for example, Salkin (110) states that a total air space above the liver of 10-12 cms. denotes 600-800 c.cs. of air and that the maximum liver dullness disappears at 300 c.cs. This latter observation has not been the writer's experience; in this series of cases injections of 500-600 c.cs. of air were necessary to cause disappearance of the hepatic area of dullness.

Five patients received a phrenic crush operation in addition to pneumoperitoneum. The object in doing the phrenic operation was to produce maximum relaxation on the worse side. A patient who receives a phrenic nerve operation is instructed to lie on the contra-lateral side to the operation, so that the air in the peritoneal cavity is forced up beneath the hemi-diaphragm of the worse side, where greater elevation of the diaphragm is required. The side on which the patient reclines derives some benefit, for not only does the air under the dome of the diaphragm on the homolateral side give rest to the lung on that side but the posture adopted by the patient limits the movements of the chest on that side. The writer's reason for preceding pneumoperitoneum with a phrenic crush was to demonstrate/

demonstrate the fact that pneumoperitoneum could enhance the elevation of the hemi-diaphragm achieved by the interruption of the nerve. X-ray plates taken shortly after the operation showed the diaphragm to be only slightly raised, and radiographic examination after the administration of a pneumoperitoneum showed the diaphragm to be elevated at least 2 ins. and the rise to be progressive (Cf. X-ray plate No. VII).

Just how long a pneumoperitoneum should be maintained is a matter on which no definite statement can be made. If the continuance of refills over two or three months makes a patient less comfortable and gives no symptomatic relief, the pneumoperitoneum should be abandoned. Similarly, if, in a patient who is making no progress, nor actually deteriorating, and average refills of 500-700 ccs. fail to raise the diaphragm, there is little to gain by continuance of the treatment. It can be remarked however, that in common with other forms of treatment the abandonment of a pneumoperitoneum is often the commencement of a rapid decline, much of which is unquestionably due to the despair which the move initiates.

Among those who do well, the duration of the treatment is often a matter of some difficulty. The object to be kept in view is the clearing up of the exudative lesions/

lesions which prevent more permanent steps being taken. So soon as this is achieved serious consideration should be given to the questions of cavity drainage (33) (107) and localised thoracoplastic operations.

(6) COMPLICATIONS OF ARTIFICIAL PNEUMOPERITONEUM.

In the writer's opinion, the hazards attending this surgical procedure are more theoretical than practical. Eight hundred and fifty air inflations of the peritoneal cavity have been administered in the present series of cases, and, but for one case which terminated fatally, the complications have been of a most trivial character.

Since no study of artificial pneumoperitoneum, however, would be complete without some reference to the complications, trivial or serious, potential or real, the writer proposes to discuss this section under the following schematic representation:-

Complications.

(1) Occurring during the administration of an artificial pneumoperitoneum.

(a) Pain referred to the shoulder or epigastriac region.

(b) Local rigidity of the abdominal wall.

(c) Emphysema - (i) Abdominal

(ii)/

(ii) Mediastinal

(d) Air Embolism.

(e) Dyspnoea.

(f) Perforation of Viscus.

(g) Sudden death - cause unknown.

(2) Following the administration of an artificial pneumoperitoneum.

(a) Ascites

(b) Abdominal adhesions.

(c) Peritonitis.

(d) Pleural effusions.

(1) (a) Pain referred to the shoulder or epigastrium.

Pain of a dull aching character, not fluctuating in intensity, was a constant feature during the initial insufflation of air into the peritoneal space. It became manifest when about 200 ccs. of air had been introduced into the coelom, and persisted 2-4 hours. In no instance did the writer administer morphia or other opiates to alleviate this pain. Simple analgesiac preparations such as acid salicylate, grains X, proved quite effective in giving the patients relief. The anatomical distribution of the pain was confined to one of two areas, namely the shoulder region or the epigastrium. Not one of the writer's cases complained of pain simultaneously in both areas.

The/

The experimental work of Capps (26) and Coleman has done much to explain the origin of this referred pain. The results of their investigations have been described in the chapter entitled "Anatomy of the Diaphragm".

During the induction of an artificial pneumoperitoneum the tension of the air beneath the diaphragmatic domes causes pain to be felt in (a) the shoulder region when the central area of the diaphragm is stimulated or (b) the epigastrium when its periphery is stimulated. This referred pain is absent during subsequent inflations; the diaphragm appearing to become less sensitive after the initial inflation. There is also an embryological basis to explain the anatomical distribution of the pain but this has been discussed already under the section "Embryology of the Diaphragm" and no further reference need be made to it at this juncture. The majority of patients complained of pain over both supraclavicular regions. Those who received a phrenic nerve interruption prior to the induction of the pneumoperitoneum complained of pain only over one shoulder. About 15% of patients stated that they felt pain in the epigastrium. In none of these cases was there any evidence of gastric disturbances.

(b) Local guarding of the Abdominal Wall.

During the administration of an artificial pneumoperitoneum palpation of the muscles over the site of entry of/

of the needle reveals some slight guarding of the abdominal muscles. This is due to the irritation of the needle and disappears when the needle is withdrawn.

(c) Emphysema.

Surgical emphysema of the abdominal wall was observed in 2 cases. It was of no great consequence and was recognised by the localised swelling and the presence of crepitations to the examining hand. The patients tolerated it well and made no special complaints. There was no reason to discontinue treatment because of the presence of this complication. The needle not being in free communication with the peritoneal space was the cause of this emphysema. Once it was recognised, the clips to the manometer were closed and the needle was made to pass deeper into the abdomen until contact was made with the coelomic cavity. This state of affairs was recognised by the air passing more freely along the needle and also by the fact that the ingoing air did not cause the localised swelling to be increased. In no instance did surgical emphysema appear after the completion of an insufflation. The writer can assume consequently that coincident with the removal of the needle, the aperture made in the peritoneum during the procedure, was sealed over almost at once.

Mediastinal Emphysema.

Since there are openings in the diaphragm to permit/

permit the passage of the oesophagus and large vessels, it might be thought that this complication would be a fairly frequent occurrence. The writer in the present series of cases nas never noticed this complication during or after an artificial pneumoperitoneum. Other workers like Banyai and (13) Jurgens have been less fortunate. They have reported that out of a series of forty-two cases, mediastinal emphysema was observed in seven cases. The right hypochondrium was selected by them as the site to administer the pneumoperitoneum. The mediastinal emphysema which occurred was recognised by the following symptoms - pain in and around the larynx accompanied by hoarseness, a choking sensation, coughing and dyspnoea. They ascribed this complication as being due to (1) The air in the abdominal cavity passing up through the oesophageal opening in the diaphragm to the mediastinum, or (2) the periphery of the diaphragm being pierced by the needle with the result that the air passed along the basal parietal pleura to the mediastinum.

(d) Air Embolism.

This complication should always be borne in mind when the right hypochondrium is chosen as the site for the entry of the air into the coelom.. When the needle is introduced/

introduced below the ninth intercostal space, the pulmonary tissue in the costo-phrenic angle might be perforated and the patient might die from an air embolism. The writer in choosing the left iliac fossa for the air insufflation precludes this complication.

(e) Dyspnoea.

Breathlessness occurred in one of the writer's cases. This complaint was observed towards the termination of a large insufflation (1000 ccs.) and it persisted for ten to fifteen minutes after inflation. The patient, a girl, obtained relief when the foot of the bed was raised. The writer is of the opinion that adoption of the Trendelenburg position favoured the disposition of the air from the diaphragm towards the pelvis. The resultant reduction in the tension beneath the diaphragmatic domes being followed by a disappearance of the dyspnoeic symptoms.

(f) Perforation of a Viscus.

This complication is always a potential danger especially if the patient has a plastic type of abdominal tuberculosis. It was a great danger when pneumoperitoneum was employed in radiological work as e.g. the diagnosis of carcinoma of the bowel or kidneys. It can be obviated in the case of a therapeutic pneumoperitoneum by allowing air to/

to pass along a wide bored needle while the latter is being introduced into the coelomic cavity.

(g) Sudden Death - cause unknown.

One patient died suddenly during the administration of a pneumoperitoneum. The cause of death in this case was not known since permission for an autopsy was not granted. The patient had been receiving treatment for 6 months and was responding well to it. At no time during or after treatment did she make any complaint. On the day of her death she appeared quite well. During the administration of the pneumoperitoneum there was no doubt in the operator's mind regarding the position of the needle in the peritoneal space. Since this was a well established case there was felt a lack of resistance as the needle reached the coelom, the manometer readings were excellent being + 8 cms.(spirit + 12 cms.(spirit) and there was no obstruction to the flow of air along the needle. The patient had received 100 ccs. of air when she felt some slight abdominal pain, became pale, and lapsed into a state of unconsciousness from which she never recovered. The cause of death in this case must remain obscure. The patient had not received enough air into the abdomen to produce any great alteration in the accommodation of the endothoracic structures. Peritoneal shock was regarded as being the cause of death but the writer was/

was never fully convinced of this diagnosis when he recalled that (1) adequate local anaesthetic was given to obviate pain, (2) the patient was a well established case and peritoneal shock was more likely to have occurred earlier in the course of treatment, (3) if the peritoneum was unduly sensitive on that fateful day, the shock would have occurred (a) when the local anaesthetic was being given (b) when the wide bored refill needle perforated the peritoneum, (4) if the ingoing air was the cause of the catastrophe then its action must have been delayed for the patient had received 100 ccs. before the calamity occurred. The writer felt justified in dismissing an air embolism as a causative factor since (a) the inflation was given in the left iliac fossa at some distance from the large pulmonary veins (b) the patient never complained of chest pain, (c) there was no evidence of convulsions.

(2) (a) Ascites.

Certain workers (26) have noticed free fluid appear in the abdominal cavity during a course of therapeutic pneumoperitoneum. They state that it may have been caused by the air setting up an irritation of the peritoneum. This complication has not been observed in the present series of cases.

(b) Abdominal Adhesions.

In/

In one case the writer suspected that abdominal adhesions had developed. The patient, in question had been receiving large refills 1000-1500 ccs. for more than a year when it was observed that only small refills could be tolerated. The patient began to complain of some localised abdominal pain in the left iliac fossa after these small refills and the manometric pressure became very highly positive. Fluoroscopic examination revealed that the diaphragmatic domes were becoming less well elevated. In view of (a) the high positive readings (b) the pain during small refill, (c) the poor elevation of the diaphragm, this therapeutic course was abandoned. In this case the writer believed that the air in the abdominal cavity engendered the formation of fibrotic adhesions which interfered with the free flow of air into the coelomic cavity.

(c) Peritonitis.

A rigid aseptic ritual must be observed to abrogate this serious complication.

(d) Pleural Effusion.

In 2 instances a small unilateral basal effusion occurred. The presence of this small collection of fluid did not upset the patients nor was the course of the pneumoperitoneum discontinued because of it. The writer very much questions the connection between the pneumoperitoneum and/

and the presence of the pleural effusions but since these complications occurred in 5% of cases he feels justified in mentioning them. The factors operative in the production of pleural effusions remain still very obscure. In the writer's opinion a better understanding of their production resides in a fuller understanding of the pathogenesis of pulmonary tuberculosis, a discussion of which is outwith the scope of this monograph.

PART IV.

THE RESULTS OF TREATMENT.

(1) Standards employed in the assessment of cases:

It is a notorious fact that in clinical medicine, it is frequently a matter of opinion whether or not an individual patient is, or is not, improving; and it may be said without fear of correction that in the more chronic illnesses any statement of prognosis may or may not prove correct. Tuberculosis is probably beyond question just such a disease, if one excludes it on its more acute and more immediately deadly forms; its periods of quiescence and its exacerbations have long troubled the less experienced who would attempt to give a prognosis. Perhaps to these and allied facts one can attribute the growing numbers of criteria of healing and of standards of inactivity. It is not without significance that the Ministry of Pensions recommended that no case be regarded as arrested till a period of three years has elapsed with total freedom from symptoms.

Each practitioner who treats pulmonary tuberculosis has his own set of measures by which he judges the onset of improvement and its maintenance, and his summation of his data merge imperceptibly with experience into a less tangible but even more reliable yardstick which one recognises as/

as clinical experience. He does, however, take notice constantly of certain factors; and in a large sanatorium these factors are those normally recorded for him by his staff of nurses and technicians. In this series the writer has used some of these clinical data in an effort to support his impressions that this patient has improved or that deteriorated. Later in this work will be found a table which attempts to present in summary form the results of his treatment. It cannot, however, be out of place to state and explain what standards the writer has adopted before attempting to measure his success or failure by them. They are:-

(a) Temperature Records. In the Trudeau (90) Sanatorium a temperature of 99°F in men and 99.6°F in women on three of seven consecutive days is evidence of activity in a known tuberculous person. Pottenger (98) has pointed out that elevations up to 99.5 F. has per se no significance in some persons. In advanced phthisis, such as was present in most of the members of this series, one is justified in accepting defervescence as evidence of reduced toxaemia and the maintenance of a normal temperature range as possible evidence of the increasing stability of the lesions.

(b) Tachycardia. A very similar case can be made out for the pulse record, taken at rest as an index of activity./

activity. Some writers (49) maintain that it is even more reliable provided factors liable to upset it, apart from tuberculosis, are excluded.

(c) Records of Weight Gain or Loss. It is possible to attach too much importance to the increase of weight demonstrated so frequently by patients in a sanatorium. In the writer's opinion this gain should be considered satisfactory only if it is recorded over many months. It carries additional value if records of weights are available which were made over a period prior to admission, but only rarely are these available. It is felt too, that the rapid increases of the first month or two offer no guarantee that this rise will be maintained. In the cases under discussion the majority of the patients had been in hospital long enough prior to the institution of pneumoperitoneum for this to be ignored, and a gain in weight in these patients can fairly be regarded as grounds for satisfaction.

(d) Records of Sputum Raised. In advanced pulmonary tuberculosis a diminution in the amount of sputum raised is rightly one of these signs of improvement of which even the patient is aware, and any line of treatment which achieves such a diminution may be regarded justifiably as satisfactory. It is not claimed for pneumoperitoneum that it has closed cavities/

cavities, which are the major elements in the production of sputum, but it does help in the healing of the active elements which by their break down add considerably to its bulk.

(e) Bacillary Content of the Sputum. By modern standards of public health it is very doubtful if any patient should leave a sanatorium with tubercle bacilli still in the sputum. That such a happy ruling will ever come about can be a matter for no more than speculation. Nevertheless the aim must remain to terminate the excretion of bacilli. Whether or not the presence of bacilli in the sputum connotes activity of some point of the lesion, is a debateable point, though a reasonable view would certainly deny such technical minuteness. In the 40 cases treated during the course of this investigation, it was realised fully that it was unlikely that larger cavities would be closed and therefore that a negative sputum would be attained. Diminution in the numbers of the bacilli was hoped for as representing an improvement in the lung lesion generally.

(f) Vital Capacity. It is commonly accepted that the collapse of actively diseased lung does not reduce the patient's vital capacity but rather by the reduction of activity and toxaemia it reduces the reflex spasm of the respiratory muscles and thereby allows more effective aeration. In pneumoperitoneum any reduction of activity achieved/

achieved is probably won by the progressive rise of the diaphragm. As has been pointed out already, the diaphragm in addition to being raised, becomes atonic and in many cases immobile. It seems a reasonable presumption to raise the question as to whether or not these factors, the lessening activity and the rising diaphragm, may not offset each other.

(g) Radiology. Very little need be said of the value of serial radiograms, as an accurate means of assessing the changes in intra-thoracic pathology. They were employed very freely in this series of cases, both to assess the height of the diaphragm and to follow the effects of the treatment. They were reported on by a radiologist of great experience in the reading of chest films, and each report was made after scrutiny of previously taken films.

(h) Blood Picture. In his examination of the blood the writer included in his investigations:-

1. The blood sedimentation rate.
2. The leucocyte count.
3. The differential white cell count.
4. The Arneth count.
5. The Von Bonsdorff method of expressing the Arneth index.
6. The estimation of the lymphocyte monocyte ratio.

It/

It will be noticed that the red cell count is not included but after enumerating the red blood count in a number of the cases the author found that very little information was gained from this examination. The red blood counts were almost all within fairly normal figures. It can be assumed that the numerical changes in blood cytology characteristic of tuberculosis affects the leucocytes rather than the red blood cells. The latter change but little. The haemoglobin estimations were not carried out in the cases under consideration in this study, but the fact that the red cells stained fairly well, with Leishman stain, suggests that there was on the average little, if any, tendency to secondary anaemia.

1. Blood Sedimentation Rate: The biological process of the phenomenon of Erythrocyte Sedimentation is very complex, and many theories have been evolved to explain its mechanism. Whilst the latter is not fully understood evidence is accumulating to show that it is an index of tissue destruction, the products alter the colloidal liability of the blood in such a way that the red cells settle out quickly from the plasma (Ralphs)[101].

Various methods have been employed for determining the rapidity of the sedimentation of the red cells.

Fahraeus[45,46], in 1918, first reported his technique and/

and observations on the rate of sedimentation of the erythrocytes in citrated blood. He found that the blood sedimentation rate was "increased in all kinds of infection, most distinct when accompanied by high fever, in many cases of malignant tumours and certain species of psychosis etc." Since his first publication other workers have reported various modifications of the Fahraeus technique. The underlying principle is the same but the results are recorded differently. Westergren[132,133], for example, modified the Fahraeus method and carried out an important series of observations on the sedimentation rate in pulmonary tuberculosis on 340 male patients at Stockholm.

The method employed in this series of cases is a modification of that described by Westergren. As an anticoagulent a 3.8% aqueous solution of sodium citrate is used of which 0.4 c.c. is pipetted into a small test tube which has a level marked 2 c.cs. With the usual aseptic precautions 2 c.cs. of venous blood is withdrawn from the median basilic vein and added to the citrate solution in the test tube until the now citrated blood has reached the 2 c.c. mark on the test tube. The latter is agitated but not too vigorously to avoid producing a foam. The remainder of the blood in the syringe is used to count the white blood count, make a film for the Differential Count, the Arneth Count, and the

Von/

Von Bonsdorff Count. The citrated blood is drawn up into one of the serological pipettes graduated in 200 millimetres. The pipette is then placed in an upright position. Readings are taken every fifteen minutes for one hour. These represent the number of millimetres of clear plasma above the level of the erythrocytes, i.e., the measurement is taken from the lower edge of the meniscus of the free surface of the liquid to the upper border of the corpuscles. The results of these readings are recorded graphically, in a manner very much on the same lines as that used by Cutler.(34,124) The tests were made under fairly standard conditions, for example, the patients were in bed, and the blood was taken at the same time each day. One of the fundamental difficulties in evaluating the significance of the sedimentation rate is the lack of unanimity of opinion regarding the maximum figures in normal persons, but the writer has assumed the maximum figures as follows:-

Males - 8 m.ms. Females - 10 m.ms. and 12 m.ms. during menstruation.

2. Leucocyte Count: As already pointed out, the blood taken for the white blood count in the series was acquired by aspiration from the median basilic vein. This blood/

blood is believed to be less subject to variations from local conditions than extruded blood by the stab method. The white count in some instances showed a slight leucocytosis throughout the course of treatment.

3. Differential Count: Thin blood films were made and stained by Leishman stain. The cytological examination was done using the oil immersion lens and intensifier. The classification of cells was according to the teaching of Piney (96) in his "Clinical Atlas of Blood Diseases". From this count the writer was able to watch the variations in the lymphocyte monocyte ratio. At the commencement of treatment in many cases the ratio indicated a poor prognosis and in those which showed some resistance to the disease probably as a result of treatment the lymphocyte monocyte ratio clearly illustrated the improvement that was taking place.

4. Arneth Count: A promising method of cytological study was proposed by Arneth (7) in 1905. This count is really one of the oldest methods of investigating the blood, in an endeavour to find some aid to the diagnosis and prognosis of tuberculosis. The Arneth count depends on the lobulation of the nuclei in the neutrophile cells. Arneth recognised five groups according to the number of lobes in the nucleus of the neutrophile cell. He, in studying the neutrophile cells, concluded/

concluded that an estimate of the maturity of the cell could be drawn from the number of nuclei, and in the cellular reaction to tuberculosis he noted that there occurred a high proportion of immature cells and that this was greater the more severe the infection. In health the addition of the first and second groups give the index 40. In tuberculosis the ratio of these cells is increased, that is to say the index rises. This rise is known as "a shift to the left". In this series of cases the writer observed a change in this index in those patients who responded well to the treatment.

5. Von Bonsdorff Count: This is the sum of the nuclei in one hundred neutrophiles. The five groups according to Arneth classification are added and the Von Bonsdorff figure is obtained by multiplying the percentage number of lobes in the neutrophile in each class by the number of the class. Two hundred and seventy five is regarded as a fairly normal index. In advanced pulmonary tuberculosis there is a "shift to the left", the count being well below two hundred and seventy five, indicating a predominance of immature cells. According to Houghton (64) "This count is a reliable index of toxaemia but bears no relation to the extent of the disease and but a variable one to activity." There has been a "shift to the right" in/

in some of these cases, indicating a lessening of toxaemia following on administration of pneumoperitoneum. An additional index which has been applied in all the cases is what is called the "Weighted Mean".(97) It gives the approximate number of lobes in each cell. If one divides the Von Bonsdorff index by one hundred, one obtains a figure which gives the average number of lobes in the neutrophile cells. Thus a fairly normal figure would be 2.75 or even 2.6. An increase in this figure must indicate a lessening of the patient's toxaemia and certainly an increase in his natural power of resistance.

6. Lymphocyte Monocyte Ratio: The scope of this work does not permit a discussion on the historical background underlying our present day concepts of the role played by the white cell in tuberculosis. Reports on the leucocytic reaction to tuberculosis are so numerous that any detailed account of them is considered unfeasible and impracticable, but mention must be made of the work by Cunningham and Sabin(31) which has produced evidence to show that in tuberculous experimental animals a great overproduction of the monocyte cell appeared in the circulating blood. They, thus, considered tuberculosis as a disease of monocytes. The normal relationship of the total number of these/

these cells and the total number of lymphocytes called the lymphocytes/ monocyte ratio is thereby upset. In their report they consider this ratio the most important factor. This same observation has been observed by Morris (87) and Tan in human beings whose prognosis was poor. In such cases the lymphocyte/monocyte ratio was reversed, that is, the monocytes were increased and the lymphocytes decreased. The ratio tended to rise gradually in cases showing improvement and remained high in quiescent cases. The normal ratio is said arbitrarily to be 3:1 approximately, whereas, in the group showing progressive disease the ratio is approximately 1:0.79.

Just as in the case of blood sedimentation rate the writer has not relied on this ratio solely as the main factor in determining the prognosis or progress of the patient, but has regarded it rather, in a broad sense, as one criterion worthy of consideration in making the final assessment of the disease when all the evidence in connection with the case has been accumulated.

(2) Clinical Effects.

Abbreviations used in Table No. I.

Temp	=	temperature.
V.C.	=	Vital capacity.
C.C.	=	Cubic centimetres.
B.S.R.	=	Blood Sedimentation Rate.
L:M	=	Lymphocyte/Monocyte Ratio.
$\pm$	=	positive sputum alternating with a negative sputum.

TABLE

No.	Name	Age in Yrs.	Illness Duration in Months	Sputum				Temp.		Pulse	
				Amount in ozs.		T.B. + ve - ve		Maximum daily Range		Maximum daily Range	
				Before	After	Before	After	Before	After	Before	After
1	I.C.	19	5	1	1	++	-	98.4 99	97 98	100 120	76 84
2	T.McA	18	14	1	1½	+++	+ -	98 100	97 98.4	78 108	80 90
3	A.McI.	18	3	1	2	++	+	98.4 99	98.4 98.4	80 90	80 90
4	J.S.	20	36	3	3	++	++	97 97	99 100	80 84	90 104
5	Mrs.Mat.	35	36	2	2	++	+	97 98	98 98	88 100	86 90
6	M.Mul.	18	4	2	2	++	+ -	97 98	97 98.4	80 84	74 84
7	M.G.	16	6	2	3	++	++	98.4 99	98.4 98	80 120	80 100
8	A.D.	20	4	1½	3	++	-	98.4 99	97 98.4	80 98	84 88
9	R.McP	17	19	½	1	++	-	97 98	98.4 98.4	74 80	74 80

NO. I.

V. C. in C.C's.		Blood Examination								Weight	
		B.S.R.		L : M Ratio		Arneth Index		Bonsdorff Index			
Before	After	Before	After	Before	After	Before	After	Before	After	Before	After
1500	1800	68	48	2: 1	4:1	52	43	259	268	6 sts 7 lbs	7 sts. 7 lbs
1800	1700	98	50	2.8:1	3:5:1	47	43	271	285	6 sts 11½lbs	8 sts.
2000	2100	64	58	1.6:1	2:1	56	58	252	264	5 sts 9 lbs	6 sts. 4½ lbs.
1400	1400	48	90	2.6:1	2:1	54	50	190	205	7 sts 5 lbs	7 sts. 3 lbs.
2200	2000	94	104	3.1	2:1	64	52	251	216	not	weighed
1900	2000	44	16	2.7:1	3:4:1	49	46	261	263	6 sts 2 lbs	6 sts. 9 lbs.
1800	1600	90	66	1.5:1	2:1	56	54	236	242	5 sts 11½lbs	6 sts. 2 lbs.
2500	2300	78	22	2:1	4:1	50	50	254	263	6 sts 9½ lbs	8 sts. 5 lbs.
2600	2600	20	12	3.5:1	2:8:1	44	42	280	278	7 sts 8 lbs	11 sts.

TABLE NO. I.

No	Name	Age	Illness Duration in months	Sputum				Temp.		Pulse	
				Amount in Ozs.		+ ve T.B.- ve		Maximum Daily Range		Maximum Daily Range	
				Before	After	Before	After	Before	After	Before	After
10	M.Ly.	20	5½	2	½	+++	+++	97 98	98.4 99	84 90	80 86
11	M.L.	19	24	3½	3½	+++	+++	97 99	98 100	98 106	80 96
12	M.D.	17	3	2	2	++	±	98.4 100	97 98.4	90 116	80 84
13	M.W.	23	5½	1½	2	++	· -	98.4 98.4	97 98.4	84 86	76 84
14	M.Ma.	17	24	3	4	++	++	98 99	97 98.4	80 96	78 100
15	R.B.	24	4	½	1½	++	-	97 98	97 98	76 84	76 82
16	A.C.	24	5	2½	3½	+++	++	98 101	97 98	88 106	76 86
17	H.Lo.	16	8	½	1	+	++	98.4 99	97 98.4	72 114	80 88
18	J.M.	15	6	2	3	++	++	98 101	99 101	90 100	96 100

CONTINUED

V. C. in C.Cs.		Blood Examination									
		B.S.R.		L : M Ratio		Arneth Index		V. Bonsdorff Index		Weight	
Before	After	Before	After	Before	After	Before	After	Before	After	Before	After
1400	1400	70	34	2:1	1.9:1	54	48	220	240	7 sts. 6 lbs.	6 sts. 10 lbs.
1500	1400	78	72	4:1	3.6:1	52	50	259	236	not weighed	
1500	1700	94	72	2:1	1.5:1	26	32	210	234	7 sts 1 lb.	7 sts. 6 lbs.
2400	2500	43	10	1:5:1	4:1	64	39	236	292	7 sts 9 lbs.	10 sts.
										5 sts. 10 lbs.	5 sts. 8 lbs.
2000	2100	80	28	2:1	2.2:1	42	46	245	278	7 sts. 12 lbs.	9 sts.
1800	1800	76	88	2:1	3:1	50	46	242	256	7 sts. 4 lbs	7 sts. 6 lbs.
1800	1700	86	70	1.5:1	2:1	48	54	218	262	7 sts. 2 lbs.	8 sts. 9 lbs.
										not weighed	

TABLE NO. I.

No.	Name	Age	Illness Duration in Months	Sputum				Temp.		Pulse	
				Amount in Ozs.		T.B. +ve -ve		Maximum Daily Range		Maximum Daily Range	
			Before	After	Before	After	Before	Before	After	Before	After
19	Mrs.Br.	21	6½	½	½	++	-	98.4 98.4	97 98.4	76 80	74 80
20	H.McK.	16	5	1½	1½	+++	++	98 100	97 99	92 110	80 96
21	M.McL.	21	3	1½	1½	++	++	97 98	98 99	80 100	80 108
22	T.S.	16	4½	2½	3½	++	+++	97 98	98 98	80 104	80 104
23	Mrs.McM	31	3	1	1½	+++	+++	98 100	98 100	98 112	84 110
24	A.M.	20	7	3	3	++	++	98 99	97 97	92 104	76 92
25	Mrs.Mu.	22	5	1	2	+++	+++	97 101	97 100	96 120	80 104
26	M.Bn.	19	24	2	2	+++	++	98 101	97 98	90 120	74 76
27	C. Gl.	17	8	1	2	+++	±	97 99	97 98	92 118	92 104

CONTINUED

V.C. in C.Cs.		Blood Examination									
		B.S.R.		L : M Ratio		Arneth Index		V. Bonsdorff Index		Weight	
Before	After	Before	After	Before	After	Before	After	Before	After	Before	After
2400	2100	68	40	2.7:1	2.4:1	48	42	238	226	7 sts 5½ lbs	9 sts. 7¾ lbs
1300	1300	72	66	1.8:1	2:1	58	53	216	246	5 sts. 1 lb.	5 sts. 4 lbs.
1200	1300	110	96	1.3:1	1:9:1	60	64	246	220	6 sts. 9 lbs	6 sts. 9 lbs.
1300	1300	106	94	1.3:1	2.7:1	66	56	162	216	5 sts. 9 lbs	5 sts. 9 lbs.
1900	1900	36	50	1.6:1	2:1	58	54	216	226	not weighed	
2300	2200	86	74	3:1	2:1	48	44	260	254	7 sts. 4 lbs	7 sts. 6 lbs.
1600	1500	108	88	1.8:1	3:1	58	64	196	210	not weighed	
										6 sts. 7¾ lbs	8 sts. 10 lbs
1800	1900	52	64	2.8:1	2:1	48	46	244	218	7 sts. 2 lbs	7 sts. 2 lbs.

TABLE NO. I.

No.	Name	Age	Illness Duration in Months	Sputum				Temp.		Pulse	
				Amount in Ozs.		T.B. +ve -ve		Maximum Daily Range		Maximum Daily Range	
				Before	After	Before	After	Before	After	Before	After
28	Mrs.Mo.	23	8	2	2	+++	+++	99 100	99 101	100 120	90 110
29	Mrs.H.	21	12	1	2	++	++	97 98	97 99	80 104	108 120
30	Mrs.Bro.	24	17	2	2	++	++	97 97	97 98	80 96	100 124
31	Mrs.O'R	19	9	1½	2	+++	+++	98 100	98 100	84 108	80 98
32	Mrs.Mac	23	4	3	3	+++	+++	99 100	98 98	76 100	80 106
33	Mrs.C.	27	7	1	1½	+++	+++	98 104	98 100	90 120	84 94
34	M.B.	21	18	3	3	++	++	98 99	97 98	80 98	76 86
35	R.L.	21	6	1	1	+ ++	+++	99 100	101 102	88 100	100 112
36	Mrs.Dal.	19	24	4	3	++	++	97 98	98 104	88 100	80 104

N.B. Numbers 37-40: Pneumoperitoneum induced for Haemoptysis.

CONTINUED

V.C. in C.Cs.		Blood Examination									
		B.S.R.		L : M Ratio		Arneth Index		V Bonsdorff Index		Weight	
Before	After	Before	After	Before	After	Before	After	Before	After	Before	After
										not weighed	
2300	2200	88	94	1.4:1	3:1	58	52	218	226	7 sts. 6 lbs	7 sts. 6 lbs.
1200	1100	110	100	1.2:1	1.4:1	68	60	180	203	not weighed	
1400	1300	36	50	2.1	1.2:1	56	50	226	218	not weighed	
										not weighed	
1500	1500	104	90	3:1	1.3:1	39	50	216	196	7 sts. 2 lbs.	7 sts. 2 lbs.
										8 sts. 3 lbs.	8 sts. 3½ lbs.
1400	1300	92	86	2:1	1.9:1	48	56	220	202	8 sts. 7 lbs.	8 sts. 3 lbs.
1300	1400	104	96	1.9:1	1.7:1	58	54	223	214	6 sts. 9 lbs.	6 sts. 9 lbs.

Abbreviations used in Table No. 2.

Ex = Exudative lesions; unless where stated this implies a lesion involving no less than the upper half of both lungs.

C = Cavity

Pl = Pleural thickening

Pl.Eff.= Small basal pleural effusion.

R = Right lung

L = Left lung

A.P. = Artificial Pneumothorax.

Ph. = Phrenic nerve operation.

TABLE NO. 2.

No.	Name	X-rays		Clinical Lesion			Treatment			Present State		
							A.P. Failed	Pneumop.		Alive		Dead
		Before	After	Chest bilateral	T.B. Abdomen	T. B. Larynx		Duration Months	Combined	Imp.	1 S.Q.	
1	I.C.	Ex.	Fibrotic	+	-	-	L.A.P. R.A.P.	9	-	+	-	-
2	T.McA	Ex: C	Ex: C	+	-	-	-	8	-	+	-	-
3	A.McI	Ex: C	Ex: C	+	-	-	L.A.P.	2	R.A.P.	-	+	-
4	J.S.	Ex: C	Ex: C	+	+	-	L.A.P.* R.A.P.	2	-	-	-	+
5	MrsMat	Ex:C:Pl	Ex:C:Pl	+	-	-	-	2	Gold	-	+	-
6	M.Mul.	Ex:	less Active R.	+	-	-	L.A.P. R.A.P.	7	Gold	+	-	-
7	M.G.	Ex: C	Ex: C	+	-	-	-	10	-	-	+	-
8	A.D.	Ex: C	Ex: C	+	-	-	-	6	L.Ph.	+	-	-
9	R.McD.	Ex:	less active	+	-	-	-	10	-	+	-	-
10	M.Ly.	Ex: C	Ex: C	+	-	-	-	7	-	-	+	-
11	M.L.	Ex	Ex	+	+	-	-	5	-	-	-	+
12	M.D.	Ex	Ex	+	-	-	-	7	-	-	+	-
13	M.W.	Ex	less active	+	-	-	-	9	-	+	-	-
14	M.Ma.	Ex: C	Ex: C	+	-	-	L.A.P. R.A.P.	25	Gold	-	+	-
15	R.B.	Ex	Fibrotic	+	-	-	-	10	-	+	-	-
16	A.C.	Ex: C	less active	+	-	-	-	6	L.Ph	-	-	+
17	H.Lo.	Ex: C	Ex: C	+	-	-	-	8	-	-	+	-
18	J.M.	Ex:Pl.Eff.	Ex:Pl.Eff.	+	-	-	-	5 wks.	-	-	-	+
19	Mrs.Br.	Ex: Pl.	Ex: Pl.	+	-	-	-	7	-	+	-	-
20	H.McK	Ex: C	Ex: C	+	-	-	-	8	-	-	+	-
21	M.McL	Ex: C	Ex: C	+	+	-	-	3 wks.	-	-	-	+
22	T.S.	Ex: C	Ex: C	+	+	-	-	4	-	-	-	+
23	Mrs.McM	Ex:	Ex	+	-	-	-	2	Gold	-	+	-
24	A.M.	Ex: C	Ex: C	+	-	-	L.A.P.* R.A.P.	5 wks.	-	-	+	-

25	Mrs.Mu.	Ex: C	Ex: C	+	-	-	-	2	-	-	-	+
26	M.Bu. ✱	Ex: C	Fibrotic (R) Ex: C (L)	+	-	-	-	25	L.Ph.	+	-	-
27	C.Gl.	Ex: C	Ex: C	+	-	-	-	7	Gold	-	+	-
28	Mrs.Mo.	Ex: C	Ex: C	+	+	-	L.A.P. R.A.P.	3	-	-	-	+
29	Mrs.H. ✱	Ex	Ex	+	-	-	-	1	L.Ph Gold	-	+	-
30	Mrs.Bro.	Ex (*) Massive R	Ex Massive	+	+	-	-	3	-	-	-	+
31	Mrs.O'R.	Ex	Ex	+	-	-	-	3	-	-	+	-
32	Mrs Mac.	Ex	Ex	+	+	-	L.A.P. R.A.P.	6	-	-	-	+
33	Mrs. C.	Ex: C	Ex: C	+	-	-	-	2	-	-	-	+
34	M.B.	Ex: C	Fibrotic(R) Ex:C (L)	+	-	-	L.A.P.	7	L.Ph Gold	+	-	-
35	R.L.	Ex: C	Ex: C	+	-	-	-	5 wks.	-	-	-	+
36	Mrs.Dal.	Ex: C	Ex: C	+	+	+	-	3	-	-	-	+
37	W.R. o	Ex oo	Pneumoperitoneum							+	-	-
38	Mrs.Co.	Ex: C	induced							-	-	+
39	Mrs.Du.	Ex: C				for				-	-	+
40	J.Mo.	Ex: C				Haemoptysis				-	-	+

* Pneumothoraces ineffective and subsequently abandoned.

(*) Massive disease in the Right side. Heart displaced to the Right side.

✱ Discharged irregularly.

o Discharged well.

oo Right basal lesion.

In view of the extremely variable protean manifestations of pulmonary tuberculosis and the differences in the constitutional response to treatment, it is clear that no categorical statements can be made by the writer as to which patients will respond to treatment. The basis on which he has set his standards for the assessment of each case, in this thesis, has already been discussed in the opening chapter of Part IV. These standards have been incorporated in the tabular representations of the clinical effects of artificial pneumoperitoneum.

In the cases under review the ages of the patients ranged between 17 and 35 years, and the duration of the illness extended over a period of three months to three and a half years. Clinically and radiologically these patients, with one exception, suffered from an extensive and exudative form of bilateral pulmonary tuberculosis; twenty five of them in addition showed cavitation in one or both lungs. The general indications for pneumoperitoneum in the series of cases under discussion have been outlined in a previous chapter. In five cases pneumoperitoneum was administered when bilateral artificial pneumothorax had been attempted, but failed to be established because of pleural symphysis. It was used also in two cases in which bilateral artificial pneumothorax/

pneumothorax had been ineffectively applied and was being maintained to the patients' detriment. The general condition of these seven patients, together with the activity and distribution of the disease, obviated any immediate radical surgical interference. Pneumoperitoneum was combined with a right sided artificial pneumothorax in one instance. A bilateral artificial pneumothorax was attempted, but the operator was only successful in obtaining a pneumothorax in the right side. In order to splint the left lung and give it some relaxation a pneumoperitoneum was administered. In four instances pneumoperitoneum was administered as an emergency measure. These four patients suffered from severe haemoptysis. Pneumoperitoneum was given as a last resort (1) because of the general condition of the patients which gave cause for alarm and (2) since other measures to stop the bleeding were contra-indicated. In one instance it proved very successful. In the remaining patients pneumoperitoneum or pneumoperitoneum plus phrenic nerve palsy on the worse side (5 cases) was in the writer's opinion the only active procedure which could be performed. The general condition of these patients obviated more radical surgical measures being performed.

In the period covered by this study, namely, from November/

November 1937 to July 1941, twenty-four of the forty patients continued to receive treatment in hospital. Two of them were discharged irregularly. The improvement in their general condition gave them a false sense of security and they left hospital against the wishes of their medical attendant. One other patient was discharged well. The mortality rate in the forty cases under discussion has been very high; sixteen patients out of a total of forty died. When this high death rate is analysed more fully one is struck forcibly by the number of deaths which have occurred in those patients whose chest lesions were complicated by the presence of other tuberculous lesions and the low figure that has occurred in those patients who suffered from a bilateral chest lesion per se. Seven of those who died suffered from an advanced bilateral chest lesion complicated by a tuberculous ulceration of the bowel; one patient in addition to a bilateral chest lesion suffered from a tuberculous ulceration of the bowel plus tuberculosis of the larynx. The combination of an advanced chest lesion and a tuberculous ulceration of bowel is regarded usually as a bad prognosis. It is reasonable to assume when so many people suffer from pulmonary tuberculosis and so relatively few of these patients suffer from tuberculous ulceration of bowel as a complication, that the latter must have/

have inherently poor powers of resistance, and consequently their outlook must be very poor whatever treatment they receive. The author administered pneumoperitoneum in the hope that it might serve a dual purpose (1) cause an improvement in the bowel condition, (2) promote healing of the chest lesion. These hopes were not realised. Banyai (12) reported similar observations after treating forty-four cases of tuberculous enteritis with pneumoperitoneum, he stated "They all showed a good response except two who died. They had advanced pulmonary tuberculosis". This confirms the author's findings. The combination of an advanced chest lesion and a tuberculous ulceration of the bowel augurs a bad prognosis. Three of the patients died 2-3 weeks after receiving pneumoperitoneum administered to arrest a severe haemoptysis. It was not thought advisable to continue the treatment in these patients. They suffered not only from the extensive lung lesion probably aggravated by the haemorrhage, but also from the effects of the loss of blood. Complete rest, in the writer's opinion, was the proper line of treatment. The isolated case which died suddenly during the administration of the pneumoperitoneum has been discussed already in the chapter dealing with the "complications of pneumoperitoneum". The four patients who suffered from bilateral chest lesion with no apparent complications had received pneumoperitoneum for/

for 2-3 months. They were making no noticeable progress and treatment was discontinued. Since these patients succumbed 4-6 weeks after the termination of the treatment the writer was unable to associate pneumoperitoneum directly with the cause of death in their case.

Of the twenty-one patients hospitalised, nine have shown very definite signs of improvement, while in twelve others, their condition has remained in statu$ quo. Many of those included in the latter group could be regarded as border line cases, but they have not been classified as "improved" since the accumulative evidence in these cases indicated only a slight improvement. Reference to tables 1 and 2, however, shows that these patients had received treatment for an average period of 6 months and even during that comparatively short period there was (1) a noticeable increase in weight in seven patients, (2) the blood sedimentation rate had commenced to fall, but in only one patient did it tend to approximate to the limits regarded as being normal, (3) four to five patients showed that their powers of resistance had improved, for the lymphocyte/monocyte ratio in these cases had increased at the expense of the monocytes. The Arneth index in one instance returned to normal.

Eleven of the forty patients who were considered as improved had/

had received treatment for an average period of ten months. In six instances the sputum was returned negative, in two others a positive result kept alternating with a negative finding, while in the remaining three patients the sputum remained positive. Five of these patients were admitted with a slight elevation of temperature, but this returned soon to normal; the average pulse rate was recorded throughout the course of treatment as being 80 per minute. Measurements of the vital capacity did not reveal any very important features. In all of these cases it remained at a low figure before and after the administration of pneumoperitoneum. There was a slight increase recorded in some of the patients. This improvement might be explained by a lessening of the toxaemia. Beaumont (16) and Dodds determined the vital capacity in two hundred and twenty-three cases of tuberculous diseases of the lungs and found that the "diminution of the vital capacity in pulmonary tuberculosis depends upon the activity of the disease rather than the extent of the lesion". Further confirmation of the lessening of the toxaemia in these cases was found in the changes in the Bonsdorff index. In four instances the patients returned a figure of 274 or over. As an indication of increased resistance 50% of the patients (36) showed a rise in their lymphocyte/monocyte ratio, an increase in the lymphocytes being recorded. The Arneth index did not/

not fully corroborate this latter finding for only in one instance did this index figure return to 40.

The influence of pneumoperitoneum on the radiological reports of the chest was not devoid of interest. There was no change in the patients who died, but in ten who showed signs of improvement the following results were observed. In two instances the exudative lesion became fibrotic on both sides, whereas in two others there was a disappearance of the exudative lesion in one side. Three cases were reported "less active" on both sides, while one case became "less active" only on the one side, in the remaining two patients the signs of activity were still present, radiologically.

The value of pneumoperitoneum is also reflected on the general metabolism of the patient. In the above ten patients an increase in weight was observed in every case.

Symptomatically the patients undergoing pneumoperitoneum showed an improvement. The act of coughing, for example, in many became much easier and less exhausting. The amount of sputum became increased in seventeen cases, although its character remained much the same. These patients appeared to expectorate with greater ease and were seldom sick after coughing. It can be assumed that this is a more complete emptying of the pulmonary excavations. The cough became/

became less troublesome. The diaphragm which formed a muscular barrier to the expulsive act of coughing was removed and the whole expulsive force concerned in the act of coughing was transmitted to the lungs. This means a more complete evacuation of the lungs of sputum laden with infection. The alveoli become better drained, and areas of partial atelectasis have a better chance of re-expanding and probably resuming their normal function.

Gastro-intestinal upset has not been of great consequence. There has been no complaint of sickness and in the majority of patients the appetite improved. The bowels, with two exceptions, seemed to function quite regularly. In two cases opening medicine had to be given at fairly frequent intervals.

Breathlessness has been observed only in one of the writer's cases with pneumoperitoneum treatment but this complication was only transient and soon disappeared. One of the patients obtained some temporary relief from her attacks of dyspnoea as a result of pneumoperitoneum. This patient's heart was pulled over to the right side of the chest. The writer believes that the pneumoperitoneum in this case was able to reduce the tension in the rigid thoracic cage by its effect on the diaphragm. The strain on/

on the heart thereby being relieved.

Slight dyspnoea was relieved in another case but the mechanism was slightly different for this patient had much compensatory emphysema in her chest. Her lung lesion showed a bilateral tuberculous condition with marked cavitation in both sides. There was much fibrosis round these cavities and in the surrounding lung tissue. Karol,(72) investigated the relation between emphysema and tuberculosis, and he stressed the point that a compensatory form of emphysema is most often seen in tuberculosis; especially if cavitation be present in the lung, associated with fibrosis. It would seem from Karol's findings and the fact that this patient derived some temporary relief from her dyspnoea that this result gave some support to the view that pneumoperitoneum is of some merit and value in the therapeutics of emphysema. This patient's tuberculous lung lesion did not seem to improve with pneumoperitoneum for the cavities remained patent. Treatment in this case was abandoned subsequently because of very high positive readings after a small insufflation of air had been administered. The writer regarded these readings as being due to developing abdominal adhesions and in his opinion continuance of the pneumoperitoneum endangered the patient's life.

Psychologically/

Psychologically the patients are the better of pneumoperitoneum. They become mentally brighter. In some cases this is due to the reduction in toxaemia, while in others the psycho-therapy value of pneumoperitoneum is responsible for the mental improvement. This psychic element in the handling of tuberculous patients is very important. It is rightfully a matter for careful consideration for, in no other somatic disease is there such an opportunity for the mind at all levels to exert its influence from the inception of the malady to its final issue or resolution. One of the patients, who derived mental appeasement from this line of treatment, continually talked of having "pneumothorax in the stomach", and believed herself to be no worse off than the patient in the next bed who received pneumothorax. The advanced cases are living under a death sentence. Let us try and help them in every way possible to escape from realising it. Many of these patients could be given many months of happiness in their tragic misfortune, if more attention was paid to psycho-therapy. These patients are more apt to combat successfully their disease if psychological equilibrium is maintained. The importance of this aspect in the therapeutics of tuberculosis has been recognised by many authors, thus M. Davies (39) states:- "There is some truth in/

in the idea that will power and the determination of patients to get better contributes to success"; Pottenger (99) supports this view when he says - "He is more apt to combat successfully his disease if psychological equilibrium is approximated. This requires treating the patient rather than the pathological process".

It will have been gathered from this discussion on the clinical effects of pneumoperitoneum in the forty cases under review that the writer has selected cases which would not give the best possible results. In each case, with the exception of the patient in whom pneumoperitoneum showed its effectiveness as an emergency procedure, and who was subsequently discharged from hospital, the writer applied pneumoperitoneum to chest lesions which have been advanced, active and bilateral, and also in chest lesions which have presented not only these features but have been complicated also by tuberculous ulceration of the bowel. Considering the material which has been selected for the application of pneumoperitoneum and the very poor prognosis in these cases before treatment was started, the writer cannot help feeling that the results obtained are far from discouraging.

N.B.

When pneumoperitoneum was introduced first to Robroyston Sanatorium, in November, 1937, the writer's attention was directed solely to its effects, clinically, on the patients. The realisation that those receiving this form of treatment were responding very favourably to it, prompted the writer to put his investigations on a more scientific basis. This explains the omission of certain laboratory examinations as shown in the tables in a small number of the patients. From July 1941 until March 1942 the writer has been confined to bed suffering from an illness of a severe and chronic nature. This period of invalidism accounts for the lack of data pertaining to those who continue to receive pneumopertoneum. The increased duties imposed on the medical staff of an Emergency Hospital and Sanatorium during wartime has prevented the writer soliciting the assistance of his medical colleagues in Laboratory and other investigations relating to the effects of pneumoperitoneum on those patients still receiving this treatment.

3. CASE REPORTS.

Types of cases selected for Artificial Pneumoperitoneum are exemplified by the following clinical notes:-

CASE I.

Patient's Name: I.C. Aet - 19 years.

1. History of Present Illness:

About five months prior to admission to hospital this patient, a young girl of nineteen years and working in a bondage store, first began to complain of a persistent cough which was accompanied by sputum. The former complaint had no definite diurnal periodicity but the patient stated that it appeared to be much worse at night, and in fact, on many occasions her sleep was disturbed because of it. Her expectoration was never copious and was never bloodstained. Night sweats were very noticeable about this period, as was also loss of weight. Patient did not appear to attach much importance to the above symptoms and only sought medical advice when she commenced to complain of intermittent colicky pains in the suprapubic region. These pains were not related to menstruation and the onset of this did not influence the pains prejudicially or alleviate them in any way. Patient maintained that her bowels were functioning quite normally. Her medical attendant confined her to bed until her pains had/

had subsided before he made arrangements for her chest to be X-rayed. This was done and the radiologist reported that she was suffering from active bilateral pulmonary tuberculosis. Her sputum was examined and the laboratory findings were in keeping with the X-ray report, namely, "many tubercle bacilli in the sputum".

II. Previous Illnesses:

Patient had no previous illness of a serious nature. There was no history of frequent colds, pleurisy, or pneumonia.

III. Family History:

One sister was notified as suffering from pulmonary tuberculosis.

IV. Examination on Admission: 14th May, 1940.

On admission to hospital patient appeared ill and toxic looking. She was not well nourished. Her weight was 6 stones 7 lbs. Her skin was moist and was very easily picked up from the underlying tissues. There were no palpable lymph glands.

Examination of the temperature chart revealed the following:-

Temperature 99°F., Pulse rate 120 per minute,
Respirations 22 per minute.

V./

V. Examination of the Systems:

A. Respiratory System:

(i) Inspection: Respirations were easy and regular but were not of great amplitude. There was no undue prominence of superficial veins in the anterior chest wall. Expansion of the chest was poor over both apices, anteriorly, especially in the right side.

(ii) Palpation confirmed the fact that the expansion was poor at both apices, anteriorly and posteriorly, the right apex appeared to have less power of expansion than the left. The muscles of the shoulder girdle on both sides showed signs of atrophy. There was some wasting of the pectoralis major in the right side. The sternal heads of both sterno-mastoids, on palpation, revealed increased tonus; vocal fremitus was not exaggerated.

(iii) Percussion: Percussion note was dull, of slightly higher pitch, and gave a sense of increased resistance over the right upper lobe. This difference was marked more posteriorly than anteriorly. Krönig's area was diminished over the right side.

(iv) Auscultation: The breath sounds were bronchial in character over the right upper lobe anteriorly and posteriorly, whereas in the left side anteriorly the vesicular element was much in evidence. The whole way down the posterior aspect of the/

the chest, there was a prolongation of the expiratory phase of the vesicular type of breathing. Adventitious sounds were not localised over any one area. They had a widespread distribution on both sides. They were of the medium coarse subcrepitant type and could be heard during both phases of respirations. Bronchophony was present over right upper lobe posteriorly.

(v) Radiological Examination: (21.5.40). "Active tuberculosis of the upper third of the right lung and the upper half of the left lung. There are some left sided basal adhesions".

(vi) Laboratory Examination: (16.5.40). The sputum report was - "Many tubercle bacilli present".

(vii) Vital Capacity: 1500 cc.

(viii) Laryngeal Examination: "No abnormality seen".

B. Cardio Vascular System:

(i) Peripheral Circulation: This appeared fairly good. Patient had a left sided malar flush.

(ii) Pulse: The rate was rapid being 120-130 per minute. Its rhythm was regular but the volume was poor.

(iii) Blood Pressure: The systolic blood pressure was 118 mms. of mercury; the diastolic blood pressure was 88 mms. of mercury.

(iv)/

(iv) Heart:: There was no abnormality to be detected by the usual methods of inspection palpation, percussion and auscultation. The heart rate was rapid but its rhythm was quite regular.

(v) Blood Picture:

White Blood Count.....	11,000 per c.mms.	
Differential Count.....	Neutrophils	62%
	Lymphos. (large)	7%
	Lymphos. (small)	19%
	Monos.	12%
	Basophils	0%
	Eosinophils	0%
Lymphocyte/Monocyte.....	Ratio	2:1
Arneth Count.....	1.	19%
	11.	33%
	111.	28%
	1V.	10%
	V.	10%

Arneth Index.....52

Von Bonsdorff Figure.....259

Weighted Mean.....2.59

Blood Sedimentation Rate = 68 mms. at the end of the 1st hour.

C. Central Nervous System:

Patient appeared very listless. The knee jerks were present in both sides. The planter response was flexor in type. The pupils were equal in size and reacted to light directly and consensually.

D/

D. Alimentary System:

Patient's appetite was poor; there was no history of constipation nor diarrhoea.

(i) Buccal Cavity:

(a) Teeth - Many of them showed caries.

(b) Tongue was furred.

(c) Tonsils showed no enlargement.

(ii) Abdomen: Moved easily with respiration. No palpable masses detected. There was no tenderness of the abdominal wall.

(iii) Measurements:

Planes:	Transpyloric	- 13¼ ins.	- inspiration
		13½ ins.	- expiration
	Umbilical	- 13 ins.	- inspiration
		13¼ ins.	- expiration

E. Genito-Urinary System:

The menstrual cycle was fairly regular being 3-5 days/28 days; the blood did not clot. No pain was experienced during micturition. There was no complaint of dysuria. Chemical examination of urine revealed no abnormality.

VI. PROGNOSIS:

The prognosis in this case did not appear very good as patient was suffering from an active and fairly extensive/

extensive bilateral pulmonary lesion which was tuberculous in nature. This was proved clinically, radiologically and also by a laboratory examination. She was very toxic on admission and according to Houghton (64), the Von Bonsdorff figure in this case gave an indication of the degree of toxaemia present, 256, being a much lower figure than 274. Confirmatory evidence of a poor prognosis was gained from the lymphocyte/monocyte ratiol The ratio 2/1, instead of 3/1, revealed and signified an outlook which appeared poor for the patient. Estimation of the rate of sedimentation of the erythrocytes confirmed the above findings. The temperature in this case was certainly never very high but this observation is not always an indication of the degree of activity of a chest lesion, for a patient may have an active bilateral chest lesion, and show little or no elevation in temperature. In the Trudeau (90) Sanatorium a temperature of 99°F or a pulse of 90 in men, and a temperature of 99.6°F or a pulse of 96 in women, on three of seven consecutive days, not due to any demonstrable cause, is considered evidence of activity. This point was emphasised by Krause (79) when he stated: "It will be a great advance in diagnosis when the generality of medical men give up the idea that elevation of temperature is the chief and most important symptom in pulmonary tuberculosis or the sine qua non of activity".

VII/

VII. TREATMENT:

This case was considered at the hospital clinical conference. The above criteria were appreciated and a poor prognosis was predicted unanimously. It was decided, however, since many a bilateral lesion, which appeared hopeless on admission, had improved with a carefully induced bilateral artificial pneumothorax, that this form of collapse therapy should be attempted in this case. Accordingly, about six weeks after admission to hospital, an attempt was made to induce the right side. The right sided pneumothorax appeared initially to be successful, but with each subsequent refill the manometer readings became more positive, even with small refills, that it was decided, for the patient's welfare, to abandon this form of treatment. So far, patient was not disturbed in any way from this unsuccessful attempt at pneumothorax in the right side. She was given a month's rest and then an attempt was made in the left side to induce a pneumothorax despite the radiological findings relating to the presence of adhesions. A left sided artificial pneumothorax was induced accordingly in the left side on 20th August, 1940. Once again similar complications were met in this side as in the contralateral side. The refills began with fairly good negative manometer readings but they became soon very positive, and it was necessary to abandon this side too, or continue the pneumothorax/

pneumothorax and let the patient run very grave risks.

An interval bilateral artificial pneumothorax had been attempted and failed. Accordingly this case, presented now very clear indications for an artificial pneumoperitoneum and on the 18th October, 1940, patient received her first insufflation of air, 500 c.cs. being injected into the peritoneal cavity. This induction of an artificial pneumoperitoneum was uncomplicated. Her only complaint was some slight shoulder pain but this was not of any great moment, and it was relieved readily by aspirin (gr.x). Patient received bi-weekly refills of 500 c.cs. for the first fortnight followed by weekly refills of 1,000-1,500 c.cs.

She made no complaints during these large refills. Occasionally, when the air was being administered, it was noticed that her respiratory excursions became deeper when the 500 c.c. mark was reached, but there was no great departure in her normal respiratory rate. This feature disappeared when the refill was completed. One very persistent noticeable feature of the large insufflations was the increase in size of abdomen, and the absolute obliteration of the hepatic area of dullness. When the abdominal binder was tightly applied the abdominal protuberance became less pronounced.

Fluoroscopic examinations were done at varying intervals to gauge the proper elevation of the diaphragm. Both diaphragmatic domes were seen to be much elevated and partially/

partially immobile, but not completely immobile. The domes were seen also to be very much thinned out and atonic. The liver and the spleen were outlined very well. These features were confirmed radiologically (c.f. X-ray plate No. v).

VIII. RESULT:

This patient had received artificial pneumoperitoneum for nine months. Weekly refills of 1000-1500 c.cs. were given, and there were no complications. On the contrary, she improved with this form of treatment. She became much brighter. She began to sit up in bed, took her food, slept well and continued to put on weight, one stone was gained during the nine months' treatment with artificial pneumoperitoneum. Blood examinations were done at monthly intervals. On page 139 are presented the Differential Counts from which the lymphocyte/monocyte ratio, the Arneth Counts, and the Von Bonsdorff figures can be obtained. An attempt is made to represent also the changes graphically in (1) the differential White Cell Count (p.141), (2) the blood sedimentation rates (p.142). There is no doubt that an examination of the changes in the blood cytology, supported the view that artificial pneumoperitoneum played a part in improving this patient's power of resistance; under treatment with pneumoperitoneum this patient, who had an apparently hopeless lesion became, after a period of nine months/

months better equipped to stem the onrushing attack of the invading host and was able to offer much greater powers of resistance to it.

DIFFERENTIAL COUNT.

Patient's Name: I.C. Aet - 19 years.

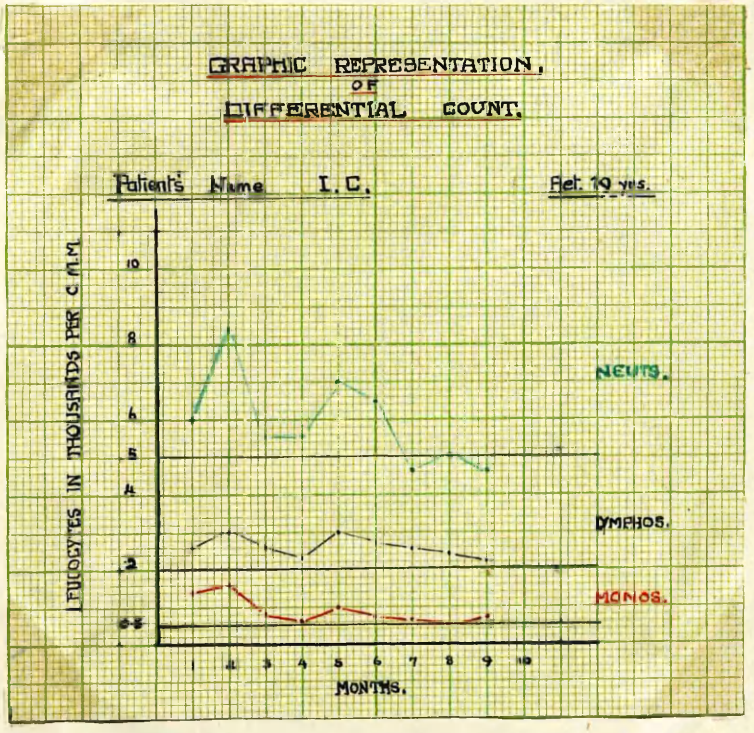
Date	Total Count	Neutrophils		Lymphocytes		Monocytes	
		Total	%	Total	%	Total	%
1940							
Oct.	10,000 per c.mm	6,000	60	2,600	26	1,400	14
Nov.	13,000 "	8,580	66	2,860	22	1,560	12
Dec.	9,000 "	5,400	60	2,700	30	900	10
1941.							
Jan.	8,500 "	5,440	64	2,295	27	765	9
Feb.	11,000 "	6,930	63	3,190	29	880	8
March	10,000 "	6,500	65	2,700	27	700	7
April	7,800 "	4,524	58	2,652	34	624	8
May	8,000 "	5,120	64	2,400	30	480	6
June	7,000 "	4,410	63	2,030	29	560	8

N.B. The Eosinophils and Basophils have been excluded in the above table. Their absence explains why some of the columns do not add up to 100.

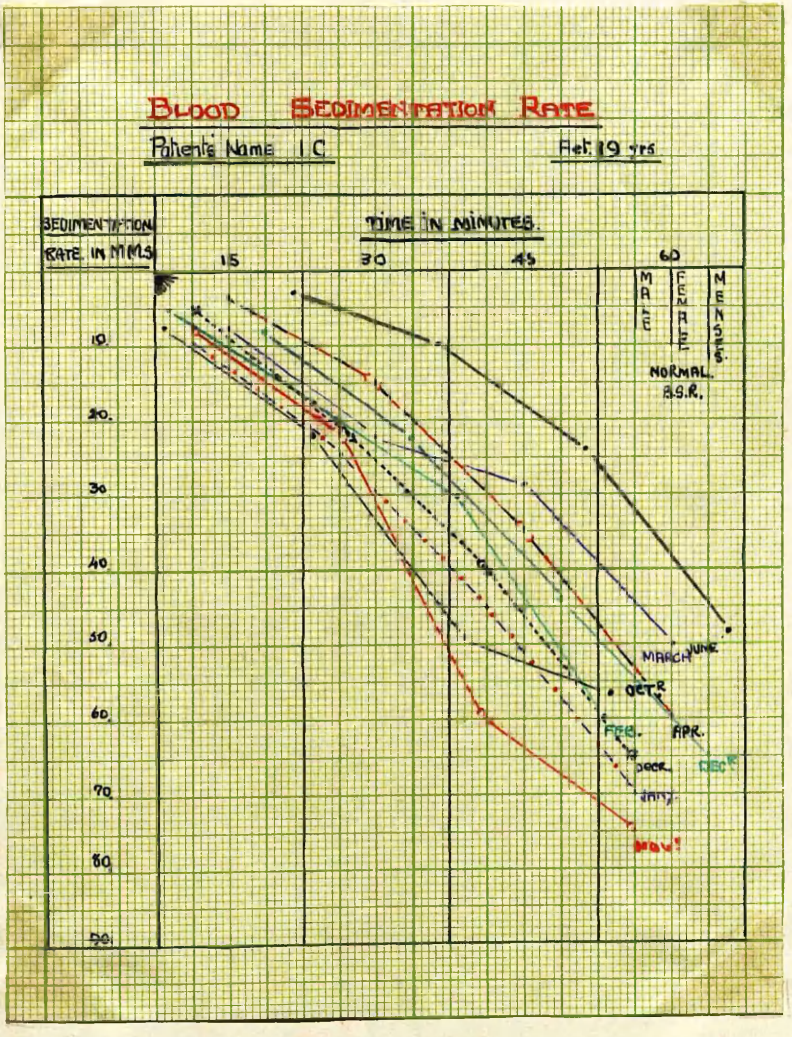
LOBULAR ASSESSMENT OF LEUCOCYTES - DURING TREATMENT.

Patient's Name: I.C. Aet - 19 years.

Date	No. Lobes in each Group					Arneth Index	V.Bonsdorff figure	Weighted mean
1940	I.	II.	III.	IV.	V			
Oct.	16	38	28	10	8	54	256	2.56
Nov.	14	36	22	18	10	50	275	2.74
Dec.	14	28	30	16	12	42	284	2.84
1941								
Jan.	10	34	36	15	5	44	271	2.71
Feb.	12	35	38	12	3	47	259	2.59
Mar.	14	30	32	14	10	44	224	2.24
April	10	38	34	15	3	48	263	2.63
May	8	34	32	20	6	42	278	2.78
June	7	36	40	16	1	43	268	2.68



Charts representing the differential counts are plotted on the same scale and represent the total number per c.mm. of each type of cells shown. The number of each type was obtained by taking percentage (number of each cell was obtained from the differential count) of the total count. The writer has accepted arbitrarily as the normal base line for neutrophils, 5,000 per cmm.,for lymphocytes 2,000 per c.mm., for monocytes 500 per c.mm. Points above these lines represent an increase, and below a decrease of the leucocytes in the circulating blood at the time the count was taken.



The above biological changes appeared to be working in harmony with the clinical picture, for this patient's sputum became negative for the tubercle bacilli.

Patients/

Patient's temperature remained at 98.4°F, the pulse rate at 80-90 per minute, and the respirations at 18-20 per minute. Patient looked well and the malar flush noticed on admission disappeared. The chest signs did not vary much however. Certainly the dullness was not so marked over the right apex, but the bronchial character of the breathing persisted. The expiratory phase remained prolonged in the left side, and the crepitant râles could be discerned still in both sides. If anything, they became perhaps more difficult to hear. An X-ray plate taken at the completion of the treatment revealed the following "Disease seems to be fibrosed, I see no activity" (c.f. X-ray Plate No. V).

The persistence of the râles in the chest when other clinical signs are in keeping with a general improvement is certainly very discouraging, but how much importance can be attached to these adventitious sounds? Formerly, it was thought that when the lesion in the chest began to improve there was a diminution in the number of and the area over which râles were heard, and vice versa. It is now generally accepted that the presence of these râles, the most characteristic physical finding in tuberculosis, may be of little value in portraying the underlying lung lesion and when taken alone should not be considered as a sign of active disease. The râles to which the writer refers are the moderately coarse râles/

râles known as crepitations. They are regarded now as atelectatic râles caused by collapse of parenchymal alveoli by exudation or infiltration in a neighbouring lobule; or by the constriction or contraction of fibrous tissue; or by partial occlusion of bronchioles by inflammatory tissue. In other words, they are produced in partially collapsed more or less normal lung tissue, such collapse being produced by adjoining tuberculous infiltration. They are not caused by moisture, and may persist for years after clinical arrest or cure. (62) Heise, who made a study of the relationship of râles to prognosis, has shown that of one hundred and eleven patients, in whom râles remained unchanged as to area and character over a period of six months, 93% showed definite X-ray evidence of improvement, 2% X-ray evidence of relapse, and 5% stationary conditions in the X-ray appearances. Moreover, râles were found over a greater area in ninety-two patients, of whom 71% showed improvement, 23% X-ray spreads, and 6% remained stationary. From this report it appears that more patients show improvement with increased râles than show relapses, and when râles develop anew or increase, it does not follow that the disease is spreading, for in more than three-quarters of such instances, according to Heise's observations, they are accompanied by improvement or a stationary condition in the radiological/

radiological findings.

In conclusion, it is felt that artificial pneumoperitoneum, combined with rest in this case, has produced results which cannot be disregarded particularly when treatment was carried out in a patient whose prognosis was considered hopeless, not only by clinical and radiological findings but also after certain biological features had been taken into consideration in the final assessment of the case, and also when other forms of treatment were plainly contra-indicated or unsuccessful in their execution.

CASE II.

Patient's Name: T.McA. **Aet - 18 years.**

1. HISTORY OF PRESENT ILLNESS:

Patient, a domestic servant aged 18 years, stated that five months before she was admitted to hospital she complained of some slight pain in the left side of chest accompanied by a short sharp cough. Sputum was present but it was scanty in amount and was never streaked with blood. Patient stated that she was easily tired, noticed she was losing weight and that she perspired frequently at night in bed. Suppression of the menses was also noticed about time; it appeared to worry her unduly, the chest pain and slight cough/

cough being subservient symptoms to this disturbance of the menstrual cycle. Patient consulted her doctor regarding this complaint and during the routine examination he noticed that she had a chest condition. She was given a "tonic" and arrangements were made for her chest to be X-rayed. The X-ray report confirmed the doctor's suspicions and the patient was transferred to Robroyston Sanatorium.

II. PREVIOUS ILLNESS:

Pleurisy in the left side in June 1939. No history of pneumonia.

III. FAMILY HISTORY:

Father and Mother well. Brother and sister well. No history of tuberculosis in family.

IV. EXAMINATION ON ADMISSION: 9th August, 1940;

On admission patient was thin, pale, and toxic looking. Her weight was 6 stones 11½ lbs. Her skin was moist abd chilblains were present in both hands, but no obvious evidence of clubbing of the fingers was observed. There was generalised muscular wasting, and the skin was found to be but loosely attached to the underlying structures. Examination of the temperature chart revealed the following - temperature 98-100°F: pulse rate 108 per minute; respirations

20/

20 per minute.

V. EXAMINATION OF THE SYSTEMS:

A. Respiratory System:

Inspection: The respiratory excursion was poor over both apices anteriorly. Its rhythm was regular; the rate was not increased unduly; flattening of both intra-clavicular fossae or Möhrnheim's fossae, was noticed.

Palpation: The respiratory excursion was found diminished not only over both upper lobes anteriorly but also posteriorly. Atrophy of the muscles of the shoulder girdle and accessory muscles of respiration was noticed; the vocal fremitus was increased over both apices.

Percussion: The percussion note was impaired over both apices anteriorly and posteriorly. Krönig area was diminished in both sides.

Auscultation: Breath sounds were bronchial in character over both upper lobes. Adventitious sounds of the coarse moist variety were preseht over the left upper lobes posteriorly, while rales of the finer subcrepitant variety were present over the right upper lobe. Broncho-phony was present over both upper lobes posteriorly.

Radiological Examination: (24.8.40) "There is tuberculosis of the upper half of the right lung and the whole of the left lung".

Laboratory/

Laboratory Examination: (29.8.40) "Sputum contains many tubercle bacilli".

Vital Capacity: 1800 c.cs.

Laryngeal Examination: (10.8.40) "No abnormality seen".

B. Cardio-Vascular System:

Vasomotor System: Congestion of the peripheral blood stream was noticed. Patient had very marked chilblains on both hands.

Pulse: The rate was rapid being 110 per minute. Its rhythm was regular and the volume was fairly good.

Blood Pressure: The systolic blood pressure was 126 m.ms. of Mercury, the distolic pressure being 74 m.ms.

Heart: - no abnormality was detected by the usual methods of inspection, palpation, percussion and auscultation.

Blood Picture:

White Blood Count.....	13,200 per c.mm.	
Differential Count.....	Neutrophiles	62%
	Lymphocytes	28%
	Monocytes	10%
Lymphocyte/Monocyte rates.....		2.8/1
Arneth Count.....	I.....	18
	II.....	29
	III.....	25
	IV.....	20
	V.....	8
Arneth Index.....		47

Von/

Von Bonsdorff Figure.....271

Weighted Mean.....2.71

Blood Sedimentation Rate 98 m.ms. at the end of the 1st hour, c.f. graph.

C. Central Nervous System:

No abnormality was detected by the usual methods of examination. The pupils were equal in size and reacted to light directly and consensually. The plantar response was flexor in type.

D. Alimentary System:

Patient's appetite appeared good.

Buccal Cavity: Teeth - were in good condition. Tongue - was not furred. Tonsils - were congested slightly.

Abdomen: The abdomen moved freely with respirations.

Measurements: Transpyloric - 27¼ ins. Inspiration
27½ " Expiration

Umbilical - 25½ " Inspiration
26 " Expiration

E. Genito-Urinary System:

Amenorrhoea was present at the time of the examination and for a period of five months prior to admission. Chemical examination of urine revealed no abnormality. There was no complaint of dysuria nor frequency of/

of micturition.

VI. PROGNOSIS:

This case was presented to the members of the hospital staff at one of the clinical conferences and after all the criteria available had been considered a unanimity of opinion was pronounced in favour of a very poor prognosis. The extensive bilateral distribution of disease obviated any possibility of a bilateral artificial pneumothorax. The low vital capacity appeared too a contra-indication for a bilateral pneumothorax. It was uncertain in this case to determine how much importance was to be attached to the blood picture, for the results from the blood investigation on admission were difficult to interpret, as they were rather conflicting. Thus, the differential blood count, the lymphocyte/monocyte ratio, the Von Bonsdorff figure, and even the Arneth Count, on the one hand, gave results which were not too discouraging for the future welfare of the patient, while on the other hand the Blood Sedimentation rate showed a very rapid sedimentation of the erythrocytes indicating a poor prognosis. Much weight was given to the positive findings, namely, the X-ray findings, the clinical picture presented by the patient, the vital capacity, the persistent amenorrhoea and rapid sedimentation of the erythrocytes; and fluctuant/findings like the cytological features of the white cells, seen in a blood film, were not permitted by themselves/

themselves to prejudice the prognostications of the medical staff at the conference. Since tuberculosis is a disease in which all stages of the lesion are met, it was regarded that the present favourable blood picture was just an indication of a certain reparative process in progress at the time of the blood examination which predominated the blood picture.

VII. TREATMENT:

On the 26.9.40 patient had an insufflation of air into the peritoneal cavity (500 c.cs.) There were no complaints and since it was tolerated very well a second insufflation was given three days later. She received bi-weekly insufflations for about three weeks, after which period weekly administration of 1000 c.cs. of air were instituted. Patient received pneumoperitoneum for approximately a year, no complications were encountered. On two occasions her sputum examination was returned "negative for the tubercle bacilli" from the bacteriologist. The negative results alternated, however, with a positive result; so far the writer has not obtained three consecutive negative sputum examinations in this case.

Patient was screened repeatedly and the diaphragmatic domes were both elevated and partially immobile. X-ray films, which confirmed the elevated position of the diaphragm, are shown/

shown in the section headed "Radiological Illustrations". It will be noticed that the cavity in the left lung remained patent. The writer has never been successful in closing an apical cavity with pneumoperitoneum, but this result should not, in his opinion, minimise the beneficial effects of pneumoperitoneum nor cause one to underestimate its value, for even although it was not successful in closing the cavity it increased the patient's powers of resistance, for she gained approximately two stones in weight, the night sweats disappeared, and the pulse rate kept regularly at 80-90 per minute. Patient became afebrile, her sputum became negative. A rough parallelism in the improvement of this patient's clinical condition can be drawn from the graphic representation of the differential white cell count, and also the blood sedimentation rate similarly represented.

The assessment of the segmentation of the nuclei of the leucocytes, and the differential white blood counts, observed during the course of treatment are represented herewith in tabulated form.

DIFFERENTIAL COUNT.

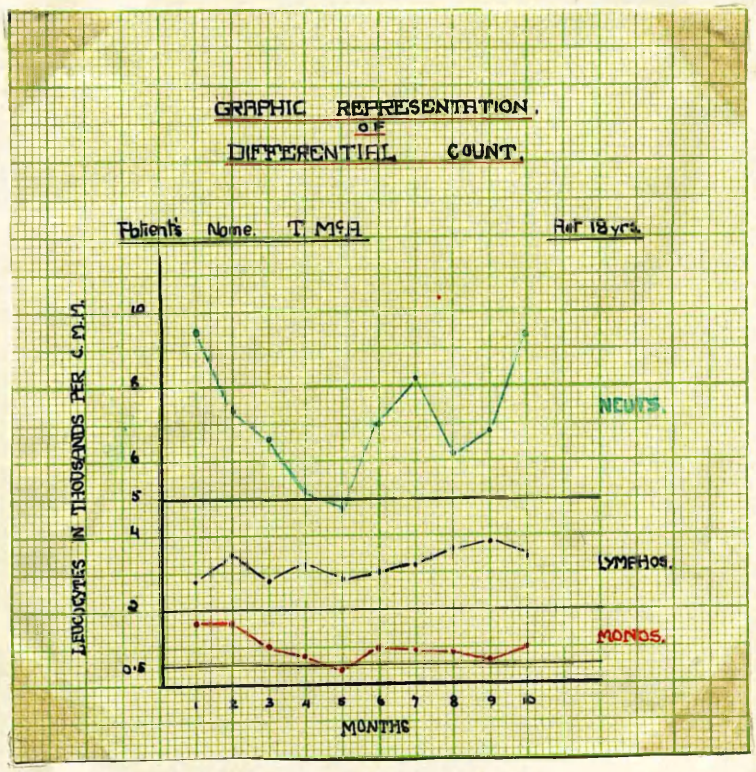
Patient's Name: T.McA. Aet - 18 years.

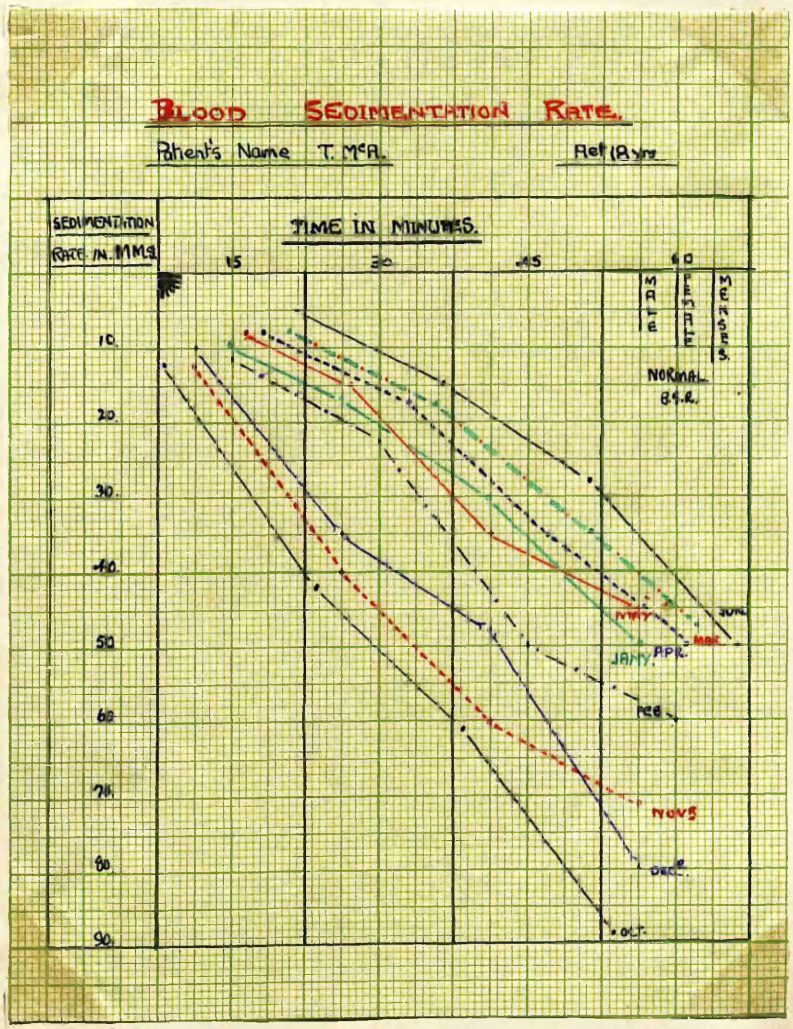
Date	Total Count	Neutrophils		Lymphocytes		Monocytes	
		Total	%	Total	%	Total	%
1940							
Sept.	14,000 per c.mm.	9,520	68	2,800	20	1,680	12
Oct.	12,800 "	7,424	58	3,584	28	1,792	14
Nov.	10,600 "	6,784	64	2,756	26	1,060	10
Dec.	9,000 "	5,130	57	3,150	35	720	8
1941							
Jan.	8,000 "	4,800	60	2,800	35	400	5
Feb.	11,000 "	7,150	65	2,860	26	990	9
Mar.	12,000 "	8,160	68	3,000	25	840	7
April	10,500 "	6,195	59	3,685	33	840	8
May	11,200 "	6,832	61	3,808	34	560	5
June	14,200 "	9,656	68	3,550	25	994	7

ARNETH COUNT - DURING TREATMENT.

Patient's Name: T.McA. Aet - 18 years.

Date	No. Lobes in each group					Arneth Index	V. Bonsdorff Figure	Weighted Mean
	I.	II.	III.	IV.	V.			
1940								
Sept.	18	32	24	18	8	50	266	2.66
Oct.	16	36	30	15	3	52	253	2.53
Nov.	14	34	31	19	2	48	261	2.61
Dec.	16	30	31	20	0	49	255	2.55
1941								
Jan.	12	38	32	14	4	50	260	2.60
Feb.	10	34	38	16	2	44	266	2.66
Mar.	8	36	32	18	6	44	278	2.78
April	10	31	40	15	4	41	272	2.72
May	5	37	42	14	2	42	269	2.69
June	8	35	29	20	8	43	285	2.85


GRAPHIC REPRESENTATION
OF
DIFFERENTIAL COUNT.
Patient's Name. T. McH
Age 18 yrs.
LEUCOCYTES IN THOUSANDS PER C.M.M.
10
8
6
5
4
3
0.5
NEUTS.
LYMPHOS.
MONOS.
1 2 3 4 5 6 7 8 9 10
MONTHS


BLOOD SEDIMENTATION RATE.
Patient's Name T. McA.
Ref (Ayre
SEDIMENTATION RATE IN MMS.
TIME IN MINUTES.
15
30
45
60
10
20
30
40
50
60
70
80
90
MALE
FEMALE
NORMAL
M.
F.
MAY
JUNE
MAR.
APR.
JAN'Y.
FEB.
NOV'S
DEC.
OCT.

CASE III.

Patient's Name - A.D. Aet - 20 years.

This case and Case IV are cited to demonstrate the combination of pneumoperitoneum with other forms of collapse therapy as, for example, phrenic nerve crush operation and artificial pneumothorax respectively.

I. HISTORY OF PRESENT ILLNESS:

The case history here is very much in keeping with the typical case of a patient suffering from pulmonary tuberculosis namely, four months before admission to hospital patient complained of a persistent cough accompanied by sputum which was never bloodstained, but was rather difficult to expectorate. Loss of weight, a general feeling of tiredness and night sweats all bore testimony to a generalised, systemic disturbance. X-rays taken of the chest revealed the hilateral lesion, and the sputum examination left no doubts as to its precise nature. Arrangements were completed soon for an early admission into Robroyston Sanatorium.

II. PREVIOUS ILLNESSES:

Rheumatic fever at twelve years of age. Measles and whooping cough in infancy.

III. FAMILY HISTORY:

One/

One sister was suffering from lupus of the face. Father and Mother alive and well.

IV. EXAMINATION ON ADMISSION: (12.11.40)

General Examination: Patient was not very well nourished; his skin was moist; there were no palpable lymph glands; no clubbing of fingers was noticed.

Examination of temperature chart gave the following information:- Temperature 98°F; Pulse rate 88 per minute. Respirations 20 per minute.

V. EXAMINATION OF SYSTEMS:

A. Respiratory System:

(1) Inspection: The respiratory rate was not increased. Its rhythm was regular and equal in both sides. There was noticed some flattening of both infraclavicular fossae with a poor respiratory excursion over these areas.

(ii) Palpation: This method of examination confirmed the poor respiratory excursion over both apices. Vocal fremitus was exaggerated over both upper lobes.

(iii) Percussion: Dullness and a sense of increased resistance was found over both apices. Krönig area was diminished over both apices.

(iv) Auscultation: Breath sounds were bronchial over both apices, anteriorly and posteriorly. Coarse moist râles/

râles were present over these areas during both phases of respiration. Vesicular type of breathing was heard elsewhere in the chest. The expiratory phase was prolonged down both sides posteriorly to the level of the inferior angle of the scapular

(v) Radiological Examination: (12.12.40) "There is active tuberculosis of the upper 2/3 of both lungs with cavitation in the left."

(vi) Sputum Examination: (13.11.40) "Many tubercle baccili in sputum."

(vii) Vital Capacity: 2,500 c.c.

B. Cardio-Vascular System:

(a) Vaso-motor system: The peripheral circulation appeared to be very good.

(b) Pulse: Rate 88 per minute. Its rhythm was regular and its volume was good.

(c) Blood pressure: The systolic blood pressure was recorded as being 118 m.ms. of mercury, the diastole being 80 m.ms.

(d) Heart: No abnormality was detected by the usual methods of examination, namely inspection, palpation, percussion, and auscultation.

(e) Blood investigation:

(i)/

(i) White blood count.....14,000 per c.mms.

(ii) Differential count.....Neutrophils....60%
Lymphocytes....26%
Monocytes.....14%

Lymphocyte/Monocyte Ratio.....1.85/1

(iii) Arneth count.....I..... 18
II..... 32
III..... 31
IV..... 16
V..... 3

Arneth Index..... 50

(iv) Von Bonsdorff figure.....254

(v) Weighted Mean.....2.54

(vi) Blood Sedimentation Rate - 78 per mm. at the end of 1st hour.

C. Central Nervous System:

The pupils were equal in size and reacted to light directly and consensually. The Plantar response was flexor in type. Patient had a quiet disposition and was not, in any way, temperamental.

D. Genito-Urinary System:

No symptoms referable to this system.

Alimentary System:

(i) Buccal Cavity: The tongue was clean and the teeth were in good condition. There was no enlargement of the tonsils.

(ii) Abdomen/

(ii) Abdomen: No masses to be felt.

Measurements:

Umbilical	25 ins.	Inspiration
	26 "	Expiration
Transpyloric	29 "	Inspiration
	30 "	Expiration

PROGNOSIS: Poor.

Treatment: In view of the extent and activity of the lesion it was decided that a pneumoperitoneum might be better tolerated than a bilateral pneumothorax for if the latter was to be of any value it would require to be an initial simultaneous bilateral artificial pneumothorax. This form of collapse therapy would probably be attended by disastrous results since there was very little residual healthy lung parenchyma. An interval bilateral artificial pneumothorax would produce a somewhat similar issue as the lesion was active in both sides and the artificial pneumothorax on the one side might tend to flare up the lesion on the contralateral side. Bearing these points in mind it was decided to perform a pneumoperitoneum but in this instance it was to be reinforced by a phrenic crush on the worse side. This combination was thought to produce less drastic changes in the chest than a bilateral pneumothorax. The rationale of this form of treatment was quite simple. Pneumoperitoneum would exercise a beneficial effect on both lungs while the side in which the phrenic/

phrenic operation had been performed would derive the additional benefits from the effects of the paralysed diaphragm. Going on the principle of treating the worse side first, it was decided to paralyse the left phrenic nerve. This procedure was carried out on the 9.12.40 and eight days later this form of collapse therapy treatment was supplemented by an artificial pneumoperitoneum.

Patient was given the routine bi-weekly insufflations for a period of three weeks followed thereafter by weekly insufflations of a 1,000 c.cs. of air. During the initial insufflation this patient complained of pain in the contra-lateral shoulder, that is, on side opposite to the paralysed phrenic nerve, the homolateral side being free from pain. This patient's treatment was uncomplicated. There was never any evidence of dyspnoea during or immediately following a large insufflation of air. There was no sickness following the left sided phrenic (3) nerve operation and the patient's appetite continued to be good. Clinically the usual improvement was noticed; she gained over 2 stones in weight; night sweats were absent; she had no elevation of temperature; her pulse rate ran roughly between 80-86 per minute. Patient's sputum became scanty but remained positive.

The blood pictures are represented on pages 163,164,165, and their interpretation supports the view, in a broad sense that the blood/

blood examination can in a general way, in some cases, be regarded as the mirror of the underlying pathological lesion as it reflects often the progressive, or retrogressive, changes that are occurring in the body. In this case the X-ray findings are not in unison with the cytological characteristics of the blood for the films show that the lesion remained active. It is rather difficult to explain satisfactorily this result and one must, the writer feels, lay much stress on the positive X-ray findings which are more tangible and subject to fewer fluctuations than say, the blood examination. It may be, however, that the blood investigation reveals more minute and earlier patholigical changes than an X-ray film and progressive changes become apparent much sooner here than they do in the X-ray film. In other words, the changes are first manifest in the blood long before they appear radiologically in a radiogram of the lung.

DIFFERENTIAL COUNT.

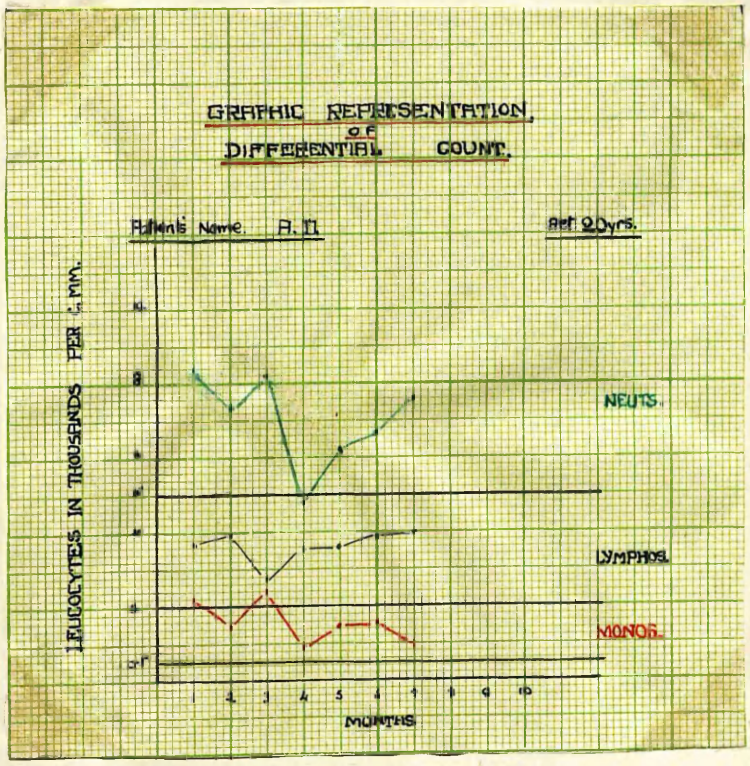
Patient's Name: A.D. Aet - 20 yrs.

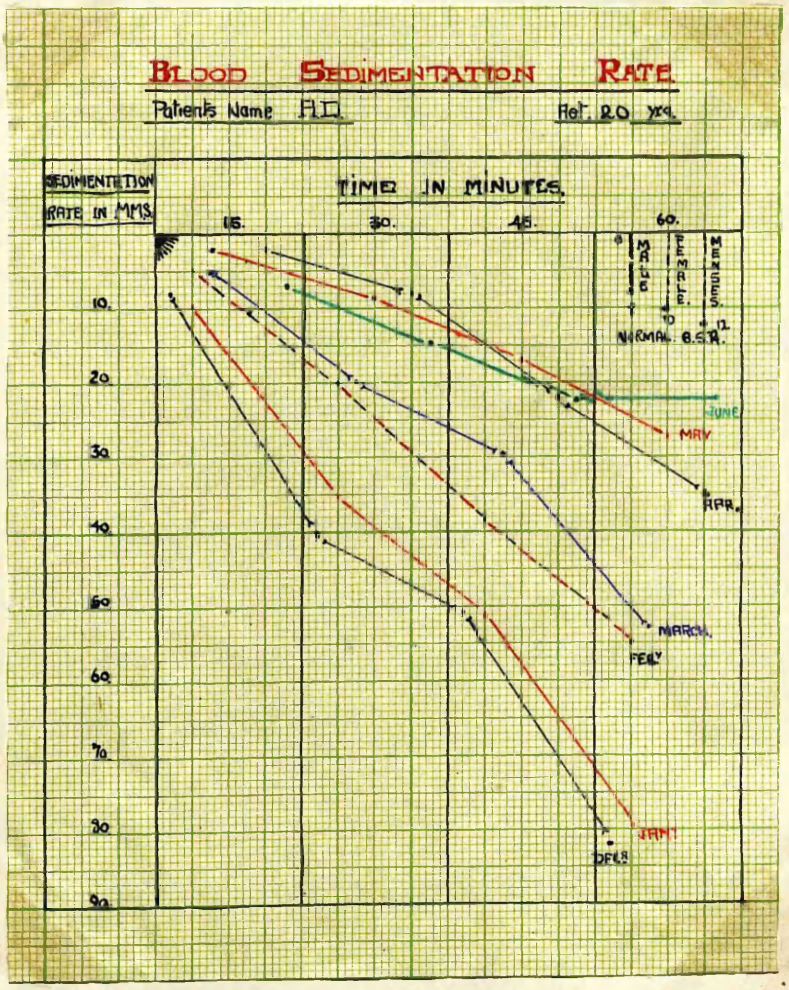
Date	Total Count	Neutrophils		Lymphocytes		Monocytes	
		Total	%	Total	%	Total	%
1940 Dec.	14,000 per c.mm.	8,400	60	3,640	26	2,040	14
1941 Jan.	12,800 "	7,424	58	3,840	30	1,536	12
Feb.	13,200 "	8,316	63	2,640	20	2,112	16
Mar.	9,200 "	4,876	53	3,404	37	9,200	10
April	11,000 "	6,380	58	3,190	29	1,430	13
May	12,000 "	6,720	56	3,960	33	1,320	11
June	10,900 "	7,085	65	3,815	35	981	9

LOBULAR ASSESSMENT OF LEUCOCYTES - DURING TREATMENT.

Patient's Name: A.D. Aet - 20 years.

Date	No. Lobes in each Group					Arneth Index	V. Bonsdorff Figure	Weighted Mean
1940	I.	II.	III.	IV.	V.			
Dec.	18	32	31	16	3	50	254	2.54
1941 Jan.	14	36	33	12	5	50	258	2.58
Feb.	19	30	25	19	7	49	265	2.65
Mar.	13	34	32	20	1	47	262	2.62
April	15	35	30	18	2	50	257	2.57
May	12	36	32	16	4	48	264	2.64
June	16	34	28	15	7	50	263	2.63


GRAPHIC REPRESENTATION OF DIFFERENTIAL COUNT.
Patient's Name. A. M.
Age 2 Yrs.
LEUCOCYTES IN THOUSANDS PER C. MM.
NEUTS.
LYMPHOS.
MONOS.
MONTHS


BLOOD SEDIMENTATION RATE.
Patients Name A.D. Ref. R.O. yrs.
SEDIMENTATION RATE IN MMS.
TIME IN MINUTES.
15.
30.
45.
60.
10.
20.
30.
40.
50.
60.
70.
80.
90.
NORMAL B.S.R.
JUNE
MAY
APR.
MARCH
FEBY
JAN'Y
DEC.

CASE IV.

Patient's Name: A. McI. Aet - 18 years.

This case exemplifies, as in the previous case, the harmony with which artificial pneumoperitoneum can combine with other forms of collapse therapy, for in this particular instance it was used in combination with an artificial pneumothorax.

I. HISTORY OF PRESENT ILLNESS:

Patient appeared to have enjoyed good health until 3-4 months before admission to hospital when she complained of an intractable cough, which was accompanied by sputum, there was no history of haemoptysis. Night sweats and loss of weight were present. X-rays and sputum examination were completed before admission and they confirmed the presence of pulmonary tuberculosis.

II. FAMILY HISTORY:

No history of tuberculosis reported in the family.

III. HISTORY OF PREVIOUS ILLNESSES:

There was no history of previous illnesses of a serious nature.

IV. EXAMINATION ON ADMISSION (15.1.41)

Patient was inclined to be thin, though she could not be described as undernourished. Her skin appeared moist. There/

There were no palpable lymph glands. Her temperature was 97°F: the pulse rate 100 per minute and the respiratory rate was 20 per minute on admission.

V. EXAMINATION OF SYSTEMS:

A. Respiratory System:

(i) Inspection: There was some lagging of the right apex when compared with the left. The right sterno-mastoid appeared more tense when compared with the left sterno-mastoid muscle.

(ii) Palpation: The sternal head of the right sterno-mastoid was found to be more rigid than the sterno-mastoid muscle of the opposite side. This method of examination confirmed the lagging over the right apex. Vocal fremitus was exaggerated over the right upper lobe posteriorly.

(iii) Percussion: Dullness and increased resistance to percussion were found over the right and left upper lobes posteriorly. Kronig's area was diminished over both apices.

(iv) Auscultation: Vesicular breathing was present over both apices anteriorly. Numerous fine crepitant rales were present over both apices. Posteriorly bronchial breathing was heard over both upper lobes. Scattered rales were present over a wide area in both sides. Pectoriloquy was present over/

over the right apex posteriorly.

(v) Radiological Examination of the Lungs: (22.1.41). "There is active tuberculosis throughout upper half of the right lung and the whole of the left lung. Cavities are seen in both lungs, left and right."

(vi) Laboratory Examination of Sputum: (15.1.41)

"Many tubercle bacilli seen in sputum."

(vii) Vital Capacity: 2,000 c.c.

B. Cardio-Vascular System:

(a) Vaso-motor system: The peripheral circulation appeared to function adequately.

(b) Pulse: Rate 100 per minute. Its rhythm was regular. Its volume fairly good.

(c) Blood Pressure: The systolic blood pressure was 124 mms. of mercury while the diastolic pressure was 82 mms. Hg.

(d) Heart: No abnormality was detected by the usual methods of examination.

(e) Blood Investigation:

(1) White Blood Count.....13,400 per c.mms.

(2) Differential Count...Neutrophils..... 62%
Lymphocytes..... 24%
Monocytes..... 14%
Lymphocyte/Monocyte Ratio.....1.71:1

(3) Arneth Count.....I..... 17
II..... 35
III..... 26
IV..... 16
V..... 6

Arneth/

Arneth Index.....52

(4) Von Bonsdorff Figure.....259

(5) Weighted Mean.....2.59

(6) Blood Sedimentation Rate - 68 m.ms. at end of the 1st Hour.

C. Alimentary System:

(i) Buccal Cavity: The teeth were in a poor condition. The tongue was furred. There was no enlargement of the tonsils.

(ii) Abdomen: No masses were felt in the abdomen. The tone of the abdominal muscles was good.

D. Central Nervous System:

There were no abnormality detected by the usual methods of investigation.

Genito-Urinary System: There were no symptoms referable to this system.

PROGNOSIS:

The outlook in this case was not regarded as being very good. The extent and activity of the chest lesion together with the rapid blood sedimentation rate, and the characteristics of the white blood cells, together with the lymphocyte/monocyte ratio did not predict a very good prognosis/

prognosis.

Treatment: Despite the ominous portents noted, (p.168,169) a bilateral artificial pneumothorax was suggested and attempted in this case.

On the 17.2.41 an attempt was made to induce an artificial pneumothorax on the left side, but this was not successful. Two other attempts were made on the 21.2.41 and on the 27.2.41 respectively, but they were abandoned subsequently. Patient was given rest in bed for a period of three weeks before an induction was essayed on the right side. This time the induction was successful, for the manometer readings were highly negative and the patient received about 300 c.cs. without showing signs of dyspnoea. About six weeks later, it was decided that the patient should receive an artificial pneumoperitoneum in addition to her right sided artificial pneumothorax. This form of treatment was regarded as being of far more value than a left sided phrenic paralysis. The latter would have only a limited unilateral application, whereas pneumoperitoneum would affect both lungs. The diaphragmatic elevation in the latter procedure would be always under the constant control of the operator, and the return of the diaphragmatic excursion guaranteed. There would be no fear of a permanent reduction in the patient's vital/

vital capacity which would prejudice her future welfare. Accordingly, on the 27th April, 1941, an artificial pneumoperitoneum was induced as a supplementary measure to artificial pneumothorax. The patient was given 500 c.cs. at the first insufflation and this was followedthree days later by an insufflation of 700 c.cs. of air. There were no untoward complications. The artificial pneumothorax and the artificial pneumoperitoneum have been tolerated very well. c.f. X-ray Plate No. VIII.

CASE V.

Patient's Name: W.R. Aet - 23 years.

This case is mentioned in passing to demonstrate one instance when artificial pneumoperitoneum was applied successfully in a case of emergency when other measures had failed.

The patient, a boy, aged 16 years, complained for some months before admission to hospital of a cough which was accompanied by sputum. The latter was bloodstained about one month prior to admission. He stated also that he was subject to fairly frequent attacks of pain in the upper abdomen radiating to the right side of the abdomen and through to the posterior chest wall. Breathing did not appear/

appear to aggravate this pain. He had never any dysuria or renal colic. Examination of the spinal column did not reveal any bony lesion, and a detailed investigation of the genito-urinary system produced similar negative findings. Patient's chest lesion clinically and radiologically was confined mainly to the right lower lobe. There was an impaired percussion note over this area when it was compared with the same region in the contra-lateral side, and the breath sounds were vesicular in type but with the expiratory phase prolonged definitely over this lobe in the right side; vocal resonance was much increased over this area. Radiological examination 29.8.39 reported:- "There is inactive looking tuberculosis below both clavicles and in both roots. There is massive tuberculosis in the lower half of the right lung". Sputum examination 21.8.39 reported "tubercle bacilli seen".

In view of the site of the lesion, it was decided that patient should have a right sided phrenic nerve operation in preference to an artificial pneumothorax. Accordingly, this operation was performed (15.12.39) and it was attended by no complications. Patient did very well as a result of the operation. His sputum became negative for the tubercle bacilli, and he was allowed up to walk about the hospital ground. On the 9th March, 1940, however, he had rather a brisk haemorrhage amounting to about half a pint of blood. There/

There was much sickness accompanying this haemorrhage. Patient was given conservative treatment for several hours, but he continued to stain heavily and since there was no arrestment of this bleeding, it was decided that he should have a right sided artificial pneumothorax. This was attempted but was unsuccessful, and so artificial pneumoperitoneum was induced as an emergency procedure. This was given high up in the right hypochondrium under the diaphragm, 350 c.cs. being given as an initial dose. This insufflation was well tolerated by the patient and it proved soon to be effective, for the haemorrhages became less frequent and less profuse. This form of treatment was maintained for four days; after the second day there was no further evidence of haemorrhage. (c.f. X-ray Plate No. IX). It will be noticed that even with only 350 c.cs. of air given into the peritoneal cavity through the right hypochondrium route a satisfactory and effective elevation was obtained. There is much to commend this way of administering an artificial pneumoperitoneum, but the dangers, to mention one, air ambolism, which might result from piercing a large vein in the costa-phrenic angle, outweigh the advantages and persuade the writer to keep to the iliac fossa route which is much safer and achieves the same result, although much larger amounts of air require to be insufflated into the peritoneal cavity.

Many/

Many more cases could be cited as illustrations of the wide and effective therapeutic applications of artificial pneumoperitoneum, but the five cases discussed give a general impression of the usefulness to which the writer has applied this form of treatment. It will have been gathered that pneumoperitoneum serves a very beneficial purpose in the active bilateral chest lesions with toxaemia, for which the more radical forms of surgical interference are contra-indicated. The withholding of pneumoperitoneum treatment, in the writer's opinion, in these cases, and the giving of bed rest alone, exposes the majority of the patients to the ever-present menace of the dissemination of the tubercle bacilli to the healthy parenchyma, or it may permit cavity formation in the tissue already involved, or, on the other hand, facilitate pleural symphysis and the formation of other mechanical barriers to an effective therapeutic pneumoperitoneum at a later date. Much valuable time is lost and the problem of effective therapeutics becomes greater. The performance of pneumoperitoneum in these cases at an early date causes the patient little or no constitutional disturbances, helps to keep the lesion in the majority of cases in abeyance, and gives the patient time to muster up his or her natural powers of resistance. It is quite true that some cases could have been left, and perhaps have lost nothing by waiting. The

period/

period of observation would have justified itself in such a case but no one can predict with certainty the changes which will occur in a tuberculous lung lesion. Case I provides a good example of pneumoperitoneum being substituted as an alternative method of treatment to an unsuccessful bilateral artificial pneumothorax. The patient in this instance responded very well to the former line of treatment. Pneumothorax is always the first line of choice, but when this form of collapse therapy is ineffective and completely inadequate in both sides, a very welcome and apparently worthy substitute is found in artificial pneumoperitoneum. Cases III and IV demonstrate the harmony in which pneumoperitoneum can be combined with other forms of collapse therapy, namely, phrenic nerve interruption and artificial pneumothorax. None of the patients receiving these combined forms of treatment revealed any general constitutional disturbance. Case V exemplifies the effectiveness of pneumoperitoneum as an emergency measure, when all other surgical forms of collapse therapy, except thoracoplasty, of treating the pulmonary haemorrhage had been applied and found to be unsuccessful.

RADIOLOGICAL ILLUSTRATIONS.

The following Series of X-ray films demonstrate the degree of elevation of the diaphragm that can be obtained as a result of artificial pneumoperitoneum. In many of the radiograms the diaphragm is also thinned out, indicating atomicity of this muscular organ.

The effect of pneumoperitoneum on lung lesions is appreciated radiologically. In some of the films illustrated the tuberculous infiltrative process round pulmonary cavities is seen to disappear, while in others there is evidence that the tuberculous lesion has cleared up or become quiescent in one or both lung fields. The liver and spleen are outlined very well in all plates showing pneumoperitoneum.

The X-rays are arranged in this section of the thesis in such an order that each case considered has a single reference plate number for every film that appears in connection with the patient under discussion. If three films are shown relating to the same patient each of these films will have the same plate number. Copies of radiograms in print form accompany each film illustrated. The negative and positive films should be compared, for in some instances the latter demonstrate more clearly the points emphasised by the writer.

PLATE I. Two films are represented under this plate number. Note the elevation of the diaphragm that occurs during pregnancy.

PLATES II, III, & IV. Note the diaphragmatic elevation resulting from the pneumoperitoneum.

PLATE V. Comparison of these three films demonstrates the effect of pneumoperitoneum on a bilateral lung lesion. Observe the clearing up of both lung fields.

PLATE VI. Two films showing the change which pneumoperitoneum has produced in the infiltrative lesion round the pulmonary excavation and in the contra-lateral lung lesion.

PLATE VII. Observe from the three films:-

(a) the effect of pneumoperitoneum on a paralysed hemi-diaphragm.

(b) the influence of pneumoperitoneum plus a phrenic nerve paralysed on the bilateral lung lesion.

PLATE VIII. Pneumoperitoneum combined with an artificial pneumothorax.

PLATE IX. One instance in which pneumoperitoneum was successful in arresting pulmonary haemorrhage.

PLATE I.

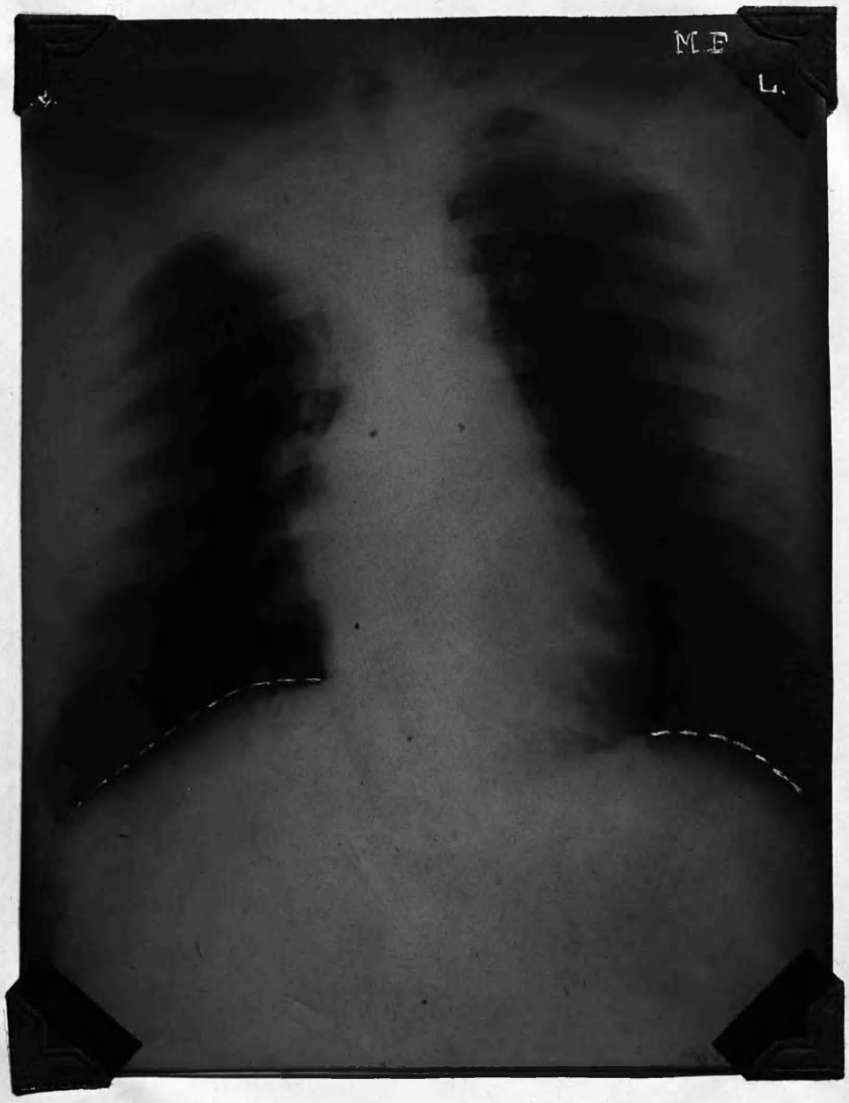


Fig. 1: M.F. (14-2-41) Patient three months pregnant. Dotted line indicates level of diaphragm. Film shows a right tuberculous fibro-caseous lesion at the apex. This type of lesion is not affected by pneumoperitoneum.

PLATE I (Print)

Fig. 1: M.F. (14-2-41)

PLATE I.

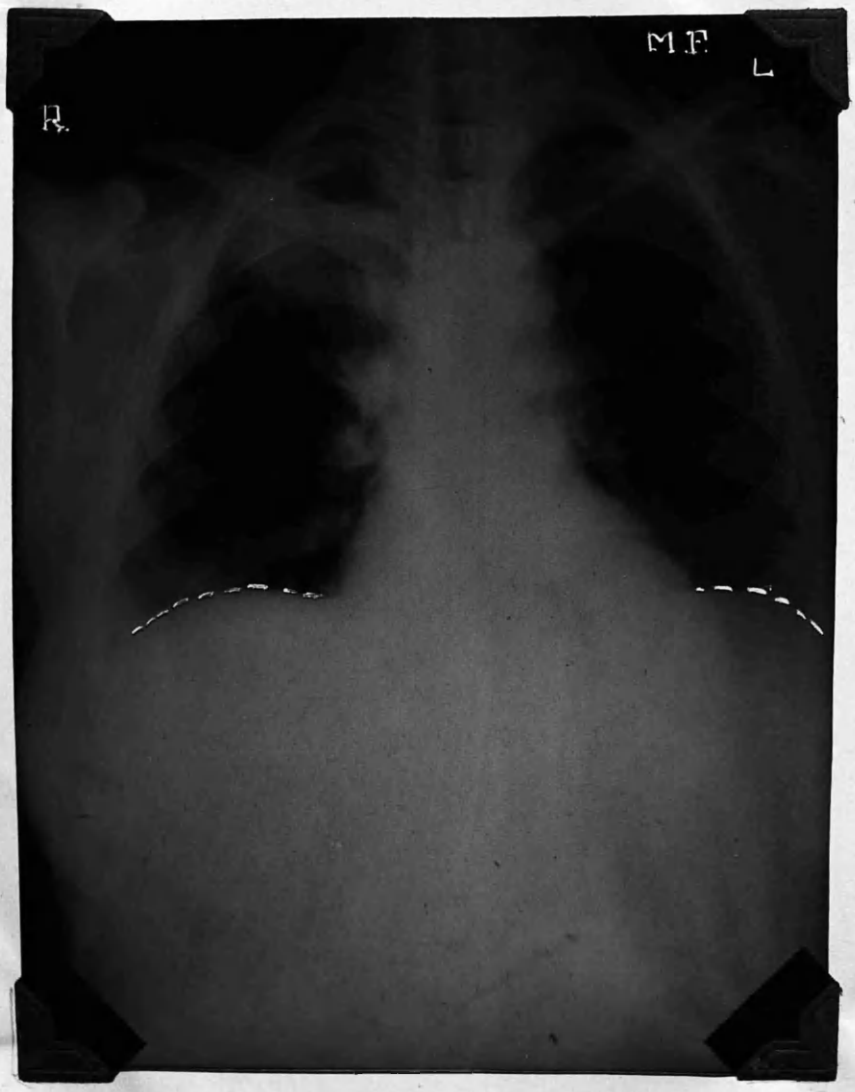


Fig 2: M.F. (21-2-41). Note the level of the diaphragm at eight months' gestation. Same patient as in Fig. 1.

PLATE I (Print)

Fig 2: M.F. (21-7-41)

PLATE II.

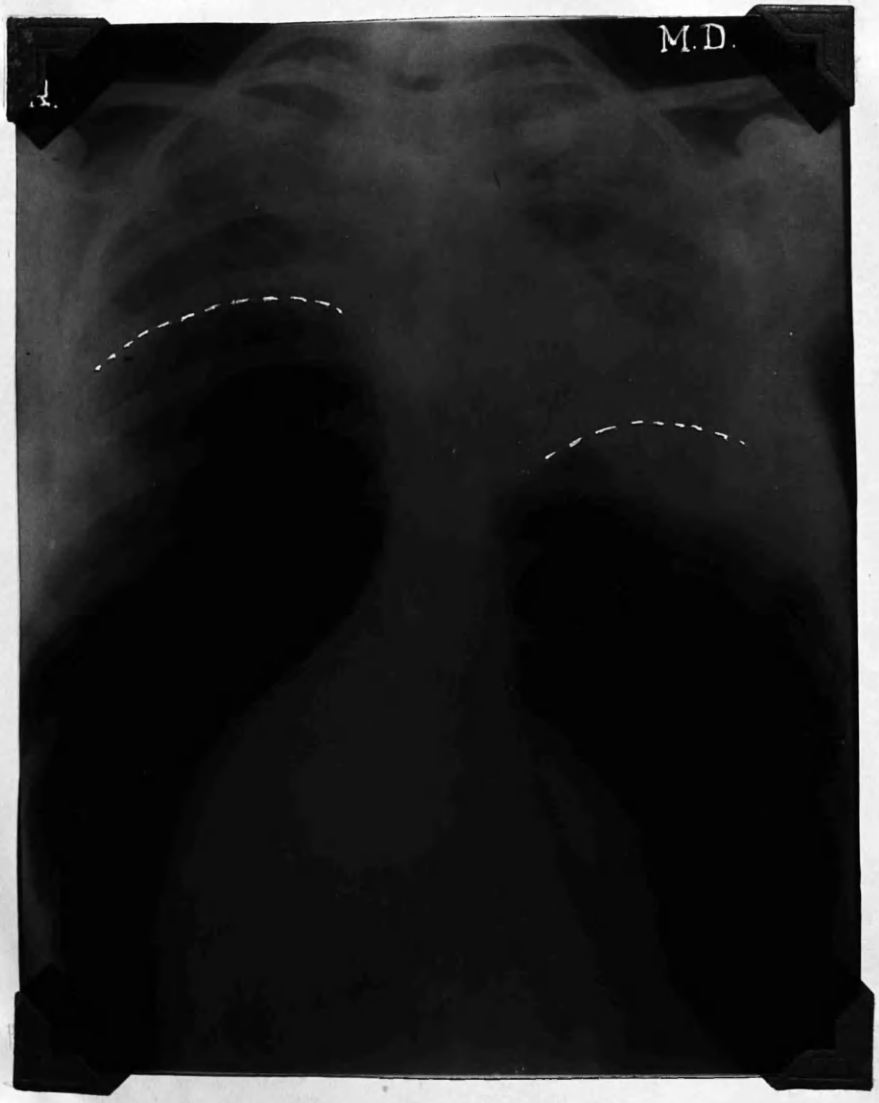


Fig. I: M.D. 14-7-41. Bilateral disease: Pneumoperitoneum has caused a marked elevation of the diaphragm, especially in the right side. This patient did not receive a phrenic paralysis.

PLATE II (Print)

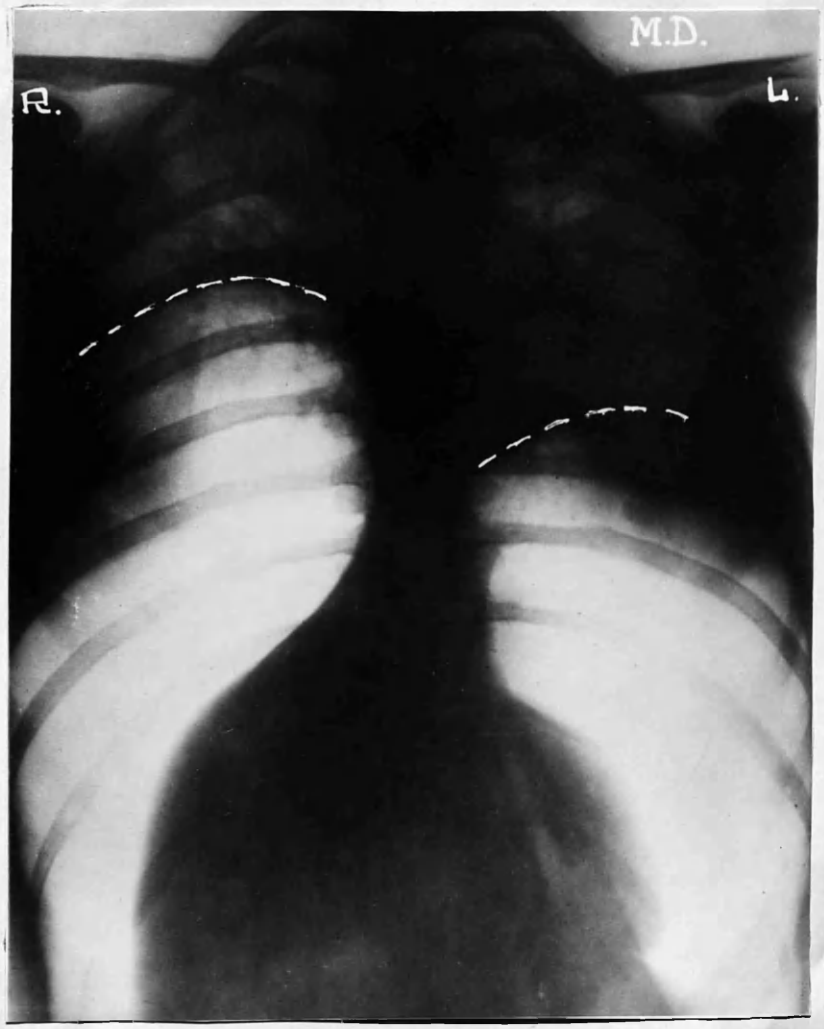


Fig. I. M.D. (14-7-41)

PLATE III.

Fig. I. T. McA. (14-7-41) Bilateral disease. Film shows the presence of a pneumoperitoneum. Note the elevation of the diaphragm in both sides.

PLATE III (Print)

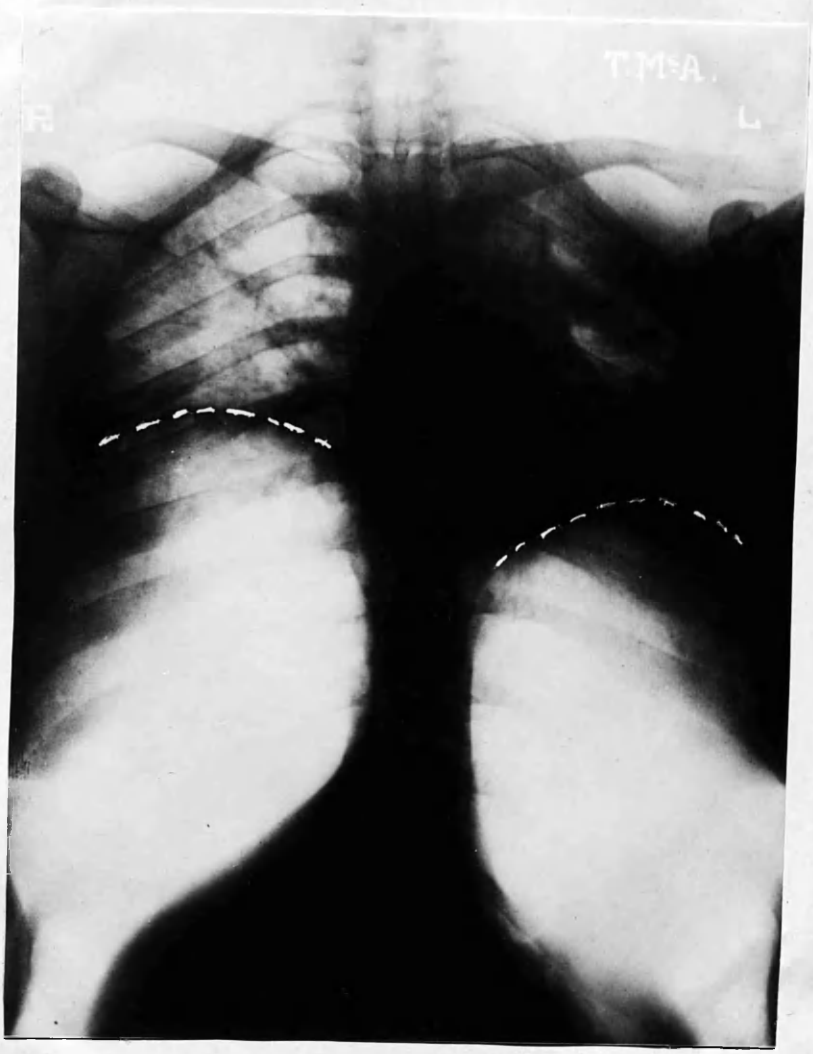


Fig. I. T. McA. (14-7 -41)

PLATE IV.

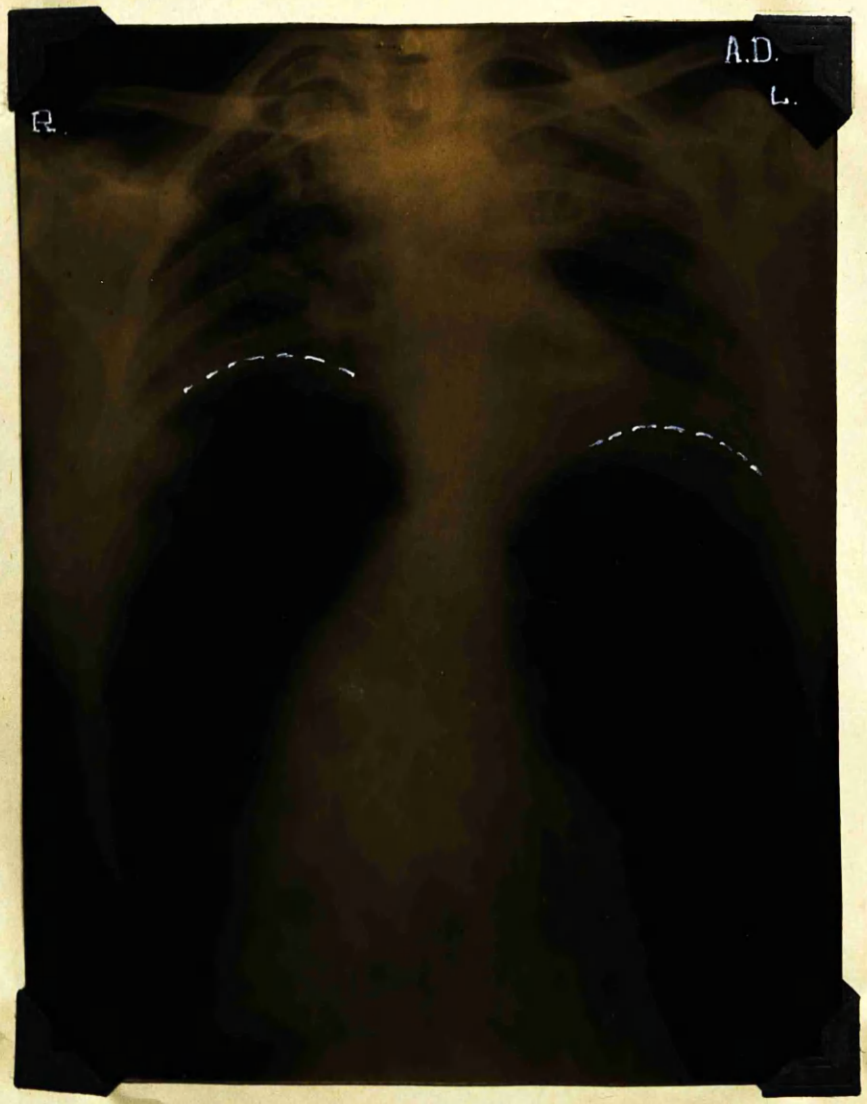


Fig. I. A.D. (14-7-41). Bilateral disease. Note diaphragmatic levels in both sides.

PLATE IV (Print)

Fig. I. A.D. (14-7-41)

PLATE V.

Fig. I. I.C. (21-5-40). Acute exudative disease in both sides. Right artificial pneumothorax ineffective (25-6-40). Left artificial pneumothorax also ineffective (20-8-40). Pneumoperitoneum applied (18-10-40) to splint both lungs.

PLATE V (Print)

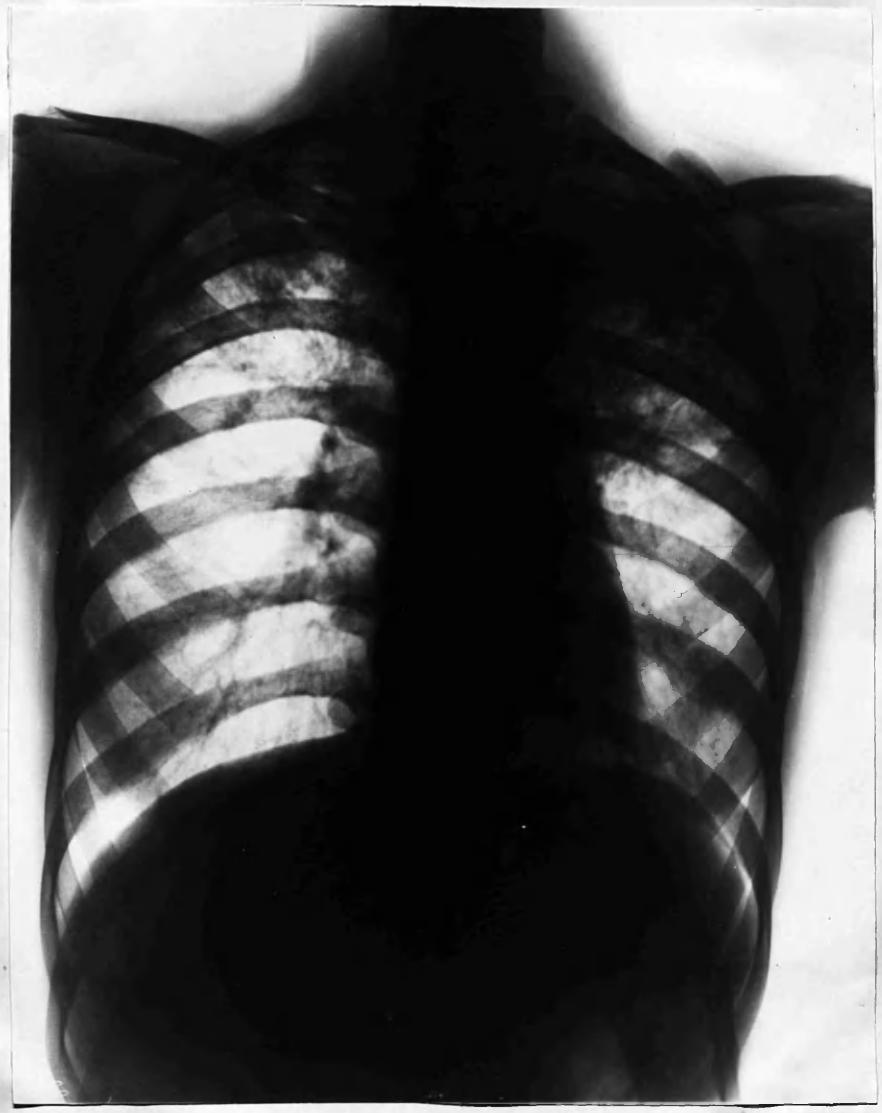


Fig. I. I.C. (21-5-40).

PLATE V.

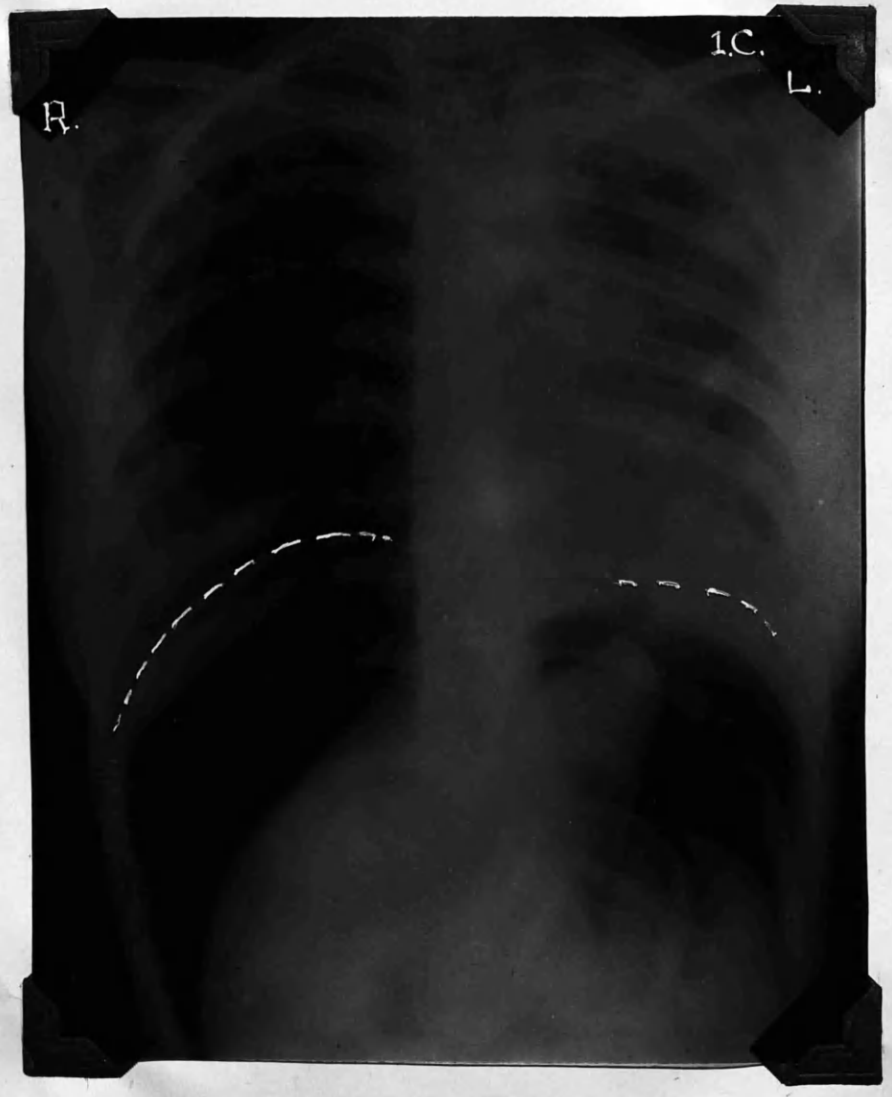


Fig 2: I.C. (1-4-41) Pneumoperitoneum. Note the clearing up of the right lung field.

PLATE V (Print)

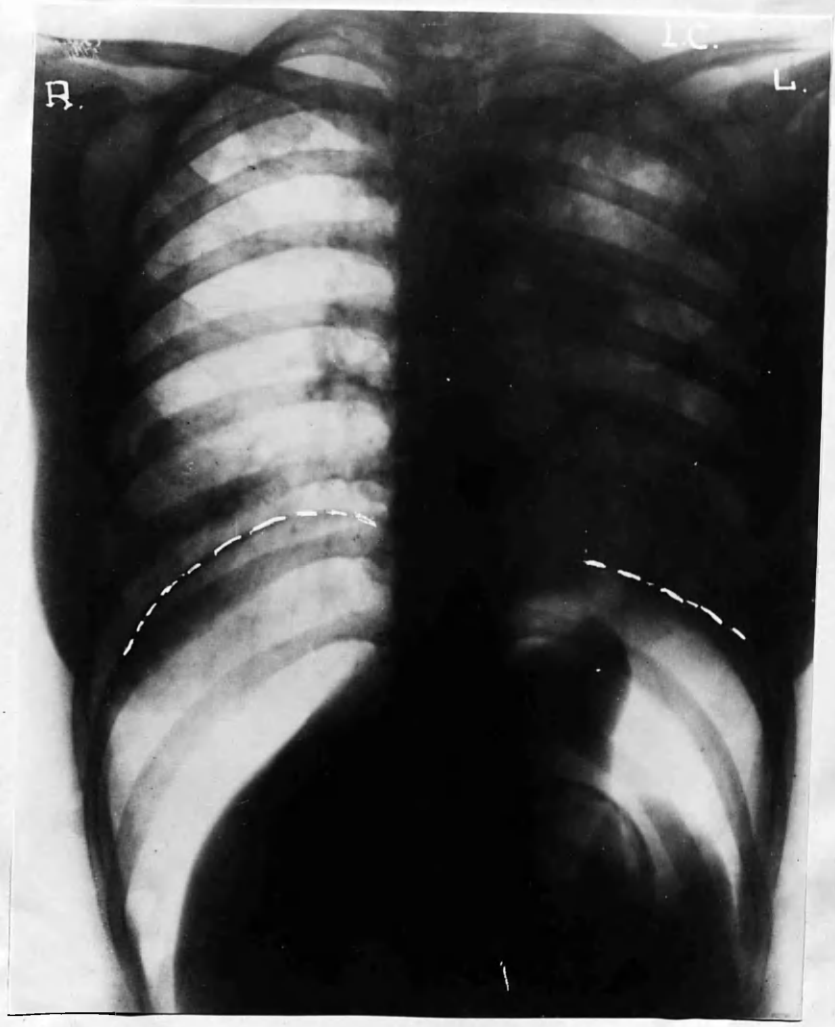


Fig. 2. I.C. (1-4-41)

PLATE V.

Fig. 3. I.C. (24-7-41). Compare this film with those on pages 188 and 190. Note the clearing up of both lung fields.

PLATE V (Print)

Fig. 3. I.C. (24-7-41)

PLATE VI.

Fig. 1: M. Bu (10-2-38). Bilateral disease. Note cavity in the left lung, also tuberculous infiltrations and basal collection of fluid in right lung.

PLATE VI (Print)

Fig. I. M. Bu. (10-2-38).

PLATE VI.

Fig. 2: M.Bu. (5-10-39). Pneumoperitoneum. Note the clearing up of (1) the exudation in the left side (2) the infiltrative process in the right side.

PLATE VI (PRINT)

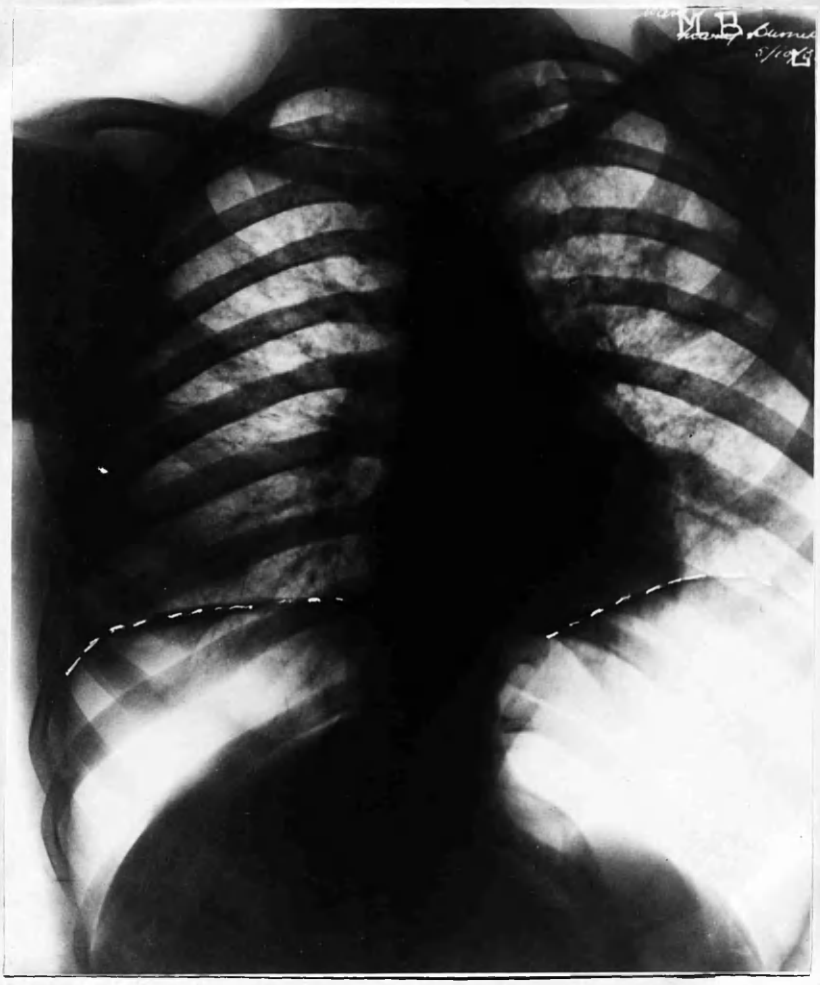


Fig. 2: M.Bu. (5-10-39).

PLATE VII.

Fig. 1. M. Br. (29-11-38). Extensive exudative lesion in both sides with large cavity in the upper third of left lung. Left phrenic paralysis performed (25-9-38). Note level of diaphragm and compare with Fig. 3. Plate VII.

PLATE VII (Print)

Fig. 1. M.Br. (29-11-38)

PLATE VII.

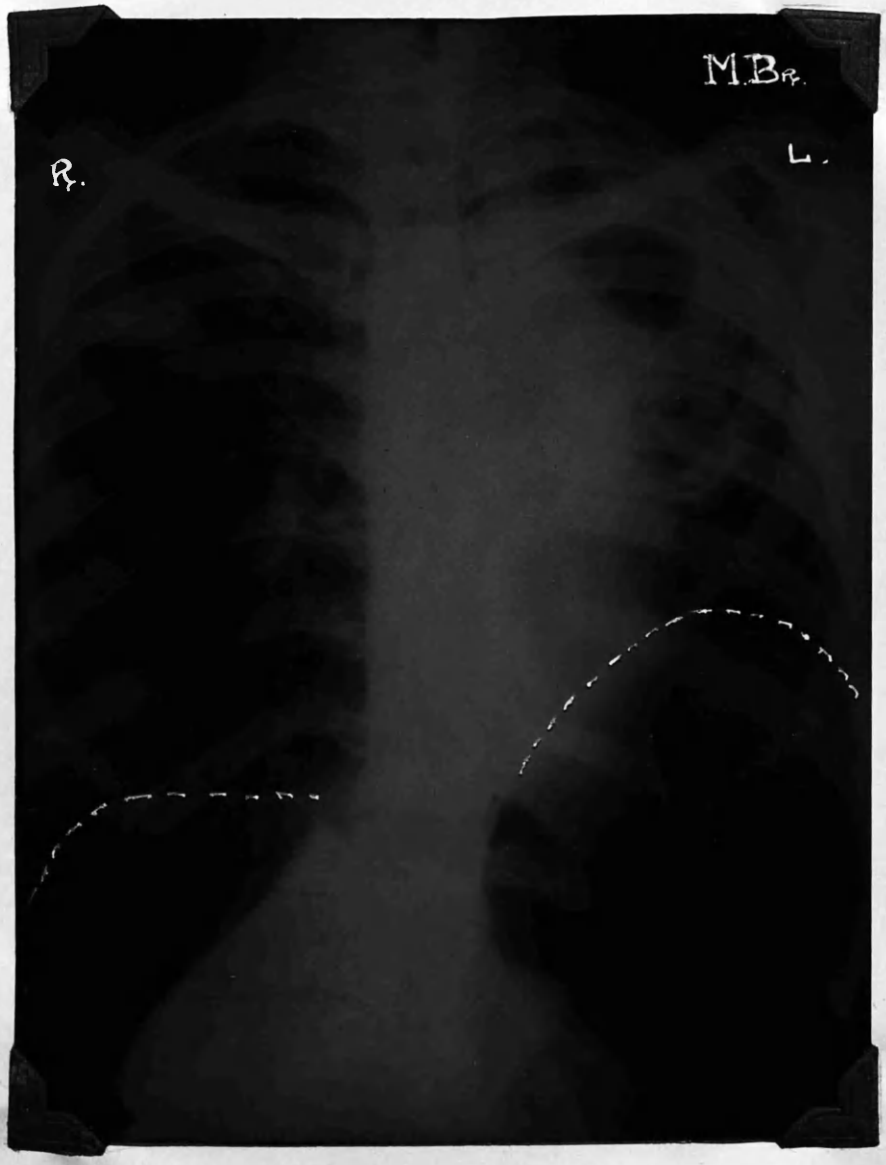


Fig. 2: M.Br. (17-9-40). Note the rise of the paralysed hemidiaphragm with pneumoperitoneum. Observe the clearing up of both lung fields.

PLATE VII (Print)

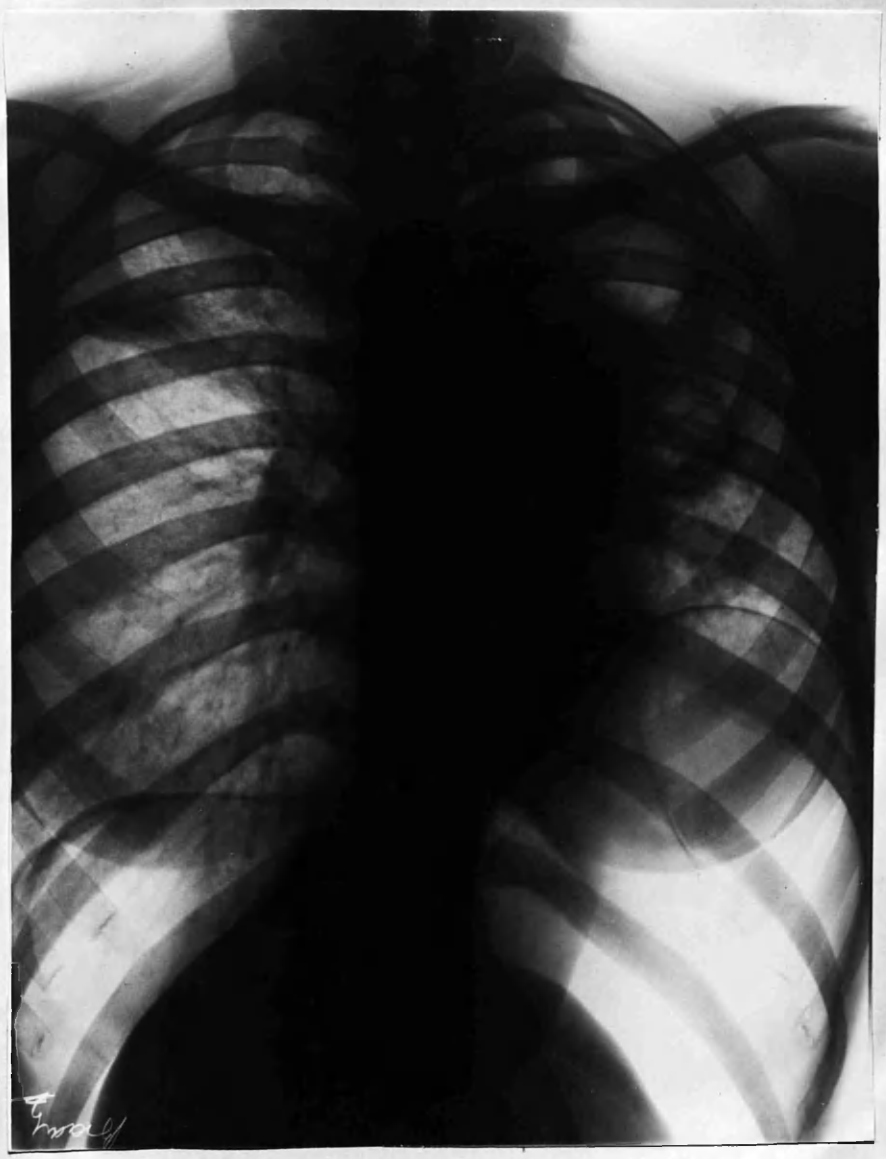


Fig. 2. M.Br. (17-9-40).

PLATE VII.

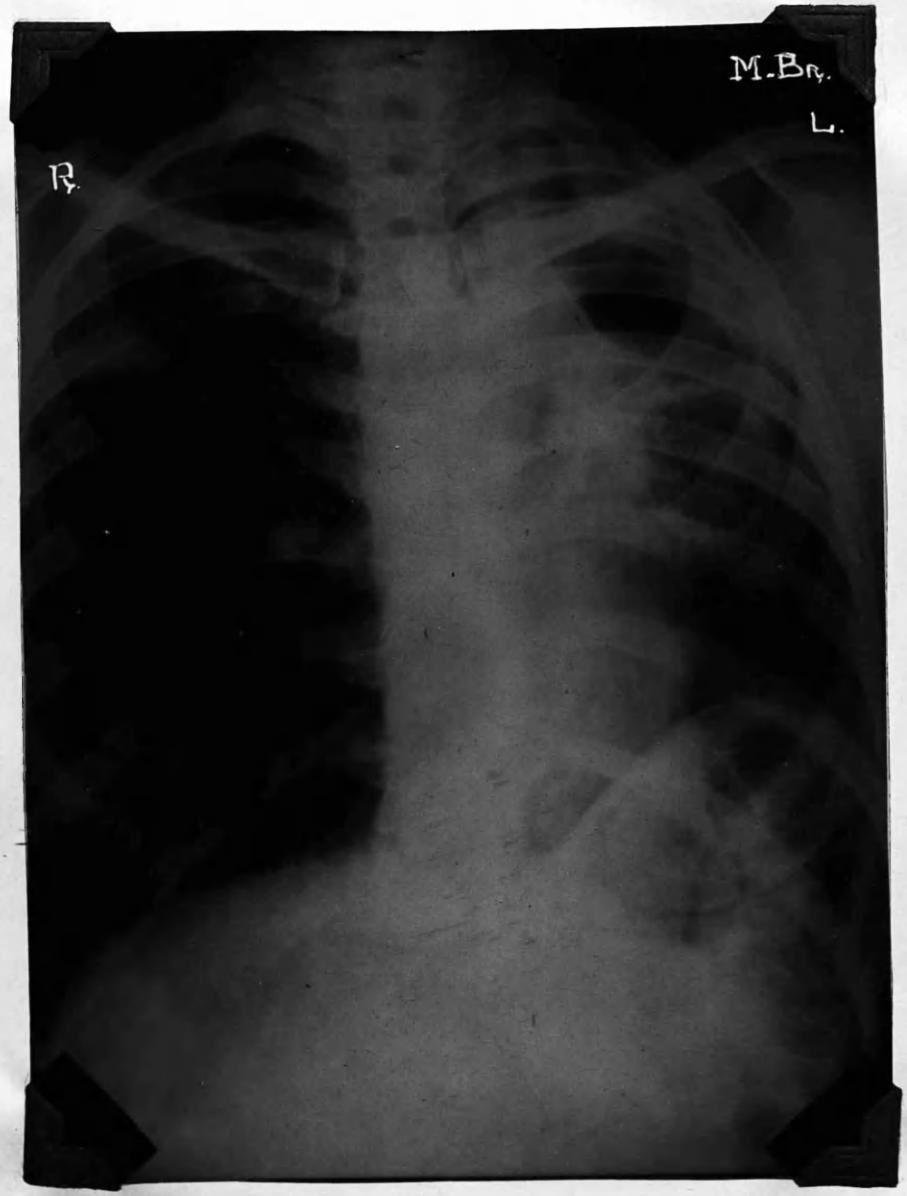


Fig. 3: M.Br. (20-6-41) Pneumoperitoneum stopped. Note End result. Right side shows now a small inactive apical lesion. The exudation has cleared up round the cavity in the left side. Patient ready for thoracoplasty.

PLATE VII (Print).

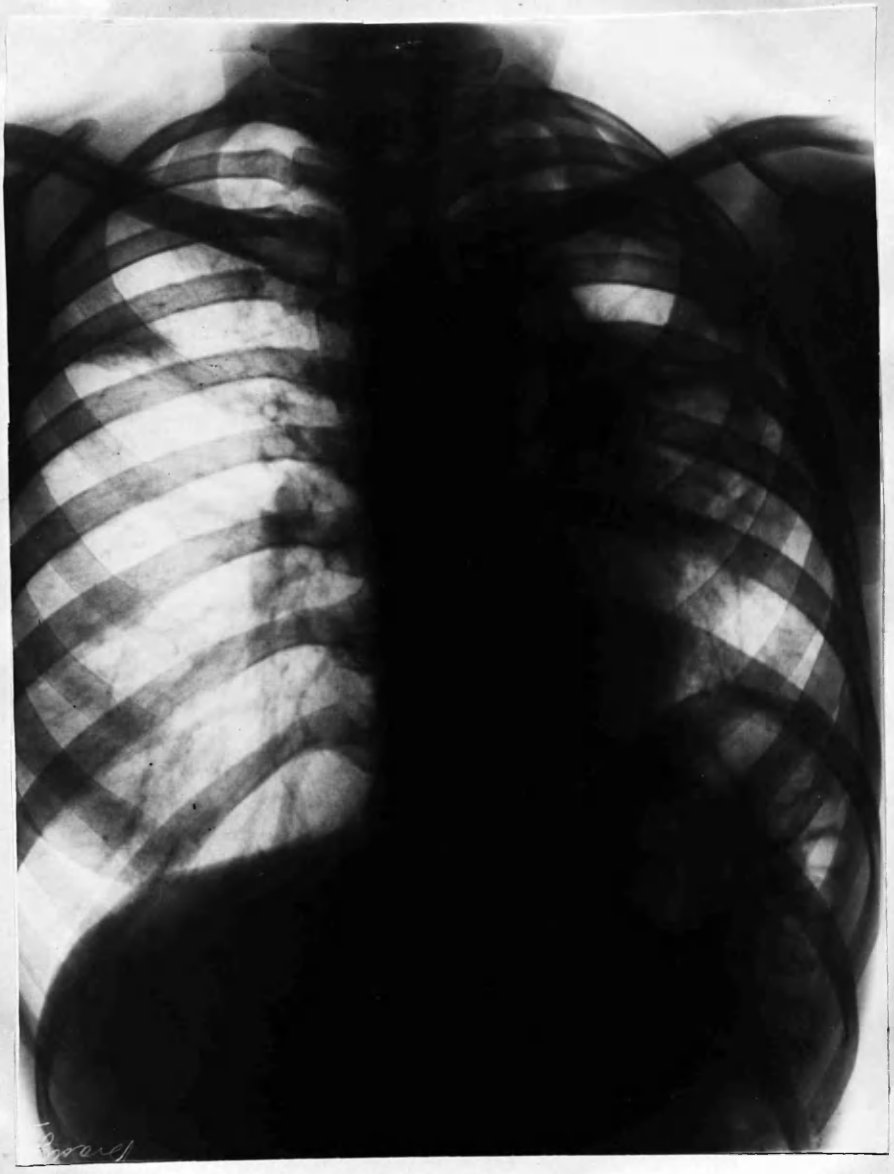


Fig. 3: M.Br. (20-6-41).

PLATE VIII.

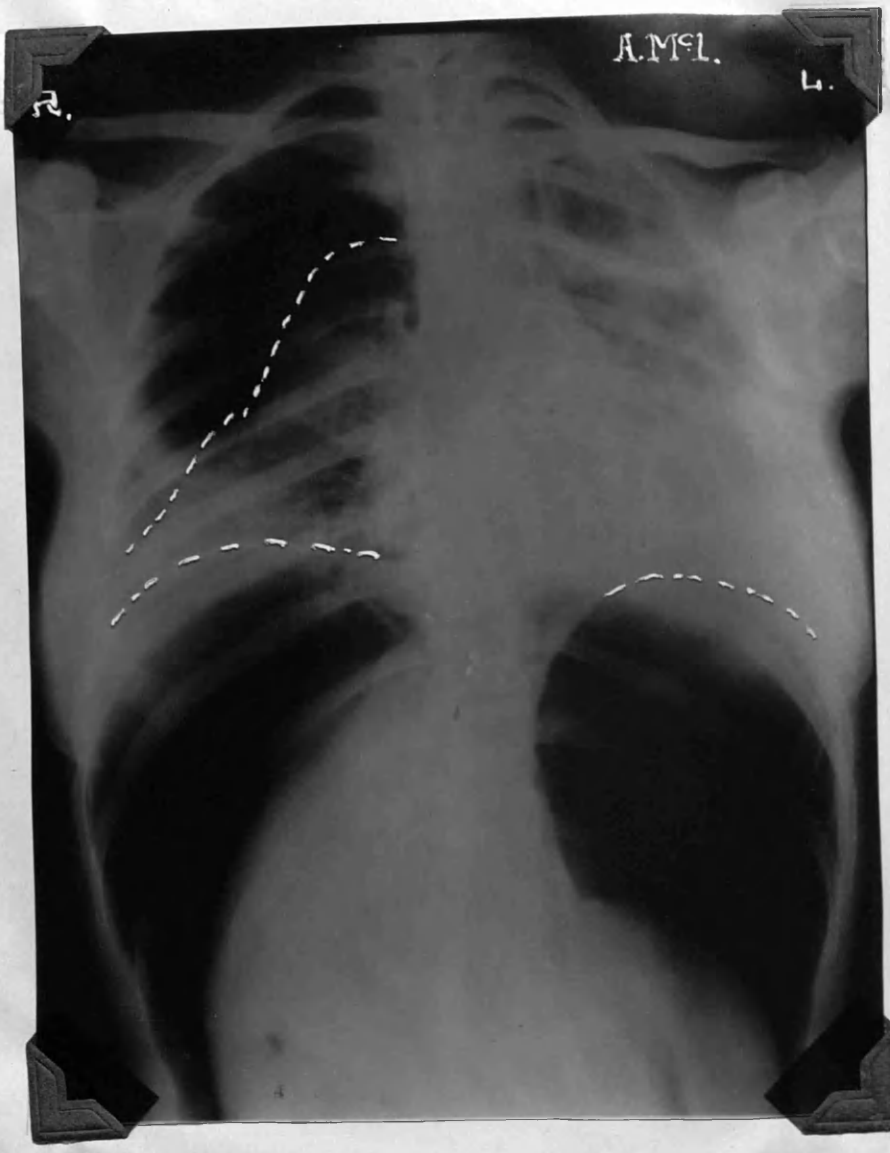


Fig.I: A. McI. (14-7-41) Selective collapse of right lung by artificial pneumothorax (25-3-41). Left sided artificial pneumothorax attempted but unsuccessful (17-2-41). Pneumoperitoneum started in order to splint the left lung (27-4-41).

PLATE VIII (Print)

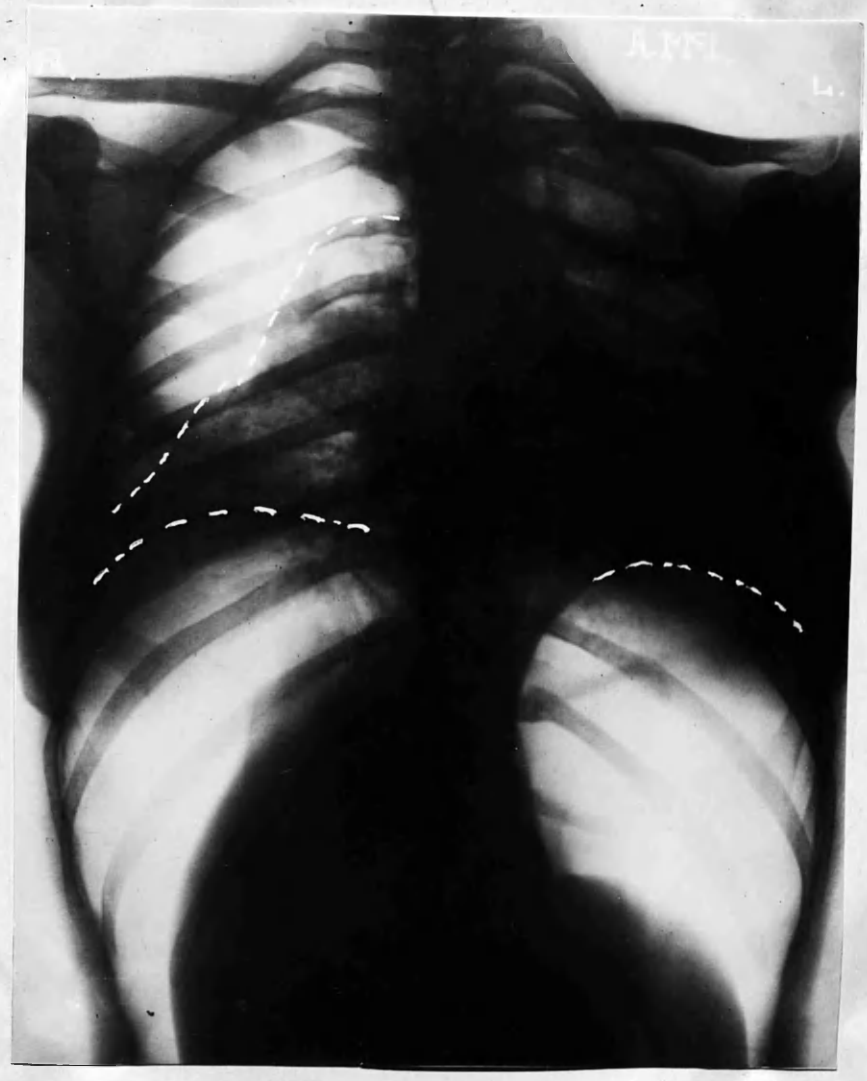


Fig. I. A.McI. (14-7 -41).

PLATE IX.

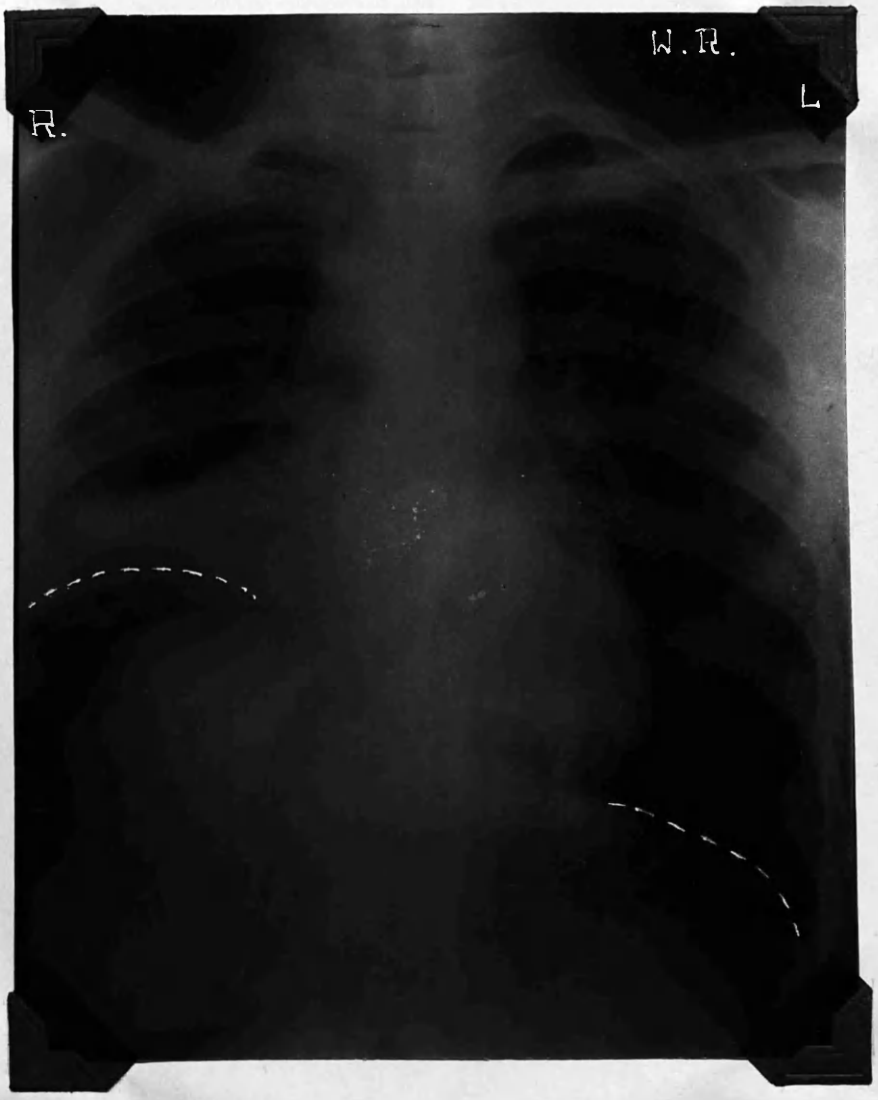


Fig. I: W.R. (14-3-40). Pneumoperitoneum. This patient who had received a right phrenic operation (15-12-39) suffered from a severe haemoptysis. An attempt to establish an artificial Pneumothorax failed (9-3-40). Pneumoperitoneum was induced, accordingly (9-3-40) to arrest the haemorrhage. This procedure achieved the desired result.

PLATE IX (Print).

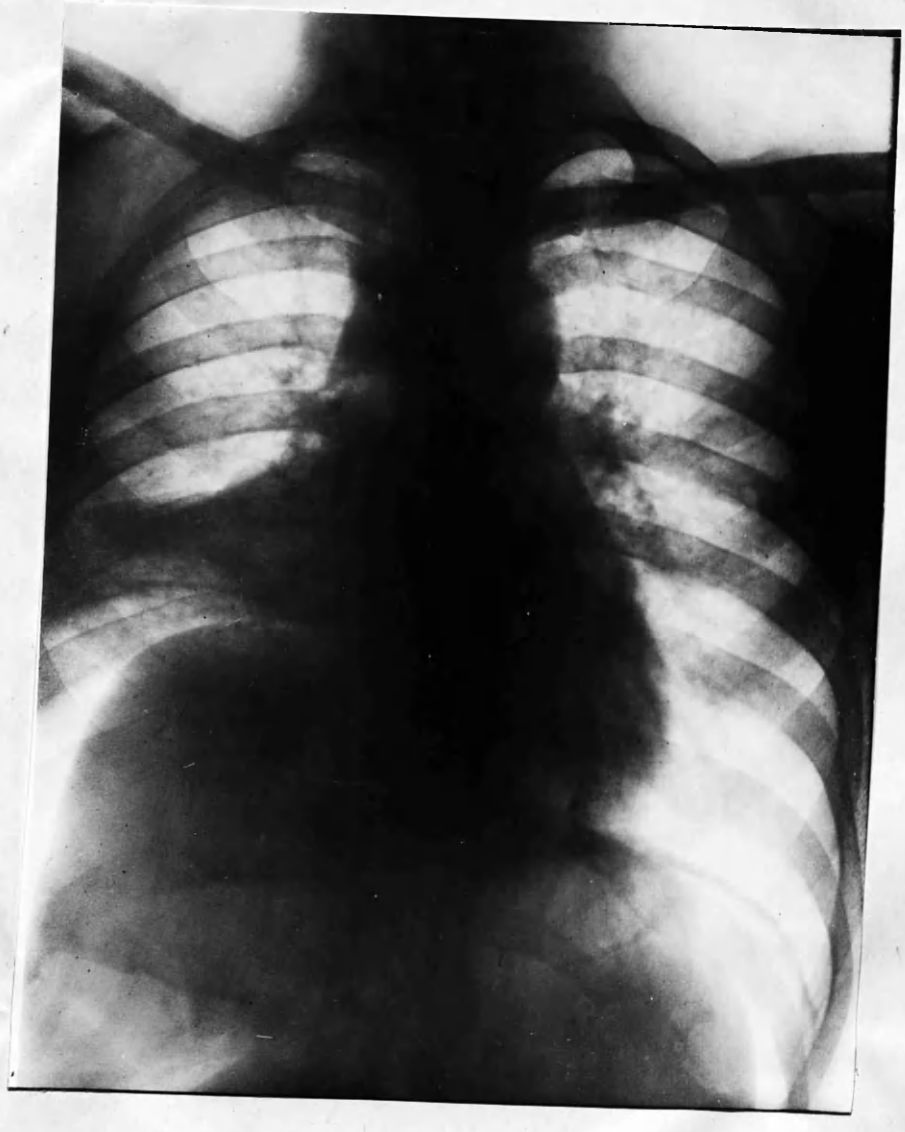


Fig. I. W.R. (14-3-40).

PART FOUR

SUMMARY & CONCLUSIONS.

The majority of the forty patients, whose course of treatment is made the basis of this study, were making no noticeable progress at the time when artificial pneumoperitoneum was undertaken. Their lung lesion, clinically and radiologically, was active and extensively bilateral. The prognosis in most of them was regarded as hopeless, and in an attempt to improve this a pneumoperitoneum was performed.

Attempts had been made previously in seven patients to perform a bilateral artificial pneumothorax, but this operation was not successful, and since unilateral phrenic nerve operations had a limited application for these patients and bilateral phrenic nerve surgery was not considered advisable, pneumoperitoneum appeared to be singly or in combination with a unilateral phrenic crush, on the worse side, the next logical step. In those cases, four in number, where artificial pneumothorax had failed to arrest haemorrhage, pneumoperitoneum became not only the operation of choice but of necessity. Artificial pneumoperitoneum has a multiplicity of advantages. Thus, to mention a few:- (1) the attractiveness of this operation is its simplicity of execution. Reasonable safety can usually be given to the patient because of the already/

already established work of pneumoperitoneum as a diagnostic agent as well as a therapeutic agent in Tuberculous enteritis. No special apparatus is required. The ordinary Lillington Pearson type of pneumothorax apparatus, which was constructed on the most simple lines, meets the occasion admirably. The patients are disturbed very little for they receive the treatment in bed sitting up. Fluoroscopic and radiological examinations are very necessary, however, from time to time in order to assess the diaphragmatic elevation for the manometer readings are valueless in this respect. Hospital supervision is to be recommended during treatment, but it is not strictly necessary as there is a small portable set on the market which takes films very well and could be used to advantage by the attending physician in gauging the elevation of the diaphragm.

(2)Pneumoperitoneum is a revocable procedure.

(3) Pneumoperitoneum lends itself to a very perfect combination with other forms of collapse therapy. Thus the author has treated five cases of pneumoperitoneum with a supplementary phrenic crush, with no harmful effects. In his experience, phrenic crush combines well with pneumoperitoneum. The phrenic paralysis appears to find a natural complement in the action of the air which favours the ascent of the paralysed diaphragm. The opportunity was taken to combine artificial/

artificial pneumothorax with artificial pneumoperitoneum in one case, with no deleterious effects. Both insufflations were well tolerated and up till the moment of writing there have been no complications resulting from the combination of pneumothorax and pneumoperitoneum. Pneumoperitoneum, too, can be combined with chrysotherapy in an effort to assist fibrosis, if the physician deems it advisable. Rest, of course forms the basic principle in the treatment of tuberculosis. The success of pneumoperitoneum depends greatly on the observance of this basic principle in the therapeutics of tuberculosis.

(4) The psycho-therapeutic value of pneumoperitoneum in cases of pulmonary tuberculosis can not be doubted. These patients undergoing this form of treatment begin to live for it. Their air of despondency disappears and they feel they are getting treatment; that something can be done for them, and that their condition is not so hopeless as was first apparent on admission to hospital.

(5) Clinically and symptomatologically, improvement is noticed in the patients. Thus they put on weight, they sleep better at night since their hacking cough does not trouble them so much. In six cases the sputum was returned negative on three consecutive occasions. It is reasonable to suggest/

suggest, at this stage, that evaluation of the effects of pneumoperitoneum be based on the comparative X-ray films, the gain in weight, the improvement in the mental outlook, sputum changes, and the changes in the blood cytology. Although pneumoperitoneum has not, in this series of cases, changed the size and shape of apical cavities, it has produced very definite changes in the surrounding tuberculous processes and in the contra-lateral lung, and in two cases the lung lesion was reported "fibrosed". Results from blood examination have not been overwhelmingly encouraging. The cases illustrated show some very definite changes which seem to run parallel with the patients' clinical improvement, but in others the changes could not be collated.

The favourable results which pneumoperitoneum has produced in some rather desolate cases has prompted this study. In view of the advanced stage of the disease from which most of these patients suffered, the mortality rate should not condemn pneumoperitoneum, as only in one patient out of forty cases was there clinical evidence that pneumoperitoneum was a factor responsible for the death of the patient. During a period of enthusiasm it is quite true that some patients were subject to pneumoperitoneum who, in the light of further experience, should never have received this form of treatment. These patients would be regarded now as unsuitable for pneumoperitoneum/

pneumoperitoneum.

In evaluating the results of the operation, inherent difficulties arise which always complicate a purely objective study. When artificial pneumoperitoneum is performed shortly after the diagnosis is made, the possibility remains that recovery in some instances might have taken place without the operation, on a simple regimen of diet and rest, particularly since bed rest for a long period used to be considered the routine treatment of tuberculosis. The value of the procedure in each case should be appraised in a critical manner, and on the basis of all associated factors, as for example X-ray findings, gain in weight, temperature and pulse character, sputum examination, and the biological changes in the blood.

In the author's opinion, as a result of this study, pneumoperitoneum should be of some value in the effective therapeutics of collapse therapy. It is his hope that further studies may bring to light a clearer elucidation of the mechanism of the action of artificial pneumoperitoneum and permit the delineation of the limits and the practical extension of this method of treatment in cases of bilateral pulmonary tuberculosis.

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