POSTURAL THERAPY IN THE TREATMENT OF CAVITATION IN PULMONARY TUBERCULOSIS

BY

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PREFACE

The purpose of this work was to evaluate the use of postural therapy in the treatment of tuberculous cavitation in the lungs.

It so happened that the organisation of the tuberculosis service in Ayrshire and the methods of treatment used fitted in well with the use of this type of measure when its possible dramatic effects were publicised in 1948. Since it was found to be of assistance it has been used consistently.

On the use of posture therapy in pulmonary tuberculosis there has been much argument. Opinion varied, from that of the people who said it had no effect, to the enthusiasm of Dormer (1951) who considered it superior to bed rest plus collapse measures. In view of this disagreement and the various modifications of the therapy employed it was felt of value to review critically the use of the method and to consider the results in a series of cases treated in this way, for in few centres could appreciable numbers of cases be collected.

From the consideration of the results it is believed that posture has a limited but useful place in the treatment of tuberculous pulmonary cavitation, causing reduction in size of almost all cavities and closing an appreciable number, but posture is better used in conjunction with other forms of treatment and cannot alone suffice to give lasting results.

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The Recognition of Cavities and their Relationship to Prognosis in Pulmonary Tuberculosis

In the times of Greek medicine postmortem studies were not common. Latèr Juvenal A.D.60-140 is considered by Webb (1936) to have been aware of lung cavities when writing "et phthisis et vomica putres".

Interest in pathological material did not develop greatly until the time of the Renaissance, but in the middle ages the terms "apostumes", signifying 'hot' abscesses as opposed to 'cold' abscesses and "ulcers" were applied to the lungs.

Following the lead given in pathological anatomy by Benevien, who diéd in 1502, there was a slow realisation of the possibilities of study in this field. The discovery of the microscope further extended this interest.

Webb also quotes Fernel (1554) as reporting that cavities in the lungs (vomicae) were frequent in consumptives, and Sylvia (1679) in the Netherlands as writing of the scattered "tubercula" in the lungs which he believed to be tuberculous glands, and which contained pus. He regarded cavities as arising from these "tubercula".

Morton (1689) in his classic "Phthisiologia" was aware of the changes in the lung in pulmonary tuberculosis and related symptoms to pathological changes, developing a surprisingly modern outlook on the behaviour of the disease. He recognised

that a considerable number of cases do not fully develop the disease and that in some patients it may regress spontaneously, but "even after the most perfect "cure of a consumption, there is reason to suspect "that there are some crude tubercles remaining, which "at length may, by often meeting with an occasion, "be inflamed and ripen into apostumes and so at "last become ulcers".

He realised also that fever would be associated with the tendency of a tubercle to "ripen" and become a cavity.

Stark, who died in 1771 but whose work was not published until 1788 had considerable knowledge of the development of cavities, recognising that the posterior part of both upper lobes was the commonest site for the disease to settle.

"In the cellular substance of the lungs are "found roundish firm bodies... of different sizes, "from the smallest granule to about half an inch in "diameter, the latter often in clusters. The tubercles "of small size are always solid, even those of a "larger are frequently so:.....on the cut surface "of some tubercles were observed small holes, as if "made by the pricking of a pin: in others were found "one or more small cavities containing a thick white "fluid, like pus; at the bottom also of each of these "cavities, when emptied, several small holes were "frequently to be seen, from which, on pressing the

"tubercle, matter issued;..... The cavities in "different tubercles are of different sizes from the "smallest perceptible to half an inch or three quarters "of an inch in diameter, and when cut through and "emptied, have the appearance of small while cups, "nothing remaining of the substance of the tubercle "except a thin covering or capsule. The cavities "of less than half an inch in diameter are always "quite shut up; those which are a little larger, "have, as constantly, a round opening made by a "branch of the trachea. At this period there being "a free passage for the matter contained in the "tubercle into the trachea and a communication between "the cavity of it and the open air, it is proper to "change the name of tubercle to that of vomica."

"Into all the vomicae, the smallest excepted, "there are several openings of the bronchia; also "openings forming communications between the different "vomicae. The bronchial openings are commonly round "and smooth, the others generally irregular and ragged. "The larger vomicae, which have numerous bronchial "openings, are found to contain scarcely more matter "than is sufficient to besmear their surface: and "what shows clearly that the matter is discharged by "these openings of the aspera arteria is that if a "deep incision be made into any diseased part of the "lungs, and that part gently compressed, the matter "will be seen to issue from the cut extremities of

"the bronchia, or if any considerable branch of the "aspera arteria is laid open and the lungs pressed "in the same manner, the matter will be seen coming "into it from the smaller ramifications."

Baglivi is quoted by Vineberg and Kunstler (1944) as considering in 1696 that opening of cavities to the surface led to their cicatrisation, while in Dublin in 1763 Barry thought it worth while to open cavities to the surface and he was then aware of the dangers of a free pleural space.

Hastings and Storks (1845) introduced a rubber catheter through the chest wall directly into a cavity in attempting to close a large apical cavity. The catheter remained in position for a month with marked clinical improvement.

However, further experience in the direct attack on tuberculous cavitation as a means of treatment was not good. Mortality and morbidity were unduly high and there was the disadvantage of a prolonged broncho-cutaneous fistula.

There remains some doubt, however, in the manner of diagnosis of cavities especially in the earlier cases mentioned for it was not until 1761 that Auenbrugger published his discovery of the useful application of percussion to the chest, but it was not until Corvisart, who was born in 1755 publicised the value of the work that it became widely known. It was 1819 before Laennec

introduced publicly the stethoscope.

With these additions to the diagnostic armamentarium the interest in physical signs in the chest flourished, and in particular signs of pulmonary cavitation were worked out and related to pathological findings.

The discovery of the tubercle bacillus, while of importance in general, concerns us little in dealing with cavitation, but gave an index of prognosis in treated cases and we shall discuss later the infectiveness of discharges from a cavity.

The development of X-rays at the beginning of this Century led to a more precise knowledge of cavitation in pulmonary tuberculosis in living subjects, but there was much difference of opinion. Even after 1920 there was discussion as to whether ring shadows on X-ray plates did in fact represent cavities (Amberson 1924, Young 1953). Twenty years ago in publishing results regarding cavitation in pulmonary tuberculosis Clarke (1934) discussed cavities under two headings - (1) clinical cavities and (2) X-ray cavities, the numbers in the two groups differing. Since that time the radiological appearance of pulmonary cavitation has been more generally agreed although difference in the personal interpretation of the films still remains.

The relationship between prognosis and cavitation in pulmonary tuberculosis has been more

definite. Von Düring, quoted by Clarke, found in 1927 that of 271 patients discharged from hospital with a relatively good prognosis, when followed up 3 to 5 years later, 57% were dead. The size of a cavity had no great effect on the result.

In Northern Ireland Clarke (1934), reviewing patients discharged between 1919 and 1924, after a 6 year follow up, during which time he lost sight of 41 cases out of a total of 729, found that of those with sputum positive to examination for tubercle bacilli 78% were dead, while in those who were not producing the organism 27.5% were dead. In a later series, patients discharged between 1926 and 1930, followed up in the spring of 1933, of those cases where cavitation was present 65% were dead.

From these and similar results the relationship between persisting cavitation and a poor prognosis was recognised but even in 1939 in their well-known book Kayne, Pagel and O'Shaughnessy were at pains to emphasize the necessity of cavity closure as a basis of treatment, as if such a concept were not generally accepted.

The influence of this important work of Clarke in emphasizing the necessity for cavity closure is seen in recent practise in treatment of pulmonary tuberculosis. It is recognised that it is not always possible to achieve cavity closure by medical means alone, but in many of the early cases now

treated the immediate aim is to produce this cavity closure, and having done so to consider supportive collapse measures or, in some centres, prolonged chemotherapy. Thus artificial pneumothorax, while less used than formerly, is used still less frequently in the presence of a cavity in the lung.

Postural therapy may have a significant influence in achieving this cavity closure before consideration of collapse measures. However, before discussing this question we must turn to the influence of the mechanical factors on a cavity in lung tissue.

The Development of the Modern Outlook on Cavity Mechanics.

Lovelace (1924) in America attempted to deal with 3 large cavities by resecting a portion of the chest and cavity wall, with the object of sterilising the cavity with methylene blue and gentian violet, and was surprised to find the cavity quickly became sterile on attempted culture of tubercle bacilli. The "progressive shrinking of the cavity until now it is little more than a sinus leading into the chest wall" was unexpected and unexplained.

Morin and Waitz (1929) recorded details of a case in which a cavity during a period of seven months increased markedly in size on six occasions, each time later becoming quite small. A similar case reported by Mantoux (1931) was given the name "Caverne Accordion".

Hudson (1936) reported a case with a large right upper zone cavity which shrank slowly in size over a period of 3 years, while many people like Pickering (1936), met a case of pulmonary tuberculosis with extensive cavitation, in which without any rest or specific treatment cavity closure occurred.

It was a series of puzzles such as these, which, combined with the interest in lung mechanics resulting from the increasing use of artificial pneumothorax therapy, stimulated thought and enquiry

by many people. From their efforts some basic agreement has resulted. Its general development can be followed briefly in the subsequent findings which help to point the way.

Even in 1922 Hall drew attention to the condition of the bronchus draining a tuberculous cavity. To explain sudden changes in size of a cavity he suggested, but without pathological evidence, that a "semi-detached" piece of lung blocking the bronchus, permitting air to enter but not to escape, was the cause of ballooning of a cavity.

Ameville is quoted by Coryllos as realising in 1927 the importance of the bronchus in the development of a cavity, but as considering that enlargement of cavities was due to blockage of the draining bronchus and resulting retention of secretions behind the block.

In explaining how the lung itself behaved as a result of damage by a tuberculous focus Reinders is quoted by Vineberg and Kunstler as emphasizing that the volume of the cavity did not represent the amount of lung actually destroyed, but largely lung tissue which is collapsed and capable of re-expansion. He compared the defect in the lung to a slit in an elastic membrane. When the membrane is pulled and becomes tense the slit takes a circular form because stretching enlarges

the hole more than the membrane. This analogy has later been taken further and lung tissue is likened to a spider's web in which a rent from any cause becomes more or less a circular hole.

Pearson (1930) needled a large cavity through the chest wall and found the intracavitary pressures raised (plus 4 and plus 16 cms of water). After removal of successive amounts of air, in all 750 ccs, he found pressures to be 0, plus 9 cms of water. Such were the figures on August 29th, 1929, but the following January intracavitary pressure was atmospheric with a range of minus 5 to plus 5 cms of water. Brooks (1931) similarly needled a large cavity and found the intracavity pressure to be positive, but after removal of air there was a return to atmospheric pressure. He considered he was dealing with a valve like obstruction in the bronchus leading to the cavity.

In America similar ideas were developing and Korol (1935) summarised the general outlook when he wrote that the cause of sudden changes in the size of a tuberculous cavity was to be looked for in the state of the draining bronchus.

Many ideas have been put forward to explain why a cavity may develop or close. Some of these ideas are summarised and commented upon :-

1. Trocme (1905), writing in a Paris thesis, is mentioned by Coryllos (1936) as first suggesting that obstruction of the bronchus draining a cavity would cause centripetal shrinkage of the hole in the lung which was the cavity. This argument was taken up and enlarged upon by Coryllos whose work we shall discuss later.

2. Forlanini had emphasized that disease in a lung focus worsened by wear and tear as a result of respiratory movement. Such remarks apply to lung disease generally and the principle of diminishing the number and extent of respiratory movements is a fundamental one in the treatment of pulmonary tuberculosis. Although it is known that increased respiratory and bodily activity may cause deterioration of disease and development and enlargement of cavities, and that bed rest may initiate improvement, yet the whole answer does not lie in this alone, for by this means we cannot explain rapid enlargement and diminution or even disappearance of cavities, nor why some cavities close without rest or specific treatment. Other factors in addition to this important concept are involved.

3. Pinner (1931) visualised two sets of fibres round a cavity in the lung, a concentrically placed series which tended to close cavities by their contraction, and a radiating series which tended to

open cavities. The resulting state of the cavity depended on which group predominated. However, pathological evidence of such an arrangement is not forthcoming. In an artificial pneumothorax where there are no adhesions present it is difficult to imagine especial pull on the lung in one direction, but changes in the behaviour of a cavity in these circumstances still occur.

4. Coryllos (1936) again quotes the Italian school in the names of Monaldi and Morelli as considering that lung parenchyma breaks at the point of the lesions; the breaking tends constantly to enlarge because of continuous tension of the elastic parenchyma which is submitted to a static force due to negative intrapleural pressure, and a dynamic force due to respiratory movement. They say the effect is greater if a bronchus is stenosed.

During wartime missiles passing through the chest, no doubt breaking and tearing lung tissue, were not frequently found to give rise to cavity formation. In addition the accordion type of cavity, with repeated enlargement and diminution in size over short periods of time, surely was not the result of alternate tearing and repairing of lung tissue. Post mortem examination at the site of such cavities after the cavity had closed did not as a rule give evidence of great disruption of lung tissue, or to much fibrous tissue used in the repair processes.

5. Closure by pressure from pericavitary emphysema was suggested by older workers such as Le Seve (1926) quoted by Coryllos and Jacquerod (1926). However, such emphysema is regarded now rather as the result of the disease, than as being a factor in causing a change in behaviour of the lesion.

6. Eloesser (1937) re-emphasized the idea of Ameville that closure of the bronchus led to retention of secretion with enlargement of the cavity, this state he called a "blocked cavity".

In general, agreement was reached on the necessity of lung damage by caseation and destruction being an essential factor in cavity formation - the hole in the lung was recognised as a real thing. Caseation reaching the bronchus may give rise to infection in the draining bronchus and cause a valvular effect in the bronchus or at the junction of the cavity and bronchus.

While the importance of the draining bronchus in closure of such a cavity was agreed, two main arguments were made. (1) Closure of the draining bronchus led to retention of cavity secretion and persistence of the cavity. Eloesser, following the argument of Ameville, considered that closure of the cavity could only occur after reopening of the bronchus. (2) Closure of the draining bronchus led to absorption of air from the cavity

with subsequent disappearance of the cavity.

Coryllos (1936 and 1938) by his work gave great weight to the latter theory, and clarified matters considerably.

He showed 3 main types of cavity.

(1) Cavity with a closed bronchus.

In this type of cavity the intracavitary pressures were negative, and at times markedly so. Oxygen concentration was 1 part per 100 or less while carbon dioxide concentration amounted to 5 parts per 100 or more. These figures resemble the concentration of gases in an artificial pneumothorax in which no recent refill has been given. Coryllos regarded this type as in the process of disappearance but he recognised that, should the bronchus reopen, then the cavity may reappear.

(2) Cavity with an open bronchus.

In this type intracavitary pressures varied but little from atmospheric pressure and there was a free swing of the manometer during inspiration and expiration. Fluid levels were not seen on X-ray films. Oxygen concentration was 16 - 19 parts per 100 and carbon dioxide concentration less than 1 part per 100. Thus the figures not differing much from the atmospheric pressure suggested a free connection for air passage.

(5) Cavities with bronchus intermittently open - the tension type or check-valve cavities.

In these intracavitary pressures were positive with little or no swing of the manometer during respiration. Fluid levels were frequently noted on X-ray films of this type. Oxygen concentrations were 10 to 17 parts per 100, while carbon dioxide concentration was 2 to 3 parts per 100.

In this type of cavity Coryllos visualised the valvular obstruction allowing passage of air through the larger bronchus during inspiration, but the valvular effect with the smaller bronchus of expiration prevented its escape, and the resultant trapping of air ballooned the cavity. A change in the state of the bronchus of small extent could influence the valve effect and hence the sudden enlargement, diminution and even virtual disappearance of a cavity could be explained on this basis. It was later shown too that coughing, especially the very deep inspiratory effort which precedes the expulsive phase, is very liable to cause "ballooning" of a tension type of cavity.

Coryllos believed that the tension type of cavity did not heal but caused slow extension of disease in the cavity and to the rest of the lung. He considered that closure of cavities occurred only by stenosis of the draining bronchus.

While this concept is a considerable advance

on the understanding of the behaviour of tuberculous cavities, some modifications have been incorporated in his scheme, but the main part is generally accepted.

Using a modified thoracoscope Coryllos (1938) examined the interior of tuberculous cavities, finding in cavities with an open bronchus that the main draining bronchus was usually easily identified, and in upper lobe cavities at least this usually opened into the lower part of the cavity. In the tension type of cavity with the bronchus intermittently open, he showed a 100% obstruction to the flow of air or fluid in the direction, cavity to bronchus, even with increasing intra-cavitary pressures. However, when air was removed from the cavity, almost at once air and fluid would escape from the cavity to the draining bronchus.

Goldman and his colleagues (1941) confirmed these findings, and regarded the valvular mechanism as being always involved in cavity formation. In a study of this aspect in 300 bronchoscopies and 100 necropsies, they differentiated 4 main types of such valvular obstruction.

1. Check valve :

2. Accordion valve :

3. Bypass valve :

4. Flutter valve :

In 1936 Salken et al. reported failure to find communication between cavity and bronchus in 14 (9.5%) of 147 cases. They injected Lipiodol into a cavity in the cadaver and observed its passage into the bronchial tree. However, Auerbach and Green (1940) later reviewed over 2000 cavities in lungs and did not find one cavity of a size greater than 3 cm in which they could not trace with a fine probe the bronchial opening into the cavity.

Brunn et al (1941) took further the study of air movement in cavities of the tension type. They did not disagree with the results of Coryllos (1938) and confirmed that by removal of air the tension element may be lost for a time. Using a kymographic recording of the pressures in a tension cavity over long periods of time they found that air leaks into the tension cavity at infrequent intervals through 24 hours, possibly once or twice, and then over a few breaths only. They estimate the leak to be under 10 ccs. in 24 hours in a cavity of twice this size.

They also enlarged on the allergic factor in producing relative stenosis of a bronchus. Although possibly a factor, this has not since been believed to be of great importance in the majority of cases.

Modern opinion has accepted in the main Corylles' theory especially in regard to tension cavities, the commonest type of cavity to present problems in planning treatment in pulmonary tuberculosis. The more recent resection of lobes and segments of lungs has allowed more study of the relationship of the cavity to the bronchus. Tuberculous involvement of the bronchus has been found an important finding, even in the absence of macroscopic changes, e.g. Houghton and Joules (1953) in the research by the British Tuberculosis Association report 95% of cases affected.

Studies such as these of Silverman (1951) in examining resected segments and lobes of lungs with tuberculous cavitation, has shown that when the state of the bronchus is related to the cavity, there is no doubt that bronchial stenosis is one method by which cavities heal.

Now in addition to development, maintenance and behaviour of tuberculosis, it is as well to consider on a wider aspect how cavities heal.

The Mode of Closure of Tuberculous Cavities.

Pathologists in the past have been puzzled when examining lung tissue at the site previously occupied by a tuberculous cavity which closed, by the absence of any marked changes in the lung. Indeed it has been argued that X-rays suggested cavities which were not true cavities.

Pinner (1937) in America and Pagel (1936) in this country have reported finding a few star-like fibres at the site of a former cavity but they showed little scar tissue.

The re-emphasis by Coryllos of the closure of the draining bronchus with resultant absorption of air, residual atelectasis, and disappearance of the cavity would fit in well in explaining the occurrences above. It may be that the majority of tension cavities close in this way, but there is another aspect to the problem for at times we meet an encapsulated mass of caseous material in the site of a former cavity.

Pagel and Simmonds (1942) reviewed this subject and found that of 11 cases of their own 9 cavities were converted into a "solid focus" or "tuberculoma". In the recorded findings of closed cavities they found 33 cases in the literature and of these 16 closed by conversion to a solid focus. They regard this method of closure like that of Coryllos above to result from closure of the bronchus, but on these

occasions caseous material was trapped in the cavity. In their own 11 cases they found the majority had occurred soon after artificial pneumothorax induction or after the establishment of an extrapleural pneumothorax, hence they suggest that rapid closure of the bronchus by outside interference may be the factor and that slow closure allowing some drainage from a cavity for a time at least may give a better healing in the end.

These authors recognise cavity healing to occur by the following methods.

1. Open cavity healing, possibly with epithelialisation of the cavity wall.
2. Conversion to a solid focus - a tuberculoma. This results from bronchial closure and inspissation or calcification of the residual contents of the cavity.
3. Replacement by a fine radiating scar.
4. Replacement by more dense fibrous tissue and formation of an area of bronchiectasis.

Auerbach and Green (1940) used the simpler classification.

I. Closure by obliteration of the draining bronchus, with resultant healing by (a) fibrous scar or (b) retention of caseous material, but they question the latter as being true healing.

II. Open healing, replacement of the diseased lining

of the cavity wall by healthy tissue, the bronchus remaining open.

In 1941 Auerbach reported the observations on 134 patients who died after thoracoplasty had been done. He found 17 cavities closed and in these the bronchus ended in the fibrous layer of the old cavity wall. In the remainder the cavity persisted and the bronchus was open.

Grenville Mathers (1947) attempted to classify by radiological observation of the appearance of cavities over a long period of time, the method of healing. He could not recognise any case of open cavity healing, always a dangerous verdict on clinical and radiological grounds alone. 9 cavities closed by solid focus and 36 by absorption atelectasis and fine residual scarring.

There has been no good reason to disagree with the classification of Pagel and Simmonds (1942) and the results of postural closure of cavities is later reviewed on this basis. However, in 1955 the same authors presented evidence, in cases which have had considerable amounts of chemotherapy for tuberculosis, of areas of partial epithelialisation in the presence of an open bronchus, areas of uncovered granulation tissue, with small pockets of caseous tissue, all being in the same cavity. In fact this amounts to some features of each of their modes of cavity closure being present in the same

cavity. They suggest that this is an effect of the drugs used and emphasize the possible instability of such a cavity, and of similar cavities which are apparently closed.

The open method of cavity closure is recognised as existing but of being uncommon. Houghton (1950) however, possibly not altogether seriously, suggested that this mode of closure was more frequent and more reliable than other methods. By clinical and radiological findings alone it is not often practical to separate a healed open cavity from an active cavity.

Closure by solid focus is easily recognised by the pathologist and the radiologist and this ease may explain the relatively greater number in Pagel and Simmonds series.

Closure by radiating scar or by fibrous scar and bronchiectasis is not always recognised easily by the radiologist and small scars may be missed by the pathologist not searching for such small findings. However, over a series of X-ray films it appears reasonable to suggest closure by this means. In the results later the cavities becoming linear type of scars on the X-ray film are included.

Now in relating cavity mechanics and cavity closure to postural therapy we must consider the changes in the action of the respiratory apparatus resulting from this means of treatment.

The Physiological Effects of the Posture Position.

The effect of lying the patient on one side in diminishing the extent of respiration has long been known, but there have been variations of opinion as to how this was actually done.

Link in 1902 noted diminished movement in the chest on the lower side in the lateral position and considered venous congestion of that side to be a factor.

Jamin (1906) described changes in the resting level of the diaphragm in various positions including the lateral position. The diaphragm on the lower side came to lie at a higher position in the thorax and that on the upper side moved to a lower resting position. There was slight mediastinal movement toward the lower side. In producing these changes he considered the weight of the abdominal viscera, especially the liver, to play an important part. From study of the movement of the diaphragm in quiet tidal respiration he believed that ventilation of the lower lung in the lateral position was reduced.

Webb, Foster and Gilbert (1921) on fluoroscopy noted that the tidal movement of the raised lower diaphragm was greater than that of the upper, but after a period of about an hour a mediastinal shift to the lower side had occurred, and then there was little difference in movement between the two sides.

On the lower side the ribs had moved closer together.

Other observers, e.g. Butler and Dana (1928), Hawkins (1948), reported that the lower diaphragm had a greater excursion in either lateral position. Adam and Pillsbury (1922) however disagreed, finding the movement of the lower diaphragm to be no greater than the upper but they believed there was a "greater respiratory efficiency" than that of the upper side.

Thomas (1948) noted the raising of the diaphragm on the lower side in a patient on posture, also found in a few cases in which bronchograms were done, that the bronchi on the lower side were narrower than normal.

Altschule and Zamchek (1942) investigated the effect of the Trendelenberg position on the components of the vital capacity. They measured the vital capacity , the reserve air, the residual air, and the complemental air in each of 3 positions :- Head inclined down 22.5 degrees, supine, head inclined up 22.5 degrees.

Their results show little variation in the residual air. In the head down position vital capacity and reserve air is smallest, while complemental air was largest. The reverse applied to the head up position.

Herxheimer (1949) in a simple experiment, measured simultaneously the phases of respiration

and thoracic cage expansion, and suggested from the results that the thoracic cage and the diaphragm both play a part in the movement of complemental air, but the diaphragm played relatively a greater part in the movement of reserve air.

Wade and Gilson (1951) in an extensive review of this field recorded synchronously the graphic record of diaphragmatic movement on fluoroscopy and the spirogram, while the patient was in different positions.

They consider the tidal diaphragmatic movement little affected by variation of the Trendelenberg position, but the resting position of the diaphragm rose when the patient was supine, and this rise was still further noted with the head inclined downwards. They confirm the results of Altschule and Zamchek (1942) that in the head down position reserve air and vital capacity are smallest and complemental air largest.

By the same method, in the lateral position they found that the diaphragmatic movement in quiet respiration and total diaphragmatic movement in deep inspiration slightly increased on the lower side when the patient lay on either side, but the type of movement on the upper and lower sides differed. On the upper side the resting diaphragmatic level was low in the thorax, and the complementary diaphragmatic movement was small, while the reserve

diaphragmatic movement above the resting level was large. In other words the position and movement of the upper leaf of the diaphragm was similar to that of both leaves in the upright position. On the lower side the resting level of the diaphragm in the thorax was high, the complemental diaphragmatic movement was large, and the reserve diaphragmatic movement small, i.e. the diaphragm on the lower side behaves as do both leaves of the diaphragm when the head is inclined downward by 45 degrees in the Trendelenberg position.

From this it would be expected that the components of the vital capacity in each lung would also differ. On the lower side in the lateral position with the diaphragm at a high level in the thorax, vital capacity would be low and reserve air would be low for Herxheimer (1949) has pointed out the effect of the diaphragm on the reserve air especially. On the upper side the reverse would be the case.

Bronchospiometric evidence, however, is not conclusive. Bjorkman's evidence is considered by Wade and Gilson (1951) to be limited although he suggests that the ventilation of the lower lung is increased. West, in a personal communication to Wade and Gilson, is quoted as suggesting that the ventilation of the lower lung is less than that of the upper.

From this evidence on the Trendelenberg position alone and on the lateral position alone, it is suggested that when the patient is in the lateral position with the foot of the bed raised by about 15 degrees, the volume of the lower lung is less and presumably there is a diminished volume of air moved in and out. If the bronchi are also smaller in that position, as shown by Thomas (1948), then there is additional evidence of diminished air movement on the lower side.

There is another factor in the use of posture as will be described. The patient is at rest for prolonged periods, with little physical activity. Oxygen requirement of the body is comparatively low, and there is little occasion for respiration to be increased in rate or depth above a relatively basic requirement. This enforced rest, one of the basic principles in the treatment of pulmonary tuberculosis, must not be forgotten in dealing with tuberculous cavitation.

Another method of treatment requiring prolonged and strict bed rest has been described by Cullen (1948), using the principle of alternating pressure in an immobilising chamber originally used in resuscitation. Having trained the patient to use the method, periods of up to 10 hours daily are spent in the chamber. Results of such treatment are said to be good. It is possible that the

advantage in this treatment arises in the effect of prolonged bodily inactivity and this idea is strengthened when, as recorded by Cullen, temperature, pulse and blood pressure are lower while in the machine.

The clinical application of these ideas and observations has been varied and between physicians there is disagreement on results and on methods of using posture. In view of such differences it may help to review the literature on the use of posture in pulmonary tuberculosis, noting especially the aim in view, the methods used and the consequent results.

A Review of Published Work on the Use of Posture in Pulmonary Tuberculosis.

Posture is regarded by many physicians as a comparatively recent method used in the treatment of cavitation in pulmonary tuberculosis, but one form of posture was used in 1902. Published papers on the subject are few, but their ideas and results are discussed here.

Mendelsohn in 1899 advocated lying patients with pulmonary tuberculosis on the good lung so that the discharges would flow more easily with the assistance of gravity into the bronchus and then be coughed up.

On the other hand Link (1902) pointed out that there was a beneficial result from lying the patient on the diseased lung. He mentioned the diminished ventilation and possible hyperaemia as factors in producing such a change.

In 1916 Webb, Foster and Houck, in America, also advocated lying the patient on the affected side. As a possible explanation of this effect they quote experiments of Rubels in injecting intravenously bovine tuberculous bacilli into rabbits, producing in freely mobile lungs disease of progressive type, while in immobilised lungs the tuberculous process is of the chronic type. In a further paper in 1921 Webb and his colleagues pressed for further use of this simple measure

and reported their own favourable impressions after dealing with more than 200 cases so treated. Their method was to lie the patient on the less diseased side for short periods for a few days to promote drainage of secretions, and then to lie him on the side of the more diseased lung for increasing periods of time, beginning with a few minutes and gradually extending until more than 20 hours per day were spent in that position. Later a small pillow might be placed below the lower chest to increase the "splinting" effect. The use of a strict regime is emphasized and they quote a case which had no benefit from halfhearted measures, but which improved greatly on a stricter regime.

Gekler and Weigel (1928) also report the good effect of intensive postural rest in the treatment of pulmonary tuberculosis. They put the patient on the side of the more affected lung first, using a special pillow below the chest to take the weight off the point of the shoulder, allowing the patient to lie at times round on the back but not on the other side. They start with a period of about half an hour and increase by half an hour daily until 16-24 hours are spent in the chosen position. A temporary increase in pyrexia and in the amount of cough and sputum may follow but these changes subside in a few days. They explain their results under three main

factors: (1) The muscles of the lower half of the chest , not being accustomed to working against pressure, become fatigued and work less well. (2) Sagging of the heart and mediastinum to the lower side. (3) Preventing spread by aspiration, of disease to other areas of lung.

The first argument is not on sound theory since muscle comparatively soon accommodates itself to a regular increased demand of moderate amount in its work, and the best way to achieve this is by slight daily increase in this work. Such circumstances are produced by increasing the time on posture by ½ hour daily. The second argument applies in some cases, but where there is fixation of the mediastinum from previous disease or injury this factor has no influence. In the third argument they make a very important point in preventing disease spreading to the good lung, a point which is even to-day not infrequently forgotten.

As contra-indications to the procedure they note the very debilitated patient, the patient who has recently had a haemoptysis, and the patient who has already marked mediastinal displacement and fibrotic disease.

Gekler and Weigel report good results being obtained in three to six months and complications, which are unspecified, are few. Even if the

measure fails there is no hindrance to the use of other modes of treatment.

Wu and T'Ang (1937), working from a radiological basis, reviewed the question of contralateral spread of disease in pulmonary tuberculosis. In 22 cases they described a fairly constant picture which they think was present when they considered the preceding events in 220 cases which they saw.

A strong recommendation is made for patients with unilateral pulmonary tuberculosis, especially in the presence of cavitation or abundant sputum, to sleep on the side of the diseased lung.

In this country Helm (1951), after reviewing 1200 in-patients, found in cases which developed new disease while under observation, that it was highly probable that the sleeping position was a factor in the spread of disease from a cavitated lesion. He also recommends sleeping on the side of the cavity.

As late as 1946 Peck was presenting the use of posture as a means of aiding drainage from the bronchi in pulmonary tuberculosis. He recommends a change in position each ½ hour through the day spending ½ hour in succession in each of 4 positions, supine, prone and right and left lateral positions. He rightly deprecates the damaging effect of

repeated explosive coughing, but there has been little support for this method of tackling the problem.

The development of the more modern use of posture dates from the work of Dilwyn Thomas (1948), who used, in addition, the raising of the foot of the bed. His method has been to locate anatomically the site of the cavity and to put the patient for 24 hours in the day in the position diametrically opposed to that of postural drainage from the affected pulmonary segment. At first the name postural retention was used but it soon became evident that the simple retention of secretion was not the only factor and then the term postural reduction was applied.

The reasons for the good effect on cavities in pulmonary tuberculosis were not at once apparent, but the effects in some cases were striking, and of 60 cases presented at the British Tuberculosis Association Conference in 1948 all but one showed reduction of cavity size.

Deshmukh and Williams (1951) reported a series of 50 cases in which postural reduction was employed as a pre-operative measure. The anti-tuberculous drugs were increasingly used as they became available. As Thomas had done they located accurately the site of the cavity and imposed a strict regime on the patient whom they placed in the position of reversed postural drainage for the lung segment involved.

Thus in posterior cavities the patient lay on the back and possibly had the end of the bed raised, anterior cavities of upper or middle lobes meant the use of the prone position, the lateral positions were maintained at an angle of 30 or 45 degrees by using plaster of paris casts. The duration of treatment was from three to four months.

As a result of this treatment the majority of cases became better surgical risks, e.g. at the end of this period of treatment in only 5 cases was sputum positive for tubercle bacilli. However, 6 cases classified at the outset as being in poor condition remained so. As a complicating factor 2 cases opened an apparently closed cavity on the non posture side.

They found postural therapy useful and helpful in the preparation of a patient for surgery, and this preparation may well be done away from the main surgical centre.

Dormer (1951) from South Africa, presents an enthusiastic account of the uses of posture but presents no figures. He considers its use "overwhelmingly superior to bed rest alone, or combined with collapse therapy". Although he claims much he presents little concrete evidence.

Aslett and Erin (1952) presented 45 cases in which postural therapy was used without localisation of the cavity, the patients lying on the cavity side with the foot of the bed raised 18 inches. They

considered several factors influencing results and report that the age and sex of the patient and the size of the cavity below 5 cm diameter were of little significance. Midzone cavities closed more often than those in the upper zone. Cavities in the left lung were more frequent than in the right lung, and less successfully treated. As unfavourable factors they mention an increasing number of cavities, an increasing amount of disease around the cavity, an increasing amount of disease in the opposite lung. One case developed a new cavity on the non posture side. No cavities which closed on posture and in which collapse measures were used, reopened later.

In a review of posture as a short term treatment for several weeks before the use of minor collapse measures, Lyons (1953) deprecated the lack of figures on this method of treatment. 62 cases are included and they were positioned with reversed postural drainage after localisation of the cavity. Later cases in the series were allowed to rise once daily for toilet purposes.

Results showed that of the 62 cavities 44 were smaller on posture and 12 closed, while 18 (including one which enlarged) were unchanged.

With no chemotherapy (47 cases) 33 cavities diminished and 14 were unchanged.

With chemotherapy (15 cases) 11 cavities diminished and 4 were unchanged.

From these figures he suggests that using postural therapy with chemotherapy gives better results than does posture alone.

With upper zone cavities results were less good than with mid zone cavities measured in terms of reduction of cavity size. Cavities of the apex of lower lobe responded best of all. Larger cavities became smaller more readily than those of moderate size.

No significant complications were met.

These papers mainly advocate a strict regime and results suggest even when there is some variation in the methods used, the majority of cavities may be expected to respond to treatment, at least in diminution in cavity size. It is noteworthy that with the exception of opening or reopening of cavities on the other side, complications are not significant.

In the series of cases presented in this thesis a strict regime was insisted upon, but at this stage it is advisable to explain the circumstances under which this particular method was used before detailing the results.

THE PLAN OF WORK.

The work has been done largely in Ayrshire, a County of population 321,184 (1951 census). Formerly an agricultural area, industrialisation has been steadily increasing, and the population tend to settle more in the towns and burghs.

Ayrshire, like the greater part of Scotland, shared in the increased post-war demand for pulmonary tuberculosis beds. Notifications of new cases were in 1948 - 320; in 1949 - 316; in 1950 - 275; in 1951 - 298. Limited surgical facilities were available and there was an appreciable waiting period for a patient after acceptance as a suitable case for surgical treatment. This period was at times over six months. During 1948, 1949 and 1950 a total of only 51 thoracoplasty cases were completed, 7 extrapleural pneumothoraces instituted, and 1 pneumonectomy done.

To decrease the time spent in hospital and as a holding measure, extensive and early use was made of pneumoperitoneum and phrenic crush. Thus in the same years 1948, 1949 and 1950 a total of 307 cases had pneumoperitoneum established.

After 1948 postural therapy was tried and preliminary results were impressive. Since 1949 this measure has been used in a definite but minor place in the scheme of treatment, fitting in

well with other forms of therapy.

The results presented here are based on the records of patients treated in the beds allocated to the Tuberculosis Service in Ayrshire, during the period 1949 - 1953. These beds are in three centres - the majority 141 at Ayrshire Central Hospital, dealing mainly with North Ayrshire, 57 at Heathfield Hospital, Ayr, dealing with the southern part of the County, and Glenafton Sanatorium by New Cumnock 101 beds, dealing with less ill and convalescent patients as well as those from that district. Out-patient supervision has continued at these three centres, with the addition of a Clinic opened at Kilmarnock Infirmary in 1953.

The beds have been under the care of one physician and the system of treatment and records at each centre has been the same. The same members of the medical staff have looked after the patient during the period in hospital and after discharge, meeting regularly to discuss mutual problems.

I knew personally the majority of cases either during the stay in hospital or during subsequent out-patient supervision, while working as Senior Registrar in this scheme. Duties were mainly at Ayrshire Central Hospital but required visits to the other centres.

The statistical cards of all patients discharged since 1949 were examined and those having postural therapy separated. From the resulting list a few cases, having had disease elsewhere interfering with treatment or given insufficient time on posture, were omitted.

There remain 100 cases for discussion.

METHOD

A strict regime was employed.

The patient was on strict bed rest, not being allowed to get up or sit up, the only exception being a visit to the X-ray department once in 4 or 6 weeks, when the journey was made by stretcher, the patient sitting up long enough to have a film taken.

Instructions were given to lie on the side of the cavity, in cases with unilateral cavitation, while those with bilateral cavitation lay on the back. As a change in position the unilateral cavity case could lie on the back but not on the other side. The bed table and locker were brought round to the cavity side to remove temptation to stretch and roll round on the other side. If in sleep there was a tendency to roll on to the non-cavity side, a pillow below that shoulder and down that side of the bed helped to prevent this until sleeping on the given side became a habit.

A small pillow was allowed below the head, but the shoulders were not at any time permitted to come on to it. The end of the bed was raised 18 to 20 inches. Some patients tolerated this in one step but more often, especially with older patients, it was necessary to raise the bed over 3 or 4 days in stages. There was occasional abdominal discomfort and vomiting at this stage, but with sedation, patience and persistence, the desired level could be reached.

Meals were taken lying on the back with the plate balanced on the chest. Toilet arrangements were carried out in a similar position, and with these procedures the ward sister reported little difficulty.

The period on posture was mainly from 1 to 5 months; a few patients had appreciably longer.

PHOTOGRAPHS SHOWING A PATIENT IN THE POSTURE POSITION.

RESULTS

Of the 100 patients with pulmonary tuberculous cavitation treated with posture 37 were male and 63 female. Neither sex showed a relative predominance in any of the smaller groups which follow.

All cavities became smaller as a result of postural therapy, with 4 exceptions. These exceptions were all unilateral cavities and of the 4, 3 were unchanged and one enlarged.

TABLE I.

TIME on POSTURE.	APEX to DIAPHRAGM DISTANCE in CMS.	
	R.	L.
0	19.3	24.2
40 mins.	18.8	23.5
1 hour	17.6	23.0
1½ hours	17.1	22.8
2 hours	17.0	22.2
2½ hours	16.6	21.8
AFTER TOILET	18.6	24.5

TABLE SHOWING THE EFFECT ON THE POSITION OF THE DIAPHRAGM WHILE THE PATIENT WAS ON POSTURE ON THE RIGHT SIDE.

The figures show that with increasing time on posture there was a steady diminution in the distance apex to diaphragm, and progressive rise of the diaphragm.

When the patient was allowed up to toilet and to wash, a procedure involving less than 12 yards walk and less than 5 minutes' time, the diaphragm returned almost to the starting level.

TABLE II.

AGE	NO.of CASES.
15 - 24	40
25 - 34	39
35 - 44	13
45 - 54	6
55 - 64	1
65	1

TABLE SHOWING AGE GROUPING OF THE PATIENTS.

While the range was from 16-65 years, 79 of the 100 patients were 15-34 years of age. The majority (51) were in the third decade.

TABLE III.

	Nos.	%
I. UNILATERAL CAVITIES (78 cases)		
(a) Cavity closed on posture	34	43.6
" " & remained closed	24	30.8
" " & later reopened	10	12.8
(b) Cavity unclosed on posture	44	56.4
II. CAVITY SYSTEM (9 cases)		
Cavity system closed on posture	3	33.3
" " unclosed " "	6	66.6
III. BILATERAL CAVITIES (13 cases)		
Both sides closed on posture	5	38.5
One side closed, one side smaller	6	46.1
Both sides smaller	2	15.4

TABLE SHOWING DIVISION OF CASES INTO GROUPS AND THEIR RESPECTIVE RESULTS.

TABLE IV.

	Total No. of Cavities	No. of Cavities Closed	% Closed
R.upper zone	23	9	39.1
L. " "	32	12	37.5
R.mid zone	10	6	60.0
L. " "	13	7	53.8
Lower zone	-	-	-
Total R.cavities	33	15	45.5
" L. "	45	19	42.2

TABLE SHOWING THE INFLUENCE OF THE SIDE OF THE CAVITY IN UNILATERAL CAVITIES.

From these figures there would appear to be little difference between results on the two sides, but more Left cavities were present in this series.

TABLE V.

I. RADIOLOGICAL DISTRIBUTION.
(There were no lower zone cavities)

	Cavities Closed on Posture.	Cavities Unclosed on Posture.
Upper Zone	21 cases (9 reopened later)	34
Middle Zone	13 cases (1 reopened later)	10

II. ANATOMICAL DISTRIBUTION.
(Not all cavities were accurately located)

		Cavities Closed on Posture.	Cavities Unclosed on Posture.
Upper Lobe	Ant. Segment	2 cases (1 reopened later)	3
	Post & Apical Segment	9 cases (6 reopened later)	21
Lower Lobe	Ant. Segment	0	0
	Apex & Sub-Apex	10 cases (None reopened later)	7

TABLES SHOWING THE INFLUENCE OF THE SITE OF THE CAVITY ON UNILATERAL CAVITIES.

1. In radiological distribution all unilateral cavities are included. More mid zone than upper zone cavities were closed.

2. In anatomical distribution not all cavities can be included since not all were accurately located.

The larger proportion of closure of cavities in the apex and sub-apex of lower lobe is distinct and in these no cavity reopened after closure.

It was a surprise to see as large a proportion of anterior cavities in upper lobe closing as apical and posterior cavities.

TABLE VI.

Size in Cms.diam.	No. of Cavities	No. Closed on Posture	% Closed	No.reopened later
Under 1.5	2	1	50.0	-
2 - 2.5	6	2	33.3	-
3 - 4.5	42	16	38.1	3
5 plus.	28	15	53.6	7

TABLE SHOWING THE INFLUENCE OF THE SIZE OF THE CAVITY IN UNILATERAL CAVITIES.

From the figures it would seem that the larger cavities close as readily as do the smaller, but with increasing size there is an increasing tendency for the cavity to reopen later.

TABLE VII.

Shadowing	Total No.of Cases	Closed on Posture & Remained Closed.		Closed on Posture - Reopened Later.	% Closed of Total
		No.	% of Total		
Fine	13	6	46%	1	54%
Medium	43	13	30%	4	39.5%
Dense	22	5	23%	5	45%

TABLE SHOWING THE INFLUENCE OF THE STATE OF TISSUE SURROUNDING THE CAVITY IN UNILATERAL CAVITIES.

The figures show that slightly fewer cases with dense and medium shadows close the cavity, but with increasing density of shadows there was an increasing tendency for a cavity to reopen later.

TABLE VIII.

UNILATERAL DISEASE				
	Total Cases	No. of Radiological Zones Involved.		
		1	2	3
Cavity Closed on Posture and Remaining Closed.	5	2	2	1
Cavity Closed on Posture and Reopening later.	1	-	-	1
Unclosed.	6	2	4	-

BILATERAL DISEASE						
	Total Cases	No. of Radiological Zones Involved.				
		2	3	4	5	6
Cavity Closed on Posture and Remaining Closed.	19	1	5	8	4	1
Cavity Closed on Posture and Reopening Later.	9	-	2	3	4	-
Unclosed.	38	1	11	12	10	4

TABLE SHOWING THE EFFECT OF THE RADIOLOGICAL EXTENT OF DISEASE ON UNILATERAL CAVITY CLOSURE.

The figures suggest that while results tend to be better with unilateral disease, a greater extent of bilateral disease did not necessarily mean that the cavity was less liable to close, but again there is with more disease a slightly greater danger of a cavity reopening.

TABLE IX.

	Total Cases	Months of Posture to Close Cavity.			
		1	2	3	4
Cavity Closed & Remained Closed.	24	9	12	2	1
Cavity Closed & Reopened later.	10	3	3	2	2
TOTAL	34	12	15	4	3

TABLE SHOWING THE TIME TAKEN TO CLOSE THE CAVITY IN UNILATERAL CAVITIES.

The greater number of cavities close within 2 months if they do close.

TABLE X.

TOTAL CAVITIES CLOSED - 34
CAVITIES REOPENED IN HOSPITAL - 5

	Years after Discharge from Hospital			
	0-1	1-2	2-3	3-4
No. reopened	2	2	1	-
% Breakdown	6.9%	8%	5.3%	-
% Success. Life Table Form.	93.0%	86%	81.0%	81.0%

TABLE SHOWING RESULTS OF FOLLOW-UP ON UNILATERAL CAVITIES CLOSED ON POSTURE.

RESULTS IN GROUPS II AND III.

II. Cavity System. 9 cases.
3 cases closed on posture.
1 case within 2 months.
2 cases within 3 months.

III. Bilateral Cavitation. 13 cases.
Both cavities closed - 5 cases.
One cavity closed, one smaller - 6 cases.
Both cavities smaller - 2 cases.

TABLE XI.

	Total Cases	Duration of Posture to Close Cavity (Months).			
		1	2	3	4
One cavity closed	6	-	5	1	-
Two cavities closed	5	-	8	1	1
Total.	11 (16 cavities)	-	13	2	1

TABLE SHOWING THE TIME TAKEN TO CLOSE CAVITIES IN BILATERAL CAVITATION.

The figures show that most cavities which closed did so within 3 months on posture.

TABLE XII.

	UNILATERAL CAVITY			Cavity System	Bilateral Cavities.
	Closed and Remained Closed.	Closed and Reopened	Unclosed		
WITH POSTURE					
Phrenic	20	6	19	7	3
None	4	4	25	2	10
AFTER POSTURE					
None	6	1	8	3	5
A.P.	-	1	2	-	-
P.P.	17	6	20	4	6
Phrenic	3	3	3	-	2
Extra Pleural Pneumo-thorax	-	3	10	2	-
Thoraco-plasty	-	1	6	2	3
Re-section	-	-	3	-	1

TABLE SHOWING OTHER MEASURES USED WITH AND AFTER CHEMOTHERAPY AND POSTURE.

TABLE XIII.

	Total Cavities	Reopened Later
CLOSED ON POSTURE		
Solid Focus	12	4
Linear Scar	26	1
Diffuse Dense Shadow	15	11
ALL CLOSED WITHOUT SURGERY INCLUDING POSTURE CASES		
Solid Focus	13	4
Linear Scar	37	1
Diffuse Dense Shadow	20	11

TABLE SHOWING MODE OF CAVITY CLOSURE.

All cavities are included - the cavity system in each case being treated here as one cavity.

COMPLICATIONS:

Gastric Upset - An undefined number.

Spinal Tuberculosis - One case.

Opening of Contralateral Cavity - One case.

Post Haemoptoic Spread of Disease - One case.

Ureteric Calculus - Two cases - both stones passed per urethram.

Discussion.

While posture has been widely known in this country since 1948 as a possible means of treatment of cavitation in pulmonary tuberculosis, various use has been made of it, and the difference of opinion as to its place in treatment has been as wide as the varying restrictions put upon a patient while on posture.

Most publications (Deshmukh 1951) advocate the use of a period of 24 hours a day on strict bed rest, but Dormer (1951) in the later stages of the period on posture allowed one toilet privilege daily, and Lyons (1953) allowed his later cases one toilet daily from the beginning of posture treatment.

In my experience in other areas many physicians used posture, allowing the patient to sit up for all meals and some also permit getting up for toilet purposes and to wash.

Webb (1921) was fully aware of the need for a strict regime to give good results and his paper reports a case in which posture, when used half-heartedly by the patient, gave little effect, but when the patient was for another reason compelled to rest in bed 24 hours a day he gained confidence in the method using a strict regime, and showed subsequently considerable improvement.

This difference in outlook in the restriction to be placed on a person on postural therapy is felt

to be one of basic principle. An attempt was made to provide an answer in this question. A patient who had been up and about was put in the posture position as described - lying on the right side with the foot of the bed raised 18 inches. X-rays were taken on assuming this position and at frequent periods during the next 3 hours. The same X-ray factors, the same machine and the same radiographer were used. On the resulting films the distance apex to diaphragm was measured on each film. Table I shows these figures.

There was a progressive rise of the diaphragm during the period on posture. However, when the patient was allowed to get up and go to the toilet and wash, walking a distance of about 12 yards, and being less than five minutes out of bed, the position of the diaphragm immediately the patient resumed the position of posture, had returned almost to the original level when posture began.

Hence it may be said that if a patient is on posture over a period of 2½ hours or more, and raises the diaphragm to a higher resting level, then with each trip to the toilet, and possibly with sitting up for each meal, the diaphragm will return more or less to normal levels.

Brunn (1941) from a study of tension cavities found that air enters a cavity infrequently in 24 hours, only on one or two occasions during this time

and then over only a few breaths. If we consider the aim in posture is to convert a cavity of tension type with an intermittently open bronchus to one with a closed bronchus, then surely a regularly changing position of the diaphragm within the chest, and of course a changing position and state of activity of the patient, are not helpful factors in producing such closure, since by these means we assist entrance of air to the cavity.

It is for these reasons that the use of a strict regime as used in Ayrshire is considered not only justifiable, but essential for best results, at least until cavity closure is achieved. It seems that failure to pay attention to this principle is a very great factor in the production of widely different results in different hands. At a later stage, with the cavity closed, a further period allows consolidation of the position, and then it is permissible to allow lowering of the bed slowly in stages, or more quickly if other supportive measures such as pneumoperitoneum and artificial pneumothorax used.

The Mode of Action of Postural Therapy.

Link (1902) considered that passive hyperaemia of the lower lung was a factor in giving good results from lying a patient on the affected side.

The effects of posture on the chest wall, mediastinum, diaphragm, and bronchi, were mentioned

from time to time by other authors as is reviewed earlier.

Before discussing further the possible factors in cavity closure I would like to state again briefly the principal factors influencing the maintenance of a tension cavity. The basic mechanism lies in the valvular effect in the draining bronchus or the junction of bronchus to cavity. Anything which assists entrance of air from the bronchus to the cavity will help to maintain that cavity, hence exercise and changing body position have their effect. The occurrence in the body which produces the greatest pressure changes in the thorax is that of coughing. In the inspiratory phase bronchi are wider than normal and negative pressure in the chest is much increased. It is at this phase that Coryllos (1938) has shown that the entrance of air to a tension cavity is more likely to occur. However, coughing from any cause is of great importance in the maintenance of a tension cavity.

The effect of posture was originally thought by Thomas (1948) to be produced by retention of secretions in the cavity and hence the name postural retention was applied. However, with further experience it soon became evident that this course of events was relatively infrequent and that other factors must be involved. He felt obliged to

change the name of retention and suggested postural reduction, leaving open the mode of action of the procedure.

Later authors speculate briefly on bronchial and mechanical factors in producing results, possibly associated with hyperaemia as suggested by Link (1902) In dealing with this subject three main factors are discussed - (1) Rest: (2) Control of Bronchial Secretions: (3) Physiological effects of the posture position.

(1) Rest. This principle of rest, which in this age of drug treatment, tends at times to be forgotten, remains of fundamental importance in the treatment of tuberculosis. The use of mental and physical rest, with good food and fresh air, remains the basic principle of sanatorium treatment. This sanatorium regime is found to improve the general condition of the patient and give every aid to the body defences to play their full part in combating the disease and in repairing the damage it causes. This question of repair we cannot overlook no matter how the patient is treated.

The patient at rest has a lower metabolic rate than one allowed to move about. Temperature unaffected by disease is lower, pulse is slower and respiration is more shallow and possibly less frequent from the lower oxygen requirement.

I suggest that one main factor in the effect of posture is that it remains a modified form of rest, the basic principle in the treatment of tuberculosis, and that by posture we produce a local intensification of this basic principle.

(2) Control of Bronchial Secretions. In reviewing cases of early unilateral pulmonary tuberculosis with cavitation it is not infrequent to find that during treatment, there is a "spill" or "spread" of disease to the unaffected opposite side, thereby making much more complex the treatment of the case.

In 1928 Gekler and Weigel in America put forward the suggestion that the position of the patient could be used to prevent such an occurrence. By lying the patient on the affected side during rest or sleep the trickling of bronchial secretion containing tubercle bacilli from the affected to the normal side is prevented.

Wu and T'Ang (1937), and again Helm (1951), argue very forcibly that it is well worth while to teach a patient with unilateral disease especially with known or suspected positive sputum, or with cavitation, to rest, and especially to sleep, on the affected side.

It seems strange that such a simple discipline, which can prevent disappointment and delay in the scheduled scheme of treatment, is not more widely

practised as a preventive measure against spread of disease in the individual patient.

Bronchial secretion normally flows under the direction of the ciliary stream of the mucosa, but in areas where bronchial damage by tuberculous disease is extensive, gravity plays an appreciable part in its movement. When such secretion reaches an area of normal mucosa, which it may do in considerable amount, then the stimulus to cough is produced. We have already emphasized the deleterious influence on cavity closure produced by coughing especially when this is repeated at intervals. In the posture position secretions less readily reach healthy mucosa and coughing is less frequent. Clinically we sometimes see a dramatic change in the tiresome repeated unproductive, or slightly productive, coughing of a patient who is becoming much wearied by this symptom. On assuming the posture position, cough within two days becomes infrequent, to the surprise and relief of a bothered patient.

Elwell (1949) has considered the use of posture - in this case raising the foot of the bed during sleep in a series of people with chronic bronchitis and in some asthmatics. He argues that secretions collect in the larger air passages during the night and are easily brought up on wakening, and as a result of this use of posture, cough and sputum gradually diminish in these patients with

much subjective improvement. Having seen the use of this procedure in young children with upper respiratory infection, I believe this may be a subsidiary helpful factor. Again any measure diminishing the frequency of cough is of help.

The avoidance of irritants from outside is advisable when we attempt to produce cavity closure, and the role of tobacco, especially as cigarettes, in increasing bronchial secretion and cough is not to be forgotten.

(3) Physiological Effects of the Posture Position. This question was reviewed chronologically in the introduction, but it may be worth while to note briefly the changes on the different parts of the respiratory apparatus:-

(a) The diaphragm:
With the feet raised the weight of the viscera tend to push up the diaphragm. Wade and Gilson (1951) point out that in the lateral position the diaphragm behaves as it would in the Trendelenberg position. When the feet are at the same time raised the lower diaphragm rises further in the chest. The movements also differ, the reserve movement is smaller but complementary movement is increased.

(b) The mediastinum.
If not already fixed the mediastinum tends to move toward the lower side.

(c) The chest wall.
The chest on the lower side appears smaller, ribs are closer together and movement is less extensive.

(d) The bronchi.
Lipiodol studies of D. Thomas showed that the bronchi on the postured side were narrower in that position.

(e) Air movement in and out of the lungs.
By bronchospirometric studies West, as quoted by Wade and Gilson, suggests that the lower lung has a smaller ventilation than the upper, but this is not yet confirmed. However, we know that in the Trendelenberg position the vital capacity and reserve air diminish, and on posture the diaphragm is raised because of the raising of the bed and the lateral position. With the addition of the observations above, it would be expected that air movement would be less on the postured side.

It seems that these factors which are known - the diminished size and movement of the respiratory apparatus on the postured side, together with the narrower bronchus, tend to convert a tension cavity with a bronchus intermittently open, to a cavity with a closed bronchus when absorption of the enclosed air would be expected. The bodily rest and the control of cough give considerable assistance.

But is this the whole story? If we block the bronchus of a cavity producing noticeable amount

of sputum and take fairly regular X-rays, we should expect to find a considerable proportion of such cavities showing fluid levels, and then, as air is absorbed, leaving evident X-ray opacities in the site of the previous cavity.

In this series, of the 34 cavities which closed on posture 10 showed evidence of a fluid level. Of the 10, only one left X-ray evidence of a solid focus when the cavity closed.

Is it that posture produces slow closure of a cavity, reducing positive intracavitary pressures by bronchial block, and avoiding the infrequent entry of air into the cavity to maintain the tension element? When tension is relieved and the intra-cavitary pressure becomes negative does discharge of secretion then occur? Coryllos showed that removal of air from a tension cavity was often followed by entrance of a small amount of air from the bronchus, at which time the fluid and secretion in the cavity was discharged to the bronchus.

A series of events such as this may occur allowing cleansing of the cavity, while the cavity is diminishing, in the absence of favourable facilities for allowing air into the cavity.

We shall return to this subject in dealing with cavity closure.

Results of Postural Therapy.

On reviewing papers published on this subject only four are found to present numerical results - Thomas (1948), Deshmukh and Williams (1951), Aslett and Erin (1952), and Lyons (1953), hence in discussing results we return fairly frequently to these names. The total cases amount to 217 cases and the largest group is 62, most of the cavities are unilateral.

The sex of the patient is not elsewhere commented upon. In this series no appreciable influence of sex is noted, although 63 of the 100 cases were female.

The age of the patient is shown in Table II. There is a considerable range from 16 to 65 years, but the majority were in the third decade and 79 of the 100 cases were between the age of 15 and 34 years.

In the 100 cases only 4 cavities did not diminish in size while on postural therapy. Of the 4, 3 were unchanged and 1 enlarged. All 4 were cases with unilateral cavitation. One of these cavities unchanged on posture had been known to be present for 18 months before posture was used. The extent of surrounding fibrotic changes may have prevented any change.

In Table III is presented the division into groups of the cases. The 100 cases include 9 cases

with cavity systems in which 2 to 5 cavities were involved, and 13 cases with bilateral cavitation having 26 cavities. Hence the number of cavities concerned is over 130 - 44.6% of unilateral cavities, 38.5% of bilateral cavities, and 33.3% of cavity systems closed on posture.

In assessing the influence of several factors on cavity closure, we deal with the unilateral cavities, 78 in all, and the percentages concerning total unilateral cavities refer to this figure.

The influence of the SIDE of the cavity in closure of unilateral cavities.

Jamin (1906) noted that the right diaphragm rose more extensively than the left when the patient was put in right and left lateral position. Aslett and Erin (1952) in their series of 45 cases noted a predominance of cavities in the left lung, and results were less good with the left sided cavities.

In this series, Table IV, while there are 45 left sided cavities as opposed to 33 on the right side, there appears to be little difference in results on the two sides.

The influence of the SITE of the cavity in closure of unilateral cavities.

Grenville-Mathers (1947) in dealing with the long term treatment by strict bed rest, found that in a series of 99 cavities treated for a period over a year, 44.7% of upper zone cavities healed while 60% of mid zone cavities healed.

Aslett and Erin (1952) and Lyons (1953) dealing with the effects of a period of posture on the diminution in size of tuberculous cavities, both found results better in mid zone than in upper zone cavities.

In these results - Table V - where we are concerned with cavity closure a statistically significant difference is present, the mid zone cavities closing more often than those in the upper zone. However, when we consider the effect of the anatomical site of the cavity there are variations. Since it was not always possible, tomography was not necessarily done in presence of obvious cavitation, but was more likely to be done in any doubtful cavity appearance. Only 52 cavities were fully localised. 2 of the 5 cavities in the anterior segment and upper lobe closed on the posture position as described. Results in the apical and posterior segments of the upper lobe show closure of only 30% of cavities with two thirds of these later reopening. Better results are found in cavities situated posteriorly in the apex and sub-apex of the lower lobes. Here 59% closed and in this group it is important to note that none reopened.

From these figures it would appear that there is little to be gained in practise, when using a standard position of posture, from routine tomography to ascertain the anatomical site of the

cavity. A lateral film is worth while to separate the anterior cavities for which a variation of the posture position may be used, and the cavities of apex of the lower lobe in which the expectation of a better result may influence later treatment.

The less favourable figures on the upper lobe cavities presented may be the result of not knowing the site of all cavities which closed, since many obvious cavities on X-ray were not accurately located anatomically but closed, and if these were included figures might be different. Tomography more often showed the site of the cavity if closure did not occur or did so very slowly.

For this reason we may regard the differences of result in different sites as biased.

<u>The influence of the SIZE of the cavity in closure of unilateral cavities.</u>

In reviewing the result of prolonged strict bed rest for at least one year Fales and Beaudet (1934) found that of cavities less than 2.5 cm. in diameter, 66% healed, while of larger cavities 33.3% healed.

In contrast, Lyons (1953) dealing with short term postural therapy noted a greater tendency for larger cavities to reduce their size than was noted in smaller ones. The results here tend to agree. Table VI shows after Bentley and Grybowski (1954) that on posture larger cavities, i.e. of diameter 5 cm. or more, appear to close as readily

as do smaller cavities. There is, however, the important additional fact that there is with increasing size a greater tendency for it to reopen later.

The influence of the state of the surrounding tissue on closure of unilateral cavities.

Grenville-Mathers (1947) in cases treated by prolonged strict bed rest found that on cavities less than 1 cm. in diameter, the state of the tissue round the cavity had no effect, but there was a distinct influence on larger cavities.

In reviewing results of posture Aslett and Erin (1952) found that the less disease in the area surrounding the cavity, the better were the results.

Figures in Table VII show only a slight effect of the surrounding disease as shown by radiological appearances, in worsening the results of cavity closure with increasing density of X-ray shadows, but there is a definite tendency for cavities to reopen with the denser type of shadow.

When we consider that the more disease there is in an area of lung, the more fibrous tissue is laid down in healing, and with more fibrous tissue there is less opportunity for compensatory emphysema to occur and help in filling the space formerly occupied by the cavity. It might be argued that the fibrosis and pulling on the cavity wall tends to keep the cavity open, but this, I feel, is a minor factor in most cases. Probably more important

are the changes in the bronchial tree, and disease remaining active then can alter the mechanics of the broncho cavitary relationship and cause return of the tension element in the area of the former cavity. With more extensive disease more bronchial drainage may be expected.

The influence of radiological extent of disease on cavity closure in unilateral cavities.

Aslett and Erin (1952) in their review of posture noted that increasing radiological extent of disease led to worse results.

The figures in Table VIII do not wholly agree, although cavity closure was achieved more often in the cases with unilateral than with bilateral disease. Increasing extent of bilateral disease does not necessarily mean that a cavity is less liable to close, but it does mean that a cavity once closed is more likely to open, e.g. among cavities where 3 radiological zones are involved with bilateral disease, of 18 cavities the number closed on posture was 7, but of these 2 reopened, while with 5 zones involved, of 18 cavities, 8 closed on posture, but 4 reopened.

The duration of posture required to close cavities in unilateral and bilateral disease.

Posture was used by Deshmukh and Williams (1951) for a period of 3 to 4 months, while Lyons (1953) found that a period of six weeks or less sufficed for most of his patients to reduce cavity

size, though some took a further period of 6 weeks. These writers were interested in reducing the cavity size in preparation for other methods and were not really concerned with cavity closure.

In this series cavity closure was the aim and Table IX shows the time taken on posture to close unilateral cavities, while Table XI shows the time required to close bilateral cavities. From these tables it would seem that the majority close within two months on posture. Even with bilateral cavitation more closed within the first two months than later. Hence, in using posture, a trial period of two months is justified, and unless there are signs that the cavity is much smaller and considered likely to close in a further period, it is not reasonable to continue ineffective treatment longer if cavity closure is the end in view.

Results of Follow up of Unilateral Cavities which closed.

10 of the unilateral cavities which closed on posture reopened later, and of the 10, 5 reopened while the patient was still in hospital. One cavity reopened following the introduction of pneumo-peritoneum, which presumably altered the broncho cavitary mechanics in an area which was unsoundly healed. The response to a second period of posture was as good as the first.

Table X shows the time of reopening, dating from the time the patient left hospital. After 2

years from the time of discharge from hospital only 1 cavity reopened.

Since, of the 34 cavities which closed, 10 (22.7%) reopened and half of these before discharge from hospital, it seems advisable, especially in the case of upper zone disease, a large cavity, dense shadows surrounding the cavity, or extensive disease in the remainder of the lung fields, to follow up closure of the cavity with supportive collapse measures. Aslett and Erin (1952) in 19 cases where artificial pneumothorax or pneumoperitoneum and phrenic crush were used after posture, found that in no case did the cavity reopen.

Table XII shows the other measures employed with posture and chemotherapy. Rather more than half (55%) of the cases had a phrenic crush before or during this period of treatment. However, in the last 2 years phrenic crush has been less extensively used and the impression given is that results are no less satisfactory.

Other measures used after posture and chemotherapy are also presented. Table XII shows that most cases had pneumoperitoneum after posture. While reflecting the general increase in use of pneumoperitoneum in recent years, it was used at first as a supportive measure, but with some patients it became the definitive line of treatment.

Operations following posture were not numerous, being employed especially in failures. During the period in which this work was done extrapleural pneumothorax operations outnumbered thoracoplasties, and only 4 resections were done, but 2 of these had pneumonectomy.

The Mode of Closure of a Cavity.

An evaluation of the mode of closure was made from the radiological appearances in the 53 cavities which closed, each cavity system being for this purpose counted as one cavity. After Pagel and Simmonds (1942) the cavities were classified in three groups. None were considered examples of open cavity healing since it is unsafe to diagnose this only on clinical radiological-bacteriological grounds. These three groups were :- (1) Closure by formation of a solid focus. (2) Closure by linear or radiating scar. (3) Closure by dense diffuse shadowing in which tomography showed no cavity. The results are shown in Table XIII. In the second part of that table 17 cases are added in which the cavity did not close by posture, but in which closure resulted later, from further rest, or from the use of peritoneum or artifical pneumothorax.

Closure by formation of a solid focus.

From the conception of postural retention originally put forward by Thomas (1948) it is perhaps surprising that this type of cavity closure is not

more frequently encountered in postural treatment.

Pagel and Simmonds (1942), reviewing the literature of pathological evidence of the mode of cavity closure report that in 33 cavities which healed 16 did so by this method. Grenville Mathers (1947), classifying cavities from radiological appearances considers that 9 out of 45 cavities which closed on prolonged strict bed rest, did so in this way.

There has been doubt (Auerbach and Green 1940) as to how stable is a cavity closed by formation of a solid focus, but not all physicians regard it with such circumspection as Houghton (1950), who refers to a "time bomb" which will one day break out and discharge infective material into a bronchus. Other authors, e.g. Macleod (1952) are less pessimistic.

In this series of 53 cavities closed while on posture 12 closed by solid focus formation, and of these 3 reopened before the patient left hospital. One reopened 36 months after discharge from hospital. Thus we must recognise that we take a certain risk in treating, without further interference, cavities which have been observed to close in this way.

Closure by linear type of scar.

Almost half, 26, of the 53 cavities which closed, did so in this manner.

From clinical impressions as well as from these figures this method of cavity closure appears relatively common. From table XIII too it is noted that only one of the 26 broke down later, although the period of observation extends in some cases to over 4 years after discharge from hospital. When we add to this series the 17 cavities which became smaller but did not close on posture but which closed later without surgery, then we find that of 70 cavities which closed, 37 closed by linear scar and only one reopened later.

Hence it would seem that this is a relatively safe and stable method of cavity closure and it is the most desirable one.

Closure by dense, diffuse shadowing.

In this group there appeared at the site of the cavity a dense X-ray shadow of indefinite outline, in which tomography did not show cavitation. This mode of closure is not presented by previous authors.

At times this appearance was produced fairly rapidly and it is suggested that the picture is the result of atalectasis from closure of the segmental bronchus probably with trapping of tuberculous material in considerable amount behind the block, although no "solid" type of focus was suggested by tomography.

Aslett and Erin (1952) found that an atalectatic zone around the cavity was a favourable

factor in giving better results with posture.

When we follow the 15 cases in this series Table XIII we note that 11 of the cavities reopened later. As a means of closure of a tuberculous cavity it is unstable and unreliable. Moreover, since of the 11 which reopened later, 7 did so after discharge from hospital, even up to 3 years later, and the reappearance of active disease and cavitation led to a further period of treatment, then it may be argued that we did the patient a disservice in being satisfied with an unreliable means of cavity closure and in the end prolonged the period of hospital treatment. However, when we consider separately these cases in which cavities diminished on posture, remaining open, but closed later with comparatively simple measures, then we find 5 cases presenting the same dense diffuse shadow at the site of the cavity, but none of these showed the cavity reopening. Is the question of the marked difference between these cavities closing on posture and those closing more slowly later, one of the rate of closure of the cavity?

<u>The Influence of the rate of Closure of the Cavity</u>.

Brooks (1938) published the immediate effect of putting an air filled balloon into a lobar bronchus to produce deliberately atalectasis of the area of lung containing the cavity. This resulted within 6 hours. However, the absence of further

results published suggest there is little to be gained by this method.

Pagel and Simmonds (1942) finding 9 cases of their own where cavities were converted to solid foci, regarded this result as following bronchial closure, trapping caseous material in the position of the cavity. They noted that most of the incidents followed the induction of artificial pneumothorax or the establishment of extrapleural pneumothorax, presumably with fairly rapid bronchial occlusion. They suggest that slower closure of the bronchus, allowing drainage from it in the meantime, results in a sounder method of healing.

The results of posture here with the breakdown in 4 out of 12 solid foci and especially in 11 of the 15 dense diffuse shadows, are strongly in favour of this suggestion, the most rapid closure - the dense diffuse shadows giving the more unstable healing and the slower formation of linear scar, a sounder scar. But if this were so we might be able by observation of a fluid level in a cavity which is becoming smaller on posture, to foretell closure by this less secure way. Lyons (1953) dealing with cavities treated by posture notes that many cases showed a fluid level, but none of these closed by conversion to a solid focus, for after the institution of minor collapse measures most of the

cavities were recognised by the presence of fibrous streaks in the area of former cavitation.

In the present results of 53 cavities which closed on posture 10 showed a fluid level on routine films during posture. Of the 10, one closed by formation of a solid focus, 3 by dense diffuse shadows and 6 by linear scar. There were, on the other hand, only 3 occasions when cavities which did not close on posture showed a fluid level.

If we consider together the cases where there was a supposed bronchial block and retention of secretions then 4 (40%) of the 10 cases above closed thus, while of all cases 51% closed thus. Hence it would seem that the presence of a fluid level is possibly a favourable factor in cavity closure, but that a cavity showing a fluid level is more likely than others to close by linear scar and not by retention of secretions.

Coryllos showed that in a tension cavity when the intracavitary pressure is made less negative by removal of air, then escape of air and fluid from the cavity to the bronchus frequently follows. Is it that with posture, when fluid collects in the cavity, the factors which tend to maintain tension in the cavity are overcome by posture and when the air has absorbed sufficiently to cause a less positive pressure, the occasional escape of fluid from the cavity to the bronchus is permitted?

It is possible that it is in this way that large cavities with much necrotic material can discharge their secretions and dead tissue and eventually heal with a linear type of scar. If so, then posture is a desirable method in producing cavity closure.

However, it is not feasible at present to foretell how a particular cavity will close, or that it will close. Also only half the cavities close by the desirable linear scar. Posture then must remain a method of trial. If the cavity closes by linear scar we shall be satisfied. If closure is by solid focus we must recognise the risk that the cavity may reopen in about one third, but where other methods are not possible or desirable then we may accept this risk. If closure by dense diffuse shadow results we must regard the future as doubtful and proceed to other measures of treatment.

The Influence of Chemotherapy.

The majority of the cases here had one or more of the new drugs which influence tuberculous infection. A few of the early cases in 1949 had a course of streptomycin alone, up to a total of 90 grams of the drug, given in doses of ½ gm twice daily. Most had a course of two to four months on a regime of streptomycin 1 gm daily and para amino salicylic acid 12 or 15 grams daily in divided doses.

The later cases since April 1952 have mainly had streptomycin 1 gram twice weekly and para amino salicylic acid 12 to 15 gm daily, during a period of from 2 to 5 months.

5 of the 100 cases did not have chemotherapy with posture, but these 5 cases had previously had chemotherapy while on strict bed rest. On this latter treatment only 1 cavity closed, and this reopened a few weeks after drug treatment ceased. In the same 5 cases with posture, 2 cavities closed and remained closed for 4 and 13 months after posture ceased.

Although these figures are small, this sample suggests that postural therapy itself has as great an influence as chemotherapy in producing cavity closure. The two methods may be complementary. Lyons (1953), dealing with reduction in cavity size while on posture, found that there was, if anything, a slightly better result when chemotherapy was used with the posture, than with posture alone. In this series it was not felt justified to withhold streptomycin during the period of posture and the impression was gained that better results came from the use of both means of treatment together.

It can be argued, however, that when posture tends to cause blockage of a bronchus which is intermittently open, and thus cause gradual disappearance of the cavity, chemotherapy tends to

produce resolution especially of the bronchial lesion and thereby to allow again passage of air through the bronchus, which passage might be intermittent thus becoming a factor in maintenance of the element of tension in the cavity. Thus the two methods of treatment could be completely opposed in the mechanical effect of their use. Such might be the case if the bronchus was the only factor. However, the control of cough, and the physiological effects of posture on the diaphragm, the mediastinum and chest wall, diminishing movement of the lung, and the bronchi themselves being narrower, are felt to counteract the small change in the volume of the bronchial mucosa.

The reduction of the amount of sputum by chemotherapy is a help, making coughing to raise sputum less frequent, and giving less opportunity for infected sputum to involve new areas of lung.

It might be suggested that chemotherapy be used for a preliminary period to deal with the bronchial lesion and then posture be employed to help close the cavity while drugs continue to consolidate the position. In some cases in this series, especially those acutely ill, the drugs were used for a period before posture was brought in, but no difference in the later behaviour of the cavity while on posture was noticed.

In the Medical Research trial report (1948) it is stated that the streptomycin therapy alone

does not lead to closure of the larger cavities, and the British Tuberculosis Association report on research on bronchial tuberculosis (Houghton and Joules 1953) showed an incidence of such disease in 95% of their cases.

With the effect of drugs on the bronchial disease there may be alteration of cavity size but the production of healing in large cavities is doubtful with such measures alone.

Recently Pagel and Simmonds (1955) studying cavities in the pathology department from cases which had chemotherapy for considerable periods of time, noted that there were small areas of tuberculous tissue tucked away in crypts in the wall of the cavity, while alongside were areas of uncovered granulation tissue. Some areas of the cavity wall showed epithelialisation and there was some fibrosis. Even in a closed cavity such areas can persist. Although there is much interest in the prolonged use of chemotherapy, the recurrence of activity after a year or more of apparent stability must make us question carefully, as do Pagel and Simmonds on their findings, whether chemotherapy alone is a measure to be relied upon. Posture may be regarded as a mechanical aid in treatment but even with chemotherapy the result may not be stable and a plea is put forward for the use of minor collapse measures to follow, even if this is regarded

as a holding measure to assist healing and employed only for two years or so.

The outlook of the patient to posture.

Many patients were alarmed at the prospect of spending an appreciable time immobilised to a considerable extent, in an unusual and apparently unnatural position, but during the period of observation only two patients refused such treatment. It was of considerable help to have in the same ward, patients who had had or were having, with benefit, their own experience of this regime.

However, we were surprised to find in patients who had already been treated by posture with good effect, and who later had reactivation of their disease, that some emphatically requested to be again treated by posture, prefering this to the relatively unknown difficulties of artificial pneumothorax or pneumoperitoneum or to the approach of the surgeon. In several of these cases posture was used again with no less effect on the second occasion. In one case 3 periods were spent on posture with good effect each time.

Lying as they did with the foot of the bed raised, and having a considerable part of their view cut off, and being forbidden to turn on to the other side, most patients preferred to be in a corner bed facing the rest of the ward. In this way, although immobilised they did not feel isolated and remained part of the community in the ward. Those in single rooms were moved from time to time nearer the heat

panel and radio, or nearer the view of the world outside, as their approach to life varied.

As might be expected, younger patients soon became used to posture but required more supervision as they tended to bump about in bed. Older patients became more slowly accustomed to their position and its effects, but once settled were usually contented and on the whole easy to deal with.

Complications of Posture.

In the published papers on posture few complications are recorded and Lyons (1953) regards posture as being virtually free from complications. In this series complications may be enumerated and discussed as follows :-

1. Gastric upset.

An indefinite number developed discomfort and a few even had vomiting during the first few days on posture, but with sedation and reassurance while the uptilting of the bed was continued very gradually symptoms soon settled. In one case symptoms persisted and interfered with the period on posture but a little later posture was used successfully. The cases with more severe symptoms had to be elevated at a much more gradual rate than the others, but once settled at the full elevation troubles did not noticeably recur.

Dormer (1951) also noted this difficulty and he went as far as to advise against the use of

posture in cases with a history of peptic ulcer. Our experience did not lead to agreement but in the presence of active peptic ulcer it may not be possible to use posture. Gastric symptoms of close relationship to those of peptic ulcer are not infrequent in the acute stage of pulmonary tuberculosis and it would be a pity, because of such symptoms, to avoid the use of a possibly helpful mode of treatment.

2. Spinal Tuberculosis. (1 case).

One case in poor condition with extensive bilateral disease was found while on posture to have active tuberculous spinal disease, recognised by the appearance of abscess formation on chest X-ray films. It is not believed that this condition resulted from posture. In any case treatment was not altered by the discovery except by provision of a short posterior plaster shell while the patient continued on posture.

3. Opening of a cavity on the non-posture side. (1 case)

This event occurred in an unco-operative patient who had a good effect from posture with apparent cavity closure, but as soon as she felt really well she departed home against advice, returning again only when feeling truly ill. The cavity had reopened and there was new disease on the other side. During the second period on posture cavitation occurred in the opposite side.

Aslett and Erin (1952) record 2 such cavities appearing on the non-posture side in a series of 45 cases. One patient reopened a cavity apparently closed and one developed a new cavity. However, of 6 known cavities on the side opposite that on which posture is used they report as a result that 1 was larger, 2 were unchanged, 1 was smaller, and 1 closed after a spontaneous pneumothorax. The fate of the 6th is not recorded.

I understand from assistants of Dilwyn Thomas, although failing to find published evidence, that this man may at times use posture to close cavities on one side in a case with bilateral cavitation, and having succeeded, proceed to use posture to close the cavity on the opposite side. This method has been used on more than one occasion.

It would seem that while cavitation can occur on the opposite side this event is not frequent and is not a valid argument for not using posture.

4. Post haemoptoic spread of disease. (1 case).

In this case of active disease in an adolescent male an extensive haemoptysis occurred and considerable spread of disease followed. It may be that the patient in the emergency was allowed to change his position but in any case there was evidence of a poor resistance in this case.

I have since seen haemoptysis occur in moderate amount during posture and have maintained the posture

position on the basis that if spread of disease does occur it is likely to be in the area of lung already involved. However, so far this spread has not been found.

5. Ureteric Calculus. (2 cases).

These 2 cases had small stones both of which passed per urethram, but the presence of the stone in each case upset the programme of surgery intended for the patient. The stones could possibly be attributed to posture. In no other series is this complication mentioned.

Case 20 spent 7 months on posture over 3 separate periods during one year. 3 months after the last spell of posture renal colic developed on the side opposite the posture side. X-ray showed an opaque stone low in the ureter. This was later passed per urethram. Operation was delayed several weeks by the incident.

Case 56 spent 10 weeks on posture on the left side ending October 1950. In November 1951 when, after a long uphill struggle, she was awaiting the operation of thoracoplasty, renal colic led to discovery of a left ureteric stone. The urologist advised against interference and the stone was passed eventually in May 1952. By this time, however, thoracoplasty was no longer feasible and pneumonectomy was done.

It is surprising to find 2 women of age 30 and 31 in different hospitals showing calculus formation. Both had prolonged bed rest which may be a factor, and the fact that one was on the same side and one on the side opposite the cavity is against posture being the direct cause.

Although posture for a limited time might be used with no thought of this complication it makes one wonder if, when posture is used for periods of say 3 months or more, the patient should be turned daily for a short time, as was the habit in the prolonged treatment by plaster beds of spinal tuberculosis.

Contra Indications to Posture.

In 1928 Gekler and Weigel recognised the futility of postural methods in the presence of considerable fibrosis round the cavity or mediastinal displacement, and there is no reason to question this view. However, they were also against using posture in a debilitated patient. While this remains true on the whole the outlook in modern times has changed. Few would disagree with Lyons (1953) in considering very active disease or tuberculous pneumonia in a "toxic" patient to be a contraindication. However, after a period of treatment with the sanatorium principles and the use of modern drugs the general condition may change remarkably. At that phase posture can be used with benefit.

Dormer (1951) considered that a quiescent peptic ulcer may become active and for this reason posture was better avoided in such patients. Experience in this series does not agree. Dormer also thought that chronic bronchitis and asthma may be a contraindication, but he was aware of the work of Elwell (1949) who used the mechanism of raising the bed at night in cases of chronic bronchitis with improvement in a considerable number. Although I have no figures to present, the results of posture in cases with chronic bronchitis have seemed less good than in other groups, but we are not justified in depriving them entirely of this treatment. Results depend to a large extent on how much, by general measures, a warm stable atmosphere, anti-biotic drugs if necessary, and the use of the anti-tuberculous drugs, we are able to control cough. Elsewhere the significance of cough is discussed, when in deep inspiration, air tends to enter a cavity with a bronchus intermittently open, and thus maintain or increase the element of "tension" in such a cavity. For this reason if cough continues to be frequent posture will be likely to achieve little, but if cough is controlled then posture is worth using although results are still less good than in more normal people.

An important factor in this question of coughing is the use of tobacco, especially as

cigarettes which are inhaled. Such smokers usually have a period of coughing on rising in the morning. Brunn (1941) showed that the entrance of air from a bronchus intermittently open to a cavity of tension type took place but once or twice in 24 hours, and then was over a few breaths only. If there is a period of coughing each morning then excellent opportunities are given for maintenance of the tension element in the cavity by entrance of air at that time. For this reason I feel smoking is best avoided at this stage. If the patient cannot co-operate to the extent of ceasing smoking, or reducing it to a very low level, then good or early results of posture cannot be expected.

Heart failure and advanced cardiac disease are listed by Dormer (1951) and Lyons (1953) as contraindications. With this there is no argument.

The "elderly patient" in whom Lyons (1953) is unwilling to use posture is not defined. Age itself is not a contraindication, and in this series posture assisted in the control of disease in a woman of 65, but before using posture we must consider carefully the dangers of putting such a patient to bed for a prolonged period.

SUMMARY and CONCLUSIONS.

(1) The recognition of cavitation in pulmonary tuberculosis and its importance in prognosis is reviewed.

(2) The method of cavity formation, and the development of modern outlook on the mechanical influences on the formation, maintenance and closure of a cavity is followed.

(3) The physiological effects of the Trendelenberg and the lateral position on the respiratory apparatus have been examined and applied to the posture position.

(4) The published work on posture has been reviewed.

(5) The circumstances leading to the fairly extensive use of posture in Ayrshire are presented, and the method used in this series is detailed.

(6) The results are set out and briefly commented upon.

(7) The necessity for a strict regime of posture over the period of 24 hours daily is emphasized.

(8) The age and sex of the patient and the side of the cavity had little effect on the results.

(9) All cavities except 4 diminished in size while the patient was on posture.

(10) Mid zone cavities closed more easily than upper zone cavities.

(11) The size of the cavity, the state of tissue surrounding the cavity and the radiological extent of the disease, was each of no great influence on closure of the cavity, but was of importance in that an increase in the extent of each was associated with an increasing tendency for the cavity to reopen.

(12) Most cavities closed within the first 2 months on posture.

(13) The mode of action of postural therapy is discussed, referring especially to rest, the control of bronchial secretions, and the physiological effects on respiration of the posture position.

(14) The mode of closure of tuberculous cavities is considered and related to the rate of closure of the cavity.

(15) Closure of a cavity leaving a linear type of scar is regarded as the most reliable form of healing, and the rapid production of a dense diffuse shadow appears to be the least stable.

(16) The influence of the anti-tuberculous drugs on the effect and results of posture is reviewed.

(17) A plea is made for the use of minor collapse measures when a cavity is closed by posture and chemotherapy.

(18) Complications while on posture and contra-

indications to its use are few.

(19) Posture is a simple and useful measure, producing cavity closure in 44.6% of unilateral cavities.

(20) Even if cavity closure is not achieved, reduction in the size of the cavity may be expected by the use of postural therapy.

(21) The use of postural therapy is not a hindrance to the use of another form of treatment later.

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APPENDIX

Summary of case 13.

Born 1907. Female. Housewife.

Duration of symptoms - 2 months.

Admitted to hospital - 19.7.51. Sputum positive.

Chemotherapy 21.7.51 - 5.1.52.

Left Phrenic Crush 3.10.51.

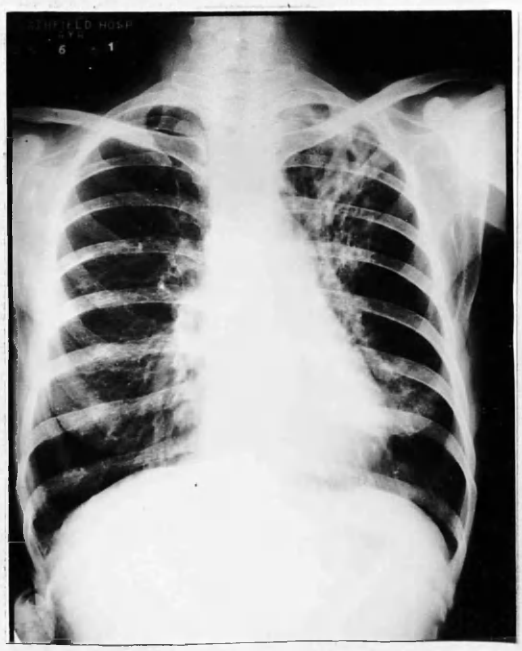
Postural therapy 10.10.51 - 8.1.52.

Pneumoperitoneum induction 8.1.52.

Upgrading began 5.52.

Discharged home 27.8.52.

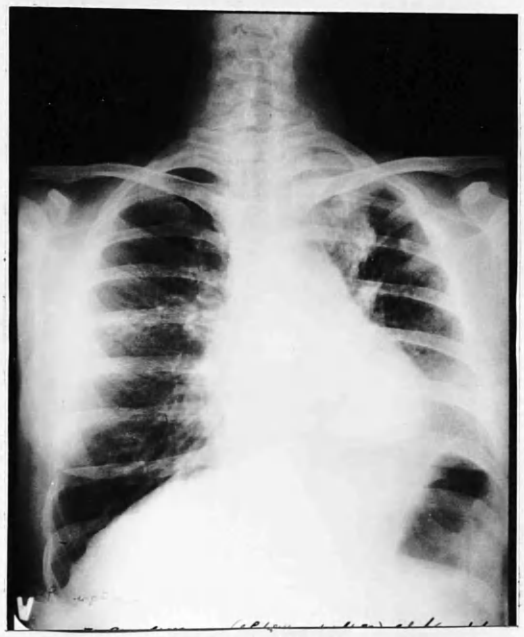
X-ray films:



(1) Before admission.
Large left upper zone cavity.

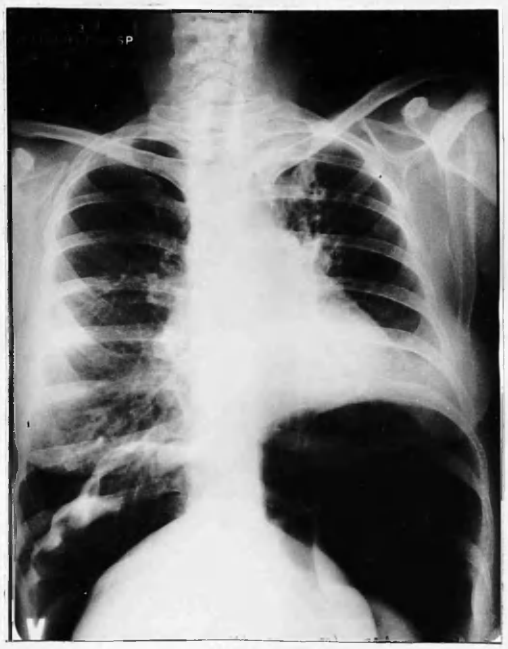
(2) After 7 weeks of chemotherapy and strict bed rest. Cavity slightly smaller. Left diaphragm raised.

(3) After 6 weeks posture. Cavity is smaller.



(4) After 13 weeks posture.
Cavity small but still present.

(5) 6 weeks after posture ceased.
Pneumoperitoneum present.
Cavitation doubtfully present.

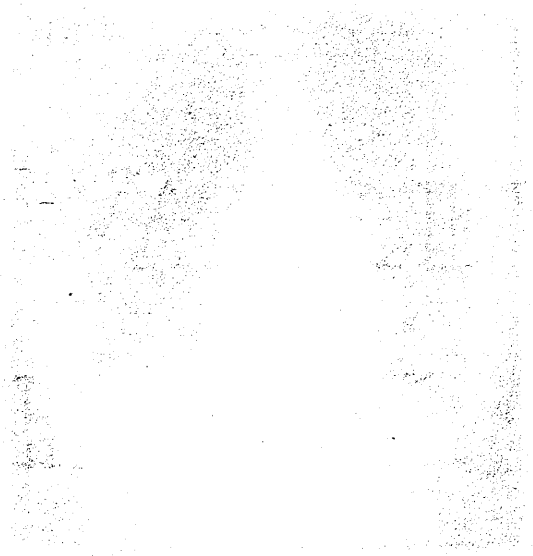


(6) 12 weeks after posture ceased.
Cavity again present.

(7) 21 months after discharge.
No evidence of cavitation.

This case shows slow diminution of the cavity size on posture, where results of chemotherapy alone were not marked, but the cavity remained open. Following establishment of a pneumoperitoneum apparent cavity closure followed but the cavity reappeared before finally closing without an alteration of treatment.

The mode of closure appeared to be by dense diffuse shadowing but the last picture shows almost linear type of residual shadows.



Summary of Case 98.

Born 1916. Female. Housewife.

Duration of symptoms - 4 months.

Admitted to hospital - 26.6.52. Sputum positive.

Chemotherapy 1.7.52. - 11.12.52.

Postural therapy 3.7.52. - 14. 8.52.

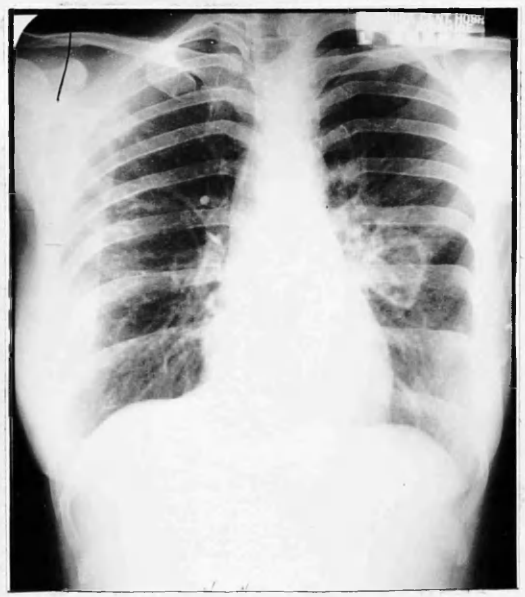
Phrenic blocks used 14.8.52. - 15.10.52.

Left Phrenic Crush 20.8.52.

Upgrading began 5.2.53.

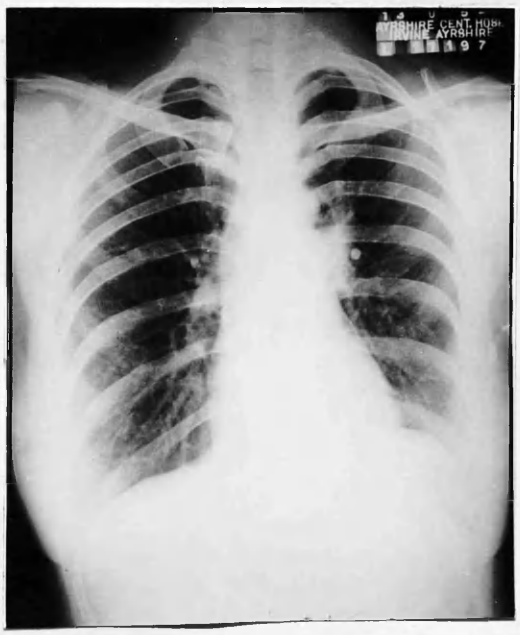
Discharged home 20.5.53.

X-ray films:

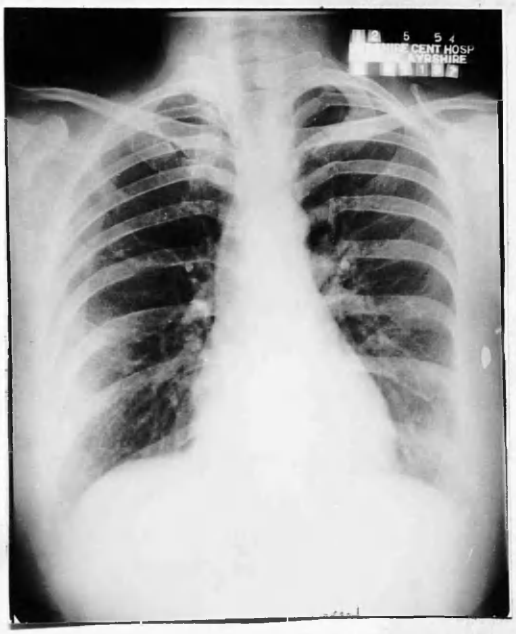


(1) Before treatment.
Right scanty mid zone shadows.
Left - cavity in apex of lower lobe.

(2) After 6 weeks posture.
Cavity not evident.



(3) 2 months after posture ceased.
Cavity not evident.
Left diaphragm raised.



(4) 1 year after discharge from hospital. Almost a normal picture!

This case shows the effect of posture on a cavity in the apex of left lower lobe, closing on posture with little residual evidence.

Summary of case 100.

Born 1898. Male. Railway worker.

Duration of symptoms - More than 1 year.

Admitted to hospital - 11.9.52. Sputum positive.

Postural therapy 13.9.52. - 23.12.52.

Chemotherapy 13.9.52. - 6. 2.53.

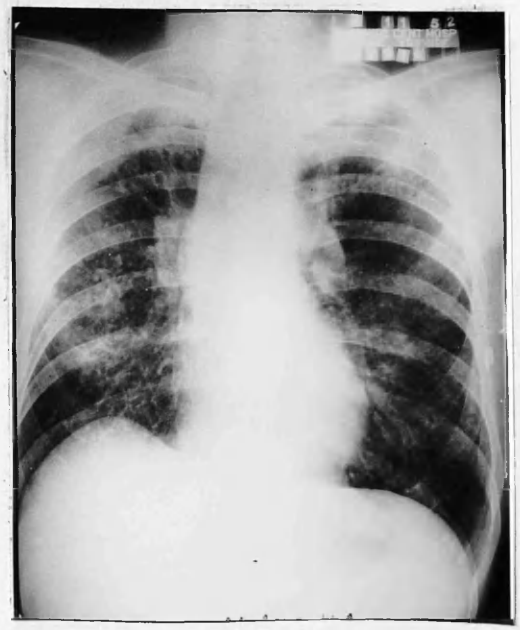
Pneumoperitoneum induction 27.12.52.

Upgrading began 5.53.

Discharged 24.7.53.

X-ray films:

(1) Before posture.
Large apical cavities.



(2) After 8 weeks posture.
Cavities smaller, fluid level on the left.

(3) After 14 weeks posture.
Tomogram showed no left cavity.

(4) 6 weeks after cessation of posture.
Pneumoperitoneum present.
Apical cavities enlarging.

(5) 10 months after discharge from hospital.
Cavities almost as at picture (1).

This case shows the effect of posture in a bronchitic man who had a long history of respiratory symptoms. Large bilateral cavities, Right - 8 cm diameter and Left - 7 cm diameter, reduced markedly in size while on posture, and tomography after 14 weeks on posture did not show a cavity on the left side. Respiratory reserve was poor and surgery was not possible. Pneumoperitoneum was not well tolerated and during upgrading cavities progressively enlarged to their previous size.