

POSTURAL DRAINAGE OF THE LUNGS*

BY

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The assumption of the upright posture has necessitated readjustments which affect every anatomical structure in the body and modify all the vital physiological processes.¹ As a secondary outcome of this posture many spaces of the body are so situated that gravity causes their contents to accumulate farthest from their natural outlet.

In the upright position the upper respiratory tract is situated above the lower respiratory tract and can drain freely into it, and even in the supine position lipiodol, if it is introduced into the nasopharynx while the patient is heavily asleep, will enter the bronchi.² This fact explains the close relation between nasal and bronchial infection. Through force of habit the majority of people sleep with two pillows, and patients with respiratory infections are provided with twice or three times this number, so adopting a position in which gravity drainage is impossible.

The natural methods of emptying the tracheo-bronchial tree of accumulated secretion are on the whole extremely inefficient. Ciliary action only removes minute particulate matter such as dust or bacteria, and is of no value when there is much secretion.⁷ Although a peristaltoid movement of the bronchi has been described by one or two observers, its existence is extremely doubtful. Coughing is, of course, the physiological method by means of which secretions in excess are expelled from the tracheo-bronchial tree. The cough reflex functions in the larynx, trachea, and primary bronchi,⁵ but diminishes very rapidly distal to this, and a high degree of tolerance to the presence of pus can be obtained. Reinberg⁶ observed that when he ran opaque material in through a bronchial fistula no cough was produced until one of the primary bronchi was filled, and I have been surprised when bronchoscoping long-standing cases of bronchiectasis to see the whole of the lower lobe bronchus completely filled with pus without the patient having any desire to cough. The expulsive force of the cough is considerably hampered by the contraction of the lumen and shortening of the bronchi which occur during expiration and, even more so, on coughing.⁸ In children the lumen of a bronchus appears through the bronchoscope to close completely on coughing. The cough also scatters pus throughout both lungs, and the deep inspiration which precedes the cough drives it distally.⁹ In addition, coughing is a severe drain on the strength of a debilitated patient.

Intermittent Postural Drainage

The inadequacy of the physiological methods of cleansing the lung when secretion is considerable has led me to investigate the assistance which might be obtained from posture—namely, of using gravity to empty the lungs. It is clear that postural treatment is only likely to be successful and can only be properly applied when a precise anatomical knowledge of the position and direction of each broncho-pulmonic unit is obtained. What is usually implied by postural drainage, however, is the tilting of the patient into an almost vertical position with the head downwards for a few minutes several times a day. This should be called intermittent inverted postural drainage. It is effective in clearing the trachea and primary bronchi of accumulated secretions, but has very little effect on the secondary or tertiary bronchi, which

are the ones affected in bronchiectasis. In a case of bronchiectasis, if bronchoscopy is performed immediately after this type of posture quantities of pus will still be found in the lower bronchi, and lipiodol will often remain there for a week or more, in spite of frequent inversion of the patient. In the case of lung abscess, the communication with the bronchus is rarely large enough for the free escape of pus, and this brief inverted posture only gets rid of that which has overflowed into the main bronchi. It is obvious that this posture can be of no assistance in draining those bronchi which do not run upwards towards the mouth. Again, the sudden change into a head-downwards position is distressing to adults, and with acutely ill patients is usually impracticable.

Continuous Postural Drainage

The object of this paper is to describe a technique for continuous postural drainage as opposed to intermittent postural drainage. This is no new idea,^{3 11} and was described by William Ewart⁴ in 1901, and later referred to by him as the "empty bronchus treatment by posture in the bronchiectasis of children." By this means the area of suppuration, whether it is bronchus or pulmonary cavity, is subject to an almost continuous drainage, which permits the pus to find its way out and prevents its reaccumulation. In continuous drainage the posture is maintained not for minutes but for hours at a time, and it must therefore be more or less comfortable, so that the patient can even sleep in the correct position. The posture must be such that the bronchus leading from the affected area is dependent, and the bifurcation of the trachea is the centre to which drainage is directed, and not the mouth. This can be expressed diagrammatically by imagining the chest to be a sphere, the centre of which is the bifurcation of the trachea and the affected area a cone in this sphere; then the correct posture is obtained by placing the sphere so that the base of the cone is uppermost. By means of a gentle cough pus can easily be expelled from the trachea, and if it has accumulated there while the patient is asleep leaning over the side of the bed on waking will assist its expulsion.

Anatomy of Postural Drainage

The postures which are here suggested for internal bronchial drainage are based on investigations which I have carried out on the bronchi and their distribution in the lung. This anatomical work will be published elsewhere, and only the briefest outline is given in this paper. The three figures (Figs. 2, 3, and 4) are tracings from lipiodol fillings of the bronchi; each comes from a different case, and they are chosen because of their close approximation to the average anatomical arrangement.

It is customary to describe the lungs as having three lobes on the right side and two on the left, but despite this fact the internal structural relations are the same on the two sides and are symmetrical. It is therefore permissible to describe the two lungs in terms of four principal areas—namely, upper, middle (ventral), dorsal, and lower, which are set out in Fig. 1.

Upper Lobe, Right Lung

The bronchus to the upper lobe of the right lung arises from the lateral wall of the main bronchus, opposite to the bifurcation of the trachea (see Fig. 2). It runs horizontally outwards, lying in the same plane as the trachea and primary bronchi, and cannot, therefore, be identified in Fig. 3. After a course of approximately 1 cm. it divides into three branches:

1. *Apical*.—Running upwards, outwards, and slightly backwards to supply the true apex above the level of the clavicle and the posterior surface of the lobe (see Figs. 2 and 3).

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2. *Axillary*.—Continuing the direction of the parent bronchus outwards to supply the axillary surface of the upper lobe. This can be seen in Fig. 2, but in Fig. 3 all except one small branch is in cross section.

3. *Pectoral*.—Running horizontally forwards to supply that portion of the upper lobe lying underneath the pectoral muscles between the clavicle and the fourth rib in front. In Fig. 2 this is in transverse section, but can be seen in Fig. 3.

Upper Lobe, Left Lung

The bronchus to the upper lobe of the left lung corresponds on the left side to a composition of the upper and middle bronchi of the right side. Its origin is from the antero-lateral surface of the left main bronchus at its termination, and after a course of less than 1 cm. it divides into two component parts—namely, left upper bronchus and left ventral (middle) bronchus (see Fig. 1).

On account of its low origin, the left upper bronchus and its branches all tend to have an upward direction. The

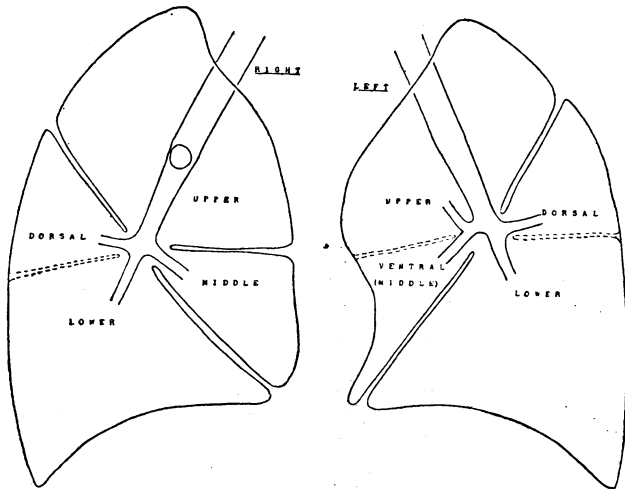


FIG. 1.—Diagram showing the four principal areas in each lung.

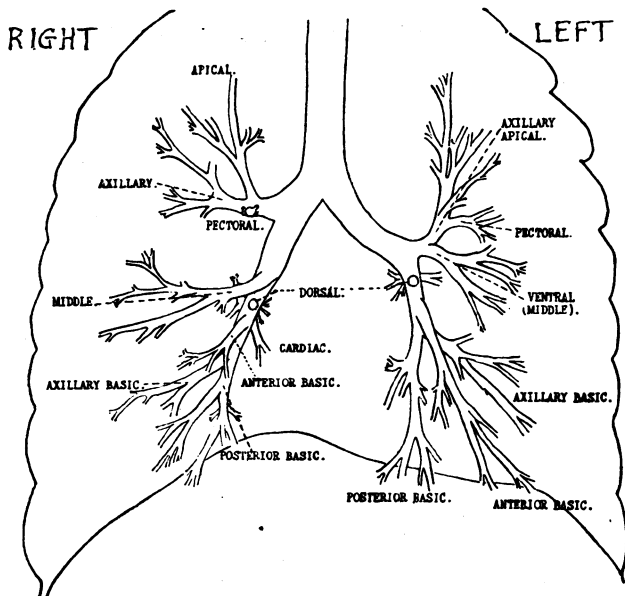


FIG. 2.—Antero-posterior view showing the distribution of the bronchi. For descriptive details of anatomical figures, see text.

bronchus itself is not more than about 5 mm. in length, and runs upwards and slightly outwards (see Figs. 2 and 4). It then divides into two branches:

1. *Pectoral*.—Running upwards, outwards, and forwards to supply the pectoral portion of the left upper lobe between the level of the clavicle and the fourth costal cartilage.

2. *Axillary-apical*.—Running upwards and backwards and, as its name implies, supplying branches to the axillary,

apical (above clavicle), and posterior portions of the upper lobe. These bronchi can be seen in Figs. 2 and 4.

Middle Lobes, Left and Right

The bronchus to the right middle lobe arises from the anterior surface of the right main bronchus, about 2 cm.

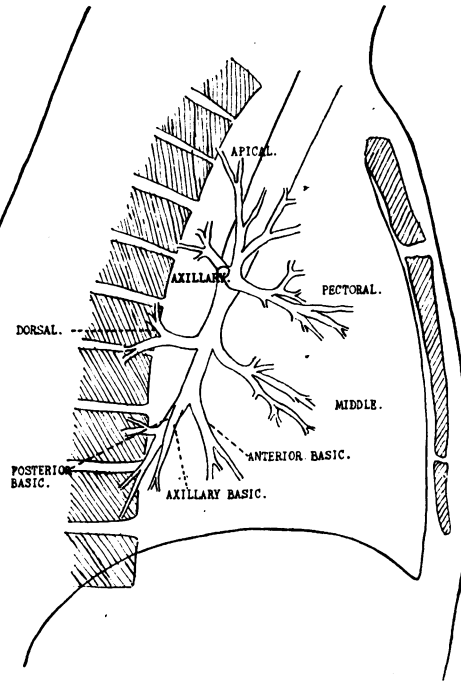


FIG. 3.—Lateral view, showing the distribution of the bronchi on the right side.

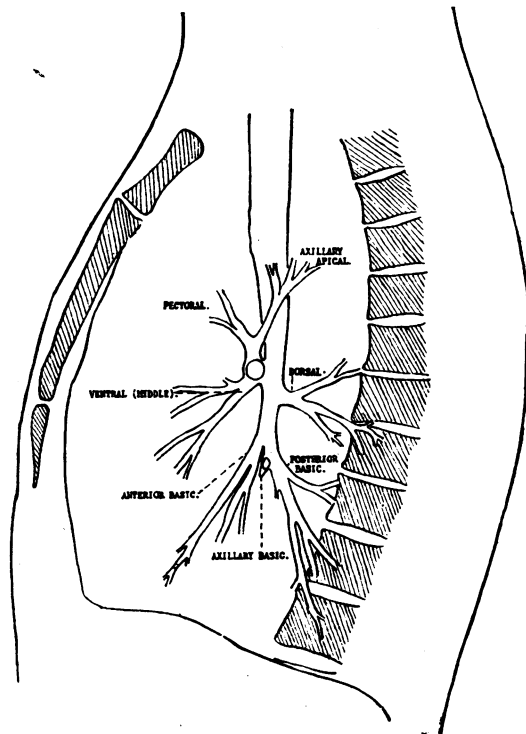


FIG. 4.—Lateral view, showing the distribution of the bronchi on the left side.

below the bronchus to the upper lobe, and runs forwards, outwards, and downwards (see Figs. 2 and 3). The middle "lobe" of the left lung is that portion situated below the plane of the fourth costal cartilage, and occasionally there is an actual fissure separating it from the rest of the upper lobe (see Fig. 1). The bronchus to this area arises, as I have explained above, from the bronchus to the left upper lobe, and runs outwards, forwards, and downwards (see Figs. 2 and 4).

The Dorsal Area

By the dorsal area is meant the upper part of the lower lobe. Although usually incorporated in the lower lobe, this area is occasionally separated from the rest of the lobe by a fissure. Anatomically and clinically it acts independently of the rest of the lower lobe, and is entitled, as I have said elsewhere,¹⁰ to be called the dorsal area, and the bronchus that supplies it the dorsal bronchus (see Fig. 1).

The right dorsal bronchus arises from the posterior surface of the right main bronchus, almost opposite the origin of the right middle bronchus (see Fig. 3). It will thus be seen that the right main bronchus terminates by dividing into three branches—middle, dorsal, and lower. The dorsal runs a short course horizontally backwards, and then divides into branches which supply the upper portion of the right lower lobe. The extent of the area supplied is variable, and may be a quarter of the whole lobe.

The left dorsal bronchus springs from the posterior surface of the left lower bronchus practically at its commencement, and has a direction and distribution like its corresponding member on the other side. In Fig. 2 the origin of this bronchus is seen on both sides as a circle, with its tertiary branches just visible, but in Figs. 3 and 4 they are shown clearly.

Lower Lobes, Right and Left Lungs

On both sides the bronchus to the lower lobe gives off at its commencement the dorsal bronchus, as I have mentioned above; it then continues for about 2 cm. and terminates by dividing into anterior-basic and posterior-basic bronchi; the latter then gives off a large branch from its lateral surface—the axillary-basic bronchus. On the right side there is a separate cardiac branch arising from the medial wall of the lower lobe bronchus; it runs downwards and slightly inwards and backwards, to supply a small area lying just below the root of the lung. On account of its small size this bronchus will not be considered again.

The anterior-basic bronchus springs from the antero-medial surface of the lower lobe bronchus at its termination, and then runs downwards and outwards and forwards to supply the cardiac surface and the antero-inferior angle of the lower lobe (see Figs. 2, 3, and 4).

The axillary-basic bronchus comes from the lateral surface of the posterior-basic bronchus at its origin, and runs downwards and outwards to supply the axillary surface of the lower lobe (see Figs. 2 and 3), but in Fig. 4 this bronchus can only be seen at its commencement.

The posterior-basic bronchus continues the line of the main bronchus and lower lobe bronchus downwards, backwards, and slightly outwards (see Figs. 2, 3, and 4). It is the largest of the four branches, and supplies the posterior surface of the lower lobe below the dorsal area, the so-called "base" of the lung.

Localization of Lesions

The correct posture cannot be determined until we know the exact position of the lesion. For this we depend on physical signs and x-ray examination. Physical signs, when present, are of the greatest value in the localization of a lesion, but when they are only vague or absent altogether we must fall back on the x-ray.

In bronchiectasis the diagnosis and localization of the lesion cannot be made by physical signs alone. For the latter x-ray examination is by far the most valuable method. It is necessary to have either stereoscopic films or two views of the chest taken at right angles to each other—namely, antero-posterior and lateral—before it is possible to state the exact position of a lesion. It is customary to centre the x-ray tube at the level of the manubrio-sternal junction, so that in the film the clavicles and posterior ends of the fourth ribs are superimposed. In addition, the tube should be at least four feet distant from the film. The description that appears in the next section is based on films taken under these conditions. For the purpose of posture the antero-posterior film is divided into three zones—upper, middle, and lower—by two horizontal lines, the first passing through the first costal cartilage and the second through

the fourth costal cartilage (see Fig. 5, A): the significance of this division will be discussed in the next section.

In a normal lateral film the following features can be observed. Anteriorly is the sternum, posteriorly the vertebrae, forming a concave line, and, below, the diaphragm (see Fig. 5, B). There are two opaque areas: one is caused by the shoulder girdle, and is at the apex of the chest posteriorly (it varies with the position and size of the limb); while the other is caused by the heart, and lies anteriorly just above the diaphragm. There are also two translucent areas: one above the heart and anteriorly and the other between the heart and the vertebrae. The trachea is seen as a clear band running downwards and backwards through the upper part of the lung field, one-third of the distance from the vertebral bodies to the sternum. This clear area terminates at about the level of the sixth rib, and on the right side there is at this point a small oval translucent area, which is at the origin of the middle and dorsal bronchi and in the plane of the oblique fissure. If the axis of the trachea is continued downwards and backwards as a straight line it reaches the diaphragm just anterior to the vertebrae: this line can conveniently be called the tracheal axis. The position of a lesion in relation to this axis is described as anterior (pectoral), posterior (dorsal), or, when it is situated on the line, as lateral (axillary).

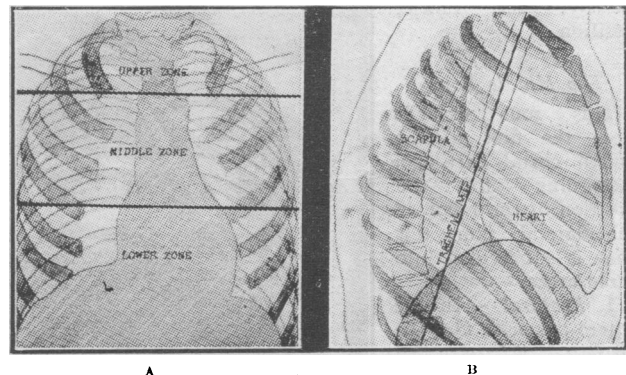


FIG. 5.—Showing the antero-posterior and lateral views of the normal chest.

The axillary border of the scapula may be seen somewhere between the trachea and the posterior border of the vertebrae.

Bronchiectasis requires lipiodol for its localization, and it is wisest not to fill both sides at the same time because of the confusion when they are superimposed in the lateral view. When filling the lower bronchi the patient should, in addition to the usual reclining position, be inclined forwards and then laterally for part of the time, so that the oil enters the anterior and laterally running bronchi: frequently the lateral film shows that only the postero-basic bronchus has been filled. Even in the best lateral films it is sometimes difficult to find an opacity that is clearly visible in the antero-posterior view, owing to its being superimposed on the opacity of the heart or vertebrae. For this reason the ideal method of localization is by stereoscopic films, and they have another advantage that in the case of lipiodol both sides may be filled at the same time. It is unfortunate, however, that stereoscopic films are not in general use in this country, and for this reason I have confined the discussion to the antero-posterior and lateral films.

The Postures

The posture which a patient should adopt will depend on the position of the pulmonary lesion. In the antero-posterior x-ray film the lesion may be in the upper, middle, or lower zone. The upper zone is in reality the apex of a cone, and as it is supplied by one bronchus

this area does not require any subdivision. The middle and lower zones, on the other hand, are each subdivided according to the lateral x -ray film into three areas— anterior, lateral, and posterior. The lung fields are thus divided into seven areas on each side of the chest, and for each of these areas there is a different posture. For purposes of postural drainage the two sides of the chest may be considered as symmetrical, with one exception, which will be mentioned later.

The Upper Zone

In this zone the main extent of the opacity is situated above the level of the first costal cartilage: it always extends up to the apex, and may extend downwards towards the root of the lung. In the lateral film the opacity is at the apex posteriorly, and cannot be distinctly seen owing to the opacity caused by the shoulder girdle. This area is supplied on the right side by the apical bronchus, and on the left side by the apical branch of the axillary-apical bronchus. On both sides the surface of the lung corresponding to this bronchus (later referred to as the surface distribution) lies mainly behind, above the spine of the scapula but extending forwards as far as the clavicle; physical signs may be found over this area. The posture for a lesion in this position is sitting upright— namely, the Fowler position.

The Middle Zone

This zone extends from the first to the fourth costal cartilage. According to the position of the lesion in the lateral film this zone is subdivided into three areas.

1. *Pectoral*.— In the antero-posterior film the opacity is situated between the second and fourth ribs in front, in the centre of the lung field, while in the lateral film it lies anterior to the tracheal axis in that normally clear area between the trachea and sternum. This area is supplied on both sides by the pectoral bronchus, which has a surface distribution in front of the chest between the clavicle and the fourth rib: physical signs may be found over this area. The posture for a lesion in this region is lying flat in bed on the back—namely, supine.

2. *Axillary*.— In the antero-posterior film the opacity is situated between the second and third ribs in front in the outer half of the lung field, and extending to the periphery. In the lateral film the opacity overlies the trachea, which cannot therefore be distinguished, and may also extend posterior to this axis. On the right side this area is supplied by the axillary bronchus, and on the left by the axillary branch of the axillary-apical bronchus. On both sides this bronchus has a surface distribution in the axilla above the line of the sixth rib: physical signs may be found over this area. The posture for a lesion in this region varies slightly on the two sides. When it is on the right the patient should be lying flat and rotated on to the left side— namely, the lateral position; but when it is on the left the patient should be sitting up at an angle of approximately 45 degrees and rotated on to the right side.

3. *Dorsal*.— In the antero-posterior film the opacity is situated in the inner half of the lung field, and appears to be in the hilum of the lung. In fact, an abscess in this situation has frequently been called a hilar abscess, but when a lateral film is taken it will be seen to lie posterior to the tracheal axis, overlying the body of the seventh, eighth, or ninth

vertebra. On both sides this area is supplied by the dorsal bronchus, which has a surface distribution posteriorly in the region of the inferior angle of the scapula, and it is here that physical signs may be found. The posture for a lesion in this region is lying flat and turned over on to the face—namely, the prone position—and when the lesion is on the right side the patient's head is turned to the right, and vice versa.

The Lower Zone

This zone extends from the level of the fourth costal cartilage down to the diaphragm. Like the middle zone, it may be subdivided into three areas:

1. *Middle and Anterior-basic*.— In the antero-posterior film the opacity is situated between the fourth rib in front and the upper surface of the diaphragm when it is in the middle lobe, or laterally and in the costo-phrenic angle when it is in the anterior-basic bronchus. In the lateral film the opacity lies anterior to the tracheal axis and is superimposed upon that of the heart, and in this view it is practically impossible to distinguish a middle from an anterior-basic lesion. This area is supplied by two bronchi: (a) the middle lobe bronchus on the right and the ventral on the left, which have a surface distribution in front of the chest below the fourth costal cartilage, where physical signs may be found; (b) the anterior-basic bronchus, which has only a small distribution on the costal surface of the lower lobe in the anterior axillary line about the level of the sixth rib, where physical signs may be found. The posture for a lesion in the middle or anterior-basic regions is lying flat on the back with the foot of the bed raised about twelve inches.

2. *Axillary-basic*.— In the antero-posterior film the opacity is situated below the level of the fourth costal cartilage in the outer part of the lung

field, extending to the periphery. In the lateral film the opacity lies in the line of the tracheal axis, and occupies that normally clear area between the shadow of the heart and the anterior surface of the bodies of the vertebrae. On both sides this area is supplied by the axillary-basic bronchus, which has a surface distribution on the lateral surface of the chest wall below the sixth rib. The posture for a lesion in this position is lying on the opposite side in the lateral position, as for an axillary lesion, but with the foot of the bed raised about twelve inches.

3. *Posterior-basic*.— In the antero-posterior film the opacity is situated in the lower zone, and extends down below the level of the diaphragm, and on the left side it may be obscured by the shadow of the heart. In the lateral film the opacity lies mainly behind the tracheal axis, over the bodies of the lower thoracic vertebrae. This area is supplied by the posterior-basic bronchus, which has a surface distribution behind over the so-called "base of the lung." The posture for a lesion in this region is lying prone with the foot of the bed raised about twelve inches. It is for lesions in this position that the postural drainage bed, described below, has been designed (see Fig. 6).

The Application of Postural Drainage

In spite of the statements made by some authorities that patients themselves usually discover the position in which they drain most satisfactorily, I find, generally, that they are sitting up in bed and in a position in which

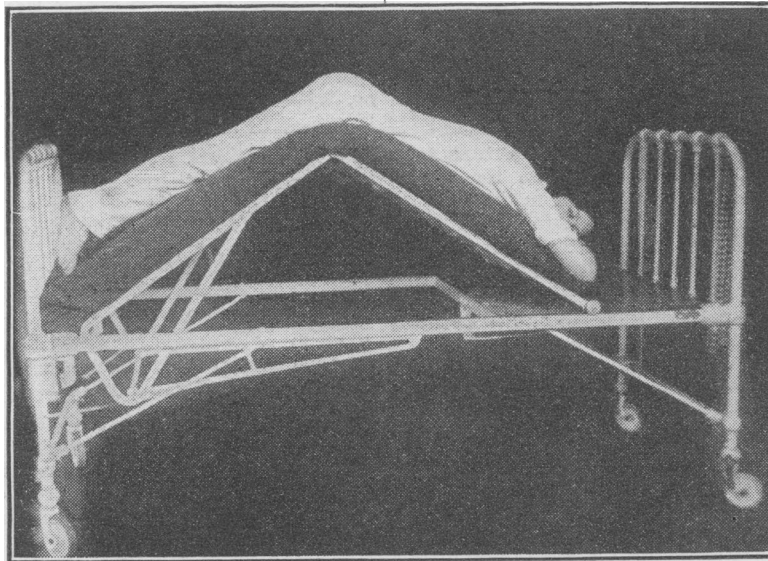


FIG. 6.—Showing patient on author's new postural drainage bed.

they are inclined to cough the least. By examination of the patient and the x -ray film the best posture is determined, and the patient is instructed that he should lie in such-and-such a way. The reply "But that is the one position in which I cannot lie because it makes me cough all the time" confirms the decision. With unwilling patients I usually suggest that to begin with they should adopt the position for ten minutes three times a day before meals, and then I find that this period can gradually be increased, until in the end the posture is maintained for at least three periods of two hours during the day and for the greater part of the night. In patients who are acutely ill the sudden change from the sitting-up position may be extremely embarrassing, in which case they must be gradually lowered during the course of several days. There is usually an increase in the quantity of sputum, followed by a gradual diminution.

In the foregoing section lesions confined to definite localized areas of the lung have been described, but frequently two or more contiguous areas are involved at the same time, as, for example, all the tertiary branches of the lower bronchus or the apical and axillary branches of the upper lobe bronchus. In these circumstances one principal posture must be adopted which is more or less common to them all—namely, the horizontal for a middle zone lesion or with the foot of the bed raised for a lower zone lesion. Again, the lateral position, being half-way between prone and supine, is found to be the most useful, with occasional changes into the prone and supine. I have noticed the frequent combination of bronchiectasis in the posterior-basic and middle or ventral bronchi; in these cases the patient is placed on the postural drainage bed or with the foot of the bed raised, and spends part of the postural time prone and part supine.

*A Postural Drainage Bed**

In this bed (Fig. 6) the mattress frame is hinged across the middle, and on winding a handle at the foot of the bed the centre gradually rises. Before starting to "wind up," the patient's pillows are removed, and he lies in the prone position with the anterior iliac spines opposite the hinge; on winding up, the head, thorax, and abdomen hang down on one side and are counterbalanced by the lower limbs on the other. The maximum inclination that can be obtained in this bed is 45 degrees, but this is too steep for most cases, and especially for adults, who should be placed between 20 and 30 degrees. At the lower end of the bed the legs have adjustable inner tubes, so that the foot of the bed can be raised eighteen inches. The same bed can be used flat for the lateral and supine positions.

Summary

1. The advantages of a continuous posture are compared with the disadvantages of an intermittent posture.
2. The drainage should be towards the bifurcation of the trachea.
3. A brief account of the anatomy and distribution of the larger bronchi is given.
4. In the localization of pulmonary lesions the lateral x -ray film is as important as the antero-posterior one.
5. When lesions are considered according to their position in the antero-posterior film, those in the upper zone are treated in the sitting position, those in the middle zone by lying flat, and those in the lower zone with the foot of the bed raised.
6. When lesions are considered according to their position in the lateral film, those occurring anterior to the tracheal axis are treated in the supine position, those on the tracheal axis in the lateral position, and those posterior to it in the prone position.

* This bed has been made for me by Hoskins and Sewell Ltd., of Bordesley, Birmingham.

7. Some practical points in the application of postural drainage are mentioned.

8. A new postural drainage bed is described for the treatment of basal lesions in the prone position.

A full report of cases treated by these postural methods will be published elsewhere.

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Clinical Memoranda

A CASE SHOWING CULLEN'S SIGN

The rarity of Cullen's sign of extrauterine gestation, together with certain unusual features of the case, warrant record. The patient herself noted the condition, and the diagnosis was made originally on the presence of this sign.

CLINICAL HISTORY

C. S., aged 34, after seven years of childless marriage, had a normal menstrual period from August 5th to 9th, 1933. Six weeks later she consulted her doctor on account of vague lower abdominal pain of fourteen days' duration, but did not mention that suppression of the expected menstrual period had occurred. Abdominal examination did not suggest anything abnormal, and she was given mist. alba as a placebo. On the afternoon of September 26th, 1933, seven weeks after the last period, whilst taking tea with a friend, she experienced some accession of pain and examined her own abdomen. She "did not like the look" of some marks there, and sent for her doctor, who, on seeing the marks, made a diagnosis of tubal gestation. I saw the patient in consultation with Dr. Cathie of Felling-on-Tyne about an hour later. She was a spare woman with a well-marked acne rosacea; temperature 98.4°; pulse 80. Since being seen by Dr. Cathie she had commenced to pass a certain amount of dark blood per vaginam. She complained of pain, with periodic exacerbations in the hypogastric region, and the bladder was distended to the size of a five months pregnancy. On relief of this pain by catheterization she described her pain as being situated over the left iliac fossa. One inch below and to the left of the umbilicus was a purple, almost black, clearly cut mark 3/4 in. by 1/4 in. shaped like a comma. Below it, about the junction of the upper third and lower two-thirds of the distance from the umbilicus to the pubes, was a "bruise," bluish in colour, about 1 in. in diameter, whilst abutting on the inguinal fold was a reddish-purple mark like a fresh bruise, shaped roughly like the ace of clubs, about 2 1/2 in. in diameter. Neither of the two lower marks was so clearly cut or so intense in coloration as the upper mark. The whole was within the triangle formed by the midline and a line drawn to the umbilicus from the middle of the left inguinal ligament. On bimanual examination a soft mass the size of a hen's egg was evident in the left tubal region. There was not any evident dullness in the flanks.

OPERATION

She was admitted to the Royal Victoria Infirmary, Newcastle-upon-Tyne, where I opened the abdomen and removed the distal