Portfolio of Chest Radiographs

Le Roux and Dodds

A PORTFOLIO OF CHEST RADIOGRAPHS

For Undergraduate and Postgraduate Students

By

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FOREWORD

The practice of thoracic surgery provides an unrivalled opportunity, even a compulsion, to look curiously at radiographs of the chest and compare their features with the findings at operation or autopsy, thus leading to a natural growth of skill in interpretation. Many doctors are obliged by the requirements of medical practice or professional examinations to take an intelligent part in the discussion of radiographic appearances before there is time to develop skill from this or any similar process. They must learn from teaching collections of films demonstrated by a master, or from textbooks.

In this portfolio Mr. le Roux has taken the good from both systems of learning. Here is a teaching collection devoted to the frequent rather than the rare, and for which all necessary data—clinical, operative and post-mortem—are available. The short text has permitted within a compact volume the size and number of illustrations required for clarification of each point and there is no illustration which does not show plainly what is intended. The relation of many of the radiographs to surgical action makes the book an ideal companion in the study of surgery, medicine or radiology.

I have enjoyed it in its own right and wish it well.

Edinburgh, 1964 ANDREW LOGAN

ACKNOWLEDGMENTS

Most of the illustrations in this volume are reproduced by permission of the Board of Management of the Royal Infirmary, Edinburgh, and of Dr. Eric Samuel, Director of the Department of Diagnostic Radiology, and Mr. Andrew Logan, Senior Thoracic Surgeon, both of the Royal Infirmary, Edinburgh, to all of whom we are greatly indebted.

The following illustrations are reproduced by permission of the Editors of the Journals mentioned, and their co-operation is gratefully acknowledged: *Thorax* (Figs. 216, 217, 218, 219, 236, 237, 239, 240, 241, 243, 246, 247, 248, 250, 251, 252, 253, 258, 259, 262); *British Journal of Surgery* (Figs. 46, 47, 290, 291, 292); *Journal of Thoracic and Cardiovascular Surgery* (Figs. 18, 20, 21, 23, 58); *Journal of the Royal College of Surgeons of Edinburgh* (Figs. 256, 257, 285); *Quarterly Journal of Medicine* (Fig. 223); *Geriatrics* (Figs. 284, 288); *British Journal of Anaesthesia* (Fig. 19).

A large number of physicians and radiologists in the South-East Region of Scotland have collaborated directly and indirectly in making available the films reproduced; we are grateful to them for allowing us to make this aspect of their clinical material more generally available for the purpose of teaching. Messrs. E. & S. Livingstone have undertaken the publication of this portfolio with enthusiasm; to them, and particularly to Mr. Charles Macmillan, we are most grateful.

Edinburgh, 1964

B. T. Le Roux
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INTRODUCTION

THE use of radiographs of the chest is an integral part of the practice of clinical medicine and surgery, and training in the interpretation of chest radiographs is, for both undergraduate and postgraduate students, as necessary as training in the interpretation of clinical signs. Just as patterns of symptoms and signs recur, so do radiographic abnormalities. Furthermore, the common radiographic opacities are relatively few in number and easily recognisable. It is the recurrence of radiographic abnormalities which makes interpretation of chest radiographs possible and the making of such radiographs of clinical value.

This portfolio is a personally collected series of radiographs selected over several years from the very large number which have accumulated in the archives of the Regional Thoracic Unit in Edinburgh. The radiographs were selected as suitable for demonstrating to students the range of normal chest films and the range of frequently recurring abnormalities. There may be many and possibly better collections of chest radiographs in the hands of those interested in the teaching of radiology, but these collections have the disadvantage of being available to only a limited number of students. The justification for the publication of this portfolio is to make more generally available to undergraduate and postgraduate students a representative series of chest radiographs in a conveniently portable form. It is not intended as a catalogue of all intrathoracic radiographic abnormalities, some of which are uncommon and others unsuitable for photographic reproduction. From repeated scrutiny of the photographs in this volume the student can become familiar with common radiographic abnormalities in the chest; from the study of serial radiographs and a deliberately brief text he will be taught what action should be taken when he is faced with particular types of radiographic abnormality; and he will be shown radiographically the natural history of and the influence of surgical management on some of the lesions illustrated.

To look without seeing is a common failing, perhaps particularly common amongst students in their earlier clinical training and when under stress during professional examinations. The student able to scrutinise at leisure the radiographs in this portfolio will learn to see what is abnormal and to recognise the significance of the abnormality in any chest radiograph, and will become familiar with the wide range of normal in chest films as well as the wide range of abnormalities having the same significance. There is deliberate repetition throughout the portfolio since abnormalities do not recur in precisely the same way. Technically good chest radiographs, normal and abnormal, are as similar and as different as fingerprints, and could be used as effectively for the purpose of identification. As an example of an abnormality recurring in different ways, a lobar opacity may fill a normal volume of the hemithorax, or the lobe may be either shrunken or distended,

and in any of these circumstances the opacity produced by obstruction of a lobar bronchus may vary over a wide range. One object of this portfolio is to illustrate variations of common lesions rather than to illustrate isolated examples of less common lesions, since this is more the function of an atlas. Radiographic abnormalities are either shadows (opacities) or translucencies and must be described as such. In the interpretation of chest radiographs it is usually advisable to avoid offering a diagnosis in terms of pathology,

Most of the films illustrated are postero-anterior and lateral views of the chest, since by convention these are the films with which the student is most commonly presented for interpretation and from which most can be learned regarding intrathoracic abnormalities. Tomograms, films showing the barium-filled oesophagus, oblique views and occasional special views are also illustrated. An accurate knowledge of bronchial anatomy is essential for the recognition and interpretation of lobar and segmental opacities. A series of normal bronchograms and the common anatomical variations is therefore included early in the portfolio. Bronchography is an integral part of the investigation of many patients with respiratory disease; a range of abnormal bronchograms is illustrated and a technique for bronchography briefly described. The habit of scribbling on radiographs is deplored, but where an occasional arrow serves more adequately than many lines of descriptive text, this is used. Where an illustration is bespoiled by an arrow or other blemish, the same or a similar illustration is usually reproduced without the artefact. Technically poor as well as good radiographs are reproduced, since it is necessary both to demonstrate what is bad by comparison with what is good, and to become proficient in the interpretation of technically indifferent films; bad radiographic technique is not uncommon, and is especially common when there is urgent need for the interpretation of a radiograph without expert assistance, and when the repetition of films would be an unfair burden on an ill patient.

It is beyond the scope of this monograph to describe and discuss radiographic technique, but it must be stressed that a standard technique is essential for the accurate interpretation of radiographic abnormalities, and particularly where conclusions must be drawn from a comparison of serial films made during the progress of a pulmonary lesion. Bad radiographic technique can completely mask a significant abnormality or suggest one not actually present. It is a duty of the radiographer to the patient to make technique of a constantly high standard, and of hospital authorities to provide equipment suitable for the production of films of constantly high quality, irrespective of the load on the machinery or on the supply of electricity. It is the habit in some hospitals to insist that every patient investigated have a chest radiograph made. This practice is strongly endorsed, and such a radiograph should be a part of the patient's routine investigation, as is urinalysis and the counting of cells in peripheral blood. Particularly in surgical practice, to have available a normal film for comparison with films made when the patient has developed a post-operative complication is of the utmost value. The observation that a patient is too ill to be X-rayed can rarely be valid, whereas it is frequently the case that a patient is too ill not to be X-rayed.

Since most of the illustrations are of films collected from a practice in thoracic surgery, there is in the selection possibly a surgical bias, but as nearly all patients are referred for a thoracic surgical opinion by physicians, this bias is more apparent than real. Most of the patients whose radiographs are illustrated were submitted to bronchoscopy and thoracotomy, and anatomical confirmation of the interpretation of radiographic opacities was thereby obtained. Unless there is a specific statement to the contrary, the reader will know that the interpretation of an opacity has thus been confirmed. A small number of illustrations are of radiographic changes induced by thoracic surgical procedures, but this seems justified because students and recent graduates commonly come into contact with patients who have been submitted to operations on the chest.

This portfolio is not a text-book—either of thoracic surgery or of respiratory medicine ; it is intended rather as a companion in that aspect of radiology upon which both above-mentioned specialities are heavily dependent. A radiograph is never an end in itself, a truism which seems sometimes to be forgotten. Relevant clinical details are related to the radiographs throughout this volume, deliberately and sometimes repetitively, so that it is not forgotten that a radiograph always relates to a patient, that it is made as part of a service offered to a patient, and that it is a patient and not a radiographic abnormality for whom treatment is designed.

Sections on radiographic and bronchial anatomy are necessary at the beginning of such a volume, because all that is subsequently said depends on accurate anatomical interpretation. The later text, and the legends of the illustrations, are discursive rather than complete. Some uncommon lesions are discussed in detail, because of a particular interest in them ; when interest is particular, knowledge which has been gained can sometimes be condensed and reproduced with a simplicity which is an aid to memory for others. Therefore a criticism of imbalance can perhaps be justly levelled. Balance must be struck in a text-book, of which there are many, and none of which it is intended to supplant.

In the legends, the reader is regularly reminded of radiographic features which recur regularly and, to the initiated, obviously, but this portfolio is not intended for the initiated, of whom, amongst undergraduate and postgraduate students, there are surprisingly few. It is necessary to listen for only a short while to a postgraduate student, in his own view well enough advanced in his training to offer himself as a candidate for a higher degree, suggesting one unlikely explanation after another for the radiographic translucency of a bronchus, seen end-on, and see him place the posterior tracheal wall anywhere from anterior to posterior chest wall, and even below the pulmonary hilum, to realise how uninitiated it is possible to remain throughout a long period of apprenticeship. Students seem reluctant to ask for an explanation of radiographic features at which they have often looked. Perhaps they are embarrassed to exhibit ignorance in the presence of their associates, or perhaps they have looked and never seen. And because the features in question are, to the initiated, obvious and the explanation for them so simple, instructors may never think it necessary to explain them.

I

RADIOGRAPHIC ANATOMY

RADIOGRAPHIC LANDMARKS

THE lungs occupy the pleural spaces, one in each hemithorax ; the mediastinum lies between the pleural sacs.

The chest radiograph most commonly made and the one from which, for routine purposes, most information is obtained is a postero-anterior (P.A.) view made with the subject standing erect. The radiographic film which is to be exposed is rigidly supported in contact with the anterior chest wall of the subject at a standard distance (usually 6 ft. sometimes 5 ft.) from the X-ray tube anode, which is behind the subject, and the rays pass postero-anteriorly through the subject. The heart is relatively anterior, and since the rays inevitably diverge from their source, the shadow cast by the heart in P.A. films is the closest approximation to its normal size, its outline is most clearly defined and its size is significantly smaller than on a radiograph exposed when X-rays pass antero-posteriorly through the subject. In a P.A. film the large number of posterior ribs cast a less dense and less well-defined shadow on the radiographic film, since they are further from it than the few anterior ribs, with their costal cartilages which are radio-translucent unless calcified.

Antero-posterior (A.P.) chest radiographs are usually made, purely as a convenience, when the patient is confined to bed and unable to stand. The relationship between the radiographic plate and the source of X-rays is reversed—the subject faces the X-ray tube and the radiographic plate is held firmly against his back. Both P.A. and A.P. chest radiographs are made during a brief period when the subject holds his breath at the end of maximum inspiration, with arms akimbo so that the vertebral borders of the scapulae are furthest apart. The domes of the diaphragm are therefore at their lowest level and they and the scapulae obtrude least on the lung fields. Since A.P. films are routinely required when a patient is able only to sit, the domes of the diaphragm will obtrude more than on P.A. radiographs. A chest radiograph is occasionally made for an unconscious patient in the supine position. Scapulae and diaphragm obtrude yet more, the cardiac contour is distorted, and the sharp contrast between liquid and air in the pleural cavity, in a pulmonary vomica, and below the diaphragm, visible as a "fluid level" on films made with the subject erect, is lost.

The way in which a chest radiograph is placed for scrutiny is largely conventional. In some centres the film is viewed as if the scrutiniser were the source of X-rays—i.e. when a P.A. radiograph is viewed the right side of the viewer and of the patient's radiographic image correspond. The more usual convention is to view P.A. and A.P. chest radiographs as if the viewer were facing the subject—

i.e. the viewer's right corresponds with the left of the subject's radiographic image. When abnormalities are described on P.A. and A.P. radiographs, left and right refer to patient and not viewer. Lateral views, also made with the subject at a standard distance from the source of X-rays, are viewed as if the viewer were looking at the appropriate side of the patient. When a lateral view made with the right side of the subject against the radiographic plate—i.e. a right lateral—is scrutinised, the viewer places the radiographic film in such a way that the anterior chest wall of the subject's radiographic image corresponds with the viewer's right hand. There is no certain method which will allow of differentiation between a right and a left lateral film, and accurate distinction is entirely dependent on accurate marking of the casette in which the unexposed radiographic plate is secured. Pulmonary opacities and distinctive anatomical features such as the liver, below the right dome of the diaphragm, and an air-containing gastric fundus, below the left dome, and also interlobar fissures, may be seen with equal clarity on either lateral film and cannot be used for identification. The purpose of making one lateral as opposed to the other is to place an abnormality as close to the radiographic plate as possible and in this way to distort and magnify it least and provide it with the clearest possible outline. A true lateral and a precisely centred P.A. view are rarely achieved.

Radiographic films as presented to the clinician are photographic negatives on which the more solid structures—bones, liquids, mediastinal contents—are relatively white and less solid structures which contain air relatively black. From radiographic negatives positive prints can be made and in these the relationship between black and white is reversed. It is sometimes held that when positive prints are reproduced a more effective contrast is achieved than with the reproduction of negatives. Since the student must become accustomed to the interpretation of radiographic negatives there seems little point in the reproduction of positives in a book which is designed as an introduction to clinical chest radiography, simply for the uncertain benefit of an artificial increase in contrast.

In normal postero-anterior chest radiographs there are landmarks which serve to identify the right and left sides—on the left, the aortic knuckle, which is normally the most cephalad and lateral part of the aorta, the left heart border, and air in the gastric fundus below the left dome of the diaphragm ; on the right, the transverse fissure, and hepatic density below the right dome of the diaphragm. It is rare for all these landmarks to be so obscured that a radiograph cannot be accurately placed. Situs inversus is recognised at fluoroscopy. In isolated dextrocardia the relationship between gastric fundus and cardiac apex is reversed. The aortic arch may be right-sided.

Pulmonary translucency is limited below by the shadows of the domes of the diaphragm. The right dome is normally a centimetre or two higher than the left, but this relationship may be reversed, particularly in children, and particularly when there is a large volume of air in the stomach or colon. Hepatic density is continuous with that of the right dome, from which it is indistinguishable unless there is air in the peritoneal cavity. The right dome is sometimes made up of two or more arches. Air in the gastric fundus often delineates precisely the cupola of

the left dome in which separate arches are less often visible than on the right. Pulmonary translucency extends in a cephalad direction above the clavicular shadows. The posterior ends of the first and second ribs, usually the third and sometimes the fourth can be identified above the level of the clavicular shadows. Scapular shadows should not obtrude on pulmonary translucency, laterally, but often do. In the aged, costal cartilages are often calcified and become very obvious on both P.A. and A.P. films ; the first costal cartilage is usually the first to calcify.

For the purpose of identifying opacities, on P.A. films only, the lung fields are sometimes divided into " zones ". The right and left mid zones lie between imaginary horizontal lines which extend laterally from the lower borders of the second and fourth costal cartilages ; the upper and lower zones lie above and below the mid zones. The apices are those parts of the upper zones above a horizontal line through the upper border of the sternal end of the first rib in either P.A. or A.P. films.

The mediastinal density has a right and left pleural border. Above the right pulmonary hilum the superior vena cava lies at the right border of the mediastinum. Below the right pulmonary hilum the right heart border projects a short distance to the right of the vertebral shadow and this part of the heart is normally right atrium. Cephalad to the left pulmonary hilar shadow the aortic knuckle is the prominent lateral convexity at the left mediastinal edge and, below the pulmonary hilum, the left heart border, normally left ventricle, extends downwards and laterally towards the diaphragm, a short distance above which it curves medially at the cardiac apex, and immediately beyond this it joins the diaphragmatic shadow. The spine should be visible as an indistinct broad vertical density within the mediastinal shadow. The individual features of the vertebrae should not be recognisable in films of proper penetration except through the vertical median translucency above the aortic arch which is the trachea. The transverse processes are often visible beyond the right mediastinal border and through the shadow of the right atrium, and beyond the left mediastinal border above the aortic knuckle.

The hilar shadows are the right and left pulmonary arteries and their branches. The upper margin of the left pulmonary hilum is usually better defined than the right. The upper pulmonary veins are inseparable from the arterial shadows ; the right lower pulmonary vein may sometimes be separately recognisable. Pulmonary vessels are visible throughout the lung fields, normally to within a centimetre or two of the chest wall ; they fan laterally from the pulmonary hila and are often erroneously referred to as " broncho-vascular " markings. Bronchi contain air, which is radio-translucent, and are normally not visible unless they present end-on, when they appear as sharply outlined black discs. Large vessels seen end-on appear as sharply defined circular densities.

Lateral radiographs show characteristically the antero-inferior density of the heart with its antero-superior border, mainly right ventricle, convex towards the sternum and its postero-inferior border, mainly the atria, convex towards the diaphragm, and the inferior vena cava. The vertebrae are well seen posteriorly ; the ribs of both sides sweep postero-anteriorly downwards and forwards ; their point of maximum posterior extension projects posterior to the vertebral shadow ;

where costal cartilages are calcified they are well seen, anteriorly, close to the sternum. Lateral films are made with the patient's arms raised above the head and the soft tissue shadows of the shoulders and axillae usually obscure the pulmonary apices. It is usual to recognise the density of the aorta where this arches over the pulmonary hilum, from which it is normally separated by a translucency called the aortic window. In many lateral films the aortic density cannot be traced from its origin to the diaphragm but, particularly in thin elderly women, its course is well seen on either lateral film and it has the appearance of a carelessly drawn question mark, reversed in the right lateral view. The axillary borders of the scapulae, thicker than the vertebral borders, are often visible posterior to the tracheal translucency. The pleural reflection from diaphragm on to inferior vena cava outlines sharply the postero-inferior density of the cardiac shadow or is superimposed on it. Pulmonary translucency in the posterior area between diaphragm, vertebrae and posterior heart border should be of a density similar to that of pulmonary translucency above and in front of the cardiac shadow. The posterior translucency is usually traversed obliquely, from hilum towards posterior cardio-phrenic angle, by the opacity of the pulmonary artery, and where two parallel shadows are seen, they are the pulmonary arteries of both sides. The origins of the pulmonary arteries lie in the middle of lateral films with tracheal translucency above and aorta above and behind.

Pleura covers the internal aspect of the bony chest wall from which it is radiographically inseparable unless it is abnormal, and from which it is reflected on to the domes of the diaphragm and the mediastinum. The mediastinal pleura is reflected on to the lungs at the hilum and caudal to the hilum as the pulmonary ligament, and becomes the visceral pleura. The pleural reflection from chest wall to diaphragm is the costo-phrenic angle and from diaphragm to pericardium the cardio-phrenic angle ; the latter angle is commonly obscured by fat.

The visceral pleura dips into the fissures between the lobes. Interlobar fissures vary in depth and completeness and are sometimes absent. The right lung has three lobes—upper, middle and lower. The oblique fissure separates the apex of the lower lobe from the posterior segment of the upper lobe and the rest of the lower lobe from the middle lobe. The transverse (horizontal, lesser) fissure separates the middle lobe from the anterior segment of the upper lobe. In lateral chest radiographs the oblique fissure lies for much of its length in relation to the 5th or 6th rib but may extend posteriorly as high as the 3rd rib and, anteriorly, dips towards the diaphragm short of the cardio-phrenic angle so that the middle lobe normally reaches the right dome anteriorly and occupies the anterior cardio-phrenic angle. In lateral films the transverse fissure extends horizontally from the oblique fissure to the anterior chest wall at the level of the pulmonary hilum. In P.A. films the transverse fissure traverses the middle of the right hemithorax and usually crosses the 4th costal cartilage close to the pulmonary hilum.

The left lung has two lobes, an upper and a lower, separated by an oblique fissure. More specifically, the oblique fissure separates the lingular and posterior segments of the upper lobe from the anterior basal and apical segments of the lower lobe. Its course on lateral radiographs is similar to that of the right oblique

fissure. The lingular segment occupies less of the anterior cardio-phrenic angle on the left than does the middle lobe on the right.

Accessory fissures are not uncommon but are usually incomplete. The two most readily recognisable radiographically are the " cardiac " fissure and the " azygos " fissure. The first is seen as a linear opacity which in P.A. films rises upwards and medially from the right dome, which it meets, usually medial to its midpoint, towards but falling short of the right border of the heart close to the pulmonary hilum. This fissure delineates the medial basal segment from the adjacent basal segments but may separate an accessory " inferior " or " retro-cardiac " lobe from the rest of the lung.

The azygos vein, which represents the anterior end of the right posterior cardinal vein, is sometimes suspended from the pleural dome by a " mesentery " of pleura (the meso-azygos) and this mesentery is visible on P.A. chest films as a linear density which extends from the right pleural dome downwards and medially towards, but stopping short of, the right pulmonary hilum. Its inferior limit may be visible as a circular density some of which is the azygos vein. Lung lies medial to the azygos fissure. This is one " azygos " lobe, but is no more than a part of the right upper lobe and does not have its own individual artery, vein or bronchus. Azygos means unpaired, and the lung medial to the " cardiac " fissure is also sometimes called an azygos lobe.

Incomplete fissures may be found between the apical segments of the lower lobes and the adjacent basal segments, between the lingular segment and the rest of the left upper lobe, and occasionally elsewhere. These fissures are rarely confidently recognised radiographically.

A chest radiograph must include the whole of the chest, and, in the interpretation of all chest films, cognisance must be taken of the skeleton, the extra-thoracic soft tissues, the diaphragm, cardiophrenic and costo-phrenic angles, the mediastinum, including the heart, great vessels and trachea, and the lung fields. When an obvious abnormality is recognised at first sight on a chest radiograph it is common for the student to look at the rest of the film without seeing anything.

Descriptive terms used in reporting chest radiographs are usually those in normal daily use and self-explanatory.[1] " Mottling " indicates multiple discrete or semi-confluent shadows, generally less than 5 mm. in diameter. " Miliary " shadows should not exceed 2 mm. in diameter, and an alternative description is fine mottling. " Reticulations " are linear shadows which form a network in the lungs.

Tomography, or layer selection radiography, is a special radiographic technique in which a series of radiographs, made at measured depths, is provided, on which structures at a particular depth are in sharp focus while closer and more distant structures are out of focus to such a degree that they do not cast a recognisable shadow. Tomographic " cuts " are numbered—antero-posterior tomographs usually from behind forwards, and lateral tomographs usually from the lateral chest wall, medially—and the cuts are usually made at intervals of one centimetre.

[1] Memorandum 323/Med., London: H.M. Stationery Office, 1952.