BRITISH MEDICAL JOURNAL

LONDON SATURDAY NOVEMBER 9 1940

INTERPRETATION OF LATERAL RADIOGRAPHS OF THE CHEST WITH SPECIAL REFERENCE TO TUBERCULOSIS IN CHILDHOOD

BY

STEFAN ENGEL, M.D.

AND

G. GREGORY KAYNE, M.D., M.R.C.P., D.P.H.

Tuberculosis Medical Officer, Middlesex County Council

Radiography is essential in the diagnosis of pulmonary tuberculosis in children, in whom the common lesions are those of the primary infection with predominant involvement of the bronchial glands. The object of this paper is to inquire into the anatomical basis of such radiological examinations, with special reference to lateral radiographs, an aspect of the subject which in our opinion has hitherto been neglected.

Primary tuberculous infection of the lungs is manifested by a primary focus in the lung soon followed by caseation of the bronchial glands. The lung focus remains small as a rule, and is not obvious clinically unless it is surrounded by much perifocal inflammation. On the other hand, the changes in the bronchial glands are conspicuous. At first only those glands are involved which drain the site of the lung focus, but in most children other groups of glands of the same or the opposite side are soon affected. The extent of this tuberculous spread depends chiefly on the age of the child: the younger the child the greater the extent of the involvement (Engel, 1930). This applies to the number as well as to the size of individual glands. Thus in primary tuberculosis the bronchial glands appear to be clinically of greater importance than the pulmonary focus which initiated their diseased condition, and it is therefore the glands which are the main object of investigation when a child is suspected to be suffering from pulmonary tuberculosis.

Radiological examination is an essential step in arriving at such a diagnosis; for the clinical picture is so vague that an accurate diagnosis is almost impossible unless the enlargement of the glands is so enormous that symptoms of mediastinal tumour are present—a rare occurrence; and the tuberculin test, though indispensable, indicates merely a tuberculous focus somewhere in the body. The focus might be recent or obsolete, small or large, in the chest or in the abdomen. But there are obvious difficulties associated with radiological examination of the bronchial glands, due to the deep situation of the glands and their relation to other structures in the chest.

Anatomical Basis of Antero-posterior Radiographs

Studies on the anatomical basis for the radiological diagnosis of diseased bronchial glands have been concerned, on the one hand, with the visibility of normal,

enlarged, and caseous glands, and on the other with their topography in the radiograph. It has been shown that normal glands are invisible on a radiograph, that greatly enlarged glands (due to inflammation or engorgement) may appear as opacities, and that opacities are fairly conspicuous when the glands are caseous. This having been

FIG. 1.—Showing distribution of bronchial glands in relation to the trachea and bronchi (striped) and to the pulmonary artery and its branches (drawn after a cast). 1, right tracheo-bronchial group of glands; 2, right and left bifurcation glands; 3, right lateral hilar glands; 4, left lateral hilar glands; 5, right medial hilar glands; 6, left medial hilar glands; 7, aortic group of glands; 8, ductus arteriosus gland. (In all subsequent figures the above numbering of glands will be used.)

established, the topography of the glands became clearly of moment, and it was studied and reported in detail by one of us elsewhere (Engel, 1926, 1933). The situation of the glands is indicated in the self-explanatory Figs. 1, 2a, 2b, 3a, and 3b. The glands are closely attached

to the bronchial tree, and therefore the situation of the latter in the radiograph is of decisive importance. Unfortunately, in the routine antero-posterior radiograph the main bronchi are invisible owing to their inclusion in the shadow of the heart and vertebra. This applies particularly to children under 4 years of age, in whom the size of the heart relatively to the chest is greater than in older children (compare Figs. 2a and 3a, and 2b and 3b)—a fact all the more unfortunate as enlarged bronchial glands are much commoner in young children. One group of glands are, however, favoured in regard to radiological exploration. The right tracheo-bronchial group of glands, which tend to enlarge more often than other groups even when they do not directly drain the pulmonary focus, protrude towards the lung field just above the hilar shadow (see Figs. 2b and 3b). Hence in the radiograph this group of glands retain their curved outline, which is not interfered with by the structures forming the hilar shadow proper and is rendered the more

FIGS. 2a and 2b.—Showing situation of normal and enlarged glands in relation to trachea and bronchi and the radiological hila (broken line) in a child about 1 year old. (9, right and left paratracheal groups of glands. Numbering of other glands as in Fig. 1.)

FIGS. 3a and 3b.—Showing situation of normal and enlarged glands in relation to trachea and bronchi and the radiological hila (broken line) in a child about 6 years old. (Compare with Figs. 2a and 2b. To identify glands, see caption under Fig. 2a.)

obvious by contrast of the glandular opacity with the surrounding aerated lung tissue. This does not hold good with strictly hilar glands, as these are intimately mixed with the other constituents of the hilum. Hence definitely discernible glandular shadows are rarely seen in the hilar regions, and carefully controlled post-mortem examinations have shown that this may even be the case when there is marked enlargement and caseation of glands. These remarks apply with particular force to the bifurcation gland. This gland is caseous more often and to a greater extent than even the right tracheo-bronchial group of glands, yet owing to its position within the shadow of the heart and vertebra it is not seen in the radiograph, however large and caseated it may be, unless it is massively calcified, when the condition is of little clinical interest.

The obvious limitations of the antero-posterior radiograph in the diagnosis of diseased bronchial glands therefore appear to call for any help that might be obtained from lateral radiographs.

Anatomical Basis of Lateral Radiographs

We have therefore attempted in Figs. 4a, 4b, 5a, and 5b, based on topographical studies of the chest in the literature and on post-mortem investigations (including the construction of many bronchial casts) of one of us (Engel, 1933), to present diagrammatically the situation of the bronchial glands in relation to neighbouring structures, from both the right and the left side. The bronchial tree and the pulmonary artery with its branches are seen much less clearly in the lateral than in the antero-posterior view; for in the lateral view the depth of structures traversed by the rays is relatively much greater than in the antero-

FIGS. 4a and 4b.—Showing situation of glands (numbering as in Fig. 1) in relation to trachea and bronchi, pulmonary artery, and pulmonary veins, as seen laterally, from the right (Fig. 4a) and the left side (Fig. 4b). (a, trachea; b, aorta; c, carina; d, pulmonary artery; e, pulmonary veins; f and g, interlobar septa.)

FIGS. 5a and 5b.—Showing situation of glands (numbering as in Fig. 1) in relation to the trachea and bronchi alone, as seen laterally from the right (Fig. 5a) and the left side (Fig. 5b).

posterior view, the structures are crowded together in a smaller space, and there is much overlapping. The glands are anatomically connected with the pulmonary artery (see Figs. 4a and 4b), and they appear as anterior and posterior groups. This fact is of little importance in connexion with antero-posterior radiographs, in which the two groups cannot be singled out, but it might be useful in identifying individual opacities in lateral ones. Unfortunately the whole length of the pulmonary artery is not visible in lateral radiographs, so that in practice it is of little use for orientation. The trachea, on the other hand, can be made out distinctly in lateral radiographs. Figs. 5a and 5b have therefore been drawn to show the glands in relation to the bronchial tree alone. The bifurcation gland, which could not be shown in Figs. 4a and 4b, now comes into view. It will be recalled that it can in no circumstances (except when massively calcified) be seen in the antero-posterior radiograph. The aorta and pulmonary arteries may produce opacities which can cause confusion in the interpretation of lateral radiographs (see below).

Discussion

The above anatomical data will be found useful in interpreting lateral radiographs because they indicate exactly where to look for opacities, and render possible more accurate interpretation of shadows in situations that do not accord with these data. Lack of this knowledge is apt to cause bewilderment in interpreting lateral radiographs, particularly as both sides of the chest are projected on to the same plane (the side nearest to the film plays, however, a predominant part in the formation of the resultant picture).

The topographical orientation depends on the visibility of the trachea. (See Figs. 6a and 6b. These are contact diagrams, reduced for reproduction, of a right and a left lateral radiograph respectively. Normal-sized glands have been drawn in the situations determined by the

FIG. 6a.

FIG. 6b.

FIG. 7.

Figs. 6a and 6b.—A, shadow thrown by aorta; P, situation of shadow sometimes thrown by pulmonary artery; B, openings of main bronchi. (Numbering as in Fig. 1.)

FIG. 7.—The shadow of a lesion anywhere in the lungs within the dotted areas will in an antero-posterior film be included in the hilar shadow.

anatomically constructed figures 4a, 4b, 5a, and 5b.) The trachea is clearly recognizable in most films. The end of the bright stripe which it produces corresponds to the carina; the narrower continuation of it, corresponding to the main bronchus, is often also seen. The shadows thrown by the edge of each scapula must be recognized and differentiated from the shadows caused by the walls of the trachea. The situation of the different glands can now be determined (see Figs. 6a and 6b). Additional help may be provided by a shadow commonly produced by the arch of the aorta, and by one occasionally formed by the main branches of the pulmonary artery. That due to the pulmonary artery (Fig. 6a, P) is situated in front of the bifurcation of the trachea. That due to the aorta tends to be triangular in shape with its base on the posterior wall of the trachea; it is as a rule better seen in right than in left lateral films (A in Figs. 6a and 6b; see also Figs. 8b, 9b, 10b, and 11b). Both opacities are sometimes mistaken for those due to enlarged glands, especially that due to the aorta. It should be stressed that in this situation no glands exist.

The general opacities caused by the hilar regions cover each other in the lateral radiograph. To term the hilar region as a whole pathologically dense a greater degree

of density of the hilar region must therefore be demanded of a lateral than of an antero-posterior film.

In interpreting radiographs of children suspected to be suffering from pulmonary tuberculosis much critical care is required; otherwise misinterpretation is inevitable. The enlarged hilar shadow is only relatively rarely due to tuberculous glands. (This depends, however, on the material investigated—on whether, for instance, it consists of children in a general out-patient clinic or those in a contact clinic.) Only shadows with fairly definite outlines and, above all, in situations topographically in accordance with the sites of typical groups of bronchial glands should be considered glandular opacities; whether they are tuberculous or not should then be determined.

Assistance from the use of lateral films may be derived in the following circumstances:

1. An antero-posterior radiograph may be considered as within normal limits; a lateral radiograph may, however, show markedly enlarged hilar glands.

2. An antero-posterior radiograph shows suspicious enlargement of a hilar shadow, or a definite enlarged hilar shadow or shadows, or a vague shadow extending from

the hilum into the lower zone of the lung field. A lateral radiograph may detect (a) much-enlarged hilar glands; (b) a parenchymatous lesion in the plane of the hilar shadow (see Fig. 7 to discover how this is caused); (c) a lesion of the middle lobe (consolidation or collapse), with or without involvement of the hilar glands; (d) an interlobar lesion (effusion or much-thickened interlobar septum); (e) a primary lung focus in addition to enlarged hilar glands, thus confirming the primary character of the tuberculous lesion. (This is of particular importance at the present time in connexion with adolescents owing to the increased incidence of primary infections among them.)

3. Although calcified foci by themselves are of no clinical importance a lateral film, when it shows calcified hilar glands or a calcified lung focus not seen in an antero-posterior film, may confirm the primary character of a lesion seen in an antero-posterior film some months or weeks previously.

4. Interlobar pleurisy is a common accompaniment of glandular tuberculosis, particularly because the primary lung focus is generally situated close to the pleural surface. The septum between the upper and middle lobes is the only one that shows in an antero-posterior radiograph. The septum separating the upper or middle from the lower lobe is seen only in the lateral radiograph, and thickening of these septa or interlobar effusions are clearly seen. The latter two changes may be the only indications of a recent active primary tuberculous process.

The cases illustrated by Figs. 8a to 11b (among others which cannot be quoted for lack of space) demonstrate the assistance that was derived from the use of lateral

films in regard to some of the points indicated above. To lessen the expense of reproduction, contact drawings (reduced in size) are given for the cases; the opacities

FIGS. 8a and 8b.—Case 1. A girl aged 4. Father has advanced P.T.; contact broken three months before. Slight cough. Tuberculin test positive. Antero-posterior radiograph within normal limits; lateral film shows mass of enlarged hilar glands. A lateral film taken six months later showed calcified foci only and a thickened interlobar septum.

FIGS. 11a and 11b.—Case 4. A boy aged 3. Mother has advanced P.T.; brother also has P.T. No symptoms. Tuberculin test positive. Antero-posterior film shows enlargement of both hilar shadows with shadowing in the medial part of left lower zone. A lateral film shows enlarged gland and collapse of middle lobe, presumably due to pressure on bronchus. After nine months' treatment in sanatorium a lateral film shows only calcified glands and re-expansion of lobe.

FIGS. 9a and 9b.—Case 2. A boy aged 11. Father has P.T.; sputum positive. No symptoms. Tuberculin test positive. Antero-posterior film shows prominent lung markings in area above and to the right of the left hilum with two or three small calcified foci. The lateral film shows clearly the calcifying primary pulmonary focus (L) and the various enlarged hilar glands.

FIGS. 10a and 10b.—Case 3. A boy aged 5. No contact known. Mantoux test negative. Suffers from bronchial asthma. Antero-posterior film shows general enlargement of hilar shadows; lateral film shows enlargement of hilar glands (non-tuberculous) and partial collapse of middle lobe. A lateral film taken two months later shows re-expansion of lobe; enlargement of hilar shadows in the antero-posterior film no longer seen. Collapse of lobe presumably due to blockage by secretion of bronchus during a bronchial attack which also caused enlargement of hilar glands.

produced by enlarged glands are shown in black, but the latter does not represent the actual shading of the shadows thrown by the glands.

Summary and Conclusions

The bronchial glands are all-important in the clinical recognition of pulmonary tuberculosis in childhood. Radiological examination of the chest is the most important diagnostic method for the detection of enlarged bronchial glands, particularly in connexion with tuberculosis in childhood. This holds good only if the radiographs are technically satisfactory and are interpreted with caution and due regard to the topography of the bronchial glands, in both the antero-posterior and the lateral view. The help to be obtained from antero-posterior radiographs is limited, and can often be supplemented by the use of lateral radiographs. The anatomical basis for such radiographs is studied in this paper, and the interpretation and help derived from lateral films on this basis are illustrated by case reports.

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H. T. GROSS (*J. Kansas med. Soc.*, 1940, **41**, 329) records thirteen cases of erysipeloid which occurred between March, 1936, and March, 1939, inclusive among veterinary students at Kansas State College. All save two gave a history of very recent trauma associated with their work. Except for one lesion on the right forearm, all infections occurred on the hands and fingers, involving the right hand in seven and the left in five, and all the lesions had a characteristic appearance. Lymphangitis and lymphadenitis occurred in all but three cases. There were no characteristic reactions of importance. The highest temperature recorded was 100.4°. The leucocyte count never exceeded 10,000. An eosinophilia from 1 to 5% was observed in six cases. The incubation period in eleven cases averaged four days. All recovered with conservative treatment. Except in one case, in which it was thirty-three days, the average duration of the disease was fifteen days.