FURTHER EXPERIENCES WITH TOMOGRAPHY IN PULMONARY TUBERCULOSIS

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(WITH SPECIAL PLATE)

The theory of tomography, and the principles governing this method of taking x-ray pictures of a section of an organ, have been described in several papers (McDougall, 1936, 1937; McDougall and Crawford, 1937), and the present position has been well summarized in a leading article in the *British Medical Journal* (1937). The value of tomography in cases of pulmonary disease is now fully recognized, and with the elaboration and perfection of relatively simple apparatus this method of investigation is likely to enjoy an increasing popularity.

Technique of Tomography

We have continued to use the Sanitas machine as devised by Grossmann (1935), and since March, 1936, when we first began to use tomography at Preston Hall, nearly 400 patients have been investigated by this method. Grossmann's tomograph has been criticized as expensive, but the quality of the pictures is excellent, and post-mortem confirmation of the appearances of the lesion at different sections has been obtained; these afford complete proof of the general accuracy of the apparatus. Furthermore, the resultant films seem to us to present a greater degree of contrast, a more complete obliteration of unwanted shadows, and a more sharply outlined general detail than are usually obtained with simpler apparatus. Nevertheless, we agree that elaborate and costly apparatus is not essential for tomography, and Twining (1937) and Colyer (1937), working independently in this country, and Ziedses des Plantes (1932) in Holland, have all shown that simple attachments to an ordinary x-ray machine can successfully fulfil the requirements necessary for the production of tomograms.

In Grossmann's tomograph the tube and the Potter-Bucky film holder are attached to opposite ends of a pendulum, and in taking a photograph the tube describes an arc, the extent of which can be controlled. The axis in which the pendulum swings can be brought opposite any desired plane in the patient's body, and it is only objects on this particular plane which are sharply defined on the film. The geometrical principles have already been fully outlined in the papers referred to above; further details need not be discussed here.

Twining realized that an ordinary Potter-Bucky couch, embodying as it does two convenient mechanisms—namely, (1) a column capable of moving parallel to the couch, and (2) a Potter-Bucky film carrier moving along the long axis of the couch—was easily adaptable for tomography. By connecting the tube carrier and film carrier by a suitable lever he obtained the movement required—namely, proportional and opposite movement of the film. In this method, as with Grossmann's tomograph, the patient lies in the recumbent position, but in Colyer's adaptation the tube and film carrier move in a vertical instead of a horizontal plane, and thus the patient

can be photographed in the upright position. It is claimed that with this technique the upper limit of a pleural effusion or the line of a fluid level in a cavity is not obliterated.

Clinically, the widest application of tomography has been in the field of obscure pulmonary lesions, but whilst our own work has been almost entirely limited to cases of pulmonary tuberculosis, valuable information can be obtained by the use of this method in many other regions of the body. Twining has found it of considerable value in certain bone work—for example, the radiology of thin cancellous bones which are obscured by denser structures: the patella, sternum, and sternoclavicular joint, temporo-mandibular joint, zygoma, and cribriform plate, the atlas and axis. In addition the larynx, the pharynx, and the nasal cavity can all be investigated by tomography, and more precise information be obtained than by ordinary radiography.

Descriptive Cases

The cases to be described are offered as a further example of the value of the tomograph in the elucidation and localization of cavities, and the more precise analysis and interpretation of complicated fibrotic disease. A full discussion on the clinical value of tomography has already appeared in the *Proceedings of the Royal Society of Medicine* (1938), and readers are referred to this for further details.

CASE I

A patient aged 48, with a four-years history of pulmonary tuberculosis. Fig. 1A is the ordinary radiograph of the chest; the lesion is seen to be fibrotic in type and bilateral in distribution. The right lung appears to contain old-standing fibro-cavernous disease of the upper zone, with an area of recent infiltration in the lower zone; the dome of the diaphragm on this side is peaked and adherent, and the costo-phrenic angle is obliterated. The left lung shows chronic infiltration over the upper two-thirds, while the lower zone is emphysematous, the diaphragm here being sharply outlined.

Fig. 1B is a tomogram taken at a level of only 5 cm. from the back of the chest. On the right side two air loculi are now apparent over the upper and middle zones, being separated by a band of fibrous tissue at approximately the level of the interlobar fissure. Close to the mediastinum, in the inner part of the upper lobe, is a well-defined cavity, and in the lower lobe diffuse infiltrative disease is present. The left lung shows generalized fibrotic disease with a well-defined cavity in the mid-zone (which was not apparent on the ordinary film).

We feel that in this case the antero-posterior film gave an entirely incomplete picture of the actual pathological features of the lesion, and in view of the fact that the physical signs in this case were most indefinite, the existence of the spontaneous pneumothorax on the right side must have remained unsuspected in the absence of tomography. The presence of the spontaneous pneumothorax was later confirmed by inserting a pneumothorax needle, when a slightly positive pressure reading was obtained. A thoracoscopy was advised to determine the state of the collapsed portion of lung, but unfortunately the patient refused this investigation.

The entire series of tomograms in this case (not shown here for reasons of space), taken at intervals of 2 cm. from the front to the back of the chest, illustrated very beautifully the gradual appearance of the pneumothorax from the level of the plane of the lung root to the level of the paravertebral sulcus, and also indicated the genesis of the cavity shown in the left mid-zone on the tomogram. The topography of the lesion was thus demon-

strated in a way that we have never been able to equal by any other method of radiological investigation, including lateral, stereoscopic, and oblique films. In this particular case the main lesion was found to be situated in the deeper portions of the lung tissue: this finding has been borne out so often in other patients investigated by us that it would appear that the majority of tuberculous lesions in the lung begin at the back and extend by advancing into the anterior sections. Hence it may often occur that ventral tomograms fail to reveal any evidence of disease, while the dorsal sections may indicate extensive lesions.

CASE II

This patient, aged 30, was admitted with a two-and-a-half-years history of pulmonary tuberculosis. Fig. 2A is the ordinary radiograph of the chest taken on admission. On the *right* side the apex is seen to be cramped and fibrosed, with some "hard" infiltration in the infraclavicular zone. Over the lower zone, in the inner half of the lung field, is a ring shadow; just above the diaphragm the appearance is suggestive of bronchiectasis. The diaphragm itself is well raised, but the patient had not had a phrenic operation. On the *left* side the apex is also cramped, and the upper and middle zones show some increase in the normal striation, but no definite infiltrative disease.

Fig. 2B is the tomogram of this patient taken 5 cm. from the back of the chest; a very large cavity in the right lower lobe is now quite obvious, with small "daughter cavities" at its lower pole.

CASE III

This patient was 18 years old, and had a history of only six months' duration. Fig. 3A, the ordinary radiograph taken in the erect position, reveals a very large cavity occupying the whole of the *left* upper lobe and showing a fluid level; below this is considerable mottling and infiltration. The *right* lung shows fine mottling over the infraclavicular zone, and suggests a recent exudative spread from the main lesion.

Fig. 3B is a *lateral* tomogram taken of the left lung in the plane of the mid-clavicular line; the upper lobe cavity is now seen to occupy almost the entire depth of the lung from front to back. A second cavity is also visible below the large one, and appears to be lying in the paravertebral sulcus close to the bodies of the vertebrae. This second cavity was not seen on the ordinary type of lateral film which was taken in this case, no doubt being obscured by the dense shadow of the vertebral column.

CASE IV

A young man aged 20 was admitted with a three-months history of chest symptoms. His general condition was good and his sputum negative. The ordinary radiograph, shown in Fig. 4A, revealed, on the *left* side, slight infiltration at the apex and more definite infiltration over the mid-zone. The *right* side appears a little hazy, but shows no definite lesion. His blood sedimentation rate was normal and his physical signs were scanty and indefinite; in view of these findings surgical treatment was not contemplated, but to be completely certain of the extent and nature of the infiltration on the left side tomographic investigation was carried out.

Fig. 4B is the median tomogram in this case, taken midway between the front and back of the chest; in the mid-zone of the left lung can be clearly seen a fairly large, well-defined cavity with a good deal of pericavernous infiltration. The right lung is clear.

This cavity was quite obscured on the ordinary film, and a further interesting point in Case IV is that the cavity was revealed in the median section only, and was entirely missed on a preliminary series of films which were taken, thus indicating the great importance of careful "sectioning" in cases with an early lesion.

Because of the tomograph findings, repeated cultural examinations of the sputum were done, and the third specimen cultured on Löwenstein's medium proved to be

positive. Meanwhile an artificial pneumothorax had been attempted on the left side, but the pleura was found to be adherent and the induction failed. A left phrenic crush was subsequently carried out, and after five months (during which time he was also at rest) tomography confirmed that the cavity had closed, leaving only a small fibrotic patch. His sputum is now repeatedly negative to culture and the patient has returned to full work.

Conclusions

In view of the many exhaustive papers that have already been published on the additional information given by tomography in the investigation of pulmonary lesions, we have not gone into the discussions of the cases presented here in any great detail, preferring to allow the films to demonstrate for themselves the greater detail and clarity with which a lesion is revealed. A practical point we would stress is that when a large series of tomograms has been taken on an individual patient the films should be placed together on a sufficient number of viewing screens in order that they may be seen *simultaneously*; in this way the gradual change in the distribution of a lesion is emphatically brought out. The method of successive scrutiny of single tomograms on one viewing screen is quite inadequate for the correct assessment of the series as a whole.

We feel that not the least advantage of tomography is the added impetus it gives one to reconsider old problems in a new light, and to delve into the difficulties of the "pathology of the living," to use the late Lord Moynihan's phrase.

It is true that up to the present we have concentrated mainly on the formation and localization of cavities, and the exact determination of the precise area of lung tissue involved by gross disease. But in these days, with the surgical closure of cavities playing an increasingly important part in the treatment of phthisis, it is essential to adopt a more scientific approach to this particular problem than is possible with ordinary methods of radiology of the chest. With very dense lesions, or lesions of homogeneous densities, stereoscopic films are valueless, and with lesions above the clavicle lateral films often fail to be of assistance. But if cavities are to be closed with a minimum of trauma to the patient and a maximum of efficacy, it is essential to know beyond all doubt the *exact* site and extent of the cavities. From the description of the cases given it is obvious that of all the elements of a tuberculous lesion that comprising a cavity system is revealed most clearly by tomography, and we therefore feel that no apology is needed for stressing the value of this mode of investigation for all patients about to undergo a major thoracic operation.

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The London Spectacle Mission, which since 1885 has supplied spectacles to deserving poor persons, is now incorporated with the Royal Surgical Aid Society, which has lately celebrated its jubilee. Nearly 2,000,000 sufferers have been supplied with artificial limbs and other surgical aids through this charitable organization, and now spectacles are added to the many other boons it can bestow.

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FIG. 1A.—Ordinary radiograph of chest of Case I. Lesion fibrotic and bilateral.

FIG. 1B.—Tomogram of Case I taken at level of 5 cm. from back of chest.

FIG. 2A.—Ordinary radiograph of chest of Case II.

FIG. 2B.—Tomogram of Case II taken 5 cm. from back of chest. Large cavity in right lower lobe now obvious.

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FIG. 3A.—Ordinary radiograph of Case III taken in the erect position.

FIG. 3B.—Lateral tomogram of the left lung of Case III taken in the plane of the mid-clavicular line.

FIG. 4A.—Ordinary radiograph of Case IV.

FIG. 4B.—Median tomogram of Case IV, taken midway between front and back of chest.