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OBSTRUCTIVE SHADOW OF RIBS IMAGED ON THE AXIAL TRANSVERSE TOMOGRAM OF THE CHEST

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ABSTRACTS

In order to take an axial transverse tomogram having few obstructive shadows, the phantom and human experiment were perfomed and studied.

Thorax cage phantom composed of ribs made of lead wire was laid on the table of axial transverse tomograph of horizontal type and the axial transverse tomograms were taken with the central X-ray of caudalocranial or craniocaudal direction with the range of rotation of 180°, rotating from the right, front and left side of the body.

Obstructive shadow arose mostly when projected caudalocranial direction of central X-ray, while fairly few when taken with craniocaudal direction.

With exposure of full rotation of 360°, the obstructive shadow was more faint than the above two.

This was confirmed also with the human experiment.

When the axial transverse tomogram of the chest is taken, the obstructive shadows of the rib are imaged at times on the lung field and desturb correct interpretation. In order to take tomograms having few such shadows the studies of the optimal range of rotation of the X-ray tube around the human body and the angle of the central X-ray to the ribs at the tomography were made with phantom and human body experiments.

1. EXPERIMENTS WITH A PHANTOM

For this experiment the presentaions of the problem are as follows: 1) is there any difference of the appearance of obstructive shadows between the tomography conducted with the range of rotation of 180° and that of 360°? 2) does the angle of inclination of the ribs to the horizon influence on the grades of appearance of these shadows?

An axial transverse tomograph of the erect type (Shimadzu)[1)2)] was used for the experiments, with the phantom to be radiographed placed on a rotating table in the erect position. The distance of X-ray tube, phantom and film were so arranged as to produce an X-ray image 1.27 times the actual size. The

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radiography conditions were 65 kV, 3.8 mA and 8 seconds for the range of rotation of 360°, while 65 kV, 7.5 mA and 4 seconds for that of 180°.

A lead wire of 2 mm in diameter was curved to be an ellipse of 6×4 cm of which shape was made similar to the human ribs attached to a certain vertebral body.

The curvature of the rib was illustrated in Fig. 1 (d, d′, d″). The plane containing the rib in the phantom was made to incline 10° (Fig. 1, d and d″) and 30° to the horizon (Fig. 1, d′). The vertebral body stood vertically on the rotation table. Axial transverse tomography was conducted so as the cross section of the ribs was imaged 1/3 distant from the vertebra.

Axial transverse tomography was conducted with the range of rotation of 0° to 180°, with the directions of X-rays to the phantom of the body to be dextrosinistral, anteroposterior then sinistrodextral. Such a mode of rotation was termed anterior axial transverse tomography with rotation of 180°, for short, anterior axial transverse tomography 180°. When this was conducted sinistrodextrally, posteroanteriorly, and dextrosinistrally, it was termed posterior axial transverse tomography 180°.

In axial transverse tomography with full rotation of 360° the phantom was exposed with the direction of X-ray to the body in the order of the right, front, left, back and right of the phantom.

Experimental results

The appearance of the obstructive shadows on the axial transverse tomograms taken by anterior axial transverse tomography 180° (Fig. 1, a and a′) differed completely from that by posterior axial transverse tomography 180° (Fig. 1, b and b′). In the latter case density of the obstructive shadow was much more higher than that in the former cases. Rotation through 360° produced obstructive shadows composed of those made by rotation of 180° anteriorly and posteriorly (Fig. 1, c and c′). The density of the obstructive shadow in this case was lower than that of anterior or posterior axial tansverse tomography 180°.

The obstructive shadows in anterior axial transverse tomography 180° were imaged as two groups, anterior and posterior, of 2 band shadows. The anterior group superimposed to the image of the lung field but the density was low resulting harmless to interpretation. The posterior shadows of the posterior group disturbed the correct interpretation of the radiogram as the shadow produced a comma shape bulging to the back with relatively high density which disturbed the proper interpretation of the posterior mediastinal septum (Fig. 1, a and a″).

In case of posterior axial transverse tomography 180° (Fig, 1, b and b′), the obstructive shadows appeared more densely than anterior axial transverse

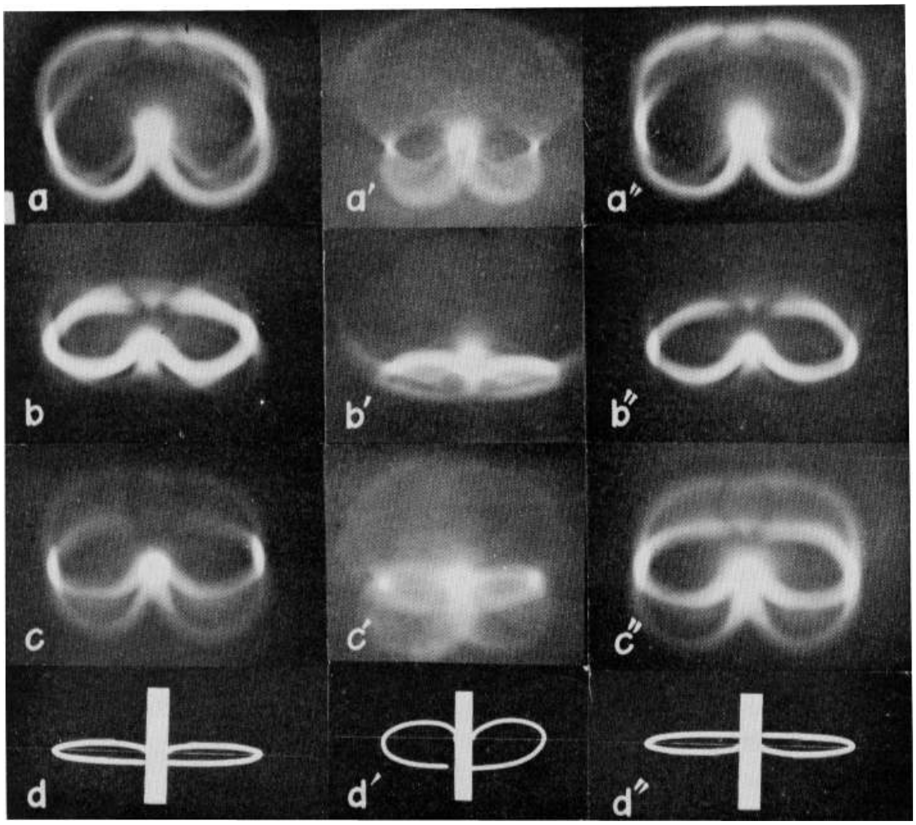

FIG. 1. Obstructive shadow formation in axial transverse tomography applied to the cage of the chest. The cage of chest with the ribs mape of wire were placed erect on the rotation table with inclination of the ribs of 10°. Angle of the plane containing the rib at the sternum to horizon was 10° as shown in figure d, 30° in figure d′, and that of the rib at posterior portion (near costovertebral joint), 10° in figure d″. Figures a, b, a′, b′, a″ and b,′ are taken by rotation of the chest with range of 180°, while figures c, c′ and c″ are that of 360°. Obstructive shadows of c, c′ and c″ are more faint as compared with that of the remaining, because the former is a superimpositition of the latter respectively. Obstructive shadow of a is similar to that of a″, although mode of rotation is different as shown in Fig. 2. Obstructive shadow a is formed by the X-ray tube A, while that of a″ by the B′.

tomography 180°, and their invasion into the lung field induced frequently errors in interpretation.

Appearances of obstructive shadows differed when the inclinations of the ribs to the horizon were 10° (Fig. 1, a, b, c, d) or 30° (Fig. 1, a′, b′, c′, d′).

With an inclination of 10° (Fig. 1, b), the occurance of the obstructive shadow was more frequent than that when the inclination was 30° (Fig. 1, b′). This was common to both of anterior axial transverse tomography 180° and posterior axial transverse tomography 180°. The shadows were more dense in the former than the latter.

In posterior axial transverse tomography 180° obstructive shadows including the transverse section images of the ribs and that of the vertebra bulged posteriorly when the inclination of the rib was 10° (Fig. 1, b). The obstructive shadow imaged with the shape of comma to the anterior aspect when the inclination of the rib was 30° (Fig. 1, b').

With the rib inclined 10° to the horizon, the obstructive shadow was seen along the entire rib (Fig. 1, a, b, c), while with an inclination of 30° the obstructive shadows, though imaged, became fainter than that of the former, and faded out, resulting almost undiscernible (Fig. 1, a', b', c').

With the phantom an examination was made to find whether or not the production of obstructive shadows differed when the direction of the central X-ray beam was changed, between anterior axial transverse tomography 180° and posterior axial transverse tomography 180°. To test the phantom placed ordinarily and upside down on the rotating table, and tomography was made. The results revealed that the production of obstructive shadows was approximately equal in the case of anterior axial transverse tomography 180° in the ordinary position of the body (Fig. 1, a and Fig. 2, A, F_A) and posterior axial transverse tomography 180° with the phantom in the upside down position (Fig. 1, a'' and Fig. 2, B', $F_{B'}$).

2. HUMAN EXPERIMENT

Above experiment was to find the reasonable technique for minimum pro-

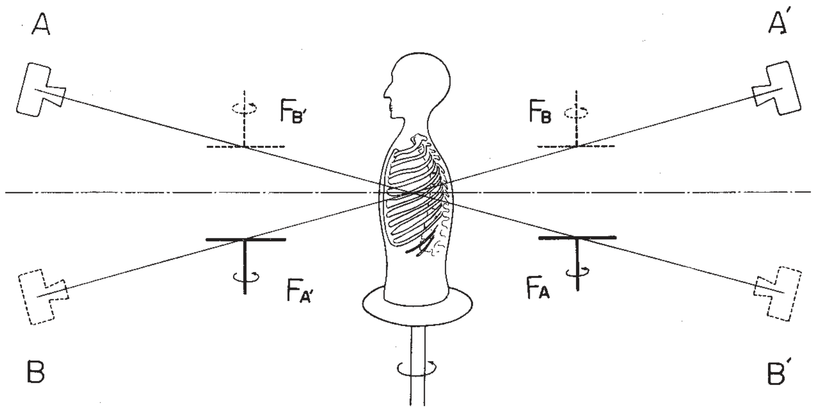

FIG. 2. Schematic illustration of the position of the X-ray tube and the model of the ribs.

A, A', B and B': X-ray tube. F_A, F_A': film on the rotation table (orbinary position). F_B, F_B': film on the rotation table (upside down) duction of obstructive shadows by comparing results obtained by rotation of 180° anteriorly, that of 180° posteriorly or through the entire 360°.

The human experiment was then made. For radiography of human subjects an axial transverse tomograph of the horizontal type (Toshiba)[3)4)] was used. The subject was made to lie still on the radiography table, while the X-ray tube and film are rotated around the subject.

The X-ray image was magnified 1.24 times the original. The inclination angle of central X-ray to the film was 20°.

The exposure conditions for chest radiography were: with tube rotation from 0° to 360°, 120 kV, 3 mA and 15 seconds, while with tube rotation of 220°, 120 kV, 6 mA and 8 seconds. The head was positioned so as to be the craniocaudal direction of the central X-rays. Breathing was asked to hold during radiography. For the range of rotation of 220° two ways of radiography, anterior axial transverse tomography 220° and posterior axial transverse tomography 220° (Fig. 2, A′) were conducted.

In human experiments the appearance of obstructive shadows in anterior axial transverse tomography 220° (Fig. 3) was much less than the posterior axial transverse tomography 220° (Fig. 4), while with complete rotation through 360° no obstructive shadows appeared (Fig. 5).

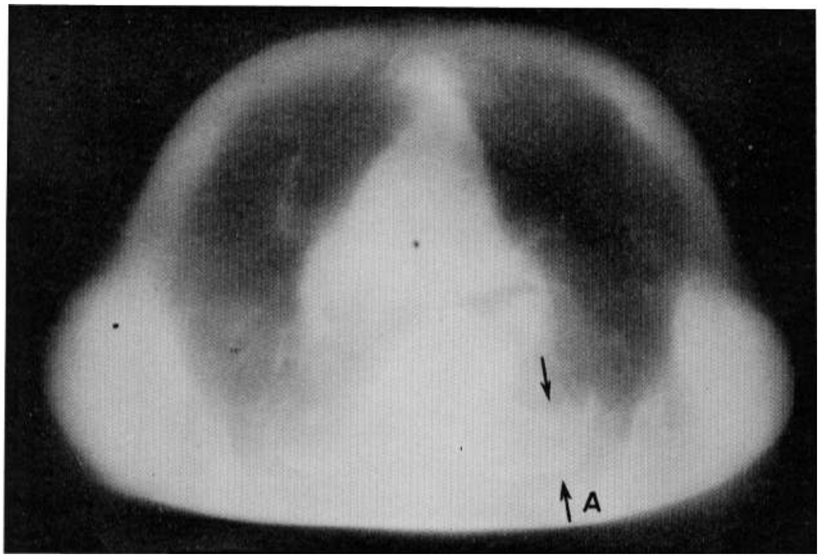

FIG. 3. Axial transverse tomogram taken with the central X-ray of craniocaudal direction. Range of rotation of X-ray tube was anterior 220° and the inclination angle of central X-ray to film 20°. Obstructive shadow does not so much disturb correct interpretation.

A: Obstructive shadow directed to the front.

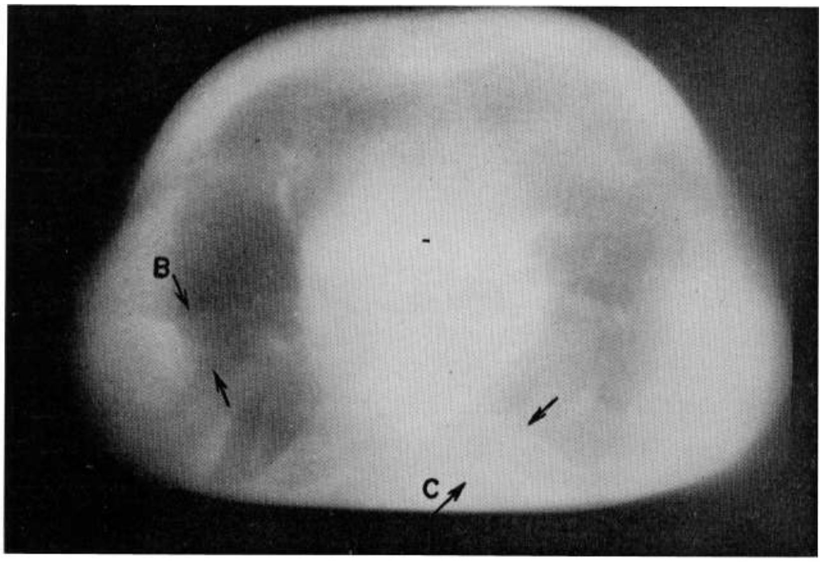

FIG. 4. Axial trasverse tomogram taken with the central X-ray of craniocaudal direction. Range of rotation of X-ray tube was posterior 220°.

Obstructive shadow disturbs correct interpretation.

B: Obstructive shadow invasing lung field.

C: Obstructive shadow directed to the back.

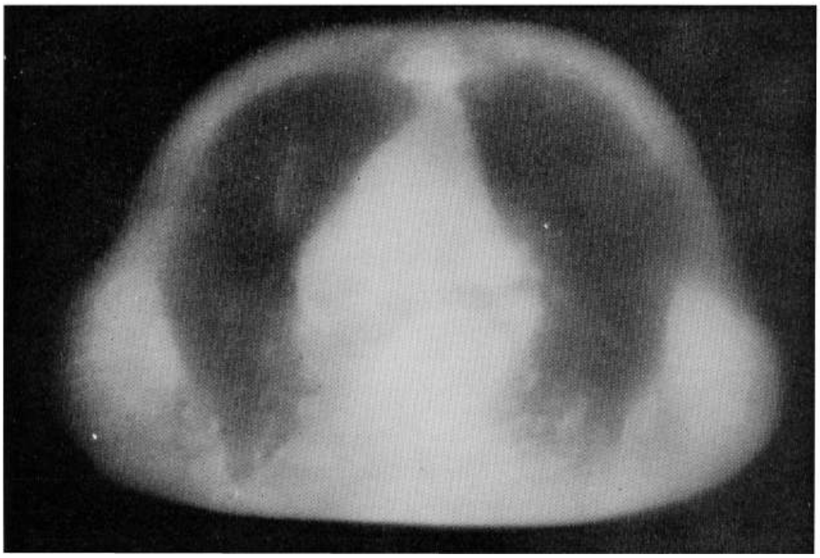

Fig. 5. Axial transverse tomogram taken with full rotation of X-ray tuhe. Obstructive shadow is not imaged.

Although in the upper chest the inclination of the ribs was smaller than that in the lower chest, the mode of occurrence of the obstructive shadows were similar to those noted in phantom experiments.

DISCUSSION

Obstructive shadows present an important problem in tomography as well as in axial transverse tomography, as they plays a role of difficulties for correct interpretation. Obstructive shadows in transverse tomography appear most in radiography of the chest, but few literature on the solution of this is available[5)6)]. An attempt was therefore made to study this problem. The reasons for employing an erect type of apparatus in phantom experiments and that of the horizontal type in human experiments lie in the entirely identical principles of the two. In case of human experiments the body has to lie to be taken the axial transverse tomography of any part of the body and hence a horizontal type was used, and as this type of tomograph was convenient for application to the patient.

The range of rotation was 180° for the phantom and 220° for human experiments, but the difference obtained is considered none for analysing the mechanism of blurring of the image.

The phantom was made of lead for the rib, as it was considered that the greater the absorption of X-rays, the more markedly the obstructive shadows will appear. The phantom was made as similar as possible to that of actual ribs, while the curve of the course of the rib were placed on a plane in order to facilitate analysis of the image.

Geometrically considered, points not contained in the transverse section to be tomographed are blurred off by drawing circles[7)−12)]. When the object tomographed was a line composed of substances with strong X-ray absorption and slant to the horizontal with smaller angle than the inclination angle of the X-ray tube, the two crossing lines, enveloping these circles of blurred points on the line, get greater densities and will be seen as the obstructive shadows. The above were confirmed by the present experiments.

Thus the obstructive shadows in the lung field of the human body were found to be derived from the ribs.

Thus, when taking axial transverse tomography of the chest in supine position the X-ray beams should be directed from the head to the foot in order to decrease the appearance of obstructive shadows, while these shadows will be decreased as well, when the tube is rotated through 360° than through 220°. To conduct axial transverse tomography by the rotation of X-ray tube from 0° to 220°, it is more convenient for setting up, as the capacity of the tomography room is usually limited. However, if the knowledge of occurance of obstructive shadows is obtained, it is possible in practice to avoid difficulties in interpretation even axial transverse tomography taken by rotation of X-ray tube in the range of 0° to 220°.

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