Angiocardiographic Findings in Pulmonary Tuberculosis*

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Earlier reports have recorded preliminary angiocardiographic studies in pulmonary tuberculosis. The purpose of this paper is to summarize the angiocardiographic experience in patients with pulmonary, hilar and mediastinal tuberculosis studied over a 14 year period. Knowledge of the status of the vascular supply to the lung affected by tuberculosis is of considerable importance, for the efficiency of the vascular supply bears a direct relationship to the efficiency of respiration. The effect of alteration in pulmonary circulation on the healing of tuberculosis may be significant as the tubercle bacillus has been shown to be an obligate aerobe requiring comparatively large amounts of oxygen for life and growth. It is conceivable that the relative hypoxia resulting from local diminution in circulation could have an adverse effect upon the tubercle bacillus. Diminution in circulation occurring in association with tuberculous lesions has been reported in post mortem pathological studies. These changes have been visualized roentgenographically by the injection of radiopaque substances in autopsy specimens. In the living, Carvalho and his co-workers utilized the cardiac catheter to inject a concentrated solution of sodium iodide. He was able to visualize a diminution in pulmonary vascularity associated with tuberculosis. Angiocardiography is a more practical method of visualization of the circulatory changes in tuberculosis.

Method

For the most part angiocardiography was conducted as originally described using a standard stereo-cassette changer permitting two films per injection. Contrast substance rapidly injected into an antecubital vein passes into the right heart chambers, then to the pulmonary arteries returning via the pulmonary veins into the left heart chambers, finally opacifying the aorta. Roentgenograms were taken at appropriate intervals to best visualize the heart, great blood vessels and lesser circulation.

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In some cases, an automatic roll-film magazine was used enabling roentgen exposures to be made at half-second intervals during the period of opacification. Either Neo-iopax 75 per cent or Diodrast 70 per cent were used as the contrast substance. Neither compound has resulted in activation of tuberculosis or iodism since the iodine is so bound in the organic molecule as to be unavailable to the body. Ninety-one patients with pulmonary, hilar and mediastinal tuberculosis have been studied angiocardiographically. These cases have been classified into groups according to the duration of the disease, the clinical and laboratory findings, the roentgen appearance of the tuberculous lesions and in some, post mortem examination as follows: fibro-cavernous, 49; caseo-cavernous, nine; caseous, eight; fibro-calcific, seven; fibroid, six; hilar and mediastinal lymph node tuberculosis, six; hematogenous (non-miliary), three; miliary, one; and silico-tuberculous, one. Of these 19 were classified as minimal, 46 as moderately advanced and 26 as far advanced pulmonary tuberculosis. Of the total number, at least 39 patients received collapse therapy of one form or another and are included in special reports dealing specifically with the angiocardiographic changes following artificial pneumothorax, thoracoplasty, artificial pneumoperitoneum and phrenic nerve crush.

Interpretation of pulmonary vascular changes was made from comparison of the opacified pulmonary circulation of the diseased and non-diseased portions of the lungs as well as from comparison of serial contrast studies in the same individual. These changes included variations in caliber, degree and rate of filling, position and configuration of the pulmonary arterial tree.

![Figure 1](http://journal.publications.chestnet.org/pdfaccess.ashx?url=/data/journals/chest/21205/ on 06/21/2017)
FIGURE 2 (G.G., No. 523): Pericardial effusion in a 22 year old white woman with hematogenous tuberculosis.—A: Angiocardiogram shows opacification of the right atrium, right ventricle and beginning opacification of the pulmonary artery. Pericardial fluid is demonstrated beyond the right atrium.—B: Tracing of A.

FIGURE 3 (M.K., No. 234): Fibro-cavernous tuberculosis in a 40 year old white man. Angiocardiogram shows abrupt termination in a huge cavity of the apical posterior branch of the left ascending pulmonary artery. The right upper lobe also shows diminished vascularity.
Findings

Diminished vascularity of varying degree occurs in local areas of the lung involved by tuberculosis. This may be seen angiocardiographically by reduced opacification of vessels as illustrated in the ascending branch of the right pulmonary artery in Figure 1 or by absence of opacification, as in the corresponding pulmonary arterial division in Figure 2. Figure 3 shows avascularity of the right upper lobe, while on the left side the posterior-apical segmental pulmonary artery ends abruptly at the site of a large left apical cavity. Marked diminution in caliber and filling of the pulmonary arterial vessels of the right lower lobe is demonstrated in Figure 4. The diminution in vascularity seen in Figure 5 involves both upper lobes. In each instance the decrease in pulmonary vascularity is found to be intimately associated with the tuberculous lesion. This association was a constant finding in this study. Exceptions to this occurred in cases where the tuberculosis was so minimal as not to involve vessels of sufficient caliber to be seen angiocardiographically.

Displacement of the heart and great vessels was commonly found in chronic pulmonary tuberculosis. In Figures 1 and 5, an upward displacement of the right and left pulmonary artery, respectively, is demonstrated. In chronic upper lobe disease this particular
FIGURE 6.1. (A) A: Conventional roentgenogram demonstrates a left mediastinal mass (excluding the diagnosis of pulmonary artery aneurysm) and ascality off the left upper lobe, probably due to obstruction by the tuberculosis. C: Angiocardiogram shows asculation of a normal aorta running out an aortic aneurysm.
change was encountered frequently and was assumed to be secondary to fibrosis and retraction of the involved lobes. As a result of tuberculosis there may occur extensive unilateral pulmonary fibrosis with retraction of the heart, mediastinum, trachea and great vessels into the affected side a condition referred to as "fibrothorax." Thus a homogeneous shadow is formed which on a conventional roentgenogram cannot be differentiated into its components (Figure 6A). Angiocardiography delineates the cardiac chambers and great vessels (Figure 6B and 6C). In this patient the heart had become rotated to the "right anterior oblique" projection. The right pulmonary artery was elongated and distorted while the left pulmonary artery (seen on end) was markedly reduced in caliber. Separation of the pulmonary vessels on the right suggest overdistension of the lung.

In silico-tuberculosis, pulmonary avascularity depends on the degree of parenchymal involvement of the combined disease. In the case studied, pronounced avascularity at the site of extensive silico-tuberculosis was seen. No detectable change in pulmonary vascularity was noted in one case of miliary tuberculosis with a complicating tuberculous pericardial effusion. Two other cases in this series also had tuberculous pericarditis with effusion. Films

FIGURE 5 (H.J., No. 80): Angiocardiogram of a 48 year old man with fibrocalcific tuberculosis of both upper lobes. There is marked avascularity of the upper lobes with elevation of the left pulmonary artery.—RA: right atrium,—RV: right ventricle,—PA: pulmonary artery,—RPA: right pulmonary artery,—LPA: left pulmonary artery.
FIGURE 8. M.S. No. 524. A: Conventional roentgenogram showing retraction of the heart, trachea and mediastinum into the left chest, forming an undifferentiated homogeneous density. B: Angiocardiogram at 1/2 seconds after the beginning of injection of contrast medium into the right pulmonary artery. The pulmonary artery is dilated and the right brachiocephalic vessel is faintly visible. The right side of the chest, a pattern characteristic of overdistension of the right lung. C: Angiocardiogram at 8 seconds after the beginning of injection shows opacification of the left ventricle, aorta and the brachiocephalic vessels.

The image depicts a thoracic film showing retraction of the heart, trachea, and mediastinum into the left chest, forming an undifferentiated homogeneous density. The right pulmonary artery is dilated, and the right brachiocephalic vessel is faintly visible. The right side of the chest shows a pattern characteristic of overdistension, indicating lung disorder.
of these patients were timed so as to opacify the heart chambers. In Figure 7 the border of the right atrium can be seen to be well within the cardiac silhouette. The intervening space represents the right atrial wall and the pericardial fluid surrounding the heart. In a repeat study at a later date this space was absent indicating resorption of the effusion.

Tuberculosis of the mediastinum or hilar area may sometimes simulate a malignant tumor or aneurysm on the conventional roentgenogram. A 32 year old Negro with a recurrent nerve paralysis was found to have a left mediastinal mass which on conventional roentgenography could not be differentiated from an aneurysm or a malignant tumor (Figure 8A). There was no evidence of pulmonary tuberculosis. Angiocardiography revealed a diminution in the blood supply of the left upper lobe in association with the mass (Figure 8B). A film was taken at eight seconds after the injection of contrast substance so as to reveal the left cardiac chambers and aorta (Figure 8C). The mass did not opacify in either film thereby ruling out aneurysm. Subsequent operation and pathological study revealed this to be a mediastinal tuberculoma. Occlusion of the descending pulmonary artery of the right lung by tuberculous hilar lymph nodes was encountered in another case previously reported. In the four other patients with tuberculous hilar and mediastinal lymphadenopathy, no vascular alterations were observed.

FIGURE 7 (M.S., No. 549 474): Fibro-cavernous tuberculosis of the right upper lobe in a 59 year old white woman.—A: Angiocardiogram shows opacification only at the origin of the ascending right pulmonary artery and marked avascularity of the upper lobe.—B: Tracing of A.
Discussion

Pathological studies of pulmonary blood vessels within an extending tuberculous process reveal early extensive thrombosis. The vessel walls become thick and fibrotic. Endarteritis obliterans may completely close the lumen reducing the vessels to thick solid cords in which subsequent organization and cicatrization may take place.\textsuperscript{8-10} The avascularity associated with tuberculous lesions has been demonstrated roentgenographically by injection of radiopaque substances in both animal and human autopsy material.\textsuperscript{11,12} Such post mortem visualization studies also demonstrate a lack of fine pulmonary arterial branching and definite diminution in size of vessels in areas of tuberculous tissue destruction.

The degree of avascularity was found to depend upon the amount of lung tissue involved. The more widespread the parenchymal tissue destruction, the more marked was the avascularity. The influence of these changes on the efficiency of respiration was shown to result in diminished pulmonary function by Cournand and Richards.\textsuperscript{20} No changes in vascularity were noted in diseased areas where the involved vessels were too small to be seen angiocardiographically. This was true where lesions were small and discreet as in the case of miliary tuberculosis. Similarly, Birkelo and Brosius failed to demonstrate vascular changes in miliary tuberculosis by post mortem roentgenographic injection studies.\textsuperscript{13}

Angiocardiography served to delineate the heart chambers and great vessels in fibrothorax, usually showing rotation, displacement and distortion of these structures (Figure 6B and 6C). The displacement of pulmonary arterial trunks secondary to fibrosis and retraction of the disease area has also been visualized (Figures 1 and 5). Cardiac chamber visualization has been utilized to establish the diagnosis of pericardial effusion (Figure 7).\textsuperscript{21} This has proved to be of considerable practical value in patients in whom the clinical, laboratory and roentgenographic findings are not diagnostic.

As illustrated in Figures 8B and 8C, angiocardiography may also demonstrate alterations in pulmonary vascularity caused by enlargement and invasion of tuberculous mediastinal and hilar lymph nodes. Masses in these areas may simulate aneurysm. Angiocardiography is most helpful in ruling out the latter.\textsuperscript{22,23}

SUMMARY

The angiocardiographic findings in 91 tuberculous patients studied during life are presented. Diminished vascularity of varying degrees was found to occur in local areas of the lung involved by tuberculosis. The degree of avascularity depended upon the amount of lung tissue involved. The more widespread the paren-
chymal lesion, the more marked was the avascularity. Displacement of vessels secondary to fibrosis and retraction was encountered frequently. In tuberculous fibrothorax, angiocardiography delineates the cardiac chambers and great vessels, often revealing marked distortion and displacement of these structures. By contrast visualization, hilar and mediastinal masses may be differentiated from aneurysm. In two instances tuberculous hilar and mediastinal adenopathy resulted in obstruction of major branches of the pulmonary artery. Finally, the use of angiocardiography in the detection of pericardial effusion is illustrated.

RESUMEN

Se presentan los hallazgos angi cardiográficos en 91 tuberculosos estudiados durante la vida. Se encontró disminución de la vascularización en grados diversos en las áreas invadidas por la tuberculososis. El grado de vascularización depende de la cantidad de pulmón comprometida. Mientras más extensa la lesión parenquimatoso más marcada es la vascularización.

A menudo se encontró desplazamiento de los vasos en los casos de fibrosis y retracción. En el fibrotórax tuberculoso la angiocardiografía delinea las cámaras cardiacas y grandes vasos frecuentemente revelando marcada distorsión y desplazamiento de estas estructuras. Por contraste, por la visualización de hilo y mediastino se pueden diferenciar del aneurisma. En dos casos la adenopatía hilar y mediastinal produjeron obstrucción de ramas mayores de la arteria pulmonar. Finalmente se ilustra el uso de la angiocardiografía para descubrir la presencia de derrame pericárdico.

RESUME

Les auteurs présentent les angiopneumographies qui ont été faites chez 91 malades tuberculeux durant leur vie pendant une période de 14 ans. Ils ont constaté que les régions du poumon atteintes de tuberculose étaient le siège d’une diminution de la vascularisation, de degré variable. Cette diminution de la vascularisation est en rapport direct avec l’étendue du tissu pulmonaire atteint. Plus il y avait d’ensemencements tuberculeux, plus la vascularisation était déficiente. Il y a également fréquemment chez ces malades un déplacement secondaire des vaisseaux, dû à la fibrose et la rétraction. Dans le fibrothorax tuberculeux, l’angiopneumographie permet de délimiter les contours du cœur et des gros vaisseaux, et révèle fréquemment un déplacement et une déformation très marquée de leur profil. Des images anormales des hiles et des masses médiastinales peuvent être différenciées de l’anévrisme. Dans deux cas, les hiles atteints de tuberculose et des adénopathies médiastinales étaient dus à l’obstruction des branches
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