16366

Studies of Fluorocardiography in Normal Subjects.

FELIX G. FLEISCHNER, FRANCISCO J. ROMANO, AND ALDO A. LUISADA.

From the Department of Medicine and the Laboratory of Radiology, Beth srael Hospital, Boston, Mass.

In previous notes,[1,2,3] the patterns of the tracings which can be obtained in normal subjects by means of fluorocardiography (electrokymography) have been outlined. The present note reports supplementary observations which deal with the following problems: the tracing of the ascending aorta, the tracing of the pulmonary veins, and the velocity of the pulse wave in the pulmonary circulation. Also the origin and shape of the pulsations of the lung parenchyma are discussed.

Technique. The observations were made by using a Sanborn apparatus for fluorocardiography (electrokymography), and a Sanborn Stethocardiette for phonoelectrocardiography. As previously reported, fluorocardiography records on a continuous film, moving at the speed of 75 mm per second, the pulsations of various areas of the cardiovascular silhouette or the opacity changes of a pulmonary field on x-ray. This is made possible by the use of the x-ray machine, a phototube, a diaphragm with a slit-like opening, a small fluorescent screen, and various stages of amplification. The tracing is recorded by the galvanometer of the Stethocardiette while a simultaneously recorded phonocardiogram permits exact timing of the fluoroscopic pulsations.

The observations were made on 15 normal subjects between the ages of 16 and 30. A total of 10 observations of the pulmonary veins, 10 observations of the ascending aorta, and 15 observations on velocity of the pulmonary arterial wave were performed.

The ascending aorta was studied in the 10 degree and 45 degree left oblique positions. The slit was placed first over the lowest point above the shadow of the right auricle showing an arterial pulsation, then it was moved step by step toward the arch.

The pulmonary veins were studied by applying the slit transversely over an area about 2 cm beyond the convexity of the right auricle in the postero-anterior position. The lung markings are essentially due to the shadows of the pulmonary vessels. The patterns of the arterial and venous ramifications are generally identical, except for the hilar regions; therefore, arterial and venous shadows cannot be identified as such on the routine roentgenograms. The stronger arterial pulsations overshadow the weaker venous pulsations; therefore the hilar pulsations, visible with the naked eye in certain instances (hilar dance), and the pulsations of the pulmonary parenchyma recorded by fluorocardiography, are mainly arterial. However, the arrangement of the larger vessels in the hilar regions is different for the arteries and veins. It has been known that veins coming from the middle and lower lobes on the right, in their almost horizontal course, cross the downward running arteries perpendicularly and stand out within the bright band of the lower trunk bronchus; they are visible sometimes on routine chest roentgenograms (Assman[4]) and more often on laminograms taken at the appropriate depth (Chatton and Maleki[5]).

Marchal[6] identified these as vascular shadows of pulmonary veins by injecting an opaque medium intravenously and observing a definite time difference of its arrival at the hilar arteries and at these vessels. These

[1] Luisada, A. A., Fleischner, F. G., and Rappaport, M. B., *Am. Heart J.*, 1948, **35**, 336.

[2] Luisada, A. A., Fleischner, F. G., and Rappaport, M. B., *Am. Heart J.*, 1948, **35**, 348.

[3] Luisada, A. A., and Fleischner, F. G., PROC. SOC. EXP. BIOL. AND MED., 1948, **66**, 436.

[4] Assman, H., *Die Klinische Röntgendiagnostik der Inneren Erkrankungen*, 5th Ed., Vogel, Berlin, 1934.

[5] Chatton, P., and Maleki, A., *J. de Radiol. et d'Electr.*, 1947, **28**, 285.

[6] Marchal, M., *Arch. Mal. Coeur*, 1946, **39**, 345.

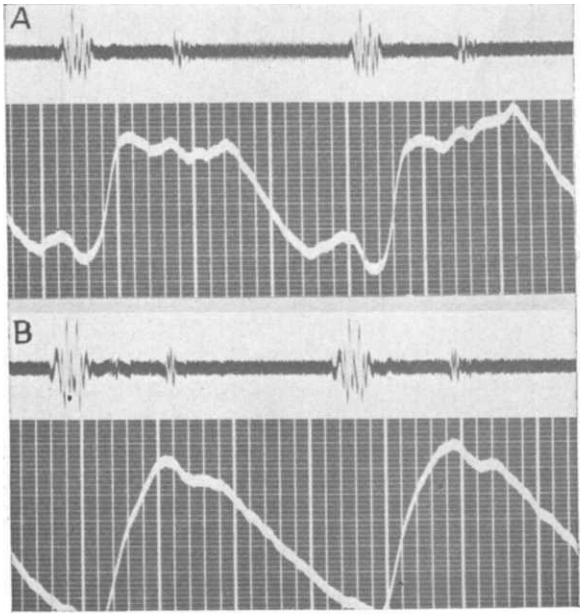

FIG. 1.
Aortic tracings in a normal adult in a 10° left anterior oblique position. (A) Ascending aorta. (B) Aortic arch.

faint vascular shadows can be identified only occasionally by fluoroscopy. However, information gained from Herrnheiser's detailed studies[7] on the hilar shadows simplified the procedure. In addition to these horizontally crossing veins (*Vena costalis* of the middle lobe and *Vena apicohorizontalis* of the lower lobe), the *Venae basalis posterior* and *axillobasalis posterior* cross the bright cardio-hilar interspace obliquely, while only one artery of sizable caliber is found in this area. This being an area with predominantly venous vascular shadows, tracings were obtained by us with unexpected frequency, which presented a distinct venous characteristic, namely a presystolic positive wave.

To identify this venous pattern and to rule out incidental waves due to positional movements into and out of the field of observation of arteries or other structures, the following test was performed. The slit was placed vertically upon the border of the right auricle. In successive steps of a few millimeters each, the slit was moved laterally across the bright cardio-hilar interspace, the final tracing being taken with the slit right upon the arterial hilar trunk. In addition, routine tracings of the right auricle in the postero-anterior view and the left auricle in right oblique view were taken. Thus it became evident that the positive presystolic wave recorded in the "venous field" corresponded temporally to the presystolic left auricular contraction; moreover, there was no evidence of any other pulsatory or positional deflections which might have caused this wave.

The velocity of the pulse waves in the lesser circulation was studied in the following way. Comparison was made of the tracings obtained by placing the slit first over the pulmonary knob, then over the right hilar shadow, and later at the base of the right lung, or better at the lowest visible point above the right diaphragm, following the previously indicated technique.[1] Measurements made in 50 chest films of adults of various sizes and habitus gave the following average data: (a) Distance between pulmonary knob and right hilar shadow, 8 cm. (b) Distance between right hilar shadow and visible base of right lung, 11 cm.

[7] Herrnheiser, G., *Am. J. Roentg.*, 1942, **48**, 595.

Results and Comments. (1) *The tracing of the ascending aorta* presents a typical pattern which is different from that of tracings recorded over the aortic arch. Its features are as follows (Fig. 1): early systolic drop; rapid rise; early peak; only slight descent (or no descent) during the second half of systole: small incisura; high and occasionally prolonged wave after the incisura; this wave may be higher than the main wave in some cases. This typical tracing resembles certain tracings of pressure recorded by Tigerstedt[8] on the carotid artery of rabbits while it differs from those recorded by the same author and by Wiggers[9] in dogs and also from the reconstruction of aortic pressures by Hamilton and Dow.[10] Intra-aortic pressure, recorded by Marey[11] in the horse, again presents a more conventional profile. This indicates that the pattern recorded by us in normal human subjects is not merely caused by volume changes (parallel to pressure changes) but is also markedly affected by motions of the heart and vessels. The lowering of the aortic root by ventricular systole and the medial displacement of the ascending aorta by rotation of the heart in the same phase apparently reduce the height of the aortic wave. This is confirmed by the initial drop of the tracing. Opposite movements, taking place in diastole, add their effect to that of the dicrotic wave and create a high wave on the tracing. The proximity of the ascending aorta to the left ventricle may contribute to the fact that in some subjects the profile of the aortic pulse during systole greatly resembles a tracing of intraventricular pressure.

(2) *Tracing of the Pulmonary Veins.* Tracings recorded in the right intercardio-hilar space as suggested by Marchal[6] and discussed above show close relation to those of the auricles. They reveal a presystolic positive wave (increased volume) synchronous with the negative wave (contraction or decreased volume) of the left auricular tracing. Such unequivocal records were not obtained in every single case, apparently because of anatomical variability and resulting technical difficulty in placing the slit at the right spot.

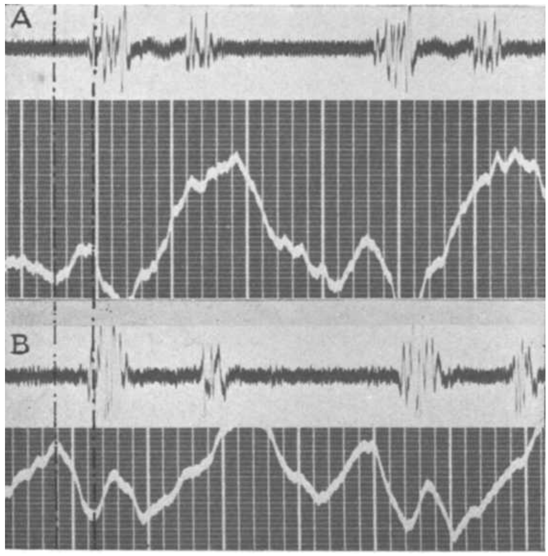

FIG. 2.
Tracing of the pulmonary veins in postero-anterior position (A) compared with that of the left auricle in left oblique (B). Normal subject. The presystolic drop of the auricular tracing is matched by a presystolic rise in the venous tracing.

(3) *Velocity of the pulse wave in the pulmonary circulation.* While examples of the tracings are given in Fig. 3, the average data obtained in 10 subjects are summarized in the following table. This also gives the maximum and minimum variations and the range of physiological variations on the basis of 8 cases out of 10, disregarding exceptional variations.

For greater accuracy, the distances between 1st sound and foot of the pulse waves were measured by using the beginning of the 1st sound vibrations but not that vibration which marks the opening of the semilunar valves.[12] This gives a prolongation of the absolute individual temporal relationship of about 0.05 seconds. However, it fails to change the

[8] Tigerstedt, R., *Die Physiologie des Kreislaufes*, 2nd Ed., DeGruyter, Berlin, 1922, **3**, p. 218.

[9] Wiggers, C. J., *Modern Aspects of the Circulation in Health and Disease*, Lea and Febiger, Phila., 1923.

[10] Hamilton, W. F., and Dow, P., *Am. J. Physiol.*, 1939, **125**, 48.

[11] Marey, E. J., *La Méthode Graphique dans les Sciences Expérimentales*, Masson, Paris, 1885.

[12] Rappaport, M. B., and Sprague, H. B., *Am. Heart J.*, 1942, **23**, 591.

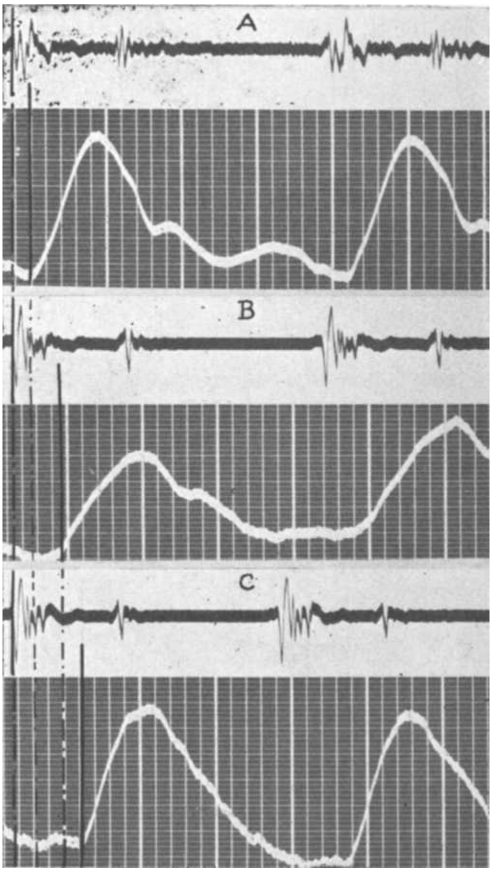

FIG. 3.

Tracing of the pulmonary knob (A), of the right hilar shadow (B), and of the visible base of the right lung (C) in a normal subject. Postero-anterior position.

relative intervals because all figures are obtained in the same way. As indicated in the table, the average times of arrival of the pulse waves are 0.08 sec. for the pulmonary knob, 0.12 sec. for the right hilus, and 0.16 sec. for the visible base of the right lung. Using the average figures of 8 and 11 cm indicated above, we obtain a velocity of the pulse waves which is 2 meters per second between pulmonary knob and right hilus and 2.75 meters per second between right hilus and visible base of the right lung. These speeds should be compared with the known speeds of the pulse waves in the greater circulation. These vary between 5 and 9 meters per second in normal subjects and are greater in the peripheral vessels (7.5) than in the aorta (4.5).[13,14]

Therefore, while the speed of the pulse in the lesser circulation is lower than in the greater, being roughly one third of the latter, the pulse increases its speed in the small, less extensible arterioles both in the lesser and in the greater circulation. The lower velocity of the pulse wave in the pulmonary circulation is caused by the lower pressure and by the greater extensibility of the vessels. This fact had been demonstrated in experimental animals and appears now confirmed for man.

(4) *Shape and cause of the pulmonary wave.* The peak and the shape of the pulsatory wave of the lung have been the object of special attention. The peak has a less fixed position in the tracing of the pulmonary parenchyma than in that of the hilus. In spite of that, it is easy to see that the peak in the pulmonary tracing is nearer to the foot than in the hilar tracing; it is followed by a more rapid descent; it often follows closely that small vibration of the 2nd sound which marks the opening of the mitral valve.[15] For these reasons, we came to the conclusion that the tracing of the pulmonary parenchyma is similar to a plethysmogram and is modified by both arterial and venous changes in the blood content of the lung. The rise and the ascending part of the wave are of arterial origin, as shown by the respective time relationships that they have with similar waves of the hilar tracing and of the tracing of the pulmonary knob. On the contrary, the descending branch of the wave reflects mainly changes in venous tracing. It is possible that occasionally some venous component is present in the hilar tracing too but this is less likely for anatomical reasons and because usually much less amplification is required for recording that tracing. Therefore, possible venous components are minimized by the technique used.

[13] Bazett, H. C., and Dreyer, N. B., *Am. J. Physiol.*, 1922, **63**, 94.

[14] Wiggers, C. J., *Ann. Int. Med.*, 1932, **6**, 12; *Am. Heart J.*, 1938, **16**, 515.

[15] Hamilton, W. F., Circulation Through Special Regions, in *Howell's Textbook of Physiology* edited by J. F. Fulton, W. B. Saunders, Phila., 1946.

TABLE I.
Velocity and Duration of Pulmonic Arterial Waves.

	Avg distance from 1st sound to foot of pulse wave	Distance between foot and peak of the same wave	Transmission time	Speed of the wave
Pulmonary knob	0.08 sec. ± 25% Mx = 0.10 Mn = 0.05	0.14 sec.		
Right hilar shadow	0.12 sec. ± 25% Mx = 0.15 Mn = 0.09	0.24 ”	Pulm. knob to rt. hilus 0.04 sec.	2 M/sec.
Right lung (visible base)	0.16 sec. ± 25% Mx = 0.22 Mn = 0.10	0.23 ”	Rt. hilus to visible base of rt. lung 0.04 sec.	2.75 M/sec.

Summary. A study of 15 normal subjects has been performed by using fluorocardiography, a method which permits recording on a continuous film of the pulsations of various cardiovascular structures revealed by the x-ray. (a) The tracing of the ascending aorta presents a typical pattern which partly is due to transmission of intraventricular pressure and partly to motions of the aortic root connected with ventricular systole and diastole. (b) It is possible to record in certain cases a tracing of the pulmonary veins. Its most typical feature is a positive wave during presystole. (c) The velocity of the pulse wave in the lesser circulation is much lower than in the greater circulation. It is more rapid in the smaller branches than in the stems of the pulmonary artery. Average figures are given. (d) The tracing of the pulmonary parenchyma is the equivalent of a plethysmogram. While the rise and the ascending branch of the wave are of arterial pulmonary origin, the peak and the descending branch of the wave are probably of venous pulmonary origin.

16367

Bacillomycin: An Antibiotic from *Bacillus subtilis* Active against Pathogenic Fungi.*

M. LANDY,† G. H. WARREN, S. B. ROSENMAN, AND L. G. COLIO.
From Wyeth Institute of Applied Biochemistry, Philadelphia, Pa.

Since the discovery of *subtilin* by Jansen and Hirschmann,[1] 3 additional antibiotics i.e., *bacitracin, bacillin,* and *eumycin* have been described as products of strains of *Bacillus subtilis* (for an excellent, comprehensive review see Benedict and Langlykke[2]). With the exception of *eumycin,* the antibiotics possess incidental antifungal properties in association with a more specific antibacterial action.

* The authors wish to express their indebtedness to Dr. E. G. Snyder and R. W. Whitley for purification and chemical studies; and to Miss Charlotte Campbell, Army Medical Department Research and Graduate School, for the systemic fungi spectrum.

† Present address: Army Medical Department Research and Graduate School, Washington, D.C.

1 Jansen, E. F., and Hirschmann, D. J., *Arch. Biochem.*, 1944, **4**, 297.

2 Benedict, R. G., and Langlykke, A. F., *Ann. Rev. Microbiol.*, 1947, **1**, 193.