

Effect of Giving Digitalis on the Volume Output of the Heart and its Size in Heart Failure.**HAROLD J. STEWART.***From the Hospital of the Rockefeller Institute for Medical Research, New York.*

It appears to be a fact that the giving of digitalis decreases the cardiac output (Burwell, Neighbors and Regen,¹ and Stewart²) and cardiac size (Stewart²) in normal human beings. The effect of its administration when hearts are diseased is, however, still unknown. With the introduction by Grollman^{3, 4} of the acetylene method for measuring the cardiac output in man, a method became available for studying this condition. In this investigation the method of Grollman has been used. In addition to estimations of the cardiac output, the size of the heart was measured from x-ray photographs taken at a distance of 2 meters. In addition to the usual hospital records, electrocardiograms were made and the heart rate counted. Blood pressure and vital capacity were also investigated, but not reported here. All observations were made with patients in a basal metabolic state, immediately before digitalis was given and at frequent intervals afterward.

The first patient, a male, 47 years of age, suffered from a first attack of heart failure. The records secured in studying his case illustrate the course of events in cases forming the group exhibiting normal cardiac mechanism and heart failure of the congestive type. The diagnosis was generalized arteriosclerosis, hypertension, rheumatic heart disease (mitral insufficiency), cardiac hypertrophy. His heart and liver were large. Ascites and edema of the lower extremities were present. The lungs were free of râles. During heart failure the cardiac output measured 2.88 liters per minute, *i. e.*, it was diminished, and the heart now 198.3 sq. cm. in area was larger than during the stage of compensation. On the first occasion that digitalis was given, diuresis occurred and the patient became free of the signs and symptoms of heart failure. On giving the drug (digitan 1.0 gm.) there occurred an immediate increase in the cardiac output to 3.54 liters per minute, decrease in size of the

¹ Burwell, C. S., Neighbors, D. W., and Regen, E. M., *J. Clin. Invest.*, 1928, **5**, 125.

² Stewart, H. J., *Proc. Soc. Exp. Biol. and Med.*, 1931, **29**, 207.

³ Grollman, A., *Am. J. Physiol.*, 1929, **88**, 432.

⁴ Baumann, H., u. Grollmann, A., *Z. f. klin. Med.*, 1931, **115**, 41.

heart to 180.2 sq. cm., slowing of the heart rate and alterations of the form of the T-wave of the electrocardiogram. As the effect of digitalis wore off, the signs of heart failure reappeared and 2 weeks later the cardiac output decreased to 2.62 liters per minute and the size of the heart increased to 193.6 sq. cm. When digitalis was given a second time (digitan 1.0 gm.) results similar to those first observed were obtained, that is to say, diuresis, increase in cardiac output and decrease in cardiac size. Later digitalis became ineffective for the relief of heart failure, for, although under its influence, cardiac output increased slightly and for a short time only; the corresponding changes in the size of the heart were slight. In each instance the maximum effect was observed 15 to 24 hours after the drug had been given.

A second patient, a male, 30 years of age, was suffering from a first attack of heart failure. The diagnosis was lues, chronic cardiac valvular disease (mitral insufficiency, aortic insufficiency) slight hypertension. He exhibited enlargement of the heart, a few râles at both lung bases posteriorly, small interlobar effusion (seen in the x-ray photograph), enlargement of the liver, ascites and edema of the lower extremities. Diuresis occurred on the administration of digitan (Merck) 1.0 gm. The cardiac output which had been 2.08 liters per minute, *i. e.*, less than normal, increased to 2.73 liters per minute and the cardiac size decreased to 130.4 sq. cm., from 143.4 sq. cm. As the effect of the drug wore off the symptoms and signs of heart failure recurred; 10 days later the cardiac output was 1.44 liters per minute only, *i. e.*, it had decreased, and the size of the heart was larger (134.2 sq. cm.). When digitan 1.0 gm. was given a second time diuresis failed to occur, but there was a moderate temporary rise in the cardiac output and decrease in the cardiac size. Theocalcin was then given. Diuresis occurred promptly and the patient became free of heart failure. There occurred in this instance also an immediate increase in cardiac output and decrease in cardiac size, these relations being maintained. It is not the intention at the present time to discuss the mechanism of theocalcin in such cases.

The effect of giving digitalis to patients suffering from auricular fibrillation was also studied. A woman, 50 years old, was suffering from a fourth attack of heart failure of the congestive type. The diagnosis was cardiac hypertrophy, chronic myocarditis, mitral insufficiency and auricular fibrillation. She exhibited a few râles at the lung bases posteriorly, edema of the lower extremities, ascites, enlargement of the liver and tachycardia. When digitan 1.0 gm

was given the ventricular rate became slower, the pulse deficit decreased, diuresis occurred and the patient became free of the signs of heart failure. The cardiac output which had been 2.44 liters per minute increased to 3.45 liters when digitalis was given and the cardiac size diminished to 167.3 sq. cm. from 185.3 sq. cm.

The effect of giving digitalis when the rhythm of the heart is normal and when there are no signs of congestive heart failure was shown in the case of a white girl 21 years old. She complained of dyspnoea. The diagnosis was rheumatic heart disease (mitral stenosis and insufficiency), and cardiac hypertrophy. The cardiac output increased from 2.19 to 3.00 liters per minute and the cardiac size diminished from 141.4 sq. cm. to 133.7 sq. cm. when digitalis 1.0 gm. was given.

It appears, therefore, from the study of these cases that in the presence of heart failure (1) the cardiac output diminishes. (2) With the administration of digitalis (a) the cardiac output increases; (b) the cardiac size diminishes; (c) the ventricular rate decreases both when the rhythm is normal and in the presence of auricular fibrillation; (d) and alterations in the form of the T-wave of the electrocardiogram occur. (3) As the effect of digitalis wears off these functions change in the reverse direction.