Proceedings
of the
Society
for
Experimental Biology and Medicine

VOL. 81 OCTOBER, 1952 No. 1

The Ballistoscope: An Instrument for the Study of the Cardiac Impulse.* (19759)

SAMUEL LOSNER. (Introduced by W. Dock.)

From the Department of Medicine, Jewish Sanitarium and Hospital for Chronic Diseases, Brooklyn, N. Y.

A small container half-filled with a dark viscous fluid, such as commercial heavy oil, reflects the light of an otoscope bulb held at a distance above the container, in such a fashion that any swift movement of the surface upon which the container rests causes a definite and characteristic displacement of the reflected image. If the container is placed upon the human body, the motion of the image forms a pattern, the shape and size of which are determined by the motion at the point of support, and specifically by motion due to cardiac activity. Such an instrument, which can be used at the bedside as easily as a stethoscope, may be called a ballistoscope.

Description of ballistoscope. As seen from Fig. 1, the instrument has a heavy brass base, 2.5 cm high, with a diameter of 6.25 cm, upon which is soldered a container 5 cm high with a diameter of 3.75 cm. The thickness of its wall is 1.5 mm. It is partly filled with commercial heavy oil No. 40. An aluminum rod 20 cm high, fastened to the base, carries wires connecting a transformer or pair of dry cells with an otoscope bulb at the top of the rod. This supplies a current of 2.5 volts. The otoscope bulb is 18 cm above the oil surface within the container, and its reflection appears as a bright point on a black background.

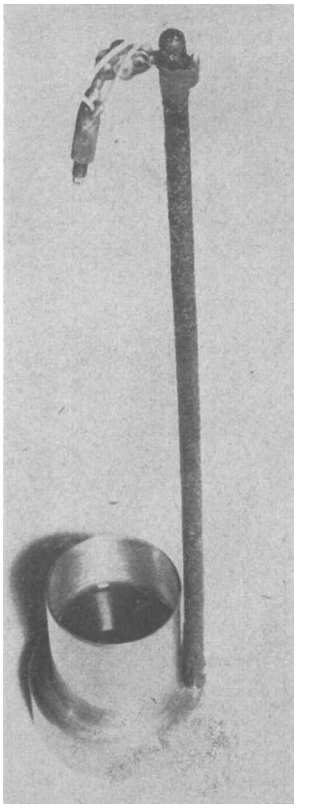
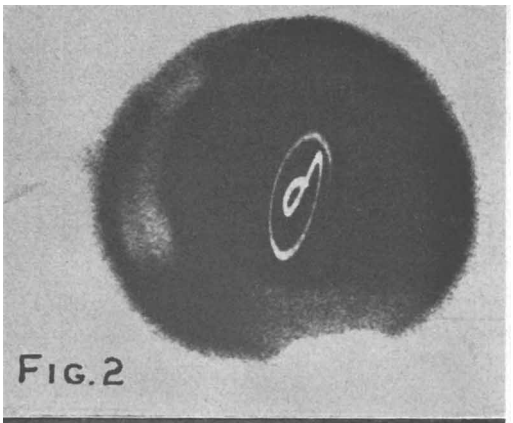
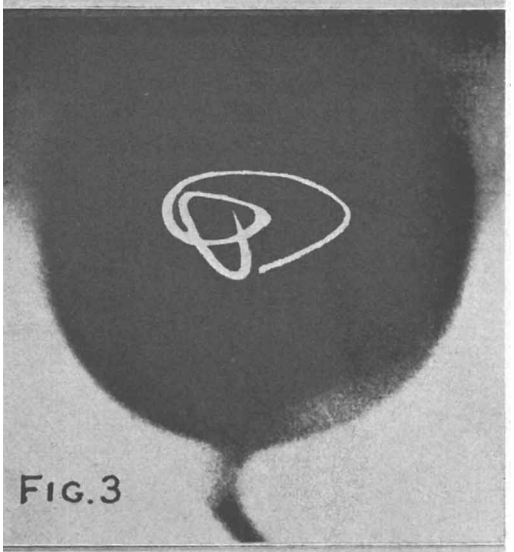


FIG. 1. Ballistoscope.

Procedure. The ballistoscope is placed

* The author wishes to acknowledge with many thanks the assistance of Mr. Herbert Fischler, Medical Photographer of the Division of Laboratories, Jewish Sanitarium and Hospital for Chronic Diseases, in the preparation of the photographs, as well as the elaboration of the photographic technic in this study.





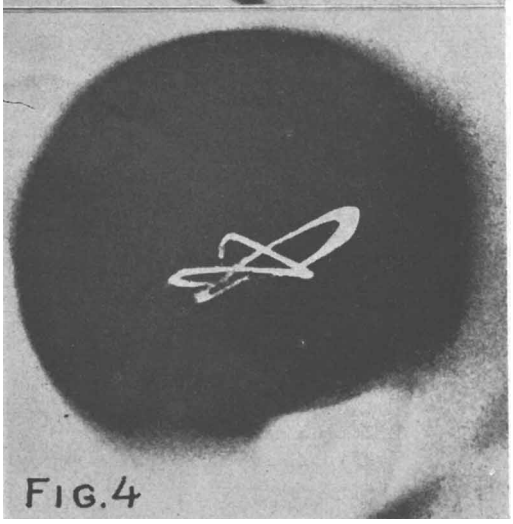


FIG. 2. Ballistoscope tracing of a normal individual.

FIG. 3. Ballistoscope tracing of a patient with mitral stenosis and insufficiency.

FIG. 4. Ballistoscope tracing of a patient with hypertensive cardiovascular disease and evidence of an old posterior wall infarction.

upon the lower third of the sternum with the patient in the supine position, so that the fluid surface is horizontal. The procedure can be employed in any desired position. If the patient is in a prone position, the ballistoscope is placed upon the back, and the reflection of the bulb is observed within the container. Similarly, the ballistoscope can be placed upon a bar across the lower legs, according to the procedure of Dock(1).

For the purpose of obtaining a permanent record, the above described procedure is followed, and a camera is focused upon the ballistoscopic flash within the container, which is photographed with a 0.5 second exposure. To identify the beginning and end of the tracing, and therefore its direction, the light of the otoscope bulb is switched on immediately after opening the shutter, causing the tracing to initiate as a thin thread, increasing steadily in thickness while the bulb is lighting up. When the shutter closes automatically, the light is interrupted suddenly, and the tracing ends therefore abruptly.

Results. As seen from Fig. 2 the ballistoscope tracing of a normal individual as obtained over the sternum is slightly elliptical, the long axis being in a longitudinal, and the short axis in a lateral, direction. The main portion of the tracing has a counterclockwise direction, and follows the first heart sound. It is succeeded by a short portion in a clockwise direction, which seems to follow the second heart sound when ballistoscopic observation is combined with auscultation. If the ballistoscope is placed upon a bar across the lower legs according to the Dock procedure, the configuration of the flash seems to duplicate the typical ballistocardiographic pattern.

Fig. 3 and 4 give examples of specific changes of the ballistoscopic pattern in patients with cardiac disease. Fig. 3, from a patient with mitral stenosis and insufficiency, is characterized by a clockwise direction of the tracing. The long axis is no longer longitudinal but more in a lateral direction. Fig. 4, from a patient with hypertensive cardiovascular disease and electrocardiographic evidence

of an old posterior wall infarction, shows again a clockwise direction of its main portion, as well as a very pronounced lateral direction of its long axis. It is succeeded by a short swing in the opposite, namely counterclockwise, direction. The amplitude of both tracings (Fig. 3 and 4) appears larger than normal.

Discussion. The high viscosity of the fluid within the container produces a considerable damping effect, so that the relatively slow respiratory motion of the anterior chest wall does not produce any direct alteration of the configuration of the flash as caused by the forceful cardiac impulse. It produces, however, indirect alterations which can be interpreted as respiratory variations. The damping characteristics of the fluid are also responsible for the failure to register vibrations coincident with heart sounds or murmurs.

The mechanism of the ballistoscope seems to reside in the formation of a sloping reflecting surface during the ballistic movement of the underlying surface, such as the anterior chest wall. The degree of slope depends upon the magnitude of the cardiac impulse. Since the excursion of the reflex increases with the degree of slope, it will necessarily indicate the magnitude of the cardiac impulse provided the distance between object and mirror, in this case the distance between otoscope bulb and fluid surface within the container, is constant. If the distance between the bulb and fluid surface is increased, the excursion of the image will also increase.

Whereas the ballistocardiograph, in its usual form, is an instrument with one degree of freedom(2), namely, in a longitudinal direction only, the ballistoscope, as presented in this study, indicates movements in both longitudinal and lateral, as well as any other intermediate direction. It therefore can be considered an instrument with freedom in a two-dimensional plane, providing both factors of a vector, *i.e.*, direction and amplitude.

It has been pointed out that lateral ballistic movements may be of considerable importance (3,4). In view of its mechanical simplicity, the ballistoscope should lend itself particularly well for determining at a glance whether the main ballistic motion is longitudinal or lateral, and also furnish an idea about the amplitude. It can serve as a screening instrument at the bedside for further ballistocardiographic investigation.

Summary. An instrument called ballistoscope is described, which registers any motion of the underlying surface in a two-dimensional plane. Placed upon the sternum it reveals ballistic patterns which are constant and characteristic in normal individuals as well as in patients with various types of heart disease.

1. Dock, W., and Taubman, F., *Am. J. Med.*, 1949, v7, 751.

2. Starr, I., Rawson, A. J., Schroeder, H. A., and Joseph, N. R., *Am. J. Physiol.*, 1930, v127, 1.

3. Braunstein, J. R., Oelker, C. E., and Gowdy, R. C., *J. Clin. Invest.*, 1950, v29, 1219.

4. Brandt, J. L., Caccese, A., Dock, W., and Schrager, A., *J. Clin. Invest.*, 1951, v30, 971.

Received July 24, 1952. P.S.E.B.M., 1952, v81.

Effect of Ethylenediamine upon Glycosuria of the Partially Depancreatized Rat. (19760)

DWIGHT J. INGLE, DEXTER F. BEARY, AND ANDREJS PURMALIS.

From the Research Laboratories, The Upjohn Co., Kalamazoo, Mich.

Ethylenediamine has been found to cause an increase in the amount of glucose excreted by the partially depancreatized rat during the period of its administration.

Methods. Male rats of the Sprague-Dawley strain were maintained on Archer Dog Pellets until they were partially depancreatized(1) at a weight of 275 to 280 g. After diabetes was established all of the rats were placed in metabolism cages and force-fed a medium carbohydrate diet(2) by stomach tube each morning (8:30 to 9:15 A.M.) and afternoon (4:15 to 5:00 P.M.). The technics and diet were modifications of those described by

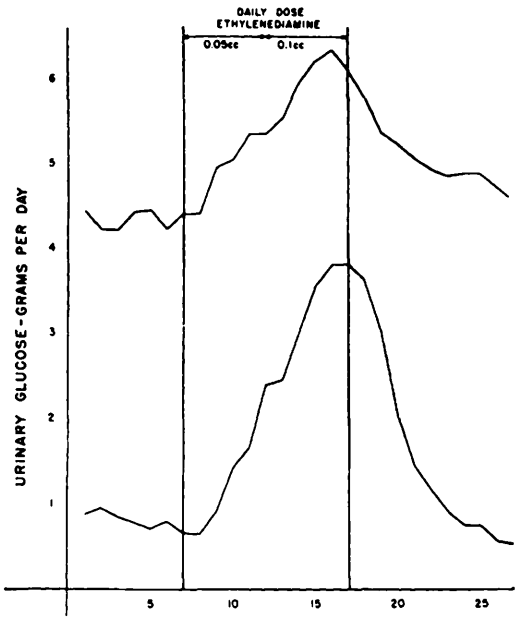


FIG. 1. Effect of ethylenediamine upon level of urinary glucose in partially depancreatized rats. Averages for 5 rats per group. Abscissa in days.

Reinecke, Ball and Samuels(3).

The animals were kept at a temperature of 74 to 78°F. Twenty-four hour samples of urine were collected at the same hour (8:00 to 8:30 A.M.) and were preserved with toluene. Urine glucose was determined by the method of Shaffer and Williams(4). Ethylenediamine, a liquid, was administered by subcutaneous injection.

Experiments and results. Five mildly diabetic rats and 5 moderately diabetic rats were each given 0.05 cc of ethylenediamine once daily for 5 days whereupon 0.1 cc was given daily in divided injections for 5 days. Each animal was observed for 10 days after the injections were stopped. As shown in Fig. 1, the glycosuria was intensified during the administration of ethylenediamine and then decreased to the preinjection level when the injections were stopped. This pattern of response was shown by each individual animal. Ethylenediamine caused a considerable amount of necrosis at the site of injection.

Discussion. Ethylenediamine is a toxic compound which is corrosive to tissue. It imposes a stress on the animal and was selected for study as a part of our research program on the metabolic consequences of various forms of stress. Other toxic agents causing skin damage, such as dilute solutions of formaldehyde(5), do not cause exacerbation of diabetes in the partially depancreatized rat. Apparently the diabetogenic effect of ethylenediamine is not characteristic of non-specific damaging agents. This effect is reversed when the compound is withdrawn. The mechanism of its action is not known to us.

Summary. The subcutaneous injection of ethylenediamine in 10 partially depancreatized rats caused exacerbation of diabetes in each animal but the glycosuria returned to the preinjection level when the administration of the compound was stopped.

1. Ingle, D. J., and Griffith, J. Q., Jr., Chap. 16, *The Rat in Laboratory Investigation.* J. B. Lippincott Co., Philadelphia, 1942.

2. Ingle, D. J., Prestrud, M. C., and Nezamis, J. E., *Am. J. Physiol.*, 1951, v166, 171.

3. Reinecke, R. M., Ball, H. A., and Samuels, L. T., PROC. SOC. EXP. BIOL. AND MED., 1939, v41, 44.

4. Shaffer, P. A., and Williams, R. D., *J. Biol. Chem.*, 1935, v111, 707.

5. Ingle, D. J., and Nezamis, J. E., *Am. J. Physiol*, 1950, v162, 1.

Received July 25, 1952. P.S.E.B.M., 1952, v81.