The Tricardiograph: A Rapid Screening Method for Cardiac Disease

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To take slit kymograms of the left hemithorax on 6½ by 8½ inch film, a carrier was designed which can be fitted to the arms of a fluoroscope, replacing the screen. On the lateral and cephalad corner, six seconds of galvanometer trace are recorded, the slit kymograph being exposed during the interval from 3.0 to 4.5 seconds. With two galvanometers, the electrocardiogram and ballistocardiogram can be inscribed, thus timing the motions of the heart border, and permitting correlation of ballistic phenomena with ventricular ejection. This device also has promise as a screening method for detecting cardiac disease.

Routine miniature films of the chest in hospitals, public health and industrial surveys have placed the problem of case finding in tuberculosis on a practical, sound and relatively inexpensive basis. The use of this survey method may contribute materially to the gradual decline in the incidence of tuberculosis among the native population of the United States. Minimal and unsuspected tuberculous infections have been detected in time to save many families from the economic disaster and sorrow which would have resulted from tuberculosis becoming clinically manifest.

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The need for an equivalent rapid, simple, accurate and inexpensive method for detecting "cardiacs" is obvious. Present day procedures for their detection are expensive and time-consuming, and do not permit simultaneous recording of several important objective aspects of cardiac function.

We have constructed a device which promises to be useful in screening groups of people.
for evidence of heart disease. This records on 6½ by 8½ inch film the slit kymogram of the left heart border for one and one-half seconds, electrocardiogram and ballistocardiogram for six seconds. These films give a permanent record of the contour and motion of the left heart border, the cardiac rhythm and intraventricular conduction, and an index of the vigor of systolic ejection, all in relation to the respiratory cycle. Less than one minute is

required for each subject to take his place and complete his film.

Since this device triangulates on three important aspects of the heart we call it a "tricardiograph." By adding additional channels for recording heart sounds, it may be converted into a true "omnicardiograph."

Figure 1 is a diagrammatic representation of the device. Essentially, it consists of a housing which fits onto the screen arms of a fluoroscope. The housing of the device contains two oscillographs, a lead grid, and a constant speed motor moving a cassette. The cassette is a specially adapted type, the upper left hand corner of which has been replaced by a sliding door to allow 6 by 6 cm. of film to be exposed to the light beams from above, and the corresponding lower surface of the cassette in the left upper corner protected by a lead strip to prevent exposure of the film to the x-rays coming from below.

In operation the patient lies on the fluoroscopic table and the leads for the electrocardiograph and ballistocardiograph are connected to amplifiers which activate the oscillographs. The device is positioned over the subject's left precordial area. (See figure 2.) Pressing a button on the x-ray control box starts the motor and the cassette is driven headward at a speed of 1.0 cm. per second. (See figure 3.) The sliding door of the cassette opens and the light beams of the electrocardiograph and ballistocardiograph inscribe their traces. At the end of three seconds the x-rays are turned on by the cassette carrier and remain on for one and one-half seconds, recording the left heart border, with the electrocardiograph and ballistocardiograph still inscribing. The x-rays go off at the end of four and one-half seconds and an additional one and one-half seconds of electrocardiogram and ballistocardiogram are inscribed, at which time the oscillograph lamp is turned off and the cassette returned to its original position with the sliding door closed. The ballistocardiogram shows the phase of respiration in which the kymograms happened to occur. (See fig. 4.) The entire cycle lasts only about 15 seconds.

Discussion

When Starr and others\(^2,3\) pointed out that unusual respiratory variation was a striking feature in the ballistocardiogram of patients who subsequently proved to have heart disease, no adequate explanation for the phenomenon was forthcoming. It is known that there is no significant alteration in the peripheral pulses during the respiratory cycle in patients who show a marked respiratory variation.
How these variations in the IJ stroke are related to variations in the excursions of the left heart border is now under study. Our records seem to confirm the theory that the normal IJ is due chiefly to right ventricular ejection, which varies in volume during each cycle of respiration in the same way as the chronously. Such records are not possible with the electrokymograph, since motion of only one or two points along the heart border can be taken at any one time in relation to other phenomena. Such analysis is not necessary to distinguish abnormal from normal tricardiograms.

IJ amplitude. The increase in this variation commonly seen in heart disease, including latent coronary disease, is apparently due largely to left ventricular scars or weakness.

It is a relatively simple matter to project the 1.5 cm. frames and trace them upon a conveniently ruled graph paper. This gives an easily interpreted record of the entire left border motion in relation to the electrocardiogram and ballistocardiogram inscribed syn-

It is hoped that this device will prove of aid in elucidating the respiratory variation in the waves inscribed by the ballistocardiogram, and also will provide a useful tool for the rapid screening of a population for latent heart disease.

**Conclusions**

1. We have described a device which records a simultaneous electrocardiogram, ballistocardiogram, and ballistomotor recording, which has been found to be of great value in the diagnosis of heart disease.

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**Fig. 3. Wiring diagram for tricardiograph.**

When the unit is turned on the 6.3 volt lamp goes on, since its transformer is in series with switch C, and a neon lamp (pilot) is also on, since power is fed to it through switch D. Switch A on the x-ray control is closed, thereby starting the motor and setting the cassette carrier in motion. When the neon lamp goes off, the other side of switch D is continuous for the motor, and switch A may be released. After 3 cm. (and 3 seconds) of its travel, the carrier actuates the x-ray switch E which is in the unit, and holds it closed for one and one-half seconds. The switch E actuates the x-ray relay which energizes the x-ray tube. Upon reaching the limit of its headward travel the cassette carrier opens switch C and the 6.3 volt lamp is turned off, eliminating the possibility of a reverse trace. The carrier then reverses itself and travels in the opposite direction. Upon reaching the limit of its footward travel the carrier closes switch C and opens switch D, thereby cutting off power to the motor and stopping the carrier. Simultaneously the oscillograph and pilot lamps are turned on, indicating a completed cycle.
Fig. 4. Tracing of a subject with a palpable impulse in second left intercostal space. Record shows normal electrocardiogram with large amplitude ballistocardiographic complexes, good left ventricular border motion and a large aortic aneurysm, with minimal pulsation. The slight undulation of the baseline of the ballistocardiogram indicates respiratory cycles.

cardiogram, and slit kymogram of the left heart border on 6½ by 8½ inch film. This device is adaptable to the recording of other cardiac phenomena, and is fitted to the fluoroscope screen arms of a standard fluoroscope.

2. The records are small, permanent and easily filed.

3. Recording requires a minimum of time and effort from both patient and technician.

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