BALLISTOCARDIOGRAM RECORDING IN ACUTE EXPERIMENTS ON DOGS

A. V. Mareev

From the Pathology Laboratory (Head – Active Member of the Acad. Med. Sci. USSR, V. V. Parin)
Therapeutic Institute (Director – Active Member of the Acad. Med. Sci. USSR A. L. Miasnikov)
Acad. Med. Sci. USSR, Moscow

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A. L. Miasnikov)

Present views on the origin of the ballistocardiogram (BCG) and on the reasons for its changes are based on the work of I. Starr and his co-workers [9] on cadavers, and on recordings from healthy and sick human patients subjected to various pharmacological, operative, and other treatments. Until now only a small amount of work has been done on animals, although all the work on dogs suggests that this animal is highly suitable as the BCG and its variations are very similar to those in man. This conclusion is all the more convincing in view of the fact that various investigators have used various types of ballistocardiograph, and have used various methods of attaching it to the animals. Of these methods the most rational appear to be those in which a reliable contact is made between the transducer and the bony skeleton of the animal. This method eliminates relative movement between the transducer and the body which always occurs when the former is fixed to the soft tissues, and gives a more reliable trace.

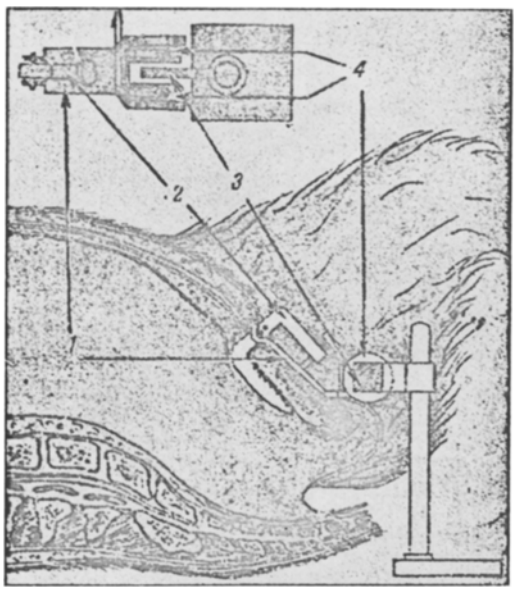

Fig. 1. Attachment of transducer for recording ballistocardiogram.
1) Duralumin platform; 2) clamp; 3) magnet; 4) coil (in the lower drawing the front coil is not shown).

However the suggestion of T. D. Darby and his co-workers [6] of fixing the transducer to the transverse processes T_6-L_5 is not convenient experimentally, as the animal must then be placed on its belly, and this complicates or even excludes the possibility of manipulation inside the thorax. W. H. Frederick, H. D. Thomas and others [8] recorded the BCG using a piezoelectric recorder with air transmission and applying the sensitive portion under a constant pressure of 5 mm of mercury to the parieto-occipital region. Both methods require the head to be fixed to the table, and this may cause distortion of the trace, particularly when it is recorded from the head.

The method of fixing V. Dock's electromagnetic transducer to the hind leg which was used by P. Cossio and his co-workers [4, 5], cannot claim to reproduce the oscillations of the body accurately as movement of the hip joint is not excluded.

The transducer we have constructed for recording the BCG in acute experiments consists of a platform which can be clamped to the canine pubis (Fig. 1). The surface of the platform which lies up against the pubis has a longitudinal groove cut in it with toothed edges which correspond with the pubic crest. The end of the

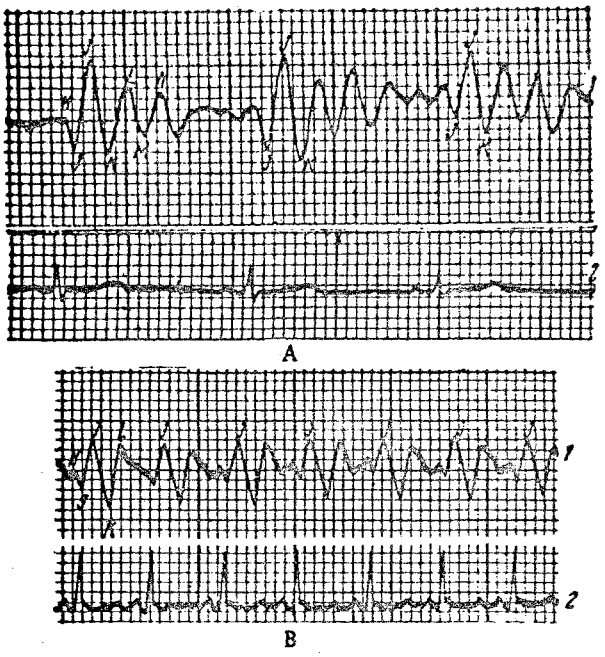

Fig. 2. (A) Human and (B) canine ballistocardiogram. For technical reasons the ECG waves are retarded by 0.04 seconds with respect to the BCG. Paper speed 40 mm/second.
Curves from above downward : ballistocardiogram of healthy male subject aged 32, electrocardiogram of the same subject; ballistocardiogram of dog with opened thoracic cavity, electrocardiogram to the same animal.

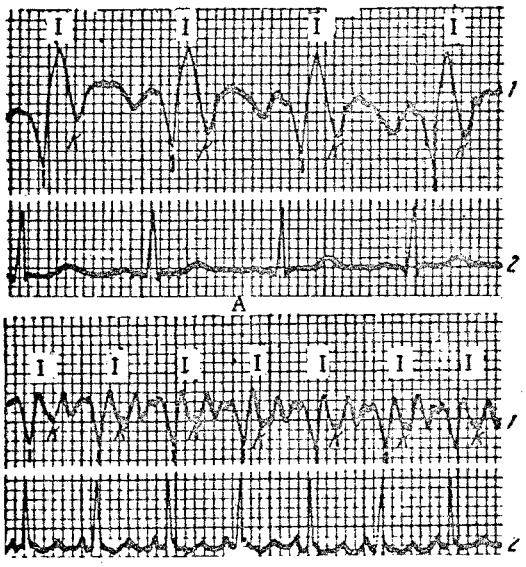

Fig. 3. (A)Human and (B) canine ballistocardiogram. For technical reasons the ECG waves are retarded by 0.04 seconds with respect to the BCG. Paper speed 40 mm/second.
Curves from above downward : ballistocardiogram of patient S, diagnosis: coarctation of the aorta, electrocardiogram of the same subject; ballistocardiogram of dog with experimental constriction of the ascending aorta, electrocardiogram of the same dog. The ballistocardiogram shows clearly a deepening of the I wave and a shortening of the K wave.

clamp which bears against the inner surface of the symphysis pubis is provided with teeth to prevent slipping. Further support is obtained from lugs in the clamp which engage with hooks on the platform. The former can be placed at any convenient level. These parts are made from sheet duralumin 5 and 10 mm thick. Any convenient system for transforming mechanical impulses into electrical ones may be mounted on the platform. We used W.Dock's [1, 7] electromagnetic system, which we had also used in our investigations on human subjects [2, 3]. The coils were fixed to the platform and the magnet to a stand.

Before placing the transducer in position, an incision is made along the linea alba of the belly. This extends from a point 4-5 cm anterior to the superior edge of the pubis to the superior apart of the perineum. The incision is made through the skin, subcutaneous tissue, superficial fascia and the aponeurosis. The recti muscles are separated without cutting, and the abdominal cavity is not opened. The pubic region is freed from fatty tissue, and in males the corpora cavernosa are displaced to one side and ligated. The parietal mesentery is separated with the finger from the inner surface of the pubis and the toothed end of the clamp is introduced between the two. The platform with the coils is screwed up tight against the pubis. The operation takes very little time and there is a negligible loss of blood.

The animal was untied and placed on its back in a box with sand or on a firm table. Sandbags were placed on either side to maintain the position. The head was fixed in the same way. The experiments were carried out in a room with a stone floor.

For anesthesia we gave a preliminary injection of 0.5 ml per kg of a 2% solution of morphine hydrochloride followed by intravenous barbamyl*; this gave a good muscular relaxation and deep anesthesia with quiet slow breathing.

In experiments in which the thoracic cavity was opened artificial respiration with slight hyperventilation was applied. After the apparatus was switched off there were no respiratory movements from the animal for more than 1 minute, which time was fully adequate for the recording of the BCG. When the thoracic cavity was not opened, the BCG was recorded during normal respiration, the frequency of which varied from 6 to 12 per minute.

To record the BCG trace the leads from the coils may be connected to the input of the amplifier of any suitable recording apparatus.

The advantages of this method consist firstly in the firm attachment of the transducer to the skeleton by means of a simple operation which takes very little time, and secondly in the position of the dog which allows free access for any operative procedures.

Figure 2 shows how close is the relation between the BCG of a dog obtained by this method and the curve for a human subject. Figure 3 shows how the same changes in the curves occur under the same condition affecting blood flow.

A full description of the ballistocardiogram in intact dogs, as well as its changes in various experimental conditions will be given in a subsequent communication.

SUMMARY

The construction of the ballistocardiogram described in this article provides reliable attachment to the movable part of the electromagnetic pickup on the dog's symphysis pubis. Thus the precise reproduction of the oscillations of its body is obtained. The operation which is required for this is very simple and does not take much time.

Position of the animal on the back gives wide possibilities for surgical interventions. Stability of this position is achieved by placing sand bags around the body. Intravenous barbamyl anesthesia caused deep sleep, slow respiration and good relaxation of muscles. In surgical interventions on the thorax, ballistocardiogram records were taken during temporary stop of artificial respiration. Moderate hyperventilation necessary for ballistocardiography excluded the possibility of spontaneous respiratory motions during the experiments. Similarity of ballistocardiograms of dogs with those of human beings gives the opportunity of studying some aspects of ballistocardiography on dogs.

* Russian trade name.

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