METHODS

AN EXPERIMENTAL METHOD OF STUDYING THE KOROTKOV SOUND PHENOMENON

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In spite of numerous studies the precise mechanism giving rise to sound effects when an artery is compressed has not been fully clarified.

To aid in doing this we have developed a method which shows the dependence of the sound effects upon the degree of artery compression and the manner in which the blood passes by the narrowed portion of the vessel.

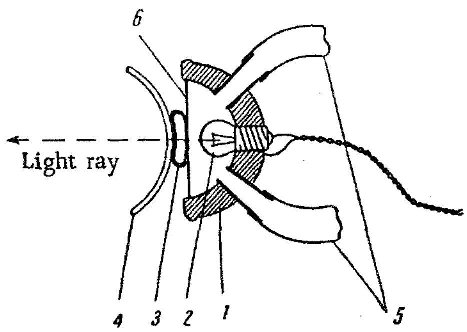

Figure 1. Diagram of the method employed for the simultaneous observation of sound effects and the manner of blood passage through the compressed portion of the artery (in experiments with local compression of a prepared artery). 1) body of bell stethoscope; 2) light; 3) artery; 4) watch crystal; 5) tubes of stethescope; 6) membrane of stethoscope.

EXPERIMENTAL METHODS

The experiments were performed on dogs under evipan narcosis. The apparatus is shown schematically in Fig. 1.

In an aperture made within the head of an ordinary stethoscope an ordinary lamp from a pocket flashlight was placed. This stethoscope was placed under the artery which had been previously dissected free of surrounding connective tissues. The artery would be compressed by the convex surface of the watch crystal against the celluloid membrane of the stethoscope. When the lamp was lighted the pulsating blood waves were readily seen while simultaneously there could be heard the sounds caused by the arterial compression.

When the artery was tightly compressed so that the systolic pressure and the elastic resistance of the arterial wall were exceeded, the lumen of the artery became completely occluded and it looked in the transmitted light like a transparent bright rose ribbon. The blood waves struck against the compressed portion of the artery but no sounds could be detected.

As the compression was slowly relaxed, occasional spurts of blood would pass during systole through the compressed artery to its distal portion, this being accompanied by the appearance of arterial sounds.

As the external pressure was diminished, larger and larger amounts of blood would be seen passing during systole through the compressed area. The sound tones became more intense and other sounds began to appear so that it became difficult to differentiate the initial tones in the general sound complex. However, it could be seen that until such time as the diastolic pressure was being exceeded the arterial lumen remained compressed during diastole so that blood passed the compressed portion in spurts and that the sounds heard in the stethescope coincided with them.

When the external compression became less than the diastolic pressure, the lumen of the artery no longer remained totally compressed during diastole; the artery lost its resemblance to a transparent ribbon and stayed filled with blood during diastole. Blood would then reach the distal portion of the artery not in spurts but as a continuous stream, its size and speed being magnified with each systole.

In the stethoscope could be heard only sounds arising from the acceleration of the blood stream passing through the narrowed portion of the artery.

The relationships just noted can be clearly illustrated by simultaneous objective recording of the sound effects(with aid of microphone) and of the passage of the blood through the compressed portion of the artery (with aid of photoelements).

The method of this objective registration is shown schematically in Fig. 2.

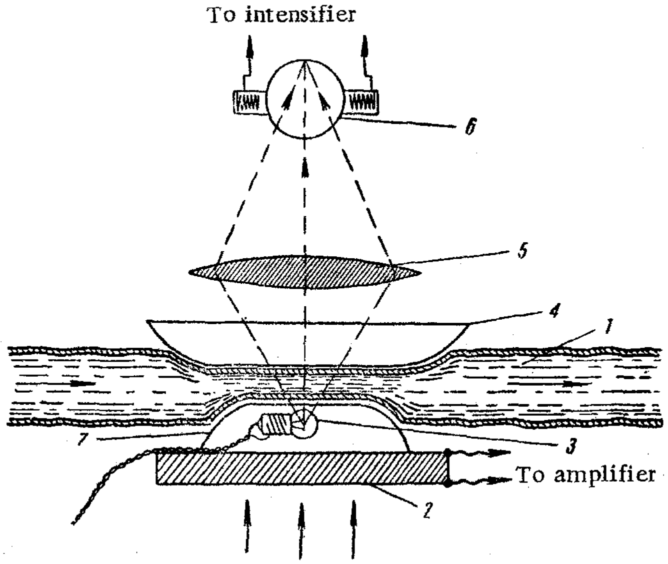

Figure 2. Diagram for objective recording of arterial sounds and the passage of blood through its compressed portion. 1) artery (arrows show direction of blood flow); 2) crystal piezomicrophone with watch glass (7) glued to it; 3) lamp for illuminating the arterial lumen (3 volts); 4) plexiglass arterial compressor; 5) objective for focusing light on the sensitive layer of the photoelement; 6) antimony cesium photoelement. The three arrows underneath indicate direction of the pressure upon the arterial lumen compressing it.

The dissected artery was placed on top the watch glass glued to the crystal piezomicrophone which served to record sounds. Under the watch glass was placed the light from the stethoscope remaining connected to its battery. The artery was pressed against the watch glass by a piece of transparent plexiglass beyond which was placed a vacuum antimony – cesium photoelement impenetrable to light, in a shielded case with an objective and diaphragm. The light from the lamp passes through the artery and diaphragm and is focused by the lens on the sensitive layer of the photoelement. Passage of some blood during systole through compressed portion of the artery altered the intensity of the light beam thus leading to fluctuations of the current passing through the photoelement, these becoming intensified and being recorded on the oscillograph. Simultaneously, the other needle recorded the sound effects within the artery which were taken up by the piezocrystal and intensified by the 3 – cascade amplifier. Altering the arterial compression enabled us to register clearly the sound effects within the artery and the passage through its compressed portion of the systolic blood portions during the different stages of decompression, as can be seen on the curves (Fig. 3).

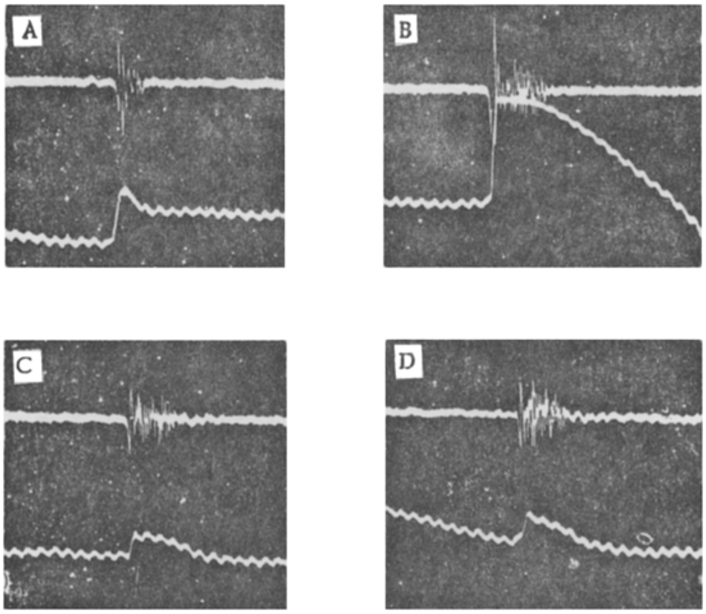

Figure 3. Registration of sound effects and the passage of portions of blood through the compressed portion of the artery when a local area is squeezed during a short experimenton a dog. Upper record – arterial sounds recorded by piezomicrophone. Lower tracing – blood passage through the compressed artery as recorded by the photoelement. Frequency of photoelement recording – 50 periods per second. Rapidity of drum movement – 107 mm/sec. Magnification two times. A) During external pressure just in excess of systolic. During systole a little blood penetrates by the compressed area. In the artery some tone arises. B) during external compression approaching the diastolic. During systole much blood passes by the compressed area. At beginning of stroke against arterial lumen wall a sound is created. During subsequent passage of blood by the compressed area noises arise. C – D) during external pressure below diastolic. Arterial lumen during diastole remains patent. During systole it dilates somewhat. Blood flow by the compressed area is uninterrupted. During systole there is only some acceleration of blood streaming by the compressed area this being accompanied by appearance of noises within the artery.

EXPERIMENTAL RESULTS

The procedures described enabled us to establish that tones and noises arise in the compressed artery for different reasons. The tone arises not, as supposed by many investigators, at moment the pulse wave strikes the obstruction but after a portion of the blood has passed by the obstruction and impinged on the blood mass (and arterial wall) below the compressed area. The tone represents short harmonic (periodic) oscillations of relatively high amplitude.

The noise arising in the mass of blood accelerated by the systolic stroke and hurrying it by the compressed portion of the artery is a series of aperiodic oscillations of different frequencies and amplitude, lasting much longer than the tone. Such oscillations are typical for whirling (turbulent) fluid movements caused by acceleration of the stream velocity.

This objective method has aided us in clarifying somewhat disputed points relating to source of sounds within the artery when its lumen is compressed,the blood pressure being investigated by the Korotkov method.

SUMMARY

A simple method for studying the Korotkov sound phenomena is described and diagramed. The sounds and blood flow can be placed in precise relation to each other. This enables one to demonstrate the precise relation of the passage of the blood stream to the origin of the sounds.