A MINIATURE TRANSDUCER FOR RECORDING THE INTRAVENTRICULAR PRESSURE AND ITS FIRST DERIVATIVE

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To record the rate of change of the pressure in the chambers of the heart requires manometric systems with a uniform frequency characteristic curve in the region of relatively high frequencies. The best results can be obtained by the use of intracavitary pressure transducers, not requiring the use of catheters. This paper describes the design of a miniature intracavitary pressure transducer operating like a strain gauge. If used in conjunction with a tensometric amplifier and loop oscillograph a uniform frequency characteristic curve can be obtained up to 800 Hz.

KEY WORDS: intraventricular pressure; transducers for strain gauges.

The value of the first derivative of the intraventricular pressure as an index of the inotropic state of the myocardium is based on a series of investigations [1, 3, 7-10].

In order to differentiate the pressure curve in the ventricles of the heart, an electromanometric system with a uniform frequency characteristic curve over a wide range of values is necessary [4].

In modern manometric systems, in which external pressure gauges are most frequently used, the greatest frequency distortions are due to the use of catheters to provide the hydraulic connection between the cavities of the ventricles and the working chamber of the transducer of the electromanometer. Even a comparatively short catheter (length 10-12 cm, internal diameter 1 mm) seriously impairs the dynamic properties of the manometric system and limits its frequency range to 8-10 Hz [6]. A second serious defect of a system with an external pressure transducer is the formation of artefacts due to movement of the catheter during the contractions of the heart. These relatively high-frequency oscillations (of the order of 40-70 Hz) are amplified sharply on differentiation of the pressure curve. To reduce this interference filters with a low cut-off frequency (15 Hz or more [5]) are used, but this restricts the potential usability of the method. Reliable data on the maximal rate of rise of the pressure inside the ventricles (dp/dt max) can therefore be obtained either by recording the intraventricular pressure by an external transducer through wide and very short catheters, so that thoracotomy is essential [3], or by the use of intracardiac pressure transducers [4, 7].

The authors have developed a design for a miniature intracardiac pressure transducer, operating on the strain gauge principle, and with a uniform frequency characteristic curve up to 800 Hz (Fig. 1). The body of the intracardiac pressure transducer consists of the base 1 and the cap 2, firmly pressed together during assembly. A window 4 is cut out of the cap, and the free curved end of the working disc 3, connected to the surface of the body, reaches up to it. The second end of the working disc is fixed concentrically in the base of the body 9 by means of epoxy resin. Two strain resistors 5 are glued to the working

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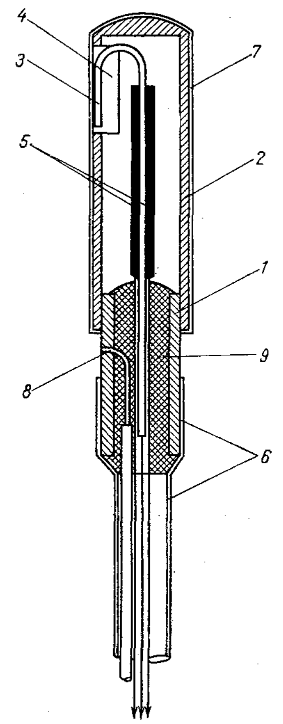

Fig. 1

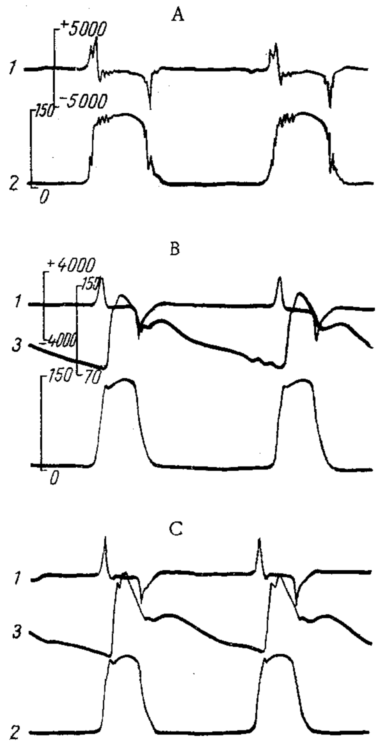

Fig. 2

Fig. 1. Longitudinal section through head of intracavitary pressure transducer (explanation in text).

Fig. 2. Curves of pressure (2) and its first derivative (1) in left ventricle. A) Recording obtained with catheter and external pressure transducer of the EM-2-01 electromanometer; B, C) records obtained with the miniature intracavitary pressure transducer: B) control, C) response to intracoronary injection of 5 μg noradrenalin. The increase in the maximal rate of rise of pressure (C) reflects the positive inotropic effect of catecholamines. Curve 3 in B and C shows pressure inside the aorta.

disc, and the leads from them are brought out through the back of the body and contained in the flexible plastic tube 6. The base and cap of the body of the transducer are made of brass and the working plate 3 is made of sheet spring steel 0.12 mm thick. The transducer is sealed to exclude blood by means of a thin latex sheath 7 wrapped over the body of the instrument.

A change in blood pressure is detected by the curved end of the working disc, deforming it and leading a change in resistance of the strain resistors fixed to it. The changes thus produced in the stress are transmitted to the input of the tensometric amplifier.

A defect of transducers mounted on the end of a catheter is the difficulty of monitoring the absolute pressure in the course of the experiment. This drawback is overcome by recording the intraventricular pressure simultaneously by means of an external pressure transducer through a catheter, the metal tip of which is mounted in the base of the body 8. The absolute pressure is monitored periodically in the course of the experiment.

The frequency characteristic curve of the transducer is linear between 0 and 800 Hz. The resonance frequency is 1100 Hz. Amplitude distortions within the pressure range from 0 to 300 mm Hg do not exceed 3%.

The apparatus for recording the first derivative of the intraventricular pressure consists of a pressuretransducer, a type TA-5 tensometric amplifier, a differentiator designed previously [2], and a type N-700 loop oscillograph.

The absence of filters in the recording system makes it possible to obtain an undamped intraventricular pressure curve, which gives the most reliable representation of the value of dp/dt and its changes.

The size of the transducer (length 25 mm, maximal diameter 3 mm) is such that it can be used in experiments on dogs.

An example of a recording of the pressure inside the left ventricle made with the intracavitary pressure transducer is given in Fig. 2 (B, C). The transducer was introduced in the retrograde direction into the left ventricle through an incision in the coronary artery. The pressure in the left ventricle was calibrated from a zero line obtained by means of the control manometer. The differential signal was calibrated by feeding a trapezoidal signal with known amplitude and known rise time of its leading edge into the input of the differentiator.

For comparison a recording of the intraventricular pressure and its first derivative obtained with the same (undamped) recording system, but by the use of a catheter and an external pressure transducer of the ÉM-2-01 type, is given in Fig. 2A. Artefacts due to movement of the catheter can be clearly seen. The maximal value of the first derivative was determined in this case as the sum of the intraventricular pressure curves and the artefacts.

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