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Determination of left ventricular volume by means of an invasive ultrasonic method*)**)

Bestimmung des linksventrikulären Volumens mit einer invasiven Ultraschallmethode

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With 5 figures

(Received September 24, 1979)

Summary

The volume of the left ventricle was determined by an invasive ultrasonic method. A new model was developed which made it possible to approximate the shape of the left ventricle. In order to evaluate the method’s validity, measurements were made on various geometrical solids and on canine hearts in vitro and in situ.

For the measurements in situ a catheter was developed. Three cylindrical transducers were mounted in that part of the catheter, which was inserted into the left ventricle. In this way, one radius was measured in three different planes. Together with the distance apex-basis which was measured on the excised heart, these measurements were used to compute the left ventricular volume. To date, only the enddiastolic and endsystolic volumes have been analysed.

The experiments which were performed on geometrical solids and on excised canine hearts showed that the method has a high accuracy and a low scatter. However, a systematic error was found while measuring the ventricular volumes of eight canine hearts in situ; the ultrasonic method underestimated the stroke volumes as compared with dye dilution (18.7%) and electromagnetic flow measurements (11.7%). This error is probably due to the fact that the ventricular length was used as a constant factor for calculating the volume. Therefore, future experiments will include the ultrasonic determination of the long axis of the ventricle.

On the basis of the present results, it appears to be realistic to combine the ultrasonic catheter with a tip manometer. This will permit the continuous measurement of left ventricular volume and pressure, and thus facilitate studies on myocardial contractility in situ.

For the last 30 years, ultrasonic methods have been used for measurements on the heart (10). Left ventricular dimensions, such as transverse diameter and myocardial thickness, have been frequently measured with

*) Dedicated to the memory of Prof. Dr. Dr. h.c. W. Lochner
**) Supported by the Deutsche Forschungsgemeinschaft (Sonderforschungsbereich 30, Kardiologie Düsseldorf)
echocardiographical techniques. These techniques can also yield a dynamic picture of the heart as it passes through the cardiac cycle.

While echocardiography can be applied both invasively (4, 9) and non-invasively (6, 13), examinations on man are usually non-invasive. This has some disadvantages. Ultrasound is nearly completely reflected at the boundary between biological tissue and air. For examination of the heart, there exists only a small acoustic window through which the sound beam may pass. To achieve a sufficient depth of penetration, the sound frequency must be relatively low (2.5 MHz), which limits the resolution. During the cardiac cycle, the heart moves with respect to the sound beam such that different parts of the ventricular wall are examined enddiastolic and end systolic. Furthermore, the long axis of the left ventricle and the sound beam are not orthogonal to each other, and the confined angle changes during contraction. While calculating the volume, incorrect