17078. Recording of Intracavity Potentials Through a Single Lumen, Saline Filled Cardiac Catheter.

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The purpose of this report is to present a simple new technic whereby the electrical potential within the human or experimental animal heart can be accurately recorded using a single lumen catheter instead of the usual indwelling wire conductor type of catheter. The column of blood or saline in the catheter acts as the linear conductor to transmit electrical currents arising in the heart.

Apparatus and methods. The technic requires a simple electrode attachment consisting of a 2-4 cm length of silver or German silver wire, an adapter to fit into the arm end of the catheter, and an ordinary battery clip. Two models are illustrated (Fig. 1) Both produced identical records. Since a secure junction is essential for tracings free from artefacts, the model with the metal adapter is recommended for general use and especially whenever high intracatheter pressures exist as in retrograde arterial catheterization of the left side of the heart, or in right heart catheterization of patients with pulmonary hypertension.

The catheter is passed in the usual fashion into the cavity of the heart and is kept patent with a slow drip of heparinized physiological saline or glucose. To obtain intracavity potentials, the above described electrode attachment is connected to the open arm end of the catheter. The exploring terminal of the electrocardiograph is connected to the battery clip of this electrode, and Wilson's central terminal serves as the indifferent electrode. The standardization has been so adjusted that 1 millivolt causes a deflection of 0.8 to 1.2 cm. A radio amplifier type of electrocardiograph is preferred. The electrocardiographic tracing thus obtained represents the potential changes occurring only at the tip of the catheter.

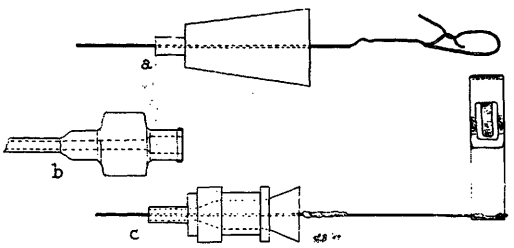

FIG. 1.

(a) Rubber stopper modified to insert into arm end of catheter (b). (c) Is metal syringe adapter with rubber center core. Through each adapter a German silver wire is passed to project 2-4 cm. into the saline filled lumen of the arm end of the catheter. Exploring terminal of ECG is connected to battery clip.

There is a certain amount of admixture of blood with the saline in the tip of the catheter. We have allowed the catheter to fill with blood and compared these tracings with those obtained with a saline flushed catheter. Heparinized saline serves as a more satisfactory conducting medium because of the lesser tendency for blood to clot within the catheter. It is our impression that *clotted* blood has a greater resistivity, as reflected by a diminution in amplitude of the deflections recorded following only minor clot formation. A study of the comparative electrical conductivity of serum, and liquid and clotted blood is planned in the immediate future.

Results. Intracavity potentials have been satisfactorily recorded in 14 patients by this technic. To prove that actual intracavity potential was being recorded, a double lumen electrode catheter was passed into the right ventricle. One lumen contained a wire which extended to the tip, and constitutes the usual cardiac electrode. The electrocardiogram obtained from this cardiac wire electrode was compared with the record simultaneously obtained from the column of blood or saline in the second lumen. In every instance intracavitary potentials were obtained. In general the form of the complexes recorded from each was identical (Fig. 2). Occasionally minor

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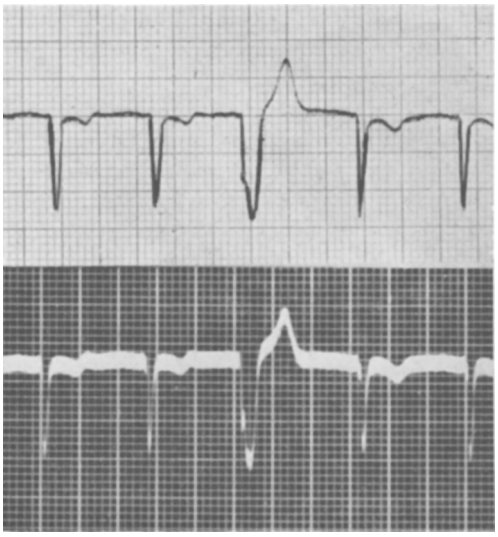

FIG. 2.
Intracavitary potentials recorded simultaneously with a double lumen catheter in right ventricle. Upper tracing was recorded with saline as conductor, lower with usual wire electrode. Form of normal and premature beats are identical. Retouched for publication.

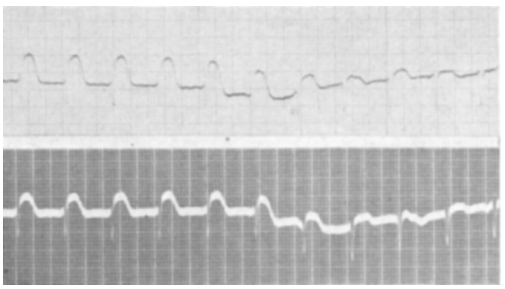

FIG. 3.
Injury in man produced by pressure of tip of double lumen catheter against the endocardium of the right ventricle. As the catheter is withdrawn injury currents disappear. The upper curves were obtained with the saline in one lumen as a conductor. Lower curves were recorded from an indwelling wire which extended to the tip of the second lumen. Note greater ST elevation in the upper record.

differences in contour occurred, due to slight differences in the spatial orientation of the wire electrode tip and the opening of the catheter within the heart. For example, in one patient (Fig. 3) the wire electrode tracing showed definite S-T elevation whereas the open catheter tracing showed more marked S-T elevation, indicating greater currents of injury at its tip, presumably produced by the open end of the catheter resting squarely against the endocardium.[1] Identical records were obtained when the catheter was withdrawn less than 1 cm. Similarly, simultaneous tracings were also recorded at different levels in the right ventricle, right atrium, and superior vena cava.

Although contour was similar, there was a difference in the amplitude of the complexes when the same standardization was used. Consistently, the tracings were larger when recorded through the usual wire electrode, due to the greater resistance of saline or blood.[2] Since the calculated specific resistance of physiological saline at 25°C is approximately 65 ohm cm^3 and that of copper wire 1.7×10^{-6} ohm cm, this difference in amplitude is quite understandable.

There are certain precautions to be observed if satisfactory intracavity tracings are to be recorded from the single lumen catheter without use of a wire. Alternating current interference is frequently encountered and means should be taken to eliminate it. Small a-c voltage is easily picked up from nearby alternating current circuits or machines. A loose connection or a high resistance at the junction at the arm end of the catheter between the saline and the adapter wire favors a-c disturbance. Extreme care must also be taken to keep the operative field dry. If the arm end of the catheter is in contact with a damp field, the electrical potentials recorded will be a summation of that arm's potential and the intracavitary potential subtended by the tip of the catheter. Thus, we have purposely converted a typical intraventricular electrocardiogram to a left arm unipolar tracing by simply placing the arm end of the catheter electrode connection in contact with a saline-saturated towel on the patient's left arm.

There are certain advantages in the use of this technic. A single lumen catheter can thus be used to obtain blood samples, pressure

[1] Hellerstein, H. K., and Katz, L. N., *Am. Heart J.*, 1948, **36**, 184.

[2] Kaufman, W., and Johnston, F. D., *Am. Heart J.*, 1943, **26**, 42.

[3] MacDougall, F. H., Physical Chemistry, New York, Macmillan Co., 1947, pp. 468, 475.

curves, and intracavitary potentials. Some adults and most children have veins too small to allow passage of the usual double lumen catheter electrode.

During the procedure of introducing the catheter, electrocardiographic tracings from the tip of the catheter are valuable in determining the exact anatomical location of the tip. We have found that changes in the contour of the P and QRS complexes may be a more reliable index of the location of the tip of the catheter than either the fluoroscope or the pressure curve, especially in the region of the lower right atrium near the tricuspid valve, or in the coronary sinus.

Summary. A new technic is described to obtain intracavitary cardiac potentials through the single lumen saline filled cardiac catheter without use of the usual copper wire electrode. If the exploring terminal of an electrocardiograph is connected to the open arm end of a column of blood or saline in a catheter which has been introduced into the cavity of the heart, and if the indifferent electrode is connected to a central terminal, the completed curve will represent chiefly the fluctuations of intra-cardiac potential at the tip of the catheter.

Prior to submitting this article for publication we were unaware of the report of Kisch *et al.*, *J. Mt. Sinai Hosp.*, 1948, **15**, 257, who described a similar technic although he advocates the introduction of a thin wire into the catheter to avoid a.c. interference.

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17079. Reflex Modulation of Heart Rate on Closure and Opening of an A-V Fistula.*†

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Branham[1] described the well known slowing of the heart rate which ensues upon temporary obliteration of an A-V fistula by digital compression. The reverse phenomenon, *viz.*, increase in heart rate, also takes place when the pressure is released. That the vagus nerves are the efferent pathway of the reflex arc responsible for this reaction has been demonstrated by Weber,[2] Lewis and Drury,[3,4] and Holman,[5] by use of atropinization techniques. While it is logical to infer that the sinus and aortic nerves constitute the afferent arcs from the arterial side, the possibility that afferents from the venous side may also be concerned has not been excluded. Since closure of an A-V fistula causes a fall, and opening a rise of central venous pressure,[6] such changes in pressure could evoke reflex alterations in heart rate if the Bainbridge reflex is operative. The question as to which afferent pathways are dominantly and subdominantly concerned was therefore resubmitted to experimental study.

Method. Dogs varying in weight from 10 to 12 kilos were anesthetized with chloralose because this anesthetic increases the sensitivity of the cardio-inhibitory mechanism, whereby the vagal tone is well maintained. An

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3 Lewis, T., and Drury, A. N., *Heart*, 1923, **10**, 301.

4 Lewis, T., and Drury, A. N., *Heart*, 1923, **10**, 365.

5 Holman, E., *Ann. Surg.*, 1924, **80**, 801.

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