INTRACARDIAC ELECTROCARDIOGRAPHY

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Intracardiac electrocardiography is one of the modern techniques of medical investigation which has become routine in every laboratory. It has been used in our catheterization laboratory for three years.

The importance of this technique in diagnosis is obvious. It is especially useful in diagnosing infants with heart problems, who are often in serious condition or in heart failure. In these cases, intracardiac manipulations are extremely difficult and must be done very gently. Catheterization should be completed in as short a time as possible. Catheterization with intracardiac electrocardiography will probably supersede simple catheterization, especially with newborns and infants because the former is quicker, safer, and more informative.[1]

Intracardiac electrocardiography is performed with an electrode catheter. A silver wire inside the catheter, which projects one or two millimeters beyond the end of the catheter, serves as an electrode. Its position can easily be controlled by simultaneous roentgen ray screening.[2,3] The catheters are obtainable in all sizes from 5F to 14F, and are 50, 100 or 125 cm. long. A simple device is required to connect the catheter to suitable recording apparatus.[1] The intracardiac electrocardiogram is useful both during cardiac catheterization (when it can be seen on an oscilloscope, either alone or with simultaneously recorded pulses) and later, when the photographic record of the electrocardiogram is studied in more detail.[1] We use both procedures in our laboratory. Intracardiac deflections may be recorded either with the catheter tip in a relatively static position or as it is moved about inside the heart and its great vessels.[1]

Intracardiac electrical potentials are often of a high voltage. In normal standardization the ventricles produce wide and high QRS complexes. Therefore, for routine work, the intracardiac lead should be adjusted at two millivolts for each centimeter. If it is required to record a low voltage complex, the sensitivity should be increased.[1]

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The deflection which is produced from the atrial cavity is called the atriogram and that produced from the ventricular cavity is called the ventriculogram.

The Usefulness of Intracardiac Electrocardiography

1. *Indicates location of catheter.* The intracardiac electrocardiogram shows exactly where the catheter is (fig. 1, 2, 3).

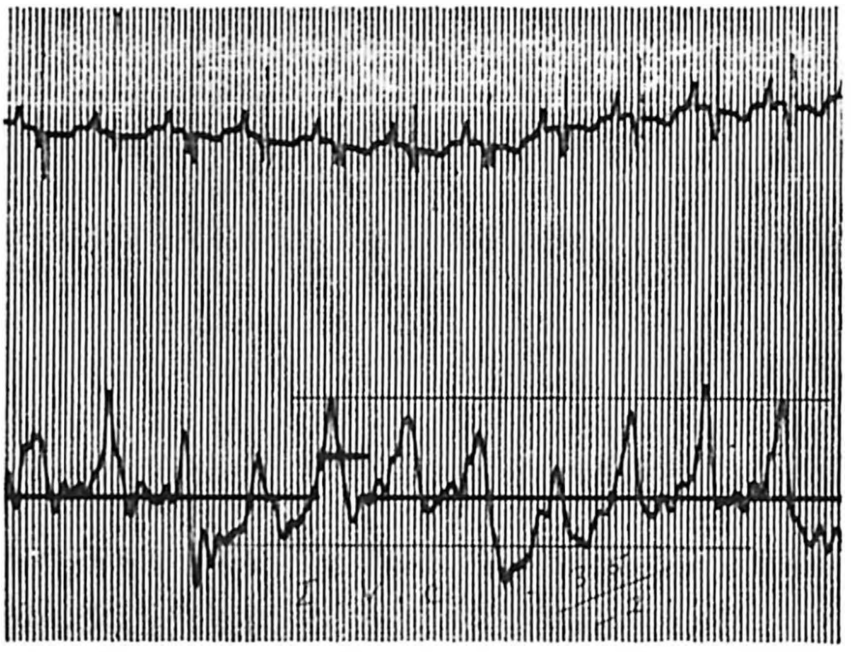
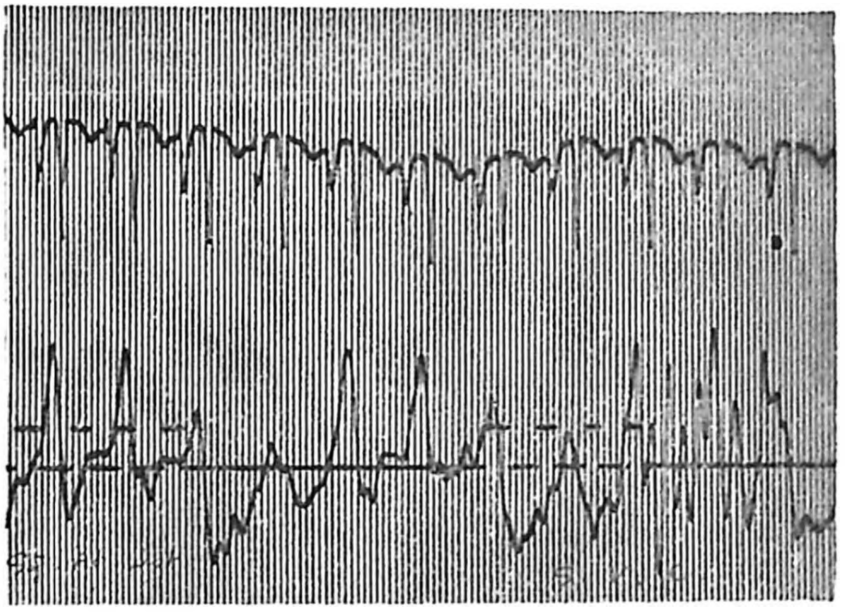


Figure 1. A record made in the inferior vena cava showing the characteristic cardiac electrocardiogram with pressure tracing.

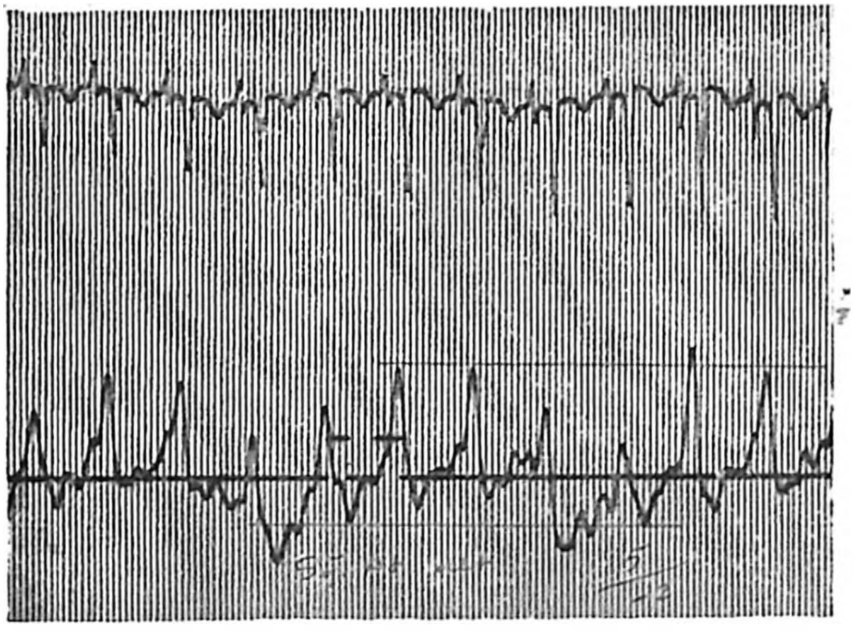
Because the heart is small, particularly in infancy, it is very difficult to determine the position of a catheter fluoroscopically. For instance, the tip of the catheter usually crosses the midline at the high level of the right atrium. It is difficult to enter the pulmonary vein from the patent foramen ovale or an atrial septal defect in this position. It is also difficult to tell whether the catheter is in the right atrium appendage or in the left atrium, as it takes time to obtain the blood or pressure to determine this position.

2. *Indicates presence and location of defect.* This technique shows the presence of the defect and determines its location exactly. For instance, in a case of atrial septal defect, the catheter can be moved from the left atrium to the right at different levels. The location of the defect is determined by the changes in the P waves recorded on the intracardiac electrocardiogram. A negative P wave means that the catheter entered the right atrium at the high level

HIGH



LOW



MIDDLE

Figures 2 and 3. A withdrawal tracing from low level to high level in the right atrium showing that as an electrode passes up through the right atrium there is gradual change in polarity of the P waves which are positive low in the atrium, biphasic in mid-cavity and negative high in the atrium.

of the septum. A biphasic P wave indicates entry at the middle level, and a positive P wave indicates entry at a low level.

3. *Prevents intracardiac injury.* If the catheter tip should injure the endocardium or myocardium, one can see the injury pattern immediately (figures 4, 5, 6).

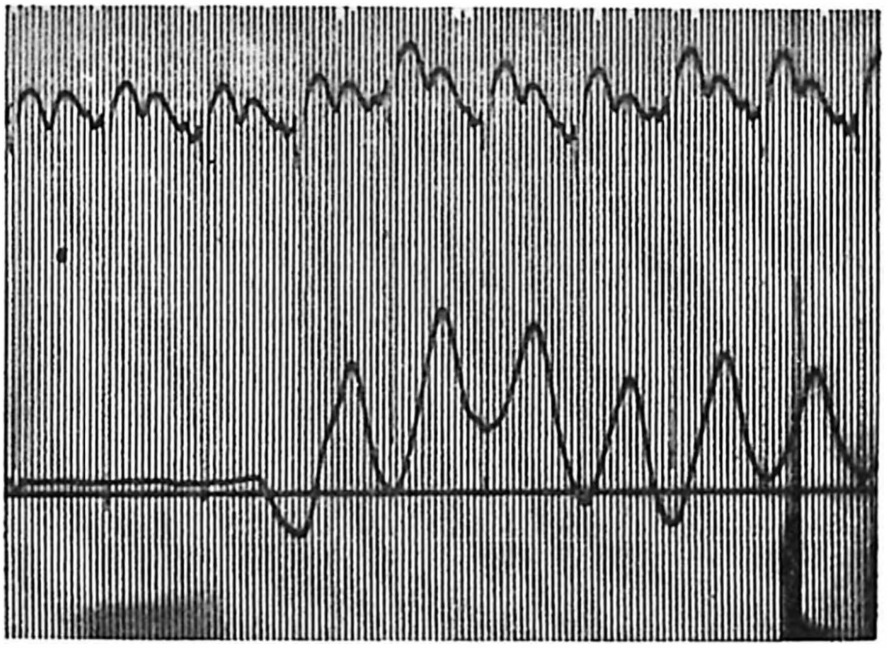


Figure 4. Electrode catheter is in the right ventricle. S-T elevations indicate that the tip has been pushed into the wall with no pressure pulse. As withdrawal begins contact is lost and the right ventricular pressure pulse reappears, dampened, and there is still S-T elevation. The catheter should be withdrawn further.

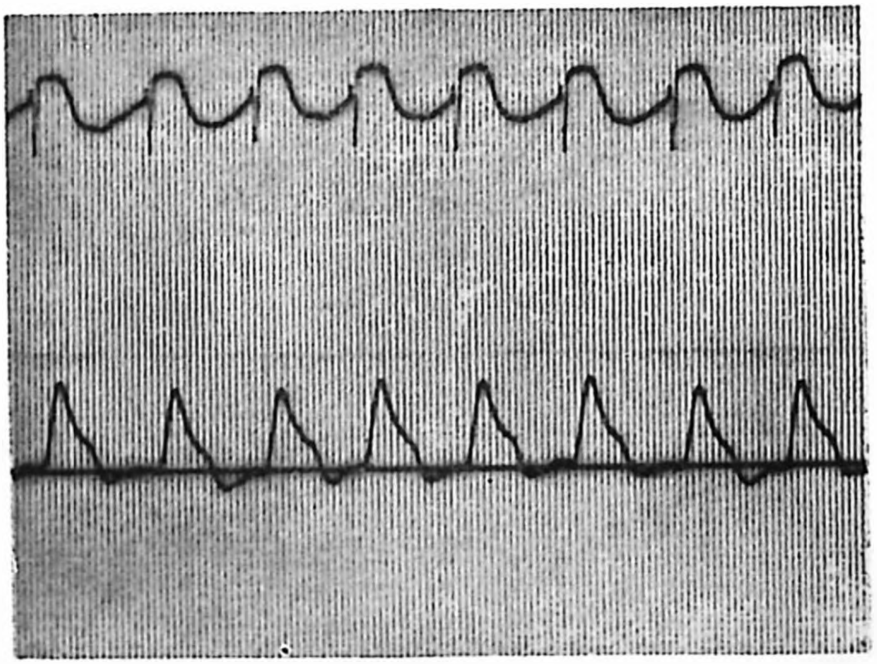


Figure 5. This is a characteristic intracardiac electrocardiogram for intracardiac injury showing damping of the pressure pulse of the right ventricle.

4. *Aids in diagnosis.* This technique helps in differential diagnosis and identification of the types of malformations. For instance, one can differentiate infundibular or valvular, or the combined type of stenosis, with an intracardiac electrocardiogram as well as with a pressure tracing.

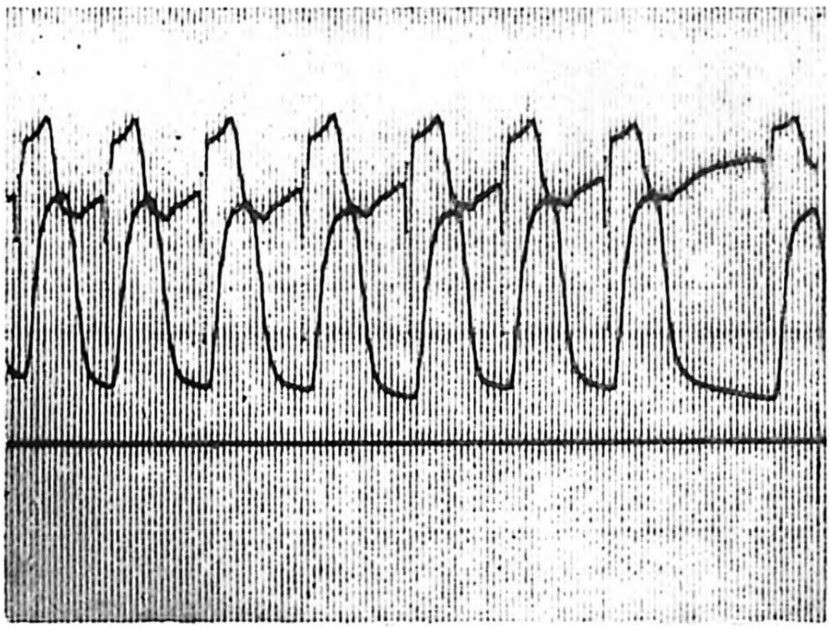


Figure 6. Illustrating the gross S-T elevations which appear on the intracardiac ECG when the tip of the catheter is pressed against the ventricular wall.

5. *Aids in angiocardiography.* In angiocardiography it is very important to be sure where the tip of the catheter is before the contrast medium is injected. Perhaps the greatest danger is from injections of contrast medium under high pressure into the coronary sinus, where the pressure pulse may closely resemble a right ventricular pulse. If S-T elevation is present in the intracardiac lead it means that the catheter tip is either pressed against the ventricular wall or buried in the columnae carneae, and the heart may be seriously damaged.[1]

Intracardiac Leads

Intracardiac leads from the cavity of the right ventricle show a small initial r wave followed by a deep S wave. When the catheter is inserted into the pulmonary artery, the small r wave seen within the cavity of the right ventricle disappears in favor of a monophasic Q wave, because the pulmonary artery takes its potentials from the surface of the left auricle. If the catheter is passed through a patent foramen ovale and the left auricle into the left ventricle, a monophasic Q wave is obtained.[4] Figure 7 shows pulmonary artery, right ventricle, right auricle and superior vena cava cavity leads.

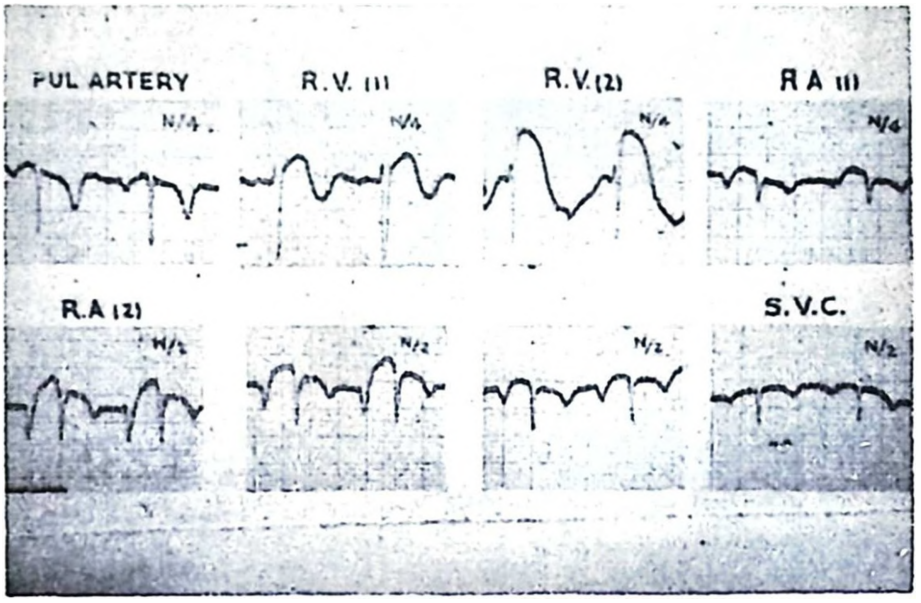


Figure 7. PA, RV, RA and SVC cavity leads.

All ventricular deflections encountered in clinical electrocardiography are thus represented by a limited number of basic QRS patterns as shown in figure 8.[4]

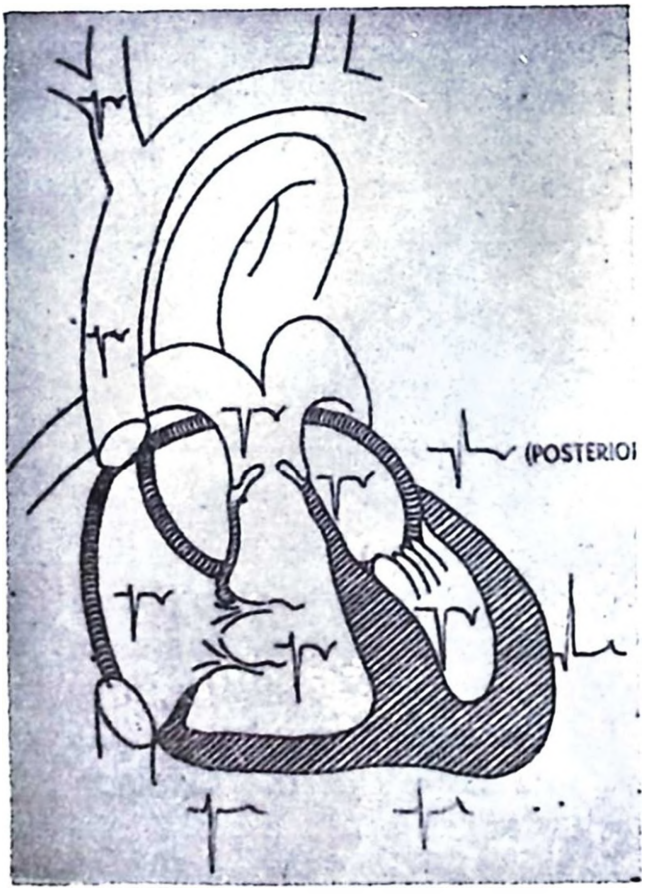


Figure 8. The basic QRS-T complexes.

The left ventricular surface lead shows the QR complex (normally upright T wave); the right ventricular surface lead shows the RS complex (usually upright T wave); left ventricular cavity lead shows the monophasic Q wave (normally inverted T wave); and the right ventricular cavity lead shows the RS complex (normally inverted T wave) and the balanced QR pattern is shown by a combined left ventricular cavity and surface lead from the back of the heart. The direction of the T wave which is the second ventricular deflection is opposite to theoretical prediction in all the basic patterns, and suggests that the recovery wave starts at the surface of the ventricles and is directed towards the cavities.[4] Figure 9 shows the left ventricular cavity complex in AVL in a vertical heart.

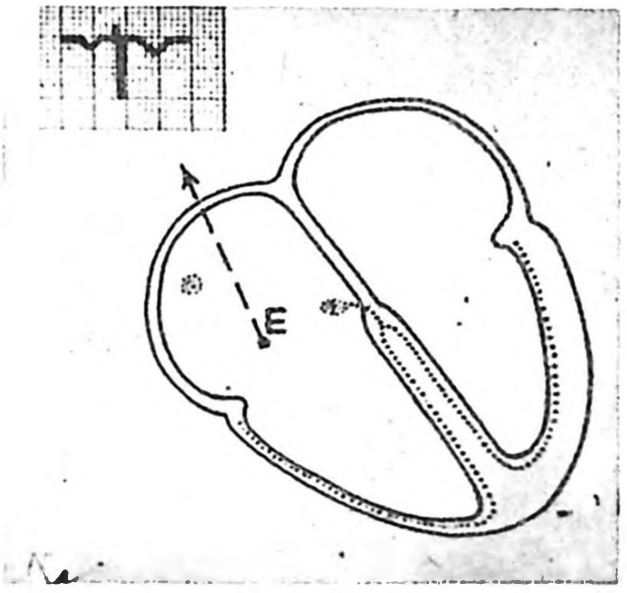


Figure 9. The left ventricular cavity pattern in AVL.

The P wave is inverted if the electrode is above the A - V groove and upright if below. The entire ventricular depolarization complex (QS complex) will be a downward deflection, because the intial septal activation, as well as all subsequent myocardial activation, is travelling away from the exploring electrode. The ST segment is iso - electric, and the T wave is normally inverted. This complex is recorded by actually inserting an electrode within the left ventricular cavity.[5] Figure 10 shows the right ventricular complex in AVR.

The P wave is inverted, biphasic or upright. As a result of septal activation from left to right, an initial small r wave may be registered. Actually this occurs only if the electrode is in close

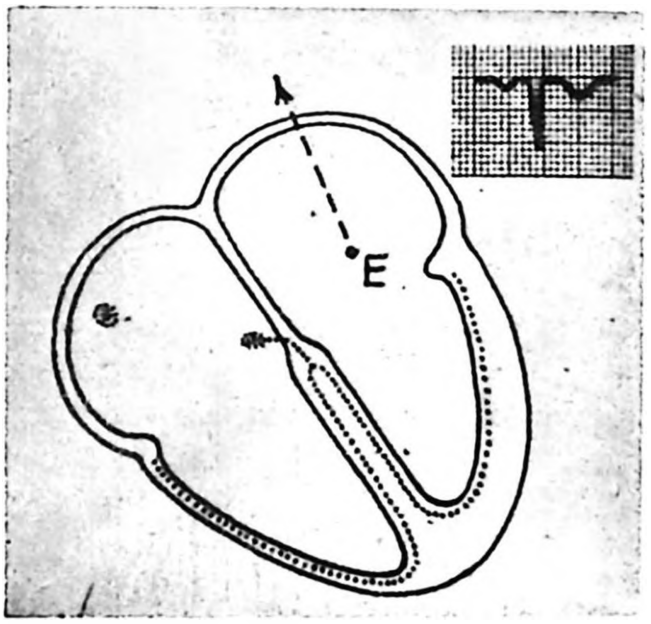


Figure 10. The right ventricular cavity pattern in AVR.

proximity to the septum. As the excitation wave passes through the right myocardium from the endocardial to the epicardial surfaces and passes into the left ventricle, all impulses will be spreading away from the electrode, producing a deep negative deflection, the S wave. Occasionally (about 5 per cent of the time) the late activation of the posterobasal surface of the left ventricle and the region of the pulmonary conus, occuring in the direction of the exploring electrode, produces a second small upright deflection, an r′ wave. Thus, a late r′ may be recorded.[5]

Esophageal Leads

The esophageal lead takes its potential from the surface of the left atrium when high, and from the posterior surface of the left ventricle when low. Left atrial potentials are transmitted from the cavity of the left ventricle, and show monophasic Q waves and inverted T waves. The cavity of the left ventricle is negative throughout the inscription of the initial and second ventricular deflections. The posterior surface of the left ventricle gives rise to a QR complex similar to that obtained anteriorly or laterally. Esophageal patterns therefore show monophasic Q waves or QR deflections, Q dominating when the electrode is relatively high up, R when the electrode is relavitely low down. T is usually negative when the electrode is high, positive when low.[4]

Summary

Keith[6] in 1956 showed that the deaths from congenital heart disease occur chiefly in the first year of life.

Cardiac surgery has advanced rapidly and provided a constant stimulus to the development of precise diagnostic methods. Cardiac catheterization may have to be abandoned at any stage, so speed is essential, and any method of reducing the length of time required for the investigation is of value. An electrocardiogram recorded inside the heart by an electrode at the tip of the catheter is most helpful.

This paper illustrates a few of the ways in which the routine use of intracardiac electrocardiography can make cardiac catheterization in newborns, infants and children quicker, safer and more informative.

REFERENCES

1. Watson, H.: Intracardiac electrography in the investigation of congenital heart disease in infancy and the neonatal period, Brit. Heart J. **24**: 144, 1962.
2. Holzmann, M.: Clinical Electrocardiography, Trans. by Douglas Robertson, London, Staples Press, 1952, p. 122.
3. Luisada, A. A.: Heart, A Physiologic and Clinical Study of Cardiovascular Diseases, second edition, Baltimore, Williams and Wilkins Co., 1954, p. 128.
4. Wood, P.: Diseases of the Heart and Circulation, second edition, Philadelphia, J. B. Lippincott, 1960, p. 81.
5. Goldman, M. J.: Principles of Clinical Electrocardiography, third edition, Los Altos, Calif., Lange Medical Publications, 1960, p. 46.
6. Keith, J. D., Rowe, R. D., and Vlad, P.: Heart Disease in Infancy and Childhood, New York, Macmillan Co., 1958, p. 4.