Supplemental Value of the Intracavitary Electrocardiograph in Cardiac Catheterization


Characteristic intracavitary electrocardiographic complexes at various sites within the heart in normal individuals have been described previously. The intracardiac tracings in 150 catheterizations, 129 of which were abnormal hearts, predominantly congenital defects, were studied in relationship to the position within the heart as determined fluoroscopically. In our experience, the tracings remain sufficiently unchanged in abnormal hearts so that the intracavitary electrocardiogram may be used successfully as a guide, making it possible to decrease total x-ray exposure time considerably. In addition, the significance of an intracavitary injury current became apparent. A few diagnostically useful variants were found and are described.

During the last 2 years, intracavitary electrocardiography combined with cardiac catheterization has become an increasingly useful procedure in our hands. Reports are available describing the rather characteristic complexes obtained at various sites in the normal heart,1-7 and others indicate the possible value of such tracings in specific cardiac abnormalities.8-11 In our studies in 150 cases, 129 of which were abnormal, it has become apparent that, as a rule, the characteristic tracings at the various sites within the heart,1,2,5 continue to be present.

The intracavitary electrocardiogram refers to the tracing that is recorded as a V lead through an electrode ring affixed to the distal tip of the cardiac catheter. The advantages resulting from its use may be described in terms of increased safety to the patient and the additional information gained.

Increased Patient Safety

Particularly prominent at this time is the diminution in x-ray exposure time required for the usual cardiac catheterization. Whereas a total fluoroscopy time of 10 to 15 minutes was previously accepted as an inherent part of the procedure, it is now possible to complete the entire examination in a total of 1 to 3 minutes of fluoroscopy time in most cases. This is because one can recognize the position of the catheter tip in various chambers of the heart by the intracavity electrocardiogram. It follows that direct fluoroscopic observation is required infrequently during the procedure. Occasionally when the tip is at the junction of the subclavian and innominate veins (when an arm vein is being used) it may be passed blindly upward into the neck unless directly observed. This deviation is readily recognizable, however, since the intracavitary lead assumes the form of aVL. On such occasions, fluoroscopy may be needed to redirect the catheter. Fluoroscopy is also necessary when the tip of the catheter fails to pass directly out of the right ventricle into the pulmonary artery and further manipulation is required. Except for these instances, the recognition of the catheter tip's position and its passage within the heart is practicable with intracavity electrocardiogram and the simultaneously viewed pressure record. Customarily, these are inspected on a monitoring oscilloscope during the actual procedure.*

Beginning in the superior vena cava, a pattern is recorded remarkably similar to

*An inexpensive 2-channel monitor can be assembled for less than $100.00 by combining a single-beam oscilloscope with a Heathkit electronic switch.

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that of the proximal right atrium except for the generally lesser amplitude of the complexes (fig. 1). Subsequently, in the proximal, mid, and distal right atria, distinctive patterns are inscribed although the pressure records from all points within the atrium are identical. If the catheter tip should enter the coronary sinus, this too becomes apparent in the intracardiac lead. The P-R interval is appreciably shorter with the peak of the P wave appearing later than the peak of the P wave in lead II or that of the right atrial tracing. In contrast to the right atrial pattern, the T waves are upright or occasionally flat. Correspondingly, in the passage through the right ventricle, distinctive patterns are encountered although the pressure waves are of essentially constant form. Once the tip of the catheter is in the pulmonary artery, there is a progressive lessening of amplitude that labels the tracing as extracardiac. Whether the catheter tip is in the proximal or distal pulmonary artery becomes clearly evident from the progressively diminishing size of the complexes.

A further increase in safety to the patient results from reduction of arrhythmias. It has been most impressive to observe how frequently an injury current may be recorded by the intracavity electrode while a concurrently normal complex is inscribed by the conventional lead II monitor (fig. 2a). Previously we attempted to recognize injury currents during the procedure from a V1 lead, but this is far less sensitive and further complicates handling of the patient and equipment. If such an injury current is not heeded and the catheter tip is allowed to remain in the position from which it is generated, disturbances in rhythm frequently make their appearance or become much more severe within the ensuing few minutes. It would appear logical to assume that at such a time, the tip of the catheter is either impinging directly on the ventricular endocardium or else is lodging among the interdigitations of the trabeculae carneae. Furthermore, even though the tip of the catheter is pointed toward the main pulmonary artery when viewed fluoroscopically, it has proven futile to advance the catheter into this vessel once the injury pattern has appeared. Rather it is necessary first to withdraw the tip and then redirect it through a channel which does not elicit such a response. When the catheter is withdrawn from such an "injury area," normal complexes can be expected to reappear within a dozen beats. Since this phenomenon has been recognized and avoided as more than a transient manifestation, catheterization procedures have never been delayed or discontinued because of rhythm disturbances. On the other hand, if these injury currents are ignored, rhythm and conduction disturbances can develop progressively as is demonstrated by an early example in which an intraventricular block developed following the unheeded appearance of an S-T segment elevation (fig. 2b).

Additional Information Derived

In addition to the ability to localize the catheter tip within the chambers of the heart
electrocardiographically, we have observed additional variants that are diagnostically useful and that do not obscure the basic chamber patterns. Several of the more useful ones are cited.

The intracavity tracing obtained from the left atrium resembles that of the right except that atrial depolarization occurs later. The right atrial P wave is written during the ascending limb of the lead II P wave, whereas the left atrial complex is inscribed during the descending limb (fig. 3). This occurrence is useful diagnostically when an abrupt increase in oxygen saturation is detected in the atrium. Ordinarily, such an increase indicates a left-to-right shunt through an atrial septal defect and the atrial pattern will be as expected. It has been our repeated observation that when such occurs in the presence of ostium secundum, the recorded pattern is that of the proximal right atrium. In ostium primum, the abrupt increase in oxygen saturation occurs at a level where the right atrial P wave is diphasic.

It is of additional note that with the catheter tip within the silhouette of a prominent right atrium, abrupt increases in oxygen saturation can occur with 3 less frequent conditions. If the oxygen content becomes that of full saturation, the tip of the catheter may have passed through a functionally
unimportant foramen ovale or into an acutely angled anomalous pulmonary vein. In the latter instance, a right atrial tracing will be recorded. In the former, the late P wave of the left atrium will be seen. Occasionally, in the presence of peripheral cyanosis, an abrupt increase may occur as well. This may result from the usual left-to-right shunt as with pentalogy. Such an oxygen increase will be equally possible if there is a right-to-left shunt with dilution and resulting partial desaturation of the left atrial blood. In this circumstance, the catheter tip would lie within a small left atrium. The writing of a late P wave in the latter situation easily clarifies this problem, which may be critical when complete anomaly of the pulmonary venous drainage is a diagnostic consideration.

In right atrial enlargement, frequently QRS complexes are obtained from many points within the right atrium that are indistinguishable in configuration from those recorded from within the right ventricle. These complexes begin with initial small R waves followed by deep S waves. Presumably, in right atrial enlargement, the wall of this chamber comes to overlie the right ventricle. During ventricular depolarization, it, too, reflects the QRS of the right ventricle. In such cases it is observed further that the amplitude of the P waves in the right atrium frequently exceeds that of the associated QRS.

Finally, characteristic variants appear to be emerging within the right ventricle that correlate well with a few anatomic lesions. It would seem reasonable to anticipate that such intracavitary patterns, after further and more complete observation, may prove to have considerable diagnostic significance.

**Summary**

The basic characteristic intracardiac tracings obtained at various locations within the right heart in normal individuals have been found to persist as a rule in 150 cases, the majority of which represented congenital heart disease. For this reason it has been possible to reduce greatly the fluoroscopic time required for cardiac catheterization in most cases. The value of recognizing the otherwise inapparent intracardiac current of injury has been discussed. The diagnostic implication of certain contained variants in the endocardial pattern has been presented briefly.

**Summario in Interlingua**

Studios in 150 casos—representante principalmente congenite morbos cardiac— indica que le basic e caracteristic curvas intracardiac obtenite a varie situo intra le corde dextere de subjectos normal se distingue usualmente per lor constantia. In consequentia de iste constatation il ha essite possibile in le majoritate del casos reducir grandemente le tempore fluoroscopic requisit in catheterismo.
cardiac. Es discutite le valor de recognoscere le alteremente inapparente currente intracardiac que es determinate per le injurias presente. Le signification diagnostice de certe circumscripte variantes in le comportamento electric del endocardio es brevemente delineate.

REFERENCES

Up to the last 25 years, Cardiology has remained in the hands of physicians with long training at the bedside and the various instrumental methods of investigation devised by von Basch, Mackenzie, Roentgen, and Einthoven could all be applied by the physician himself directly to his patients, so that the information they provided was incorporated into the clinical picture as a whole and assessed in proper perspective. But today, we are more and more employing instrumental methods which require technical experts to operate them, and which appertain to the Laboratory rather than to the Clinic. Indeed the term “Cardio-vascular Laboratory is already in current use.— Evan Bedford. Address of the President of the European Society of Cardiology, 111rd World Congress of Cardiology, Brussels, September 14-21, 1958, p. 29.
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