THE PHYSICIAN who purchases an electrocardiograph and expects it to write out the correct cardiac diagnosis in all patients is deluding himself, and he may become a danger to his community. Unfortunately, most patients and many physicians consider the electrocardiogram to be nearly infallible, and many people have been wrongly condemned to the life of a cardiac cripple solely on electrocardiographic evidence. These patients illustrate the seamy side of electrocardiography and indicate how a basically accurate and reliable technic may go astray.

Some years ago electrocardiographic errors might have occasionally been due to technical difficulties arising in the actual registration of the tracings. In recent years, however, improvements in the design of equipment, including the use of differential amplifiers and the practice of grounding the subject with an electrode on the right leg, have made it possible for any physician, nurse, or technician to secure records of good quality, provided a few simple instructions are followed. Today, electrocardiographic errors are usually due to inexperienced or overenthusiastic interpretation, and not to technically bad records. This statement does not mean that the technical quality of the tracings may be ignored. This is not, and never will be true, since lead wires will occasionally be mixed, and fuses, resistances, or condensers in the electrocardiograph will go bad. The experienced electrocardiographer is always alert to recognize such mishaps and is constantly trying to maintain and improve the technical quality of the records.

How may one avoid errors in the interpretation of electrocardiograms? Experience in reading tracings and knowledge of some of the basic electric phenomena going on in the heart and how various leads function are perhaps the best answers to this question. Many other factors are, however, involved. Even in a large teaching hospital there is often pressure on the individual or group interpreting electrocardiograms to read as much as possible into the reports. Such pressure may be much greater on the internist in practice. If he doesn’t come through with a report that confirms Dr. X’s suspicion that Mrs. Goldrocks has “myocarditis,” he will soon get a reputation of not knowing much about electrocardiography. Although it may not be easy, the physician interpreting electrocardiograms should resist the tendency to over-read the records. By so doing he will not be a party to the creation of iatrogenic heart disease and will come out ahead in the long run.

A certain number of electrocardiograms show changes that justify a clinical diagnosis without any further information. For example, the majority of tracings taken on patients with acute myocardial infarction show RS-T segment, T wave, and QRS alterations that allow the electrocardiographer to make the diagnosis in question with no other data relating to the patient. Tracings may also have similar specific diagnostic value in connection with the arrhythmias and in a few other conditions like hyperkalemia and hypocalcemia. In contrast to electrocardiograms of this kind is the large group of records that are abnormal but do not point to any single cardiac condition. Included in this category are tracings suggesting right or left ventricular hypertrophy, showing bundle-branch block, and the large heterogeneous
class of electrocardiograms that show abnormal T waves. Tracings of this kind may be very helpful by limiting the number of diagnostic possibilities and also by supplying some evidence favoring the presence of organic heart disease in the patient. It is in connection with assistance of the latter type that the electrocardiographic "eager beavers" do most of their dirty work. They do not know that bundle-branch block, even left branch block, may occur without any significant myocardial disease and do not appreciate how frequently T wave "abnormalities" are found in the complete absence of heart disease.

Over a period of years it has been found that in most normal subjects the T waves are upright in leads I, II, and in precordial leads taken from sites over the left ventricle. If one remembers how easily the recovery process in cardiac muscle is influenced by factors such as temperature, electrolyte levels, and hyperventilation, that have nothing to do with heart disease, it is not surprising that electrocardiograms from individuals with normal hearts may show "abnormal" T waves at times. The sensible electrocardiographer appreciates these matters and never makes a diagnosis of "coronary insufficiency" or, even worse, "coronary sclerosis" on the basis of T-wave changes alone.

A few words must be said about the hyperventilation syndrome. Although this common functional difficulty has been recognized for a long time, many physicians, including some with long experience, fail to suspect the condition either as a major or complicating cause for a patient's symptoms. Several features of the syndrome serve to confuse the unwary physician. Among its protean manifestations are pain, often in the precordial area, and sensations of air hunger, which the patient often will report as true dyspnea. Although the chest pain may superficially resemble angina pectoris, a careful history usually makes it clear that it is quite unlike true angina. Furthermore, the frequent occurrence of numbness and tingling in the extremities and circumoral region, peculiar sensations of tenseness and increasing hyperpnea, often culminating in syncope, usually make the nature of the disturbance clear. Finally, as mentioned above, hyperventilation frequently causes RS-T segment and T-wave abnormalities. These may be either transient or chronic and are often indistinguishable from changes due to coronary artery or other types of heart disease. The existence of electrocardiographic changes with hyperventilation has been known for many years, and in 1943 Thompson reviewed the previous literature and pointed out very clearly the character of the abnormalities and the importance of their recognition. A number of other papers on this subject, including several recent ones, will be found in the literature; in spite of fairly adequate discussion, however, this matter and its important implications seem to be widely ignored. The writer believes that many hundreds, and perhaps thousands, of patients are being treated today as victims of coronary disease when they actually have nothing but hyperventilation syndrome. Poor electrocardiography is, of course, only partly responsible for this situation.

Again, we may ask, how should the physician interpreting electrocardiograms report tracings showing only T-wave abnormalities in a manner that will be as helpful as possible to the clinician and yet minimize the danger of overreading the records? There is no entirely satisfactory way for meeting this situation, but we use the deliberately vague term "suggests myocardial changes" in our reports. Most physicians in our hospital have learned that this noncommittal expression means that we consider the record to be outside of the commonly accepted limits of normal but we don't know why this is true. Physicians interpreting electrocardiograms should always have at hand as much clinical data about patients on whom tracings are taken as is possible. When this information is available, the records may be interpreted in much more specific terms than when such data are lacking. The ideal situation is for the physician responsible for the patient to interpret the electrocardiogram himself, provided he is qualified to do so. The doctor who purchases an electrocardiograph and tries to interpret the tracings himself without adequate experience and training is not much worse than is the physician who sends the tracings away to some agency for interpreta-
tion, particularly if the records are sent without much clinical data.

The foregoing material refers almost entirely to clinical interpretation of electrocardiograms. This facet of electrocardiography must always be the responsibility of the physician. Many physicians, in addition to this purely clinical use of the records, have carried out important investigations that have added immeasurably to our knowledge and the usefulness of the science. One could mention dozens of individuals who have contributed in this way, but few would disagree that Sir Thomas Lewis and Doctor Frank N. Wilson were leaders of this group. It must be pointed out, however, that the first great electrocardiographer, Wilhelm Einthoven, was not a physician but a physicist, and that one of the most important contributions in recent years, the concept of the lead vector, was developed by H. C. Burger, another Dutch physicist working with J. B. van Milaan, a physician. In this country several biophysicists and electrical engineers, including Schmitt, Frank, McFee, and Nelson have done and are doing outstanding work on electrophysiology of the heart and electrocardiographic leads. Although some of this work is rather complicated and technical in nature, many of the important ideas developed by these scientists will in time be used to improve routine diagnostic techniques.

It has been assumed for many years that, during excitation of the ventricles, the accession wave spreads in a roughly radial fashion from the endocardial to the epicardial surfaces of these chambers, and interpretation of the form of the QRS complexes in direct and semidirect (precordial) leads has been based to a considerable degree on this premise. Recent studies by Prinzmetal and associates, however, suggest that the subendocardial layers are excited very rapidly with no clear tendency to radial outward spread and that this type of activation occurs only in the subepicardial regions. Similar work by Durrer, van der Tweel and Blickman and Sodi-Pallares and associates supports this view. Investigations carried out, with a somewhat different technic, by Scher and co-workers, however, are interpreted to support the original contention that activation of the ventricles occurs in a basically endocardial to epicardial direction. This matter is of great practical as well as theoretical importance. If Prinzmetal’s view is correct, the subendocardial muscle will contribute nothing to the QRS complexes obtained in direct or semidirect leads and therefore even extensive infarcts in this inner region will cause no abnormalities of the QRS complexes in the leads in question. At the moment, the writer finds it hard to believe that the subendocardial muscle is so completely silent, but further work must be done to clarify this point.

Vectorcardiography is an interesting field that has been the subject of great activity in recent years. Although Doctor Wilson and the author recorded some of the first records of this kind, using the cathode-ray oscillograph nearly 20 years ago, we have never in our laboratory had a great deal of interest or enthusiasm about vectorcardiography as a practical clinical diagnostic tool. The reasons for this view have been recorded in some detail elsewhere and can only be briefly outlined here.

Since vectorcardiograms are figures obtained by combining with a cathode-ray tube 2 cardiac voltages that might be recorded individually as ordinary scalar electrocardiograms, the vector figures contain no information not present in the 2 ordinary tracings. Phase differences between peaks of R waves in the scalar records, for example, are clearly shown in the vectorcardiogram, but, except for this, the latter has little advantage. The vectorcardiogram is simply a different way of displaying the data present in the 2 ordinary tracings.

If these facts are granted, it seems obvious that leads good for vectorcardiography should also be good ones for scalar records. Most vectorcardiographers have never considered their choice of leads from this point of view. If 3 leads or lead systems can be devised that will yield entirely satisfactory orthogonal components (i.e., transverse, vertical, and sagittal) of cardiac electromotive forces these leads would not only be ideal for vectorcardiography but would provide a scheme by means of which most of the data now requiring at least 9 leads
could be recorded in 3 electrocardiograms. The writer believes that the lead-field concept developed by McFee and Johnston⁷⁻⁹ points to methods for accomplishing this desirable end. These ideas are further discussed in a recent paper by Reynolds, Cordes, Willis, and Johnston.¹⁰

Electrocardiography has advanced a great deal in the past half a century, but even though technical advances in the future may simplify and improve methods for the registration of records, the human element, concerned with interpretation of records will always be with us. In this connection it is well for all of us to keep in mind a remark so often made by Doctor Wilson. "The more one learns about the fundamentals of electrocardiography the more conservative he becomes in the interpretation of tracings."

FRANKLIN D. JOHNSTON

REFERENCES


Medical Eponyms

By Robert W. Buck, M.D.

Valsalva Maneuver. This maneuver was described by Antonio Maria Valsalva (1666-1723) in his Treatise on the Human Ear (De Aure Humana Tractatus), Utrecht, 1717. The following quotation is taken from the edition published at Leyden in 1735, chapter 5, 8, page 84.

"If a person who has a continuously discharging abscess in or near the eardrum will attempt, with his mouth and nostrils closed, to compress the air inside, then, as this is done, the bloody matter will usually flow out freely into the auditory meatus."
Editorial: Reflections on Electrocardiography
FRANKLIN D. JOHNSTON

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