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The Invariants of the Electrocardiogram.*

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By recording electrocardiograms with many different leads it is possible to find those characteristics which are common to all the curves, that is, which are independent of the particular lead employed. Such characteristics are called the *Invariants* of the electrocardiogram and correspond to the essential properties of the electrical changes created during the heart action. It is found that these invariants are (1) recurring cycles of 3 complexes each, and (2) the time-intervals between the complexes and of the span of the individual complexes.

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Electrocardiographic Studies in Subtotal Atelectasis and Pneumectomy in Dogs.

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Changes in the shape of the complexes of the electrocardiogram have been observed in pathologic intrathoracic conditions not primarily cardiac. These conditions include pericarditis,[1] pericardial effusion without demonstrable inflammation,[2] and lobar pneumonia.[3] Bettman and Priest[4] described the electrocardiograms of patients before and after chest operations, including in their series 7 patients on whom extrapleural thoracoplasty was performed. One of the 7 developed the so-called "coronary type" T-wave and 3 others diminution in the amplitude of the QRS complex. These findings suggested a study of the electrocardiograms of dogs following the production of atelectasis or the removal of one or more lobes of

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1 Porte, Daniel, and Pardee, H. E. B., *Am. Heart J.*, 1929, **4**, 584.

2 Scott, R. W., Feil, H. S., and Katz, L. N., *Am. Heart J.*, 1929, **5**, 68.

3 Shearer, M. G., *Am. Heart J.*, 1930, **5**, 801.

4 Bettman, R. B., and Priest, W. S., *Am. Heart J.*, 1930, **5**, 366.

lung. The operations were done as described elsewhere by Adams[5] and the amount of functioning lung tissue calculated according to his table.

Nine dogs were studied in which collapse of one or more of the pulmonary lobes had taken place more than a month previously. In this group 2 had sinoauricular block and 4 had inversion of the T-waves in leads 2 and 3. One had depression of the ST segment below the isoelectric line with inversion of T in leads 2 and 3. QRS was of very low amplitude in all leads in one dog. This finding was confirmed in repeated tracings. The dogs in this series had from 43% to 57% of functional lung tissue.

On one dog a tracing was taken the next day after the collapse of the left upper lobe. The entire right lung had been collapsed more than a month previously, so that at the time the tracing was taken only 28% of the original lung tissue remained functional. This dog had a notched but upright T-wave in all leads. The rate averaged 60 per minute. There were a few points in the tracing where the intervals between beats were exactly half the adjacent intervals and it was felt that this dog probably had a marked sinoauricular block.

One of the dogs was observed later during the collapse of the left lower lobe 11 days after the first tracing was taken. An electrocardiogram taken soon after the onset of dyspnea, before atelectasis had progressed far as observed under the fluoroscope, contained a depressed ST interval as had been previously observed. Three hours later, when fluoroscopic evidence indicated the atelectasis to be progressed much further, the ST interval began 1.5 mm. above the isoelectric level, was conves downward to the isoelectric level, and ended in an upright T-wave. An inverted T-wave preceding the upright peak which had been present 3 hours previously had completely disappeared. Electrocardiographic tracings taken 24 hours after the onset of dyspnea showed no further change. Following this collapse the left upper lobe was the only functional lung tissue in this dog.

Three dogs were examined in which there had been atelectasis followed by surgical removal of one or more atelectatic lobes. Of these one had an inverted T-wave in leads 2 and 3, two alterations in the shape and level of the ST segment, and one sinoauricular block. The amount of functional lung tissue was 33 to 57%.

All the dogs seen in this experiment had very well-marked sinus arrhythmia. The sinoauricular block type of curve occurring in 4

[5] Adams, W. E., PROC. SOC. EXP. BIOL. AND MED., 1931, **28**.

of the 13 dogs with part of the lung out of function may be considered to differ from the sinus arrhythmia in these cases only in degree. Both types of rhythm are seen in normal dogs, although in our experience they do not occur so frequently. We consider these arrhythmias to be due to vagal action. The inversion of the T-wave is of questionable significance when the frequency of this phenomenon in the dog is considered. The ST changes are slight, but are sufficiently unusual to suggest further investigation, including control electrocardiograms preceding operation. We do not feel that we have sufficient data to explain the ST changes at the present time.

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Rate of Elimination of Certain Toxic Substances from the Blood.*

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In certain diseases it is believed that the symptoms are due to a toxin which circulates in appreciable amounts in the blood stream. Efforts have been made to demonstrate this substance in the blood of diseased men and animals by chemical analysis, or by the injection of their whole blood, blood serum or blood extracts into healthy animals. These injections have been given intravenously or intraperitoneally. It was believed that if the individual was poisoned by such a toxin, the injection of his blood or blood serum into healthy animals would produce toxic symptoms in them. The negative results in these experiments have been considered proof of the absence of such an intoxication.

It seemed to us, however, that toxic substances might be so rapidly removed from or inactivated in the blood that although an individual was suffering from a profound poisoning, the substance might not be demonstrable in the blood stream.

The following experiment was devised to test this assumption. Dogs were matched as for size and the compatibility of their bloods and were anesthetized with sodium barbital intravenously (200 to 250 mg. per kg.) or by stomach tube (250 to 300 mg. per kg.). They were then prepared for the typical carotid-artery-jugular vein

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