CHANGES IN THE ELECTROCARDIOGRAM PRODUCED BY THE NARROWING OF THE ASCENDING AORTA IN WHITE RATS.

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(With 3 Tables in the text.)
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In our preceding communication (Hajdu and Beznák, 1946) we published a method by which, through the narrowing of the ascending aorta, a state was produced in many respects similar to the aortic stenosis known in human pathology. To get a picture of the condition of the heart an electrocardiogram was made at different times after the narrowing. Our present communication contains the results and evaluation of these observations.

METHODS.

The electrocardiograms were made on the experimental animals of the preceding communication. The rats lay on their stomachs in light ether anaesthesia. Needles were pushed through the skin in the usual Einthoven leads and records were taken with a Swedish Elmquist electrocardiograph. The first electrocardiogram was made immediately before, the second immediately after the narrowing. Afterwards a record was taken each week until the deaths of the animals. Our results were based on the electrocardiograms of 40 rats. In one case, only the record before, and in one, only that after the narrowing was available. There were 2 records after the narrowing in 19 cases, 3 records in 11 cases, 4 records in 11 cases and 5 records in 11 cases.

EXPERIMENTAL RESULTS.

Table I. shows the cardiac frequency of rats before, immediately after the narrowing, and later once every week. It is seen from the Table that the cardiac frequency of normal rats is 436±58/minute. This decreases to 329±43/minute immediately after the narrowing. This decrease is transitory, as the frequency returns to normal 1 week after the narrowing and decreases only during the 4th week. The decrease amounts to —24% immediately after and to —18% four weeks after the narrowing.

TABLE I.

Cardiac frequency/min. of rats																	
Normal			Immediately after the narrowing			1 week			2 weeks			3 weeks			4 weeks		
No	M	± μ	No	M	± μ	No	M	± μ	No	M	± μ	No	M	± μ	No	M	± μ
38	436	58	37	329	43	19	420	47	11	448	42	11	420	34	11	357	84

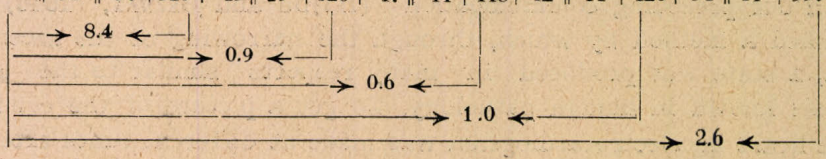
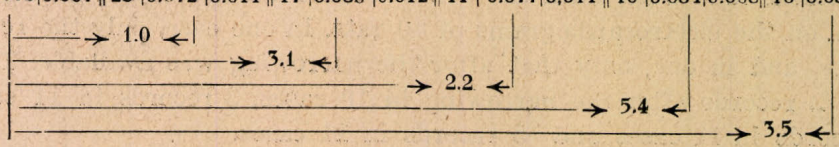


Table II shows the length of the electric systole (Q—T distance) in σ. In normal animals this is 70±7σ; it gets gradually longer in consequence of the narrowing. Immediately after the narrowing it has the same value as normally, it is 14% longer on the first, 10% longer on

TABLE II.

Duration of electric systole (Q—T distance) in seconds																	
Normal			Immediately after the narrowing			1 week			2 weeks			3 weeks			4 weeks		
No	M	± μ	No	M	± μ	No	M	± μ	No	M	± μ	No	M	± μ	No	M	± μ
34	0.070	0.007	25	0.072	0.011	17	0.080	0.012	11	0.077	0,011	10	0.084	0.008	10	0.086	0.014



the second, 20% longer on the third, and 23% longer on the fourth week.

Table III. is constructed of the data of Tables I. and II. It shows what percentage the electric systole makes of a whole revolution. It is seen from this Table that normally an electric systole takes up 50% of a whole revolution. As the heart rate slows down immediately after

TABLE III.

An electric systole as % of a whole revolution

Normal			Immediately after the narrowing			1 week			2 weeks			3 weeks			4 weeks		
No	M	± μ	No	M	± μ	No	M	± μ	No	M	± μ	No	M	± μ	No	M	± μ
34	50	4	25	39	7	17	55	7	10	56	8	10	59	9	10	48	10

→ 6.6 ←
→ 2.7 ←
→ 2.3 ←
→ 3.0 ←
→ 0.6 ←

the narrowing and the duration of the electric systole is unchanged, it occupies a smaller part — only 39% — of a whole revolution. Later the electric systole becomes longer (Table II.) and the frequency increases to the normal value (Table III.); correspondingly an electric systole takes up a greater part of a whole revolution during the 1st, 2nd and 3rd weeks. The situation changes during the 4th week, when the electric systole is longer than normal, but the heart rate is again — if to a smaller extent — slower. At this period the electric systole consists of 48% of a whole revolution, a value statistically equivalent to the normal 50%.

The atrio-ventricular conduction time (P—Q distance) is $47 \pm 4\sigma$, in normal rats. Immediately after the narrowing its value increases to $51 \pm 5\sigma$, but percentually takes up a smaller part of a whole revolution (28% instead of the 33% normal value); that is, it behaves similarly to the electric systole. Later on the atrio-ventricular conduction time shows no change.

The T-waves are positive in normal rat electrocardiograms, here and there a small ST depression occurs in the 1st lead.

In one rat we observed ventricular premature contraction and in two, transitory a-v block in normal condition. The rat which normally showed ventricular extrasystoles lived 28 days after the narrowing in clinically compensated condition. Of the two animals showing a-v block

normally, one lived also for 28 days in compensated condition; no signs of block were seen on later records. The other rat died in consequence of the rupture of the aorta before we were able to take a second electrocardiogram. On the record taken immediately after the narrowing no a-v block was seen.

Qualitatively, the following changes in the electrocardiogram may be observed after narrowing the ascending aorta: The T-waves become flat immediately after the narrowing, later they become transitorily positive again. In the animals living longer than 2 weeks after the narrowing, the T-waves again become flattened and remain thus until the end of the experimental period (28 days).

A longer or shorter time after the narrowing ST depression occurred in 13 rats in one, two or all the three leads. We observed auricular extrasystoles in two, ventricular extrasystoles in two, auricular fibrillation in two, sinoauricular block in one, partial block (3:1, 2:1) in two and total atrio-ventricular block in one case.

Comparing the changes of the electrocardiograms with the clinical observations of the rats and their autopsy findings, the following statements can be made:

There is no correlation between the initial heart rate, the ensuing bradycardia and the clinical state of the animals. As we stated in our preceding paper, 60% of the rats died in consequence of aortic rupture during the first 10 days; 20% of the animals showed signs of decompensation, and 20% remained alive until the end of our experimental period (28 days).

Changes in the electrocardiograms appeared at least one week, generally two weeks after the narrowing. Accordingly there is but little change to be seen on the electrocardiograms of the rats dying in the course of the first 10 days as a consequence of aortic rupture. Only in 5 of 21 animals which died thus did we observe a flattening of the T-waves in all the three, and in one in the 1st lead only. In three of these ST depression also occurred in the 1st lead during the course of the 1st week. In one animal of the above 5, a partial block (2:1 resp. 3:1) also occurred.

The other changes described — as they generally appear only after the second week — were seen in rats living longer than this period; that is, in rats dying either in decompensation or living in a compensated state for 28 days. There was no correlation between the severity of the changes in the electrocardiograms and the state of the animals; i. e., compensation or decompensation.

In five cases we observed a marked rise of the P-wave which at

the same time became more pointed (P-pulmonale) in the IInd and IIIrd lead. Three of these were seen in decompensated animals. In one case P-pulmonale was observed already one week after the narrowing, in one on the 2nd, in one on the 4th week. In two cases it was seen in rats which lived for 28 days in a compensated state and where on autopsy we found a relatively small heart and "induratio brunea" of the lungs. Of these one developed during the 2nd, and one during the 3rd week after the narrowing.

DISCUSSION.

By narrowing the ascending aorta we produce a state in many ways resembling the aortic stenosis seen in human beings. From the electrocardiograms taken immediately after the narrowing a sharp fall in the heart rate can be observed. Similar results were gained by DALY and VERNEY (1927), who increased the pressure in the left ventricle and found bradycardia if the vagi were intact. This bradycardia is, however, only temporary, for 1 week after the narrowing the frequency is again normal. The bradycardia of the 4th week is different from that seen immediately after the narrowing. It is observed in every animal immediately after the narrowing, whereas in the 4th week a sharp decrease in frequency takes place in some animals, while others scarcely change. That accounts for the greater deviation of the mean value.

The electric systole becomes longer after the narrowing. Immediately after the narrowing its value is the same as normally but as the heart rate is slowed down at the same time, the electric systole takes up a smaller part of a whole revolution than it normally does. This means that in the ensuing bradycardia only the diastole becomes longer. The conduction is unchanged but the impulse formation becomes slower. Later the time of the electric systole is longer. The frequency being normal at the same time, the electric systole takes up a greater part of a whole revolution than normally. During the 4th week bradycardia is again present, with longer electric systole at the same time, so that the relation of electric systole to whole revolution is the same as under normal conditions. Somewhat similar results were obtained by RASSMUSSEN (1942), who found that the QRS complex changed in dogs from 0.03—0.04 sec. to 0.07—0.09 sec. after the ligature of the aorta. The changes generally observed after the 2nd week are: flattening of the T-waves, St depression, in some cases block. These symptoms occur with the same frequency in decompensated rats and in those living 28 days

in a compensated state. In these experimental conditions, therefore, no conclusion can be drawn from the changes in the electrocardiograms of the clinical state of the rats.

It is interesting to note that the same experimental procedure — aortic stenosis — produces very varied changes in the impulse formation and conduction. We cannot say that a definite procedure — narrowing the ascending aorta — produces such and such a change in the electrocardiogram. Behind each change the breaking down or disturbance of a definite biochemical process is to be suspected. Depending on the individual hearts, the same experimental procedure produces a disturbance in varied biochemical processes, the results of which are the manifold changes in the electrocardiograms.

SUMMARY.

Electrocardiograms taken of 40 rats before, immediately after, and then weekly after narrowing the ascending aorta show the following changes:

1.) Narrowing the ascending aorta causes bradycardia. This is transitory, for the heart rate becomes normal one week later and a decrease occurs again only 4 weeks later.

2.) A later consequence of the narrowing is the lengthening of the electric systole.

3.) The T-waves flatten immediately after the narrowing. Later they may again become transitorily positive.

4.) In the majority of cases ST depression occurs.

5.) Observed changes are: auricular extrasystoles (2 cases), ventricular extrasystoles (2 cases), auricular fibrillation (2 cases), sino-auricular fibrillation (2 cases) sino-auricular block (1 case), partial block (2 cases), total auriculo-ventricular block (1 case).

6.) P-pulmonale was observed in 5 cases.

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LITERATURE.

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