Physiology. — *"On the heart-rhythm."* III. By Dr. S. DE BOER.
(Communicated by Prof. J. K. A. WERTHEIM SALOMONSON).
(Communicated in the meeting of April 23, 1915.)

On the components of the a-v-interval.

- In the estimation of the disturbances of the rhythmic functions of
the heart the *a-v*-interval plays a comparatively important part. It
is consequently of great interest to know exactly by what factors
the duration of this interval is determined. When determining this
interval, we measure the time that elapses between the beginning
of the auricle-systole and the beginning of the next following systole
of the ventricle. What we determine in this way is consequently
not only the time of transmission of the stimulus from the place of
entrance into the auricle till the time of entrance into the ventricle;
for it is obvious that, in our determination, we have not left out of
account the time that the stimulus has required to exert influence
upon the ventricle, i.e. the time of the latent stimulation. If now we
make our estimation by means of mechanical curves, then the latter
amount is rather important, but with electrograms this latent time
exists likewise.

It is now my intention to represent this with some curves.

In Fig. I we see two rows of curves of a suspended frog's heart;
the rhythm of auricle and ventricle is halved. A stimulator is applied
to the basis ventriculi by which we administer at the end of the
diastole an extra-stimulus (the closing strokes at which the signal
goes down are prevented, the opening strokes,— motion of the signal
upwards — reach the ventricle). The first stimulus of the upper row
of curves falls in the refractory period. The second opening stroke,
which takes place later in the heart-period occasions an extra-systole
with a rather long latent period. After this extra-systole follows the
auricle-systole of the normal rhythm, the *a-v*-interval between this
auricle-systole, and the then following systole of the ventricle is almost
twice as long as the *a-v*-interval of the normal rhythm. It is obvious,
that the cause thereof is to be found in the decreased irritability of
the ventricle-musculature by the shortening of the preceding pause, the
stimulus coming from the auricle requires more time to exert influence
upon the ventricle.

In the second row of this figure we see a repetition of this
phenomenon with the same result for a stimulus occurring a little
earlier. We see here, at the same time, that the latent time after
an extra-stimulus is the longer in proportion as the stimulus takes
place earlier in the heart-period. This figure illustrates likewise
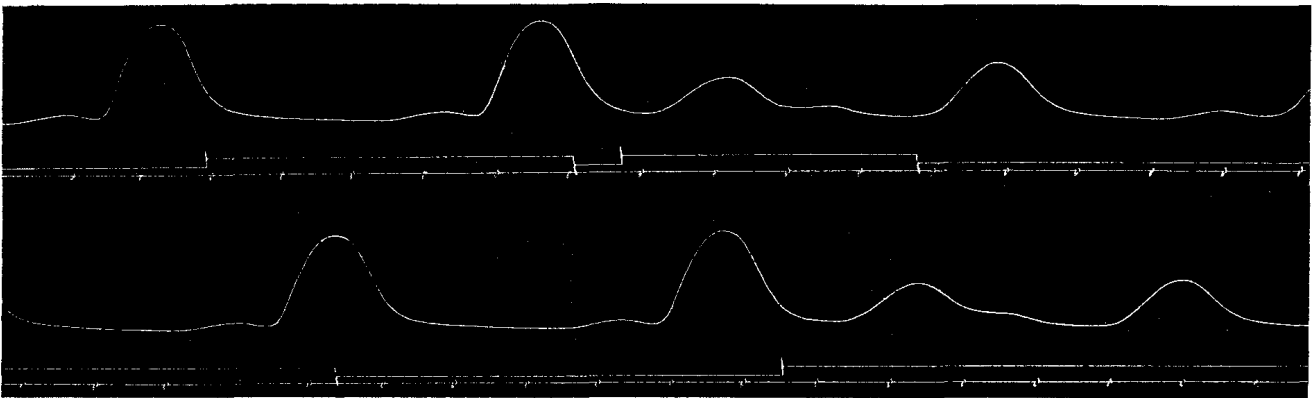
Fig. 1.

Two rows of curves of a frog's heart poisoned with veratrine after halving of auricle- and ventricle rhythm. The first opening induction-stroke on the basisventriculi (motion of the signal upward) takes place in the refractory period The 2·ᵈ opening-stimulus, which takes place later in the heart-period, gives an extra-systole. The then following auricle systole of the normal rhythm is followed with a *lengthened a v-interval* by a ventricle-systole. In the 2·ᵈ row repetition of this experiment with the same result. The closing-stimula (motion of the signal downward) are prevented. Time 1 sec.

condition of the heart-musculature. I found this fact everywhere confirmed in my frog's hearts poisoned with veratrine.

By a second observation of my frog's hearts poisoned with vera- trine, it is shown, that the duration of the *a-v-interval in unchanged*

metabolic condition of the ventricle-muscle can depend upon the condition of the transmission-systems from the point of beginning in the auricle to that of the ventricle. If namely first the ventricle-rhythm has been halved and afterwards the rhythm of the auricle, then I saw after the latter halving the a-v-interval considerably reduced.
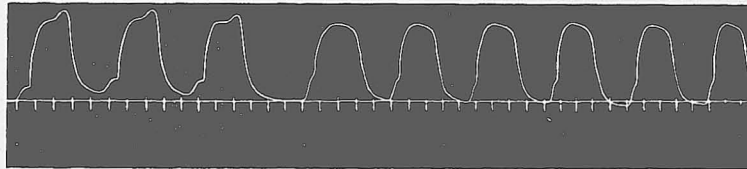
Fig. 2.

Halving of the ventricle-rhythm during the first 3 systoles, whilst the rhythm of the auricle is still normal. Thereupon the rhythm of the auricle halves likewise. The a-v-interval is then considerably shortened.

As an example we cite as follows: In Fig. 2 we see a row of curves of a suspended frog's heart, represented 40 min. after the injection of 10 drops of acetas veratrini into the abdominal cavity. During the first three systoles the rhythm of the ventricle is halved, whilst the auricle-rhythm is still undisturbed. After this the following auricle-systole falls out, so that on each then succeeding ventricle-systole an auricle-systole appears. It is remarkable how considerably the a-v-interval is now shortened. Apart from the influence of the hiatus, that during some succeeding systoles can improve the metabolic condition of the heart-muscle, the condition of the ventricle-
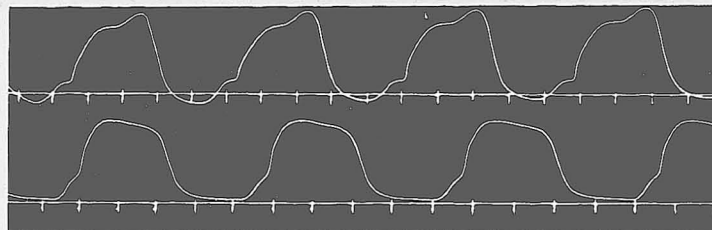
Fig. 3.

The lower row of curves was represented 5 minutes after the row of curves of fig. 2 with greater rapidity of the drum. The a-v-interval is still considerably shortened. The upper row of curves was represented 10 min. before that of fig. 2. Time 1 sec.

musculature remains unaltered, for the ventricle continues to pulsate in the same rhythm. The condition however of the track of the transmission of stimula from the point of beginning in the auricle to that in the ventricle has changed.

Formerly the stimulus was twice transmitted during one ventricle-systole along this track, now only once; formerly on each ventricle-systole two auricle-systoles occurred, now only one. [1])

That the hiatus, caused by the falling out of one auricle-systole is indeed not the cause of the shortening of the a-v-interval is proved by the further progress of the curves. Thus we see in the lower row of curves of Fig. 3, which is represented 5 minutes after that of the former figure, the a-v-interval still constantly shortened. The upper-row of curves of Fig. 3 was registered 10 min. before that of Fig. 2. We must pay attention to the fact that, when noting down the curves of Fig. 3, the rotations of the drum were quicker, and for the lower row again quicker than for the upper row; consequently the curves are drawn out more in width.
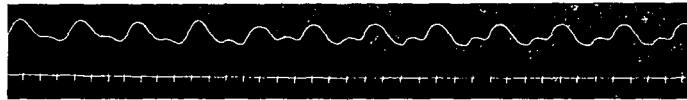

Fig. 4.

During the first 4 systoles halving of the ventricle-rhythm. Thereupon the rhythm of the auricle halves likewise. The first auricle-systole that falls out ought to have stood on the 5th ventricle systole. This is the cause that there occurs no hiatus. The a-v-interval after it is shortened. The curves show the falling out of every 2nd auricle systole as the tops of the ventricle-curves become rounder.

We see in Fig. 4 another example. Half an hour after the injection of 8 drops of 1 $^o/_o$ acetas veratrini the ventricle-rhythm of this frog's heart was halved, half an hour later when a few times variations of the ventricle-rhythm had taken place, the rhythm of the auricle halves. The first auricle-systole falls out on the top of the fifth ventricle-systole of the figure. The acute ventricle-top becomes by the falling out of the auricle-systole, that stood on its top, obtuse and rounded off (by looking at the heart I have also observed that afterwards on each auricle- one ventricle-systole occurred). Because the first auricle-systole, which falls out, ought to have come on the top of the ventricle-curve no hiatus occurs now. The shortening of the a-v-interval is also here obvious. By exact measurement we see, that after the halving of the auricle-rhythm

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[1]) The stage of the latent irritation of the auricle will certainly be shortened, but we may safely admit, that this has no influence on the a-v-interval, only the si-a-interval is shortened by it.

the a-v-interval is not suddenly reduced to the definitive extent, but becomes smaller from systole to systole; thus before this halving the a-v-interval amounts to $1^1/_4$ sec., for the first systole after the halving of the auricle-rhythm $1^1/_8$, for the second $1^1/_{10}$ till for the fifth, sixth and seventh this amount is 1 sec.; $1^1/_2$ min. later (vide Fig. 5 lower row) this amount is likewise still 1 sec. The upper-row of curves of Fig. 5 has been represented 15 min. before the lower. Here we see a variation of rhythm of the ventricle.
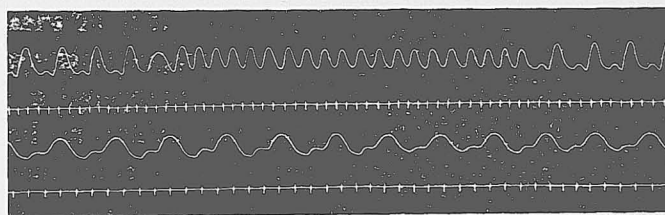

Fig. 5.

The lower row of curves has been represented $1^1/_2$ minutes after the curves of fig. 4. The a-v-interval is still shortened. The upper row has been represented 15 minutes before the lower. We see hereupon a variation of rhythm of the ventricle.

When estimating the variations of the a-v-interval we must consequently always ask, which amount of it must be attributed to the transmission of stimuli, and which amount is caused by the possibility of exerting influence upon the ventricle-musculature. So the shortening of the a-v-interval after the halving of the ventricle-rhythm must be attributed to the improved possibility of exerting influence upon the ventricle-musculature. If the rhythm of the auricle halves at the same time as that of the ventricle, then both factors contribute to the shortening of the a-v-interval.

For the extra-systole after irritation of the auricle both factors contribute to lengthen the a-v-interval, for the then succeeding post-compensatory systole to shorten the a-v-interval. For the post-compensatory systole after extra-irritation of the ventricle the a-v-interval is again shortened by the possibility of exerting influence more rapidly upon the ventricle-musculature.

We shall however continue to speak of the power of transmission of the connecting-systems, and estimate this in accordance with the a-v or P-R-interval, but the above evidence must guide us when drawing our conclusions.

Along a quite different way I showed that the ventricle-systoles have a latent stage for the irritation coming from the auricle, of a

duration that changes in accordance with the metabolic situation of the ventricle-musculature. I found in fact that the duration of the R-V-interval (this name I gave to the interval between the beginning of the R-oscillation of the ventricle-electogram and the beginning of the ventricle-suspensioncurve belonging to it) increases considerably after poisoning with veratrine; when then the ventricle-rhythm halves this R-V-interval decreases again, and increases afterwards again when the poisoning-process continues. [1])

Mathematics. — "*A particular bilinear congruence of rational twisted quintics*". By Prof. J. DE VRIES.

(Communicated in the meeting of April 23, 1915).

1. In a communication in these Proceedings of March 27th last, (volume XVII, p. 1250) I considered a congruence of rational twisted quintics, ϱ^5, which is determined by a net of cubic surfaces the base of which consists of a twisted cubic, a straight line and three fundamental points. We arrive at a $[\varrho^5]$ differing from this by starting from a net of cubic ruled surfaces R^3 having a straight line q as nodal line. Two arbitrary surfaces of that net have another ϱ^5 in common, which is rational, because it has q as a quadrisecant. An arbitrarily chosen third surface intersects ϱ^5 eight times on q, consequently seven times outside q; hence all base-curves ϱ^5 of the pencils (R^3) comprised in the net have seven fundamental points F_k in common.

The congruence $[\varrho^5]$ *consists therefore of the curves* ϱ^5, *which intersect the straight line* q *four times and pass through seven points F.*

2. The hyperboloid R_1^2, containing the straight line q and the six points F_k $(k = 2$ to $7)$, has with an R^3 of the net another *rational curve* ϱ_1^4 in common of which q is a trisecant. This ϱ_1^4 is a component part of a degenerate curve of the congruence; the second component part is the straight line r_1, which connects F_1 with the point R_1, where ϱ_1^4 moreover intersects the plane $(F_1 q)$. To each ray of the plane pencil (r_1) belongs on the other hand a

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[1]) Erelong an elaborate communication about this subject will appear in "The Journal of Physiology." Compare fig. 2, 3, 4 and 5 of communication I: "On the heart-rhythm" by Dr. S. DE BOER. Koninkl. Akademie van Wetenschappen at Amsterdam. Verslag van de gewone vergadering der Wis- en Natuurk. Afdeeling van 30 Januari 1915. Deel XXII, p. 1026 and 1027. Proceedings of the meeting of Saturday February 27 1915. Vol XVII p. 1075.