The Heart and Electrocardiogram of an Alligator

By L. Minor Blackford, M.D.

The phylogenetic evolution of the cardiovascular system of animals and man has been a subject of continued interest. The reported study of the cardiovascular system and electrocardiogram of the alligator bears on this subject. The author has cogently remarked that this journal, which has reported similar studies in the beluga whale, should be the vehicle of his report.—Ed.

SPITZER in 1923 was not the first to point out the similarity of certain anomalies of the human heart to hearts that are normal lower in the evolutionary ladder. He remains however one of the staunchest proponents of the theory that "The phylogenetic cause [of congenital heart disease] is an arrest of development at a lower phylogenetic level, related to but not identical with that of reptiles, and the coordination of the features of this stage with those already developed in the mammalian stage." The heart of the crocodile, with an aorta arising from each ventricle, in addition to a pulmonary trunk from the right ventricle, particularly impressed him. The anomaly called by different authors "dextroposition of the aorta," "überreitende Aorta," and "riding aorta" Spitzer explained as "a fusion of both [right and left] aortas extending from the proximal bulbus to the ventricle."

Accepting this thesis, in 1932 we suggested "biventricular aorta" as a term readily understandable, one phylogenetically and anatomicallly correct, and one that would simplify terminology by the elimination of eponyms. If this term were accepted, "Eisenmenger complex" would be supplanted by "biventricular aorta," and the condition commonly known in this country as "the tetralogy of Fallot" would be "biventricular aorta with pulmonic stenosis."

In 1935 a case in a 19-year old boy in which both ventricles sent blood into the aorta, without pulmonary stenosis, and other cases in which the aorta arose from both ventricles with pulmonary stenosis or atresia, aroused my interest in the heart of the Crocodilia. An alligator about 75 cm. long was therefore secured from Jacksonville for study.

Taking an electrocardiogram on a live alligator is not without difficulties. It was necessary to muzzle the reptile and then to anesthetize it with ether. Electrodes applied to the hide caused no deflections. Pins were then inserted into the forelimbs and into the left hindlimb, and these were connected with the electrodes.

That warm October afternoon the rate was 50. Probably on a cold day without ether or in a state of hibernation, the rate would have been slower. In lead I no deflections were observed; today this might be best explained on the basis of a vertical electric axis. No tracing in this lead was preserved. In leads II and III, low deflections were noted (fig. 1). As in the case of the beluga whale, the P waves were not very distinct, but it was thought that the P-R interval was 0.28 sec. The R wave in lead II was 2.5 mm. In lead III the R was slightly lower and rather slurred. The T waves were also poorly defined in both leads.

Later, again under ether, the ventral wall of the alligator was sectioned. The heart was located about midway between the forelimbs and the hindlimbs. It was interesting to watch it slowly beating. In systole the myocardium was almost white, overlaid with tiny, cyanotic coronary vessels; in diastole the whole heart was dark blue-red. This indicated that the circulation through the heart muscle beneath the epicardium was carried on essentially during the resting period. It also indicated that
FIG. 1. The electrocardiogram of the alligator, taken October 15, 1935. The rate is 50. Lead I showed no deflections and was not preserved. Though the P waves are not very distinct, the P-R interval is 0.28 sec. The R waves are low and slurred. The T waves are also indistinct.

FIG. 2. The heart of the alligator with cross sections of the great vessels, showing the foramen of Panizza. The aorta arising from the left ventricle and arching over the right bronchus is continued caudad as the systemic aorta. Just above its origin it communicates with the aorta from the right ventricle, a small continuation of which loops over the left bronchus. Back of the heart this descending limb of the aorta from the right ventricle joins again the systemic aorta.

There was considerable mixing of venous blood from the right ventricle with the freshly oxygenated blood from the left ventricle through the foramen of Panizza.

The heart continued to beat after being placed in saline. The laboratory grew cold that fall night and in the morning the heart was still. Further dissection showed that the wall of the right ventricle was about as thick as that of the left, as might be expected, for it has to sustain a pressure equal to that from the left ventricle. No attempt had been made to determine the pressure in the great vessels, nor have I encountered any blood pressure determinations in an alligator. Though pulmonary hypertension had unquestionably been present, the pulmonary arteries were not examined for arteriosclerotic changes, nor for hypertrophy of the muscularis. Because so little has been written in the last 30 years about the cardiovascular system of the Crocodilia, and because what little has been written is not readily available to clinicians, a drawing of the alligator's heart is presented (fig. 2).
While at first blush it might seem remarkable that an alligator can get along so well with such a low degree of oxygen tension (and legend says that some live to be 100, though with the present commercial demand for alligator skins few specimens in excess of 18 feet are found), it must be remembered that fish, turtles, and frogs, all poikilothermic animals like the alligator, live active lives with probably even less oxygen. Moreover, White and Sprague\(^6\) have reported the case of a composer who completed a distinguished career in his sixtieth year, though deeply cyanotic his life long.

**SUMMARY**

Because of the intense interest in congenital heart disease today and because of the accumulating electrocardiograms of the whale, it seems appropriate now to present the electrocardiogram of a Florida alligator done in 1935.

**ACKNOWLEDGMENT**

The help of the late Dr. Edgar D. Shanks in taking the electrocardiogram and of Dr. John H. Venable in dissecting the alligator is gratefully acknowledged.

**ADDENDUM**

On September 12, 1956, an opportunity was afforded me to take another electrocardiogram on a 64-inch alligator from the Atlanta Zoo. It was a cool day, temperature 70, and cooler the night before. With the aid of 3 attendants, the reptile was not anesthetized, and it remained fairly quiet. The rate was 35; otherwise it was essentially like the first tracing from the smaller alligator.

**SUMMARIO IN INTERLINGUA**

A causa del intense interesse in congenite morbo cardiac in nostre dies e a causa del accumulate electrocardiogrammas de balenas, il pure appropriate presentar nunc le electrocardiogramma de un alligator de Florida, execute in 1935.

**REFERENCES**

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One hundred mothers of children with congenital heart disease, compared to 200 mothers of normal children, showed a statistically significant higher incidence of late menarche, irregular menstruation, temporary sterility, spontaneous abortion, and a higher age at the time of labor. Coincidence of maternal and fetal hormonal insufficiency at a critical point of fetal development is considered as the probable cause of congenital heart disease.

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