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THE CONUS ARTERIOSUS IN TARPON ATLANTICUS (CUVIER & VALENCIENNES).

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The tubular prolongation of the arterial end of the heart furnished with numerous valves, and known as the conus arteriosus, is one of the characteristic features of elasmobranchs and ganoids. In *Amia calva*, the conus arteriosus is relatively shorter than in other ganoids, and its valves are reduced to three transversely arranged tiers. It may be said that the absence of the conus arteriosus as a separate structure is a characteristic of the teleostean heart, and that this fact is emphasized by a few recorded exceptions, all of which occur in teleostean families more or less closely related to *Amia*.

Among these exceptional teleosts only one has been hitherto described, which possesses more than one tier of conus valves, this is *Butirinus* (*Albula*) which has two, and to it may now be added *Tarpon atlanticus*.

The heart from which the following description is taken, was sent to me by Mr. Charles H. Townsend, director of the New York Aquarium. It comes from a specimen 5 feet 4 inches in length.[1] I take this opportunity of thanking Mr. Townsend for his courtesy in sending this heart, also an entire *Tarpon*, 4 feet 4 inches long, the heart of which is shown in Fig. 3.

The conus of *Tarpon atlanticus* resembles that of *Amia calva* in form, but differs from it in being proportionately smaller, in having two tiers of valves instead of three, and in appearing to have been driven into the heart towards the apex, so that, instead of projecting freely from the ventricle, as in *Amia*, it is more or less buried in the latter.

In the natural position, the conus of *Tarpon* is a horizontally placed longitudinal tube, elliptical in transverse section. The longest diameter of the ellipse is dorso-ventral, and measures 16

[1] Measurements include caudal fin.

mm., the shortest measures 11 mm., and is transverse. The conus wall is slightly under 2 mm. in thickness. The total length of the conus varies according to the site of measurement, at the mid-dorsal and mid-ventral lines it measures 8 mm., laterally its measurement increases, until at the mid-lateral line on either side it becomes 10 mm.

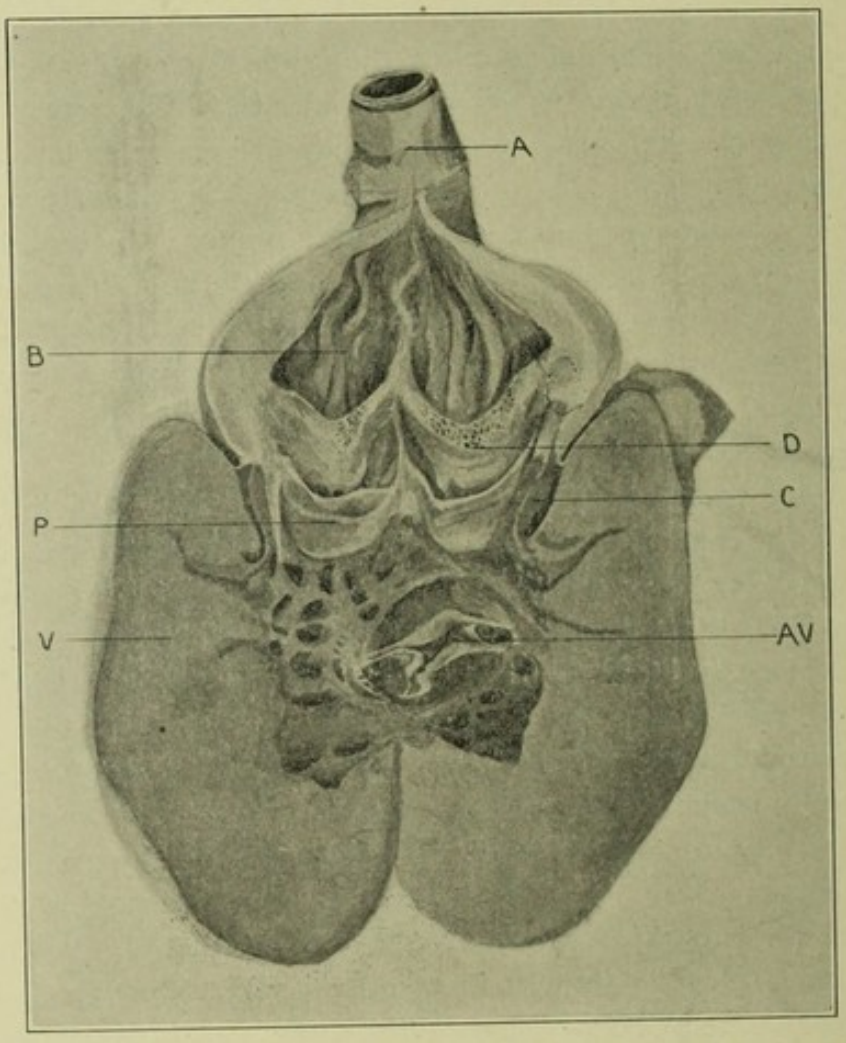

FIG. 1. The heart has been opened by a mid-ventral sagittal incision, and the parts widely separated (natural size). *A*, aorta; *AV*, atrio-ventricular valve; *B*, bulbus arteriosus; *C*, conus arteriosus; *D*, left distal conus valve; *P*, right proximal conus valve; *V*, wall of ventricle.

In order to compare the relative lengths of conus and ventricle in *Tarpon* and *Amia*, the length of the ventricle has been measured by plunging a needle into the apex of the ventricle, in such a direction that its point emerges where the ventricle and conus

blend. In this particular *Tarpon*, the ventricle thus measured is 41 mm. long, and taking 9 mm. as the average length of the conus, the proportion of the conus length to ventricle length, becomes 1 to 4.5. Six *Amia* hearts measured in the same way yield an average proportion of conus to ventricle of 1 to 1.76.

The exterior of the conus presents relations which differ in different regions. At the mid-lateral line, and ventral to this, the ventricle covers the conus completely. Dorsal to the mid-lateral line, the ventricle recedes rapidly, so as only to overlap the conus for a short distance on either side; in the interval, the conus is incompletely covered by the atrium. The area uncovered by ventricle and atrium measured back from the bulbus, is about 3 mm. in the midline, and lateral to this about 4 mm., it is covered by visceral pericardium. (These relations are indicated in Fig. 2.)

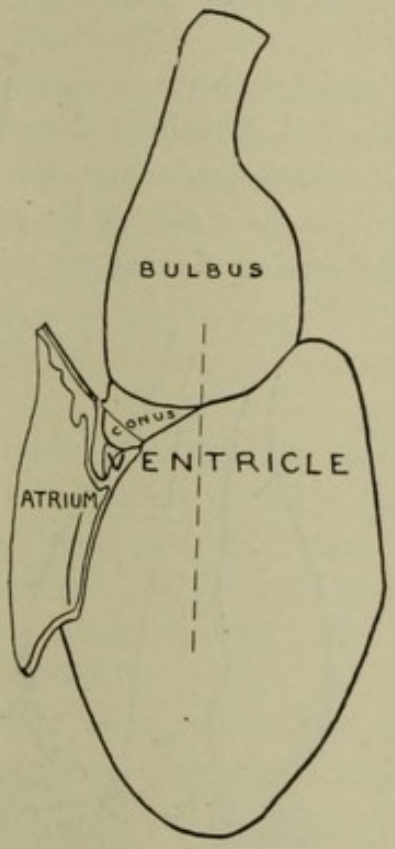

FIG. 2. Diagrammatic right lateral surface-view of bulbus, conus and ventricle. The atrium is represented as incised mesially, and the right half removed (natural size). The line across the conus indicates the site of reflection of visceral pericardium on to the atrium. The broken line indicates the site section in Fig. 3.

The conus is everywhere overlaid by a distinct layer of loose connective tissue, which separates it from the structures which cover it, and renders its outline very distinct in sections of the heart. Owing to the looseness of its connection with neighboring structures, the entire conus is easily exposed from the outside by incising the pericardium at the base of the bulbus, and stripping it away from the adjacent parts of the ventricle and atrium.

The conus valves are disposed in two transverse rows. Each row consists of a right and left cusp symmetrically placed with regard to the median dorso-ventral plane of the conus. Seen rom the lumen of the heart (as in Fig. 1) the valve cusps of

the proximal[1] and distal[1] rows appear to be approximately equal in size, this however is far from being the case, those of the distal row having a capacity far exceeding that of the proximal. The proximal valves are extremely fleshy at their attached margins, and shade rapidly into a thin semilunar area near the free edge; the edge itself is marked by a cord-like thickening, and is quite unattached, except at either end, where, having blended with the corresponding extremity of the other cusp, it is attached dorsally and ventrally to the mid-line of the bulbus a short distance beyond the conus.

The distal valves are not so fleshy as the proximal, and the marginal semilunar area is very thin and profusely perforated. The margins are free except at their extremities, the dorsal ends of the right and left valves blend at the mid-longitudinal region of the bulbus, and become continuous with an elastic cord, the other end of which is attached to the dorsal bulbus wall at its distal extremity. The ventral extremities of the distal valves blend at their point of attachment in the mid-line at the junction of the proximal and middle thirds of the ventral bulbus wall.

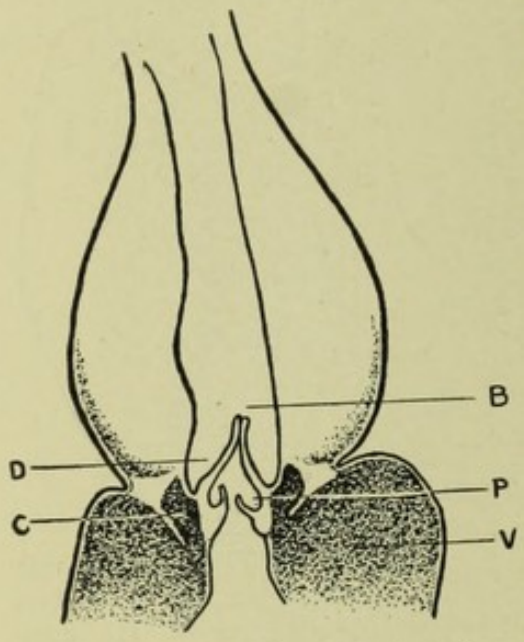

FIG. 3. Ventral face of a frontal section of the heart from the smaller, *Tarpon* its approximate source is indicated by the broken line in Fig. 3 ($\times \frac{4}{3}$). *B*, lumen of bulbus arteriosus; *C*, conus arteriosus; *D*, cavity of right distal conus valve; *P*, cavity of left proximal conus valve; *V*, wall of ventricle.

That the capacity of the distal valves is much greater than that of the proximal, is shown by the fact that a probe can be passed 11 mm. into the former, and only 3 mm. into the latter. To illustrate this point, a frontal section passing approximately through the mid-lateral line of another heart is shown in Fig. 3.

[1] The terms proximal and distal are used with regard to the ventricle.

The conus in *Tarpon* appears to differ from that of *Butirinus* (*Albula*) described by Boas ('80) in that it is less overlapped by the bulbus arteriosus, and more deeply buried in the ventricle, also in that it shows no diminution in length dorsally, as compared to the ventral measurement. The two subsidiary valves between the larger ones of the proximal row in *Albula* do not occur in *Tarpon*.

The sinu-atrial valves are two, with strong tensor muscles. There are four atrio-ventricular valves of which two are of large size, and two somewhat smaller. The hepatic vein, at its junction with the sinus venosus, is of almost cartilaginous rigidity, the size of the orifice is reduced by a thin fold of intima on either side, these almost meet mesially to convert the circular orifice into a vertical slit. The folds of intima appear to have no valvular action.

It is singular that since the appearance of Stannius's paper ('46) *Albula* should have enjoyed the reputation of being the only teleost provided with a conus having two rows of valves; whether the heart of *Megalops cyprinoides* will also prove to have more than one row of valves is an open question. So far as I am aware a description has not been recorded.

Of the other fishes showing evidence of near relationship to *Amia* the following have been examined with a negative result: *Elops saurus* by J. Mueller ('46), *Hyodon* by Mueller ('46) and Boas ('80), *Osteoglossum* by Mueller ('46) and Boas ('80), *Notopterus* by Boas ('80), *Mormyrops* by Mueller ('46). I have also examined *Elops saurus* (for a specimen of which I hereby beg to thank the authorities of the U. S. National Museum) *Hyodon tergisus* and *Notopterus borniensis*.

The original opinion of Gegenbaur ('66) which has been restated and amplified by Hoyer ('00) that the conus, although it has ceased to exist as a separate structure in the ordinary teleost heart, is represented by the portion of the myocardium adjacent to the aortic valves, is well illustrated by the conus relations in *Tarpon*. One has only to imagine the connective tissue layer between the exterior of the conus and the ventricle to have disappeared, allowing the conus muscle to be merged into the general myocardium, and the transition is complete; the relation of the myo-

cardium to the distal valve will be similar to that generally found in teleosts. An interesting transitional stage can be seen in the heart of *Dorosoma cepedianum*, where there is an extremely thin but distinct streak of connective tissue projecting into the myocardium for sufficient distance to clearly separate the areas of original conus and original ventricle.

PHILADELPHIA,
October, 1906.

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