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The bulbus aortae (*Aorta ascendens*) in the growing Common Seal (*Phoca vitulina vitulina*) (a morphological approach)

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Summary

The internal circumference of the widest part of the bulbus aortae in sixty five common seals was measured and plotted against the corresponding heart-weights.

The walls of the bulbus aortae of three animals—0, 1 and 12 months old—were examined histologically. These morphological examinations demonstrate a gradual development of the bulbus aortae, starting immediately after birth. It can be expected that the 'windkessel' function will start at the same time. This conclusion is in agreement with the habitat of the common seal.

Introduction

The balloonshaped bulbus aortae (*Aorta ascendens*) in the Pinnipedia has been a centre of the interest for a long time (Bürow, 1838; Drabek, 1976; King, 1977; Murdaugh c.s., 1966). The function of this balloonshaped bulbus aortae remained unexplained for a long time too. This function is closely related to the diving reflex (Hempleman & Lockwood, 1978). The diving reflex results in a bradycardia in mammals as well as in birds and amphibia. The deepness of the bradycardia depends on the species. An extreme bradycardia—from 120 beats per minute to 12 beats per minute—is present in Cetacea and Pinnipedia during diving. The interval between the beats during diving—five seconds—may be dangerous to the brain and the heart tissue because of damage by oxygen depletion. The main danger lies in the sharp decrease in the blood-pressure in the interval mentioned. To maintain an adequate mean blood-pressure parts of the Aorta ascendens function as a 'windkessel' or assistant heart by the width of the bulbus aortae and the quantity and the quality of the elastic fibres in the wall.

In incidental divers—like men and dog—the 'windkessel' function is restricted to the proximal environs of the semilunar valves of the Aorta (*sinus valsalvae*). In professional divers—Cetacea and Pinnipedia—the whole Aorta ascendens—bulbus aortae functions as a 'windkessel'. The postnatal development of the *Aorta ascendens* in Cetacea and Pinnipedia has seldom been studied. Drabek (1976) studied the postnatal development in the Weddell seal. He stated that the 'windkessel' function of the bulbus aortae develops during postnatal life in this species.

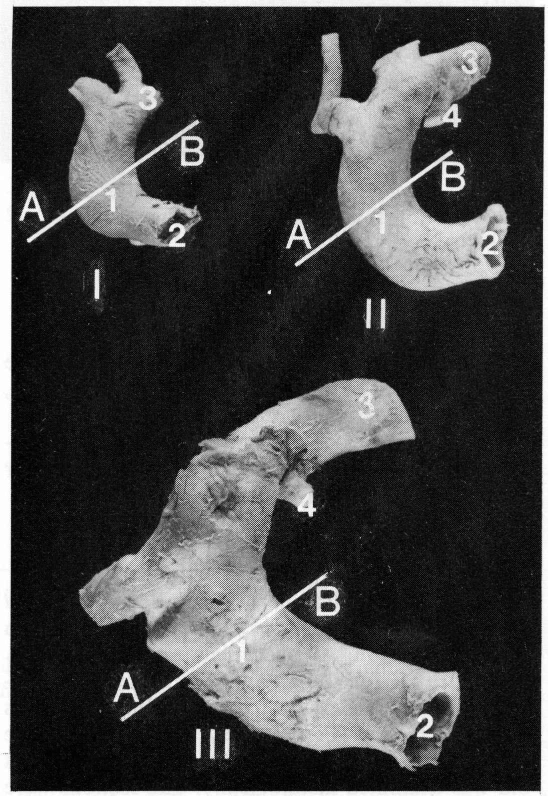

Figure 1. Three bulbi aortae from common seals. I: 0 month old; II: 1 month old; III: 12 month old. 1. Bulbus aortae; 2. proximal end (aortal ring); 3. distal end (thoracal aortal ring); 4. ligamentum arteriosum.

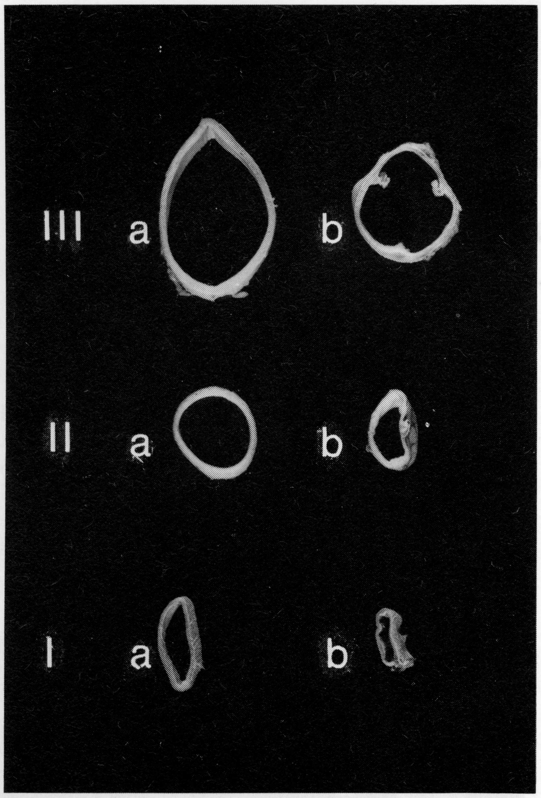

Figure 2. Rings of the bulbus aortae (a) and of the proximal Aorta (b). I: 0 month old; II: 1 month old; III: 12 month old.

The question arises: Does this development take place as a result of the diving practice of the animal, or is it an innate quality of this species?

The aim of this study is to investigate the postnatal development of the bulbus aortae in a number of common seals of various ages.

Material and technics

Sixty five arcus aortae derived from dead common seals with a heart-weight of 60 to 584 g were used in this investigation. All specimens were fixed in 4% formaldehyde for some days. The internal circumference of the widest part of the bulbi aortae was measured in mm. (Figures 1 and 2). The wall of the bulbus aortae of three animals of 0, 1 and 12 months old was examined histologically. The sections were processed by elastin stain. The hearts were weighed after removal of the stem of the great vessels and after rinsing with tap-water. The accuracy was ± 1 g.

Table 1.

No.	Heart weight g	Internal circumference Bulbus aorta mm	No.	Heart weight g	Internal circumference Bulbus aorta mm
1	60	51	34	182	84
2	64	48	35	184	77
3	68	55	36	187	75
4	70	56	37	189	88
5	74	55	38	207	90
6	81	52	39	210	81
7	86	57	40	211	71
8	87	59	41	213	81
9	87	58	42	214	81
10	99	59	43	217	83
11	100	70	44	218	71
12	100	49	45	226	111
13	103	57	46	230	91
14	105	60	47	232	83
15	108	61	48	247	93
16	109	55	49	248	86
17	110	63	50	257	75
18	124	74	51	268	89
19	127	84	52	279	81
20	134	76	53	290	90
21	148	72	54	301	81
22	148	68	55	310	90
23	150	80	56	315	108
24	151	59	57	357	88
25	155	83	58	365	115
26	157	90	59	400	117
27	165	81	60	420	119
28	168	69	61	458	122
29	172	69	62	501	99
30	172	79	63	533	129
31	175	83	64	540	108
32	177	72	65	584	114
33	177	73			

Results

The internal circumference of the bulbi aortae in mm and the heart-weights in grams are listed in Table 1. These data were averaged in groups of 5–10 and plotted in Figure 3. This figure displays a regular development of the internal circumference of the bulbus aortae in relation to the heart-weight. In early life—between zero and one and a half month of age—we find further evidence for this regular development. Figure 4 shows the individual data of twenty three specimens represented by a heart-weight between 60 g and 150 g. Although the variance in the values is important there is a tendency to a linear relation.

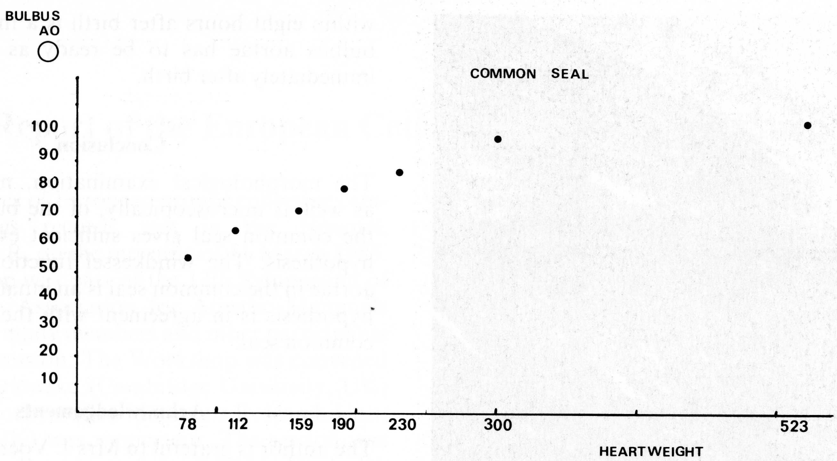

Figure 3. Absolute values of the internal circumference of the bulbus aortae in mm plotted against the heart-weights in grams. The first five points indicate the mean values of ten hearts, the sixth point indicates the mean value of five hearts.

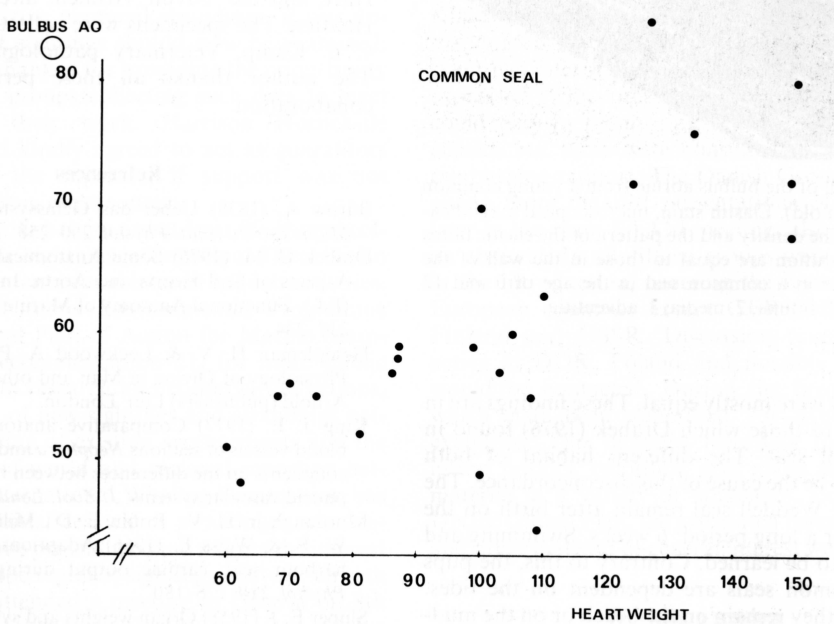

Figure 4. Absolute values of the internal circumference of the bulbus aortae in mm plotted against the heart-weights in grams in twenty three young common seals.

Since Slijper (1958) described a linear relation between the heart-weight and the age of the common seal, we may conclude, that the bulbus aortae regularly develops during the growth of the animal. This development starts immediately after birth. This is also indicated by the histological pattern of the elastic fibres in the wall of the bulbi aortae examinated (Figure 5). The quantity (per square mm) and the quality (expressed in the intensity of the stain) of the elastic fibres in the three slices

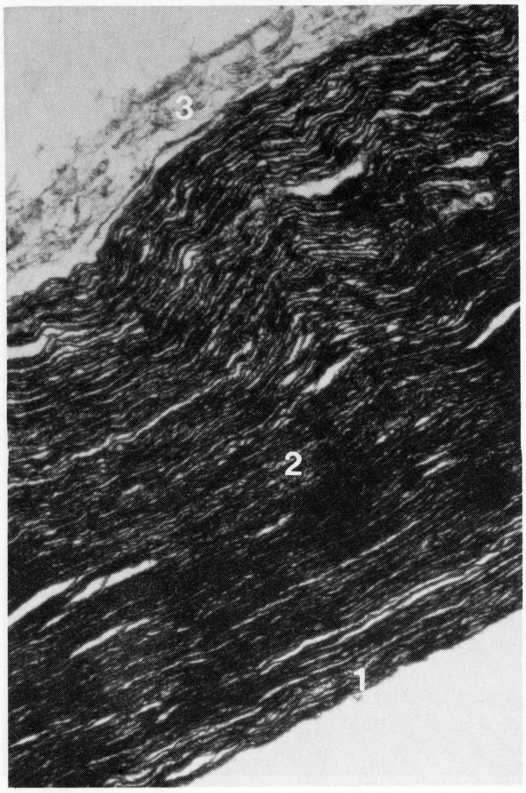

Figure 5. Wall of the bulbus aortae from a young common seal (1 month old). Elastin stain, microscopical magnification × 120. The density and the pattern of the elastic fibres in this preparation are equal to those in the wall of the bulbus aortae in a common seal in the age of 0 and 12 months old. 1. intima; 2. media; 3. adventitia.

investigated were mostly equal. These findings are in opposition to those which Drabek (1976) found in the Weddell seal. The different habitat of both species may be the cause of this disconcordance. The pups of the Weddell seal remain after birth on the ice rocks for a long period: 6 weeks. Swimming and diving has to be learned. Contrary to this, the pups of the common seals are dependent on the tides. After birth they remain on the beach or on the mud-flat for eight hours at most. Swimming and diving within eight hours after birth is a must and so the bulbus aortae has to be ready as a 'windkessel' immediately after birth.

Conclusion

The morphological examination, macroscopically as well as microscopically, of the bulbus aortae in the common seal gives sufficient evidence for the hypothesis: 'The 'windkessel' function of the bulbus aortae in the common seal is an innate quality.' This hypothesis is in agreement with the habitat of the common seal.

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