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COARCTATIO AORTAE IN THE COMMON SEAL *(PHOCA VITULINA VITULINA)* (A QUANTITATIVE APPROACH)

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Introduction

Coarctatio aortae may be defined as a stricture of the aortic arch in the environs of the aortic end of the ductus arteriosus or ligamentum arteriosum (Fig. 1 and 2) (DIRKSEN, 1973). The narrowing - stenosis - may be in the form of a ring as well as shaped like a funnel.
The condition is well known in man (DIRKSEN, 1973; NOBACK & REHMAN, 1941), but rare in animals (CHRISTL, 1970; v.d. LINDE-SIPMAN c.s., 1973; van NIE, 1964). Literature about coarctatio aortae in Pinnipedia is rare too (KING & HARRISON, 1961; van NIE, 1982;

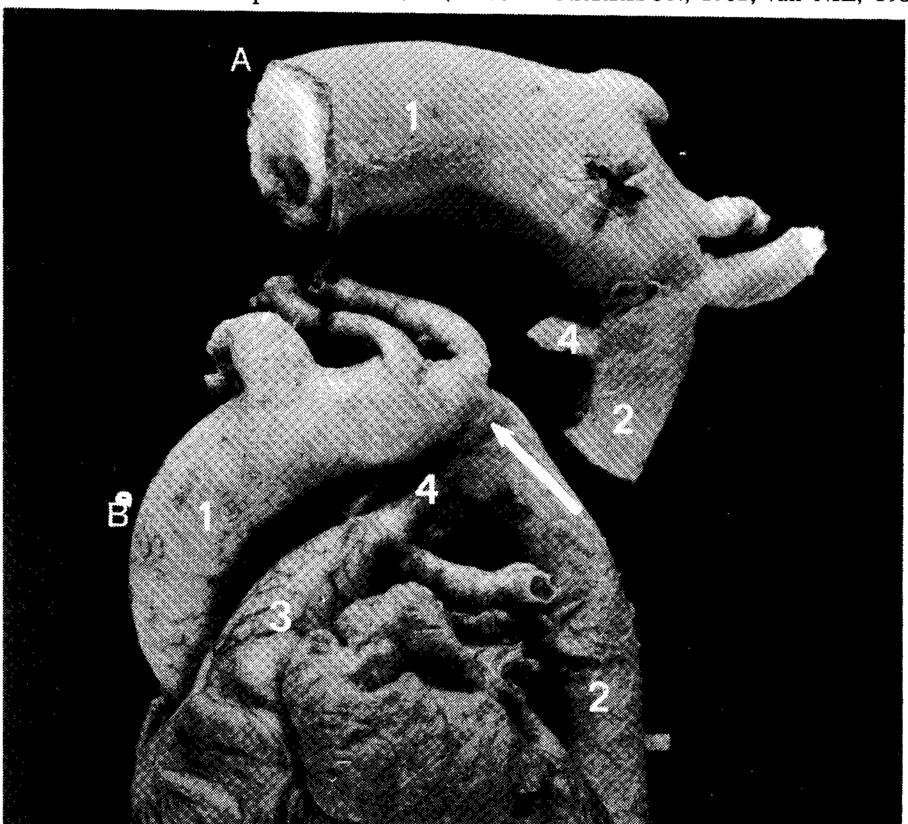

Fig. 1. Photograph of a normal arcus aortae (A) and a coarctation aortae (B). 1 aorta/ascendens/bulbus/ aortae; 2 aorta descendens; 3 pulmonary trunk; 4 ligamentum arteriosum/Arrow indicates coarctation.

MURRIE, 1874). However, it is generally accepted, coarctatio aortae is a common condition in Pinniped species.
Clinically an important gradient - i.e. difference in pressure - is present between the aortae proximal and distal to the stenosis. In post mortem studies up till now coarctatio in man as well as in animals, including the Pinnipedia, is diagnosed by morphological observations only. A theoretical quantitative approach has not been reported in the literature available to the present author.
This is a report of a theoretical physiological quantitative approach of the resistance in the proximal part of the aortic ring - the proximal aortic ring - and that in the distal part of the arch - the distal aortic ring. The calculated relation may be an indication for the incidence of coarctatio aortae in the common seal.

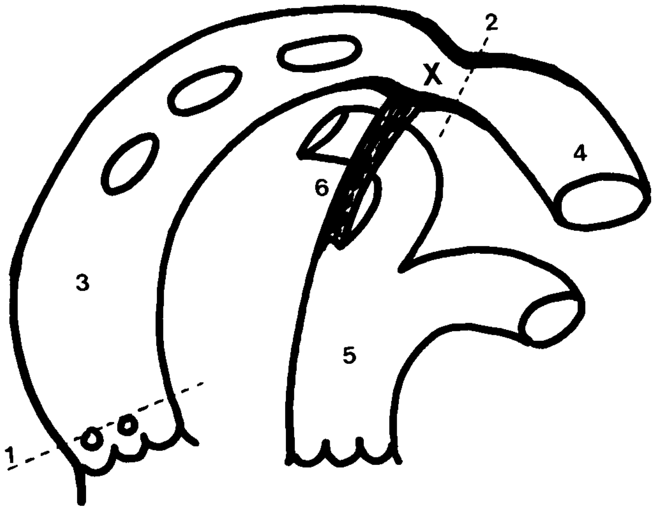

Fig. 2. Schematic representation of a coarctatio aortae. 1 proximal aortic ring; 2 distal aortic ring; 3 aorta ascendens/bulbus aortae; 4 aorta descendens; 5 pulmonary trunk; 6 ligamentum arteriosum; x stenosis

Materials and techniques

Thirty eight aortic arches of the common seal have been investigated. The arches were derived from 38 hearts with a weight from 70 gram to 540 gram. All arches were fixed in 4% formal dehyde. Before examination they had been rinsed in tap water with 1% NH_4OH.
The proximal aortic ring is taken immediately distal to the commissures of the semilunar valves. This ring is chosen for its rather rigid and independent structure with a strong elasticity. It may give a good reference to the other structures of the aortic arch. The distal ring is taken immediately distal to the aortic end of the ductus arteriosus or ligamentum arteriosum (Fig.2). The aorta descendens was not available for examination.
The internal circumference of the proximal aortic ring as well as that of the distal ring was measured in mm after opening of the ring (Fig. 3). The radius was calculated (r = circumference/2π).
The theoretical resistance (R) in the rings was calculated with the formula of HAGEN &

POISEUILLE ($R=\frac{VxLxF}{\pi x r4}$) (V=viscosity of the blood; L=lenght of the ring; F=flow of the blood). By assumption $\frac{VxLxF}{\pi}$ = C(constant). So $R = Cx\frac{1}{r4}$. The calculated resistance in the distal ring (Road) is expressed as a factor of the calculated resistance in the proximal ring (Raop). formula: R resistance (factor) = $\frac{Raod}{Raop} = \frac{C/raod4}{C/raop4} = \frac{roap^4}{raod4}$.
All aortic arches are derived from dead animals with different post mortem findings.

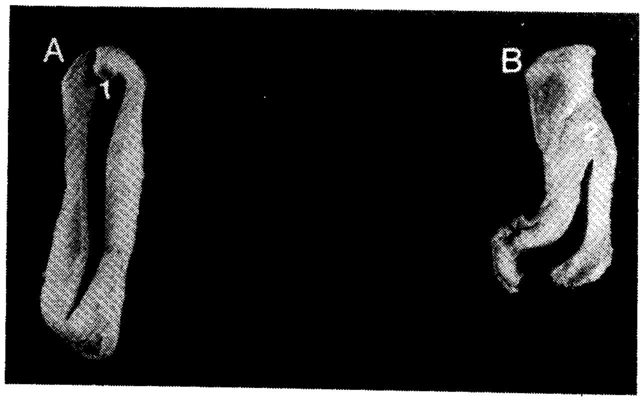

Fig. 3. Photographs of proximal aortic ring (A) and distal aortic ring (B). 1 rest of the commissures of the semilunar valves; 2 thickening of the wall caused by penetration of tissue ligamentum arteriosum.

Results

In table 1 the data concerned are tabulated.
In the column diagram the calculated resistance factors are displayed (Fig. 4).

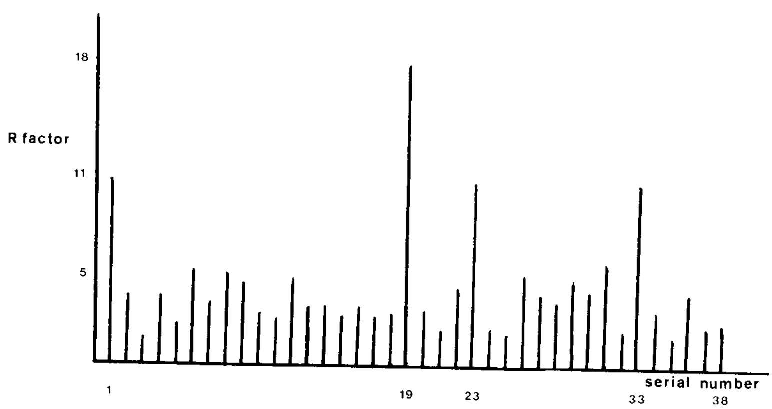

Fig. 4. Calculated resistance factors of 38 aortic arches of *Phoca v. vitulina.*

Table 1

Case number	Heart weight in grams	Calculated radius prox. ring	Calculated radius distal ring	Resistance factor
1	70	6.8	3.65	11 *
2	86	7	5	4
3	99	4.6	4	1.8
4	100	8	5.6	4
5	105	6.5	5.2	2.4
6	110	6.8	4.4	5.7
7	124	7.9	5.7	3.7
8	127	8.6	5.6	5.5
9	148	7.1	4.8	4.8
10	148	7.5	5.7	3
11	151	6.8	5.3	2.7
12	155	8.6	5.7	5.1
13	168	7.6	5.6	3.4
14	172	8.6	6.3	3.5
15	175	8.5	6.5	2.9
16	177	7.9	5.8	3.4
17	177	8.1	6.2	2.9
18	182	8.4	6.4	3
19	207	12.4	6	18.2 *
20	211	8.7	6.5	3.2
21	213	8.4	7	2
22	214	8.6	5.1	4.5
23	217	11.4	6.2	11 *
24	218	8.2	6.7	2.2
25	226	10.3	8.9	1.8
26	248	9	5	5.4
27	268	9	6.3	4.2
28	279	8.8	6.3	3.8
29	290	11	7.3	5.2
30	301	9	6.2	4.4
31	310	9.8	6.2	6.2
32	315	10	8.3	2.1
33	368	11.4	6.2	11 *
34	400	12.3	9.2	3.2
35	436	14.3	12.4	1.8
36	458	13.7	9.5	4.3
37	533	12.7	10.2	2.4
38	540	10.2	8.1	2.5

* = coartatio aortae

Comment

Four calculated resistance factors 11, 18.2, 11 and 11 (cases 1, 19, 23, and 33) differ widely from the rest of the factors. The severe increased resistance in these cases indicate a clinical coarctation. These cases are spread over all the heartweights and so likely at all ages. The minor variance in the rest of the factors (1.8 to 6.2) proves the relation between the resistance of both the rings concerned is fairly constant.

The results of the presented data are not in concordance with the published data (KING and HARRISON, 1961; van NIE, 1982). The investigations of KING and HARRISON (1961) and van NIE (1982) have been carried out by morphological observations only. KING and HARRISON described a case in the Hawaiian Monk Seal. They reported about the diameter of the stenotic part of the aortic arch and that of the first part of the aorta descendens. Van NIE investigated 40 aortic arches of the common seal. He found after a morphological examination only in this series 10 cases of coarctatio aortae.

The cause of this dissimilarity may be explained by the method of investigation, i.e. morphological against the calculated resistance factor. The morphological approach is unreliable because of the kinking of the aortic arch in the seal (van NIE, 1982). This kinking - an S-from in a three dimensional space - suggests strongly a coarctatio aortae. In human medicine the kinking of the aorta has been found an important concomittant factor in the coarctation (LAVIN c.s., 1969). Never the less the coarctatio aortae in the common seal has a relative high incidence (about 10%). The incidence in other animals has not been calculated, because the occurrence is too low (v.d. LINDE-SIPMAN c.s., 1973). The incidence in man is 0,08% in all live births (DIRKSEN, 1973).

The unequal amount of material makes a comparison of the incidence between man and seal unrealistic.

The clinical importance of the coarctation in the common seal remains unknown. The extend of the occurrence of the anomaly over all ages does not justify a classification of the anomaly in the group of perinatal congenital anomalies.

The aetiology of the anomaly remains unknown. Hypothetically the aetiology may be related to the topography of the aortic arch in the thorax with an S-form in a three dimensional space. This topography induces a sharp angle between the ductus arteriosus and the aortic arch and may further the penetration of the constrictive tissue in the aortic wall, so causing a coarctation aortae (Fig. 5).

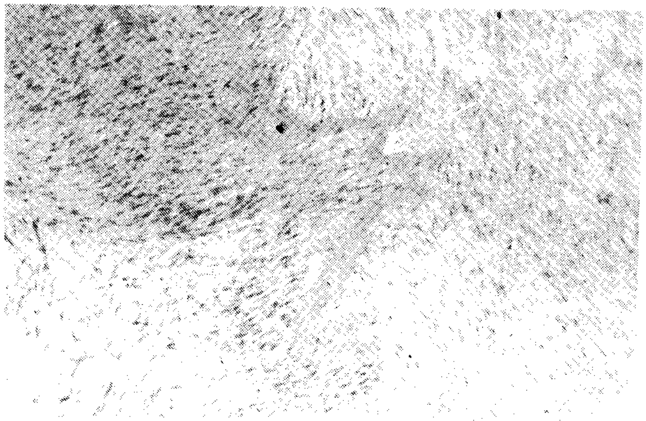

Fig. 5. Histological section of the wall of the distal aortic ring, processed by heamalun-eosin. Arrow indicates penetration of tissue of the ligamentum arteriosum.

Conclusions

1. Calculations of the resistance factor - ratio between the calculated resistance in the proximal and distal aortic ring - is fairly a good parameter for the occurrence of coarctatio aortae.
2. Coarctatio aortae happens in the common seal. The incidence is 4 cases in 38 animals (about 10%).
3. The anomaly is spread through all ages.
4. The resistance factor in normal cases varies between 1.8 - 6.2, whereas the value of the factor in cases of coarctatio aortae varies between 11 - 18.
5. The incidence of coarctation in the common seal is high (10%) in comparison with man (0.08%). The incidence in domestic and pet animals is unknown.
6. The clinical importance and the aetiology of coarctation in the common seal remains unknown.

Summary

In 38 aortic arches of the common seal the theoretical physiological resistance in the proximal and distal aortic rings have been calculated.
Calculation of the resistance factor - ratio between the calculated resistance in both the rings - showed some evidence for a coarctation in 4 cases (10%). These cases are spread over all ages.
The clinical importance and the causel genesis of the coarctation remain unknown.

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