Nature of Species Differences in the Medial Distribution of Aortic Vasa Vasorum in Mammals

By Harvey Wolinsky, M.D., and Seymour Glagov, M.D.

ABSTRACT
Thoracic aortic segments of 12 mammalian species were fixed while distended at normal physiological pressures after the vasa vasorum were filled by a perfusion mixture containing gelatin and carbon. Mammals whose aortas had 29 or fewer medial lamellar units had no demonstrable intramural vascular channels; those whose aortas had more than 29 medial lamellar units, had medial vasa. Aortas with medial vasa vasorum always had a subintimal medial zone devoid of vasa vasorum. In growing animals the width of this avascular zone increased with age; in adults, the width increased slightly with increasing species body weight. However, the number of lamellar units in the avascular zone was independent of both age and species and equal to 29.0 ± 2.5. All of the species with intramural aortic vasa vasorum as adults had 29 or more aortic medial lamellar units at birth; none of the species which had 29 or fewer lamellar units at birth had more than 29 lamellar units at maturity. In aortas with medial vasa vasorum, widening of the avascular zone during growth appeared to be due only to the uniform thickening of each of the approximately 29 lamellar units already present at birth; the vascularized outer zone widened both by enlargement of its lamellar units and the addition of new lamellar units. Species differences in medial distribution of vasa vasorum are due primarily to differences in thickness of the vascularized outer zone.

ADDITIONAL KEY WORDS
comparative anatomy of aorta
avascular and vascular zones of aortic wall
growth of aortic wall
lamellar units
nutrition of aortic wall

Blood constituents may reach the aortic media by filtration through the aortic intima from the lumen and by passage through intramural vasa vasorum derived from small adventitial arteries. Aortas of small mammals such as the rat or rabbit contain no demonstrable intramural medial vascular channels (1, 2); the entire wall is presumably supplied by transintimal filtration. In larger mammals, aortic medial vasa vasorum are present in the outer portions of the wall, but the depth to which these vessels can be demonstrated shows marked species variation (1, 2).

In the adult human thoracic aorta, vasa vasorum are found in the outer and middle thirds of the media. According to Geiringer (3), the inner, avascular third is approximately 0.5 mm wide; he has called this distance the “critical depth,” within which filtration from the lumen is adequate for medial nutrition; beyond this zone, medial nutrition must be supplemented by the vasa vasorum. It has been suggested that the relative depth of the avascular subintimal zone may be a factor in species differences in aortic susceptibility to atherosclerosis (1) and medial degeneration (4). Gradual or partial obstruction of vasa vasorum could lead to inadequate clearance of transintimal filtrate from the...
avascular zone and intimal or medial deposition of blood constituents (5); sudden or total obstruction could lead to rapid ischemic degeneration or necrosis of the media beyond the zone of intimal filtration (4). Spontaneous and experimentally induced aortic lesions have been characterized and compared in several mammalian species (6). Detailed studies of mammalian species differences in the distribution of aortic medial vasa vasorum have not been made; such investigations could provide insight into the role of medial nutrition in the pathogenesis of aortic disease.

Previous studies in this laboratory (7, 8) revealed that adult mammalian aortas are composed of uniform fibromuscular layers; each layer consists of a sheet of elastin and an adjacent compartment containing circumferentially oriented collagen, elastin and smooth muscle fibers. The number of these lamellar units in an aortic media is related to its radius, regardless of species; each lamellar unit sustains an average tangential tension of approximately 2,000 ± 400 dynes/cm and may therefore be considered to be the unit of structure and function of the aortic media. The present report will show that in mammals with aortic medial vasa vasorum the number of lamellar structural units in the inner avascular zone of the aortic wall is very nearly 29, regardless of species or age, that medial vascular channels are normally present only in the portion of the wall between the twenty-ninth lamellar unit and the adventitia and that species differences in the relative thicknesses of the avascular and vascular zones of adult aortas are due primarily to differences in the thicknesses of their vascular zones.

Materials and Methods

Thoracic aortic segments of 115 animals representing 12 mammalian species were studied. Fifty-five animals were adults and 60 were immature. The precise date of birth was known for each of the young animals and for all of the mice, rats, guinea pigs and rabbits; other individuals were considered to be adults if their body weights corresponded to accepted adult values and their dentition was of adult type. Presumed date of conception and body weight were used as criteria for the gestational age of each of the fetuses examined. The number of immature and adult animals of each species examined and the range of weights for the adults are given in Table 1.

A segment of the thoracic aorta was fixed while distended by a perfusion mixture designed to fill the intramural vasa vasorum. Pressures used for distention and perfusion of the vasa vasorum were mean physiological pressures measured for all of the cats and dogs used in the present experiment or determined previously in our laboratories in connection with other experiments for rats, rabbits and sheep (9-11). For the other species and for most of the immature animals, values were those reported by other investigators (12, 13). Distending pressures are listed for each species in Table 1. The distending mixture consisted of the follow-

<table>
<thead>
<tr>
<th>Species</th>
<th>Adult weights (g)</th>
<th>No. of animals</th>
<th>Distending pressure (mm Hg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mouse</td>
<td>28-30</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Rat</td>
<td>40-450</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Guinea pig</td>
<td>960-1420</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Cat</td>
<td>3100-3400</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Rabbit</td>
<td>2925-4500</td>
<td>20</td>
<td>8</td>
</tr>
<tr>
<td>Monkey</td>
<td>3300-4200</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Dog</td>
<td>5700-28,800</td>
<td>4</td>
<td>15</td>
</tr>
<tr>
<td>Human</td>
<td>52,000-76,000</td>
<td>9</td>
<td>5</td>
</tr>
<tr>
<td>Sheep</td>
<td>83,500-90,800</td>
<td>7</td>
<td>2</td>
</tr>
<tr>
<td>Pig</td>
<td>Approx. 200,000</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>Bull</td>
<td>Approx. 455,000</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Horse</td>
<td>Approx. 500,000</td>
<td>3</td>
<td>3</td>
</tr>
</tbody>
</table>

**Table 1**

Range of Body Weights and Distending Pressures in Twelve Mammalian Species

**Table 1**

Range of Body Weights and Distending Pressures in Twelve Mammalian Species

<table>
<thead>
<tr>
<th>Species</th>
<th>Adult weights (g)</th>
<th>No. of animals</th>
<th>Distending pressure (mm Hg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mouse</td>
<td>28-30</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Rat</td>
<td>40-450</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Guinea pig</td>
<td>960-1420</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Cat</td>
<td>3100-3400</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Rabbit</td>
<td>2925-4500</td>
<td>20</td>
<td>8</td>
</tr>
<tr>
<td>Monkey</td>
<td>3300-4200</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Dog</td>
<td>5700-28,800</td>
<td>4</td>
<td>15</td>
</tr>
<tr>
<td>Human</td>
<td>52,000-76,000</td>
<td>9</td>
<td>5</td>
</tr>
<tr>
<td>Sheep</td>
<td>83,500-90,800</td>
<td>7</td>
<td>2</td>
</tr>
<tr>
<td>Pig</td>
<td>Approx. 200,000</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>Bull</td>
<td>Approx. 455,000</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Horse</td>
<td>Approx. 500,000</td>
<td>3</td>
<td>3</td>
</tr>
</tbody>
</table>

**Table 1**

Range of Body Weights and Distending Pressures in Twelve Mammalian Species
MEDIAL DISTRIBUTION OF AORTIC VASA VASORUM

1Animals were anesthetized by intravenous injection of pentobarbital (Veterinary nembutal: 60 mg/ml, Abbott Laboratories, Chicago, Illinois) in doses of 30 mg/kg body weight.

The microscopic appearance of the medias of the adult aortas, fixed while distended by physiological pressures, was similar to that described elsewhere: elastin lamellae were relatively straight and distributed uniformly through the wall; elastin and collagen fibers and smooth muscle cells were oriented circumferentially (7). Aortic medias of immature animals were essentially similar in appearance, except that elastin lamellae were thinner and interlamellar distances smaller than those of adults. The well-defined medial structural layers formed by the elastin lamellae and their subjacent fibrocellular compartments, characteristic of the aortas of both adult (8) and immature animals will be referred to as lamellar units. Photomicrographs of several illustrative preparations are shown in Figure 1. Small mammalian species, such as the rabbit, had no demonstrable intramural
Comparison of the microscopic appearance of the thoracic aortas of the newborn and adult rabbit and pig. The entire rabbit aortic media is avascular, regardless of age. The avascular zone (white arrow) of the pig’s aortic media increases in thickness during growth but always contains only 29 lamellar units. The black arrow points to one of the vasal channels closest to the intima. Adventitial vessels can be seen in both the rabbit and pig. Weigert-van Gieson.

medial aortic vasa vasorum; the number and thickness of the medial lamellar units were greater for the adult than for the newborn. The pig is an example of a mammal with aortic medial vasa vasorum. As in the rabbit, the number and thickness of medial lamellar units increased from birth to maturity. The innermost medial vessel in the photograph of the adult pig aortic media is indicated by a black arrow. Figure 2 shows a higher magnification of this vasal channel, which is approximately 10 μm in diameter and is filled with the carbon-gelatin mixture. The thickness of the inner subintimal medial zone without demonstrable vasa vasorum, the avascular zone (Fig. 1, white arrows), increases somewhat with age; the outer zone of the media, in which vasal channels filled with the perfusate were easily seen, increases markedly. The remainder of this report deals with the quant-
The medial distribution of aortic vasa vasorum refers to the blood vessels that supply the aortic media in mammals. The primary findings are as follows:

**Figure 2**: Higher magnification of the medial vessel indicated by the black arrow in Figure 1. It is approximately 10 μ in diameter and is in an interlamellar space, bounded by thick elastin lamellae (e); the lumen is filled by the carbon-gelatin mixture. Weigert-van Gieson.

**Thickening of the Avascular Zone of the Adult Aortic Media.** The thickness of the aortic media and thickness of the avascular zone of the media are plotted against adult body weight in Figure 3. Each point represents a species and corresponds to the average of values for individual animal and animals of the species. Aortas of species with adult body weights up to approximately 5,600 g had no demonstrable medial vasa vasorum. The thickness of the aortic media of these animals ranged from 0.03 mm in the mouse to 0.32 mm in the rhesus monkey (Macaca mulatta). Adults of species weighing more than 5,600 g had intramural vasa vasorum. The thickness of the aortic media in these species increased with body weight (Fig. 3, solid line), ranging from 0.48 mm in the dog to 1.40 mm in the horse. However, the thickness of the avascular zone increased much less with increasing body weight than did the entire aortic media (Fig. 3, dotted line) ranging from 0.43 mm in the dog to only 0.54 mm in the horse, with a mean of 0.47 ± 0.06 mm. A line of best fit for the points which correspond to full medial thickness has been drawn as far as the sheep; up to this point, scatter is small (Fig. 3, solid line). The points that correspond to the pig, bull, and horse do not fit this curve and have been joined to it by a dashed line. The seemingly erratic changes in aortic wall thickness with increasing body weight beyond 100,000 g are associated with structural features of the outer, vascularized zone of the media and not present in aortas of smaller animals. Nevertheless, all of the points that correspond to the thickness of the avascular zone lie close to a straight line of best fit (Fig. 3, dotted line); this finding corresponds to the nearly identical and uniform architecture of the avascular zone for all of the species, regardless of the structure of the outer vascularized zone.

**Lamellar Units in the Avascular Zone of the Adult Aortic Media.** In aortic media without intramural vasa vasorum and in the avascular zones of aortic media with vasa vasorum, elastin lamellae and intervening interlamellar compartments were of relatively uniform thickness. The number of lamellar units in the adult aortic media and the number in the corresponding medial avascular zone are plotted against body weight in Figure 4. Each species is represented by a point that corresponds to the average of the values obtained for individual animal and animals of the species. The total number of aortic medial lamellar units increased with body weight in animals weighing up to 5,600 g and ranged from 5.0 in the mouse to 23.5 in the monkey. In animals with medial vasa, the number of medial lamellar units ranged from 36.5 in the dog to 69.0 in the sheep. The marked deviation of the points corresponding to the pig, bull, and horse (dashed line) reflects the same departures in the architecture of the outer vascularized zone noted above. However, regardless of the appearance of the outer zone, the number of lamellar units in the avascular zone was very nearly constant for all species (dotted line) and equal to 29.0 ± 2.5. Thus, the relatively small increase in the thickness of the avascular zone with body weight
increasing body weight (Fig. 3, dotted line) corresponded to an increase in the width of individual lamellar units and not to an increase in their number.

Lamellar Composition of the Avascular Zone during Growth. In Figure 5 the changes in number of medial lamellar units during growth are plotted against weight for seven representative species. Three are species that did not have demonstrable medial vasa vasorum (guinea pig, rabbit, and cat). Four are species that had intramural vasa (dog, man, sheep, and bull); for these, both the total number of medial lamellar units (dashed lines) and the number of lamellar units in the avascular zone (solid lines) are plotted. The first point for each species corresponds to a fetus or newborn animal, the last to an adult. The total number of aortic medial lamellar units increased with age during growth for all of the species studied, but the increase from birth to maturity was less for small animals than for large animals. For example, the total number of lamellar units increased by approximately 10% in guinea pigs and by nearly 100% in man. Species which had intramural vasa vasorum as adults had at least 29 medial lamellar units at birth; vasa vasorum were not seen between the intima and the twenty-ninth lamellar unit but were always present between the latter and the adventitia, regardless of age and regardless of the rate of...
accretion of medial lamellar units during growth. The mean number of lamellar units in the avascular zone for all of the animals, regardless of age, was 28.5 ± 2.0. It is particularly noteworthy that no species with fewer than 29 aortic medial lamellar units at birth had more than this number when fully grown; all of the species with medial vasa vasorum as adults already had more than 29 lamellar units at the time of birth.

**Thickness of the Avascular Zone during Growth.** Although the number of lamellar units in the avascular zone of aortas with medial vasa vasorum was independent of species or age, the thickness of the avascular zone increased with age and the rate of its growth showed considerable species variation. Thicknesses of aortic medias and of the avascular zones in species with medial vasa vasorum are plotted against body weight during growth in Figure 6. The species are the same as those shown in Figure 5; each is represented by a series of growing animals with a fetus or newborn at the left end of the curve and an adult at the right end. Medias of adults of some species which had no intramural vasa vasorum at any age, i.e. with fewer than 29 lamellar units, were thicker than the avascular zones of aortas of immature animals of some species with medial vasa vasorum. For example, the aortic media of the adult cat with 20 lamellar units and no medial vasa vasorum, was thicker than the medial avascular zone of either the newborn human or the fetal sheep containing 29 lamellar units.

**Discussion**

**Nature of Species Differences in Medial Distribution of Aortic Vasa Vasorum.** Con-
Total number of medial lamellar units and number of avascular lamellar units are plotted against body weight during maturation for seven representative mammalian species. For each species the youngest animal was a fetus or a newborn, the oldest an adult. The avascular zone of each of the aortas with medial vasa vasorum contains 29 lamellar units, regardless of age, species, body weight, or total number of medial lamellar units (dog, man, sheep, and bull). Aortas without medial vasa always contain less than 29 lamellar units, regardless of age or species (guinea pig, rabbit, and cat).

Conclusions which may be drawn from the results are summarized diagrammatically in Figure 7. Transverse sections of aortic walls of representative newborn and adult mammals are drawn to the same scale. Elastin lamellae are shown as uniform, slightly wavy lines. Portions of the walls in which no vasa vasa-rum were demonstrable are shaded. Intramural medial vasa appear as solid ellipses; adventitial vasa appear as solid circles. Total number of medial lamellar units and the number of lamellar units in the zones without vasa vasorum are given for each aorta in the columns on the right. Aortas of small mammalian species, i.e., those with 29 or fewer medial lamellar units, were devoid of medial vascular channels; the mouse and rabbit are examples. Aortas of species with more than 29 medial lamellar units always had intramural medial vasa vasorum; the dog, man, and the sheep are given as examples. Aortas of mammals with medial vasa vasorum always had an inner avascular zone; in adults, the thickness of this zone increased slightly with increasing species body weight but independently of total wall thickness, averaging 0.47 ± 0.06 mm for all the species studied. The number of lamellar units in the avascular zone (29) was independent of both age and species. Mammals with 29 or fewer lamellar units at birth had 29 or fewer lamellar units as adults and had no intramural vasa vasorum at any age. Animals with more than 29 lamellar units at birth had intramural vasa vaso-
MEDIAL DISTRIBUTION OF AORTIC VASA VASORUM

Thickness of the entire aortic media and thickness of its avascular zone are plotted against body weight during growth for the same seven representative mammalian species shown in Figure 5. For any given species with aortic medial vasa vasorum, the thickness of the avascular zone increases during maturation, but there is considerable interspecies variation in the rate of its growth. Aortic medias of adults of some species without medial vasa vasorum may actually be thicker than avascular zones in immature animals of species with vasa vasorum (compare adult cat with immature sheep or human).

rum throughout development. No species we have studied has had fewer than 29 medial lamellae at birth and more than 29 lamellar units at maturity. Aortic medial thickness increased during growth by the uniform widening of lamellar units and by the addition of new lamellar units. These new units were probably added to the media on the adventitial side (14). In aortas with medial vasa vasorum, the number of lamellar units increased during maturation only in the vascular outer zone; the inner avascular zone seemed to enlarge only by widening of its preexisting 29 lamellar units. In adult mammals, total aortic medial lamellar units are related to aortic diameter, which increases with species body weight (8). Therefore, the greater the adult species body weight, the greater is the proportion of the media containing vasa vasorum. During growth, the vascularized outer zone widened more rapidly than the avascular inner zone. In man the avascular zone occupied 80% of the media at birth but only 50% at maturity; in sheep the avascular zone occupied 50% of the media at birth and 40% at maturity.

The medial distribution of vasa vasorum in the thoracic aortic has been studied by others in the chicken, rabbit, dog, horse, bull, and man (1-3, 15-17). A subintimal medial
Semidiagrammatic representations of aortic walls of five representative mammalian species are drawn to the same scale. A newborn (Nb) and an adult (Ad) are shown for each species. Elastic lamellae are shown as vertical slightly wavy lines; the portions of the walls without demonstrable vasa vasorum are shaded. Adventitial vasa vasorum appear as solid circles, intramural vasa as solid ellipses. The total number of medial lamellar units and the number of avascular units are given for each aorta in the columns on the right. Aortas with 29 or fewer medial lamellar units are devoid of medial vessels, regardless of age or species. Aortas with more than 29 medial lamellar units have medial vasa, regardless of age or species. In such aortas differences in medial distribution of vasa vasorum in adults are due mainly to differences in thickness of the vascularized zone; avascular zones are similar in thickness and in lamellar complement. During growth all lamellar units increase in width; however, in aortas with medial vasa, lamellar units increase in number only in the vascular outer zone.

<table>
<thead>
<tr>
<th>SPECIES</th>
<th>Nb</th>
<th>Ad</th>
</tr>
</thead>
<tbody>
<tr>
<td>MOUSE</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>RABBIT</td>
<td>15</td>
<td>20</td>
</tr>
<tr>
<td>DOG</td>
<td>29</td>
<td>50</td>
</tr>
<tr>
<td>HUMAN</td>
<td>34</td>
<td>50</td>
</tr>
<tr>
<td>SHEEP</td>
<td>54</td>
<td>69</td>
</tr>
</tbody>
</table>

FIGURE 7

Zone without vasa vasorum has been noted, but the constant lamellar composition of this avascular zone of the aortic media has not been reported previously. Geiringer's value of 0.5 mm for the thickness of the nonvascular portion of the media in man (3) is close to the value obtained by us; the small difference is entirely attributable to the fact that Geiringer studied undistended vessels while our aortic segments were distended. Woodruff (15) cleared undistended specimens of horse aorta after injecting the vasa vasorum with india ink; a subintimal avascular zone, measured on his published photographs, corresponds closely to values obtained by us.

Depth of the Avascular Zone and Medial Nutrition. Clarke (18) studied aortic vasa vasorum in man during postnatal development by means of microangiography. He reported that by the age of 4 years vasa channels could be seen in the outer third of the media; at 10 years, vasa were seen in the middle third and by age 13 "maturity of vasa vasorum" was achieved and channels could be seen at the junction of the inner and middle thirds. Clarke postulated that the
vasa grew into the media, penetrating more and more deeply as the thickness of the aortic media increased. Our data indicate that the increase in medial lamellar units during growth is confined to the already vascularized zone, and that vasa vasorum are probably incorporated into the vascularized zone as new lamellar units are formed at the adventitial side of the media. There was no evidence that any previously avascular aortic tissue was penetrated by vasa vasorum.

The absence of demonstrable medial vascular channels in the aortas of all animals with fewer than 29 medial lamellar units suggests that no medial vasa vasorum are required for aortic medial nutrition if this number is not exceeded. Indeed, Adams and coworkers (19) have shown that no morphologic changes or disturbances of cholesterol filtration occurred after the adventitia of the rabbit or rat aorta was stripped off completely. Each of these species has an aorta with fewer than the apparently critical number of 29 medial lamellar units. The presence of medial vascular channels only in aortas having more than 29 lamellar units indicates that such vessels are partially dependent on vasal blood supply for their nutrition. Adams (5) has given evidence that the cholesterol transport mechanism breaks down in the middle third of the human thoracic aortic media. He has suggested that a corresponding zonal decrease in enzyme content indicates that the transport breakdown may be due to ischemia. Wilens and his associates (4) have reported that experimental occlusion of adventitial blood vessels supplying the thoracic aortas of large dogs results in partial medial necrosis. Such zones of ischemia or necrosis, located deep in the wall, may well be at or near the transition between the avascular and vascularized medial zones, where the media, dependent on two sources of nutrition, may be particularly vulnerable (20).

Vascular channels are sometimes seen in the intima and inner media of vessels affected by intimal sclerosis or thrombosis (3, 21, 22). Neither the origin of these vessels nor the nature of the process which results in their formation is fully understood. It has been postulated that sclerotic or thrombotic interference with intimal filtration and the subsequent anoxia of the underlying media results in ingrowth by channels from the deeper vasa vasorum (3, 23). This possibility is not excluded by our findings. Since vasa do not seem to "penetrate" the growing wall normally but rather seem to be incorporated into it from the adventitia, some of the vessels in diseased intimas may well arise by channelization from the aortic lumen. In any case, the neoformation of vessels in diseased aortas probably corresponds to a departure from the normal pattern of medial nutrition and architecture rather than an extension of a physiological process to a new depth. Located in scar tissue near the lumen, these vessels may also be subjected to stresses not ordinarily affecting deeper vasa vasorum (21, 24).

Medial Distribution of Vasa Vasorum and the Mechanical Properties of the Aortic Wall. The total number of medial lamellar units in adult mammalian aortas is related to aortic diameter and tangential tension; the average tension per medial lamellar unit in an aorta is apparently independent of species and equal to about 2,000 ± 400 dynes/cm (8). The observation that the increase in aortic medial thickness with increasing diameter during growth is due largely to an increase in the number of lamellar units provides further evidence that these structures are probably units of medial function. Since the number of lamellar units in the avascular zone of aortas with medial vasa is approximately equal to 29 regardless of species, total tension in the avascular zone of an adult aortic media is probably also nearly constant and independent of species and is of the order of 60,000 dynes/cm. This suggests that the energy available for the maintenance of the mechanical properties of the adult avascular zone is limited, but independent of species or aortic diameter. The extent of transintimal filtration is therefore probably related to factors, such as intraluminal blood pressure, which are independent of species.

Vasa Vasorum and Medial Differentiation,
Growth, and Adaptability. Though the thickness of an aortic wall and the total number of its medial lamellar units are related to aortic diameter or body weight in adult mammals, this close relationship does not prevail among newborn or immature animals. In general, newborn animals of species of large adult size have thicker aortic walls with more lamellar units than those of species of smaller adult size, regardless of their birth weight. During development, the aortic wall grows as the width of individual lamellar units increases and as the number of the units increases in the outer, vascularized zone. The rates of these changes show considerable species variation. Thus, for a given species, the medial distribution of vasa vasorum during growth seems to depend more on the relative maturity of an animal than on the thickness of its aortic wall. Although the number of lamellar units in the avascular zone of an aorta with medial vasa vasorum is already maximal at the time of birth, the width of its lamellar units increases as the entire media increases in thickness. This suggests that the depth of transintimal filtration also increases during growth, possibly in relation to increasing blood pressure. An adult cat, for example, has an entirely avascular aortic media 0.23 mm thick containing 20 lamellar units. A newborn human has an avascular zone only 0.16 mm thick, although it contains 29 lamellar units. Mean adult feline blood pressure is approximately 100 mm Hg, that of the newborn human 60 mm Hg.

In aortas with medial vasa vasorum the increase in the number of medial lamellar units with increasing aortic diameter is confined to the vascularized zone. This may therefore be considered to be the zone of continued tissue differentiation into lamellar units, possibly in response to increasing wall tension. Indeed, differentiation during maturation in the zone nourished by the vasa in aortas of very large animals included modifications of medial composition and architecture other than the formation of new lamellar units. Departures from orderly lamellar structure are not seen in the avascular zone. Transintimal filtration of blood constituents into the avascular zone may provide adequate nutrition for only limited adaptive tissue changes such as the increase in thickness of lamellar units. Nutrition derived from the vasa vasorum appears to permit the vascularized zone to respond with more complex patterns of tissue differentiation, including the elaboration of new lamellar units and the occurrence of different forms of tissue architecture.

Acknowledgment

The authors thank Mrs. Anne Arden for the excellence of the histological preparations and Mrs. Shirley Weinstein and Mrs. Ruth Nordgren for their efforts in preparing the manuscript.

References


Nature of Species Differences in the Medial Distribution of Aortic Vasa Vasorum in Mammals

HARVEY WOLINSKY and SEYMOUR GLAGOV

Circ Res. 1967;20:409-421
doi: 10.1161/01.RES.20.4.409

Circulation Research is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231
Copyright © 1967 American Heart Association, Inc. All rights reserved.
Print ISSN: 0009-7330. Online ISSN: 1524-4571

The online version of this article, along with updated information and services, is located on the World Wide Web at:
http://circres.ahajournals.org/content/20/4/409

Permissions: Requests for permissions to reproduce figures, tables, or portions of articles originally published in Circulation Research can be obtained via RightsLink, a service of the Copyright Clearance Center, not the Editorial Office. Once the online version of the published article for which permission is being requested is located, click Request Permissions in the middle column of the Web page under Services. Further information about this process is available in the Permissions and Rights Question and Answer document.

Reprints: Information about reprints can be found online at:
http://www.lww.com/reprints

Subscriptions: Information about subscribing to Circulation Research is online at:
http://circres.ahajournals.org/subscriptions/