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Variations in the vasculature of the aortic arch and its major branches in the rabbit

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Introduction

The 'normal' aortic arch of the rabbit has been described as giving rise to two vessels, the brachiocephalic (or innominate) artery and the left subclavian artery [BALDWIN, 1920; BENSLEY, 1945; GROVE and NEWELL, 1961]. In these studies, however, no clear distinction was made between the brachiocephalic artery and the innominate artery. SAWIN and EDMONDS [1949] described in their paper the brachiocephalic artery as arising from the aortic arch and giving origin in turn to the innominate artery and the left common carotid artery. The innominate artery then divided into the right subclavian and right common carotid arteries. This nomenclature will be followed in the present paper.

Abnormalities in the major vessels arising from the aortic arch of the rabbit have been described on numerous occasions since the beginning of the last century [CUVIER, 1810; LEGALLOIS, 1824; KRAUSE, 1884; PARSONS, 1902], the commonest one being the origin of the left common carotid artery from the aortic arch instead of from the innominate artery. This was confirmed by SMITH [1891] who also noted a case in which the right subclavian artery arose from the dorsal aspect of the aorta. The anomalies in this region have been described in some detail by EDMONDS and SAWIN [1936] and SAWIN and EDMONDS [1949].

Each subclavian artery has several branches in the first part of its course. These are the vertebral, the superficial cervical, the transverse artery of the neck, the superior intercostal and the internal mammary. On the other hand, the branches have been described differently as the vertebral, internal mammary, superior intercostal and transverse scapular, the latter in its turn usually giving off the superficial cervical artery [BALDWIN, 1920]. The subclavian artery itself terminates beyond the lateral border of the first rib as the axillary artery [BENSLEY, 1945]. The arrangement of the vessels arising from the subclavian arteries may be very variable [BALDWIN, 1920].

The present investigation was undertaken as part of a more extensive physiological study of the aortic arch of the rabbit, which necessitated vascular isolation and perfusion of the area [ANGELL JAMES, 1971]. So that surgical procedures to isolate vascularly the area could be carried out on a more secure anatomical basis, an attempt was made to establish, firstly, a clearer picture of the arterial anomalies of the vessels arising not only from the aortic arch but from its branches as well, and secondly, the relationships of these vessels to the nerves in the area.

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Methods

Hycar latex injections

The anatomy of the arterial vessels in the immediate vicinity of the aortic arch of New Zealand white rabbits was demonstrated by injection of hycar latex (B.B. Chemical Co. or British Geon Ltd.) containing Indian ink (Reeves). After killing the animal a cannula was passed through the wall of the left ventricle so that its tip lay at the level of the aortic valves. Krebs-Henseleit solution [for composition see ANGELL JAMES, 1971] was perfused through the area until the effluent, which drained by way of a cannula in the right common carotid artery, was clear of blood. The thoracic aorta was ligated at the level of the left pulmonary artery and was followed by the injection of the latex at a pressure of about 100 mm Hg.

The specimens were fixed in 10 % formol-saline for 7 days before they were dissected under a × 10 operating microscope. Drawings were made to show the main arteries arising from the aortic arch and their branches. Measurements of the lengths of the major branches were also made.

Results

A total of 31 rabbits were dissected to define the anatomical arrangement of vessels arising from the aortic arch beyond the origin of the coronary arteries, and their branches. Since considerable variations between one animal and another were found, as noted by previous workers, the branches of named vessels will be considered under the following headings: the aortic arch, brachiocephalic artery, innominate artery, right subclavian artery, left subclavian artery, and finally, other vessels. Various types of arrangement of the vessels were noted, and the type numbers given to them refer specifically to the arrangement of the branches arising from the aorta.

Aortic arch

In 22 of 31 dissected specimens, the aortic arch gave origin to the brachiocephalic and left subclavian arteries (figs. 1–6; table I). In the remaining 9 specimens, the aortic arch gave rise to three major vessels, the innominate, left common carotid and left subclavian arteries (figs. 5 and 6). The relative proportions of the length of the brachiocephalic and innominate arteries are summarized in table I from which it will be noted that the two vessels were of equal length in 12 of 22 specimens (fig. 2); the brachiocephalic was the shorter of the two vessels in 5 specimens (figs. 1, 5 and 6) and the longer in 5 specimens.

The left subclavian artery arose from the arch in all 31 specimens (figs. 1–6; table I).

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Other vessels also originated from the aortic arch. The left vertebral artery, usually a branch of the left subclavian artery, had a separate origin in 6 specimens (figs. 1, 3–6). The superior intercostal arteries which normally arise from the subclavian arteries on both sides, came from the aortic arch on the left side in 11 cases (figs. 1, 4, 5 and 6) on the right side in 4 (figs. 2 and 5).

On the right side the superior intercostal artery shared a common trunk with the internal mammary artery in 4 specimens (figs. 2 and 5; types 4, 14, 15, 16). In 2 of these 4 cases the common branch arose from the dorsal aspect of the descending thoracic aorta (figs. 2 and 5; types 4, 15). In one (fig. 2), it passed behind the trachea before dividing to form the right superior intercostal and right internal mammary arteries.

In 4 specimens, the thyroidea ima, a small vessel running up on the ventral aspect of the trachea, was found to arise from the arch be-

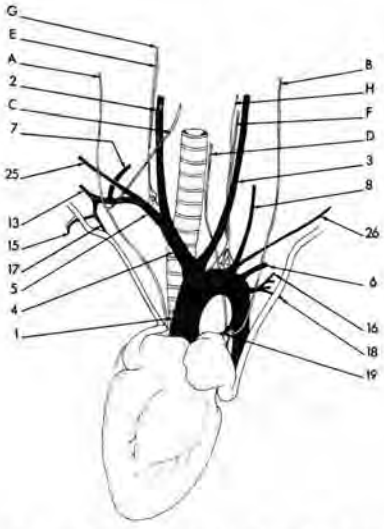

Fig. 1. Diagram of an injected aortic arch (type no. 1) showing its main branches and associated nerves. *Nerves:* A = right vagus; B = left vagus; C = right recurrent laryngeal; D = left recurrent laryngeal; E = right aortic; F = left aortic; G = right cervical sympathetic; H = left cervical sympathetic. *Arteries:* 1 = aorta; 2 = right common carotid; 3 = left common carotid; 4 = innominate; 5 = right subclavian; 6 = left subclavian; 7 = right vertebral; 8 = left vertebral; 13 = right axillary; 15 = right internal mammary; 16 = left internal mammary; 17 = right superior intercostal; 18 = left superior intercostal; 19 = ligamentum arteriosum; 25 = right transverse scapular; 26 = left transverse scapular.

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tween the origins of the innominate and left common carotid arteries (fig. 6). In another (fig. 2) an unnamed vessel arose from the inferior-medial aspect of the descending thoracic aorta and passed dorsally behind the ascending thoracic aorta.

The total number of vessels arising from the aortic arch, excluding the coronary arteries, varied from 2 to 6 (table I).

Brachiocephalic artery

This artery normally divides into the innominate and left common carotid arteries but in the present study this was not the invariable finding (table II). Of the 22 specimens possessing a brachiocephalic artery, only 17 gave rise to an innominate artery (figs. 1–6); the remaining 5 had no innominate vessel identifyable as such, and hence the brachiocephalic artery gave rise directly to the right subclavian and right common carotid arteries as well as to the left common carotid artery.

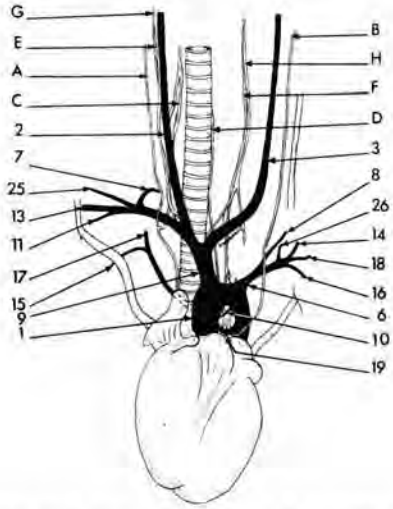

Fig. 2. Diagram of aortic arch, type no. 4. *Nerves:* A = right vagus; B = left vagus; C = right recurrent laryngeal; D = left recurrent laryngeal; E = right aortic; F = left aortic; G = right cervical sympathetic; H = left cervical sympathetic. *Arteries:* 1 = aorta; 2 = right common carotid; 3 = left common carotid; 6 = left subclavian; 7 = right vertebral; 8 = left vertebral; 9 = brachiocephalic; 10 = unnamed artery; 11 = right superficial cervical; 13 = right axillary; 14 = left axillary; 15 = right internal mammary; 16 = left internal mammary; 17 = right superior intercostal; 18 = left superior intercostal; 19 = ligamentum arteriosum; 25 = right transverse scapular; 26 = left transverse scapular.

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Table I. Arteries arising from the aortic arch

Type No.	No. of specimens	Brachiocephalic	Innominate	Left common carotid	Left subclavian	Left vertebral	Left superior intercostal	Right superior intercostal	Thyroidea ima	Other	Total no. arteries
1	1	+ b	—	—	+	+	+	—	—	—	4
2	1	+ b	—	—	+	—	—	—	—	—	2
3	1	+ c	—	—	+	—	—	—	—	—	2
4	1	+ c	—	—	+	—	—	+	—	+	4
5	1	— —	+	+	+	—	—	—	+	—	4
6	2	+ a	—	—	+	—	+	—	—	—	3
7	1	+ c	—	—	+	+	—	—	—	—	3
8	1	+ b	—	—	+	+	+	—	—	—	4
9	8	+ c(6)a(2)	—	—	+	—	—	—	—	—	2
10	1	+ a	—	—	+	—	+	—	—	—	3
11	2	— —	+	+	+	—	—	—	—	—	3
12	1	— —	+	+	+	—	—	—	+	—	4
13	1	+ c	—	—	+	+	+	—	—	—	4
14	1	— —	+	+	+	—	+	+	+	—	6
15	1	— —	+	+	+	—	+	+	+	—	6
16	1	+ b	—	—	+	—	+	+	—	—	4
17	1	— —	+	+	+	—	—	—	—	—	3
18	1	— —	+	+	+	—	—	—	—	—	3
19	1	— —	+	+	+	+	+	—	—	—	5
20	1	+ c	—	—	+	+	—	—	—	—	3
21	1	+ b	—	—	+	—	+	—	—	—	3
22	1	+ c	—	—	+	—	—	—	—	—	2
Total specimens											
	31	22 5a 5b 12c	9	9	31	6	11	4	4	1	11 with 2 branches 10 with 3 branches 7 with 4 branches 1 with 5 branches 2 with 6 branches

+ = present; — = absent. Brachiocephalic, a = longer than, b = shorter than, c = equal to, the innominate.

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The left common carotid originated from the brachiocephalic artery in 22 of the 31 specimens (figs. 1–6; table II). In the remaining 9 specimens it arose directly from the aortic arch (figs. 5, 6). There were 3 cases of the thyroidea ima artery arising from the ventral aspect of the brachiocephalic artery (figs. 4 and 6).

Table II indicates that the number of vessels arising from the brachiocephalic artery in any one specimen varied from 2 to 4.

Table II. Arteries arising from the brachiocephalic artery

Type no.	No. of specimens	Innominate	Left common carotid	Right common carotid	Right subclavian	Thyroidea ima	Total
1	1	+	+	—	—	—	2
2	1	+	+	—	—	—	2
3	1	+	+	—	—	—	2
4	1	+	+	—	—	—	2
5	1	—	—	—	—	—	0
6	2	—	+	+	+	—	3
7	1	+	+	—	—	—	2
8	1	+	+	—	—	+	3
9	8	+ (6)	+ (6)	— (6)	— (6)	—	2 (6)
		— (2)	+ (2)	+ (2)	+ (2)	—	3 (2)
10	1	—	+	+	+	+	4
11	2	—	—	—	—	—	0
12	1	—	—	—	—	—	0
13	1	+	+	—	—	—	2
14	1	—	—	—	—	—	0
15	1	—	—	—	—	—	0
16	1	+	+	—	—	—	2
17	1	—	—	—	—	—	0
18	1	—	—	—	—	—	0
19	1	—	—	—	—	—	0
20	1	+	+	—	—	—	2
21	1	+	+	—	—	—	2
22	1	+	+	—	—	+	3
Total specimens	31	17	22	5	5	3	15 with 2 branches 6 with 3 branches 1 with 4 branches 9 with 0 branches

+ = present; — = absent.

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Innominate artery

The normal situation in which the innominate artery divides into the right subclavian and right common carotid arteries was found in 26 of 31 specimens (figs. 1–6; table III). In the remaining 5 specimens the innominate artery was absent, as already stated (tables I and II). The only other vessels that originated from this artery were an internal mammary and right superior intercostal artery in one specimen

Table III. Arteries arising from the innominate artery

Type no.	No. of specimens	Right common carotid	Right subclavian	Right internal mammary	Right superior intercostal	Thyroidea ima	Other	Total no. branches
1	1	+	+	—	—	—	—	2
2	1	+	+	—	—	—	—	2
3	1	+	+	—	—	—	—	2
4	1	+	+	—	—	—	—	2
5	1	+	+	—	—	—	—	2
6	2	—	—	—	—	—	—	0
7	1	+	+	—	—	+	+	4
8	1	+	+	—	—	—	—	2
9	6	+	+	—	—	—	—	2
	2	—	—	—	—	—	—	0
10	1	—	—	—	—	—	—	0
11	2	+	+	—	—	—	—	2
12	1	+	+	—	—	—	—	2
13	1	+	+	—	—	—	—	2
14	1	+	+	—	—	—	—	2
15	1	+	+	—	—	—	+	3
16	1	+	+	—	—	—	—	2
17	1	+	+	—	—	—	—	2
18	1	+	+	—	—	—	—	2
19	1	+	+	—	—	—	—	2
20	1	+	+	—	—	—	—	2
21	1	+	+	+	+	—	—	4
22	1	+	+	—	—	—	—	2
Total specimens	31	26	26	1	1	1	2	23 with 2 branches 1 with 3 branches 2 with 4 branches 5 with 0 branches

+ = present; — = absent.

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(table III, type 21), and a thyroidea ima and an unnamed vessel in another (fig. 3; table III, type 7). A third specimen also had an unidentifiable vessel arising from the innominate artery (table III, type 15).

On the whole the branches of the innominate artery were less variable than those from other major vessels, and only 3 specimens had more than 2 vessels arising from it; one had 3 (type 15) and the other 2 had 4 (types 7 and 21). All the remaining specimens had the normal two branches. The results are summarized in tables III and IV.

Right subclavian artery

This vessel usually gives off the vertebral, transverse scapular, internal mammary and the superior intercostal arteries, and continues as the axillary artery beyond the lateral border of the first rib.

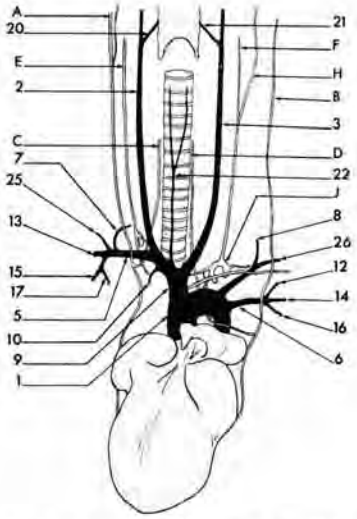

Fig. 3: Diagram of aortic arch, type no. 7. *Nerves:* A = right vagus; B = left vagus; C = right recurrent laryngeal; D = left recurrent laryngeal; E = right aortic; F = left aortic; H = left cervical sympathetic; J = inferior cervical ganglion. *Arteries:* 1 = aorta; 2 = right common carotid; 3 = left common carotid; 5 = right subclavian; 6 = left subclavian; 7 = right vertebral; 8 = left vertebral; 9 = brachiocephalic; 10 = unnamed; 12 = left superficial cervical; 13 = right axillary; 14 = left axillary; 15 = right internal mammary; 16 = left internal mammary; 17 = right superior intercostal; 20 = right superior thyroid; 21 = left superior thyroid; 22 = thyroidea ima; 25 = right transverse scapular; 26 = left transverse scapular.

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There was considerable variability in the order in which the vessels arose (table IV). In 29 cases the vertebral artery was the first branch (figs. 2–6); in the other 2 cases it was the second (fig. 1). The superior intercostal artery, either singly or in a common trunk with the internal mammary artery, arose second in 21 cases (figs. 4–6) but was the third branch in 4 cases (figs. 1, 3, 5 and 6). The combined trunk was observed in 25 specimens. The transverse scapular artery was the first branch to arise from the right subclavian artery in 1 specimen, the second in 6, the third in 13 and the fourth in 1.

The superficial cervical artery arose from the subclavian in one case.

Left subclavian artery

This vessel arose from the aortic arch in all 31 specimens (figs. 1–6; table I) and gave origin to the left vertebral, superior intercostal,

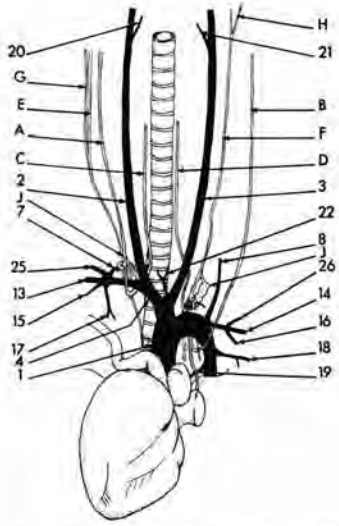

Fig. 4. Diagram of aortic arch, type no. 8. *Nerves:* A = right vagus; B = left vagus; C = right recurrent laryngeal; D = left recurrent laryngeal; E = right aortic; F = left aortic; G = right cervical sympathetic; H = left cervical sympathetic; J = inferior cervical ganglion. *Arteries:* 1 = aorta; 2 = right common carotid; 3 = left common carotid; 4 = innominate; 7 = right vertebral; 8 = left vertebral; 13 = right axillary; 14 = left axillary; 15 = right internal mammary; 16 = left internal mammary; 17 = right superior intercostal; 18 = left superior intercostal; 19 = ligamentum arteriosum; 20 = left superior thyroid; 21 = right superior thyroid; 22 = thyroidea ima; 25 = right transverse scapular; 26 = left transverse scapular.

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Table IV. Arteries arising from the right subclavian artery, numbered in order of origin

Type no.	No. of specimens	Vertebral	Superior intercostal	Internal mammary	Transverse scapular	Superficial cervical	Axillary	Other	Total no. branches
1	1	2	3	3	1	–	4	–	4
2	1	2	1	4	3	–	5	–	5
3	1	1	3	3	2	–	4	–	4
4	1	1	–	–	2	3	4	–	4
5	1	1	2	2	3	–	4	–	4
6	2	1	2	2	3	–	4	–	4
7	1	1	3	3	2	–	4	–	4
8	1	1	2	2	3	–	4	–	4
9	8	1	2	2	–	–	3	–	3
10	1	1	2	2	3	–	4	–	4
11	2	1	2	2	3	–	4	–	4
12	1	1	3	3	2	–	4	–	4
13	1	1	2	2	–	–	3	–	3
14	1	1	–	2	3	–	4	–	4
15	1	1	–	–	2	–	3	–	3
16	1	1	–	2	3	–	4	–	4
17	1	1	2	2	3	–	4	–	4
18	1	1	2	2	–	–	3	–	3
19	1	1	2	3	4	–	5	–	5
20	1	1	2	2	3	–	4	–	4
21	1	1	–	–	2	–	3	–	3
22	1	1	2	2	3	–	4	–	4
Total specimens									
	31 1st	29	1	–	1	–	–	–	12 with 3 branches
	2nd	2	21	22	6	–	–	–	17 with 4 branches
	3rd	–	4	5	13	1	12	–	2 with 5 branches
	4th	–	–	1	1	–	17	–	
	5th	–	–	–	–	–	2	–	

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Table V. Arteries arising from the left subclavian artery, numbered in order of origin

Type no.	No. of specimens		Vertebral	Superior intercostal	Internal mammary	Transverse scapular	Superficial cervical	Axillary	Other	Total no. branches
1	1		–	–	–	–	–	1	–	1
2	1		2	1	4	3	–	4	–	4
3	1		4	1	2	5	3	6	–	6
4	1		1	4	3	2	–	5	–	5
5	1		1	2	2	4	3	4	–	4
6	2		1	–	2	3	4	5	–	5
7	1		–	–	2	–	1	3	–	3
8	1		–	–	2	1	–	3	–	3
9	8		1	2	3	4	–	5	–	5
10	1		1	–	2	3	–	4	–	4
11	2		1	3	3	2	–	4	–	4
12	1		1	–	2	3	–	4	–	4
13	1		–	–	–	1	–	2	–	2
14	1		2	–	1	3	–	4	–	4
15	1		1	–	–	–	–	2	–	2
16	1		1	–	2	–	–	3	–	3
17	1		1	2	2	3	–	4	–	4
18	1		2	1	1	–	–	3	–	3
19	1		–	–	–	1	–	2	–	2
20	1		–	–	–	1	–	2	–	2
21	1		1	–	2	3	–	4	–	4
22	1		1	2	2	3	–	4	–	4
Total specimens										
	31	1st	21	3	2	4	1	1	–	1 with 1 branch
		2nd	3	11	12	3	–	4	–	4 with 2 branches
		3rd	–	2	11	9	2	4	–	4 with 3 branches
		4th	1	1	1	9	2	10	–	10 with 4 branches
		5th	–	–	–	1	–	11	–	11 with 5 branches
										1 with 6 branches

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internal mammary and transverse scapular arteries before terminating in the axillary artery (table V).

The left vertebral artery was identified in 25 specimens as arising from the left subclavian artery. In 21 of these it was the first branch to arise from the parent vessel, whereas in 3 it was the second (figs. 5, type 14, and 6, type 18); in the remaining one, it was the fourth.

The superior intercostal artery was the first branch to arise in 3 cases (figs. 5, type 13, and 6, type 18), the second in 11, the third in 2, and the fourth in 1, the total number of specimens being 17. In only 5 cases was it found to share a common trunk with the internal mammary artery, which is very much fewer than occurred on the right side of the body.

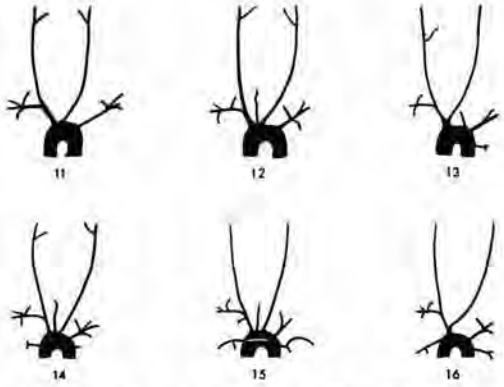

Fig. 5. Diagrams of injected aortic arches, type numbers 11–16, with their main branches.

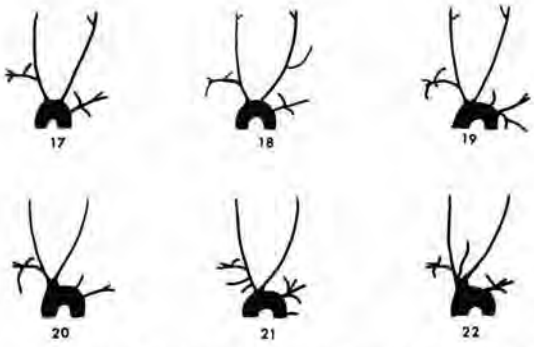

Fig. 6. Diagrams of injected aortic arches, type numbers 17–22, with their main branches.

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The origin of the internal mammary artery was variable, being the second branch of the left subclavian artery in 12 specimens and the third in 11.

The transverse scapular artery was found in 26 specimens; in 9 of these it appeared as the third branch of the left subclavian artery and as the fourth branch in 9 cases.

The superficial cervical artery was found in 5 specimens arising directly from the left subclavian artery.

Other abnormalities

The commonest other vessel seen in this study was the superior thyroid artery which usually arose on one or both sides from the common carotid artery (figs. 3–6). It is included in this section as its presence was inconstant.

In one specimen a large vessel arose from the left common carotid artery and was not identified.

Table VI. Summary of the number of vessels arising from the aortic arch and its main branches in the rabbit

Vessel of origin	Number of branches	Number of specimens	Occurrence %
Aorta arch	2	11	35
	3	10	32
	4	7	23
	5	1	3
	6	2	6
Brachiocephalic artery	2	15	48
	3	6	19
	4	1	3
Innominate artery	2	23	74
	3	1	3
	4	2	6
Right subclavian artery	3	12	39
	4	17	55
	5	2	6
Left subclavian artery	1	1	3
	2	4	13
	3	4	13
	4	10	32
	5	11	35
	6	1	3

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In one type (No. 2) a large vessel travelled from the left superior intercostal artery over the ventral aspect of the aorta to disappear below the ligamentum arteriosum. In another there were large branches from the right superior intercostal artery travelling dorsally behind the aorta on the right side. It has already been shown in fig. 2 that the combined trunk of the superior intercostal and internal mammary arteries on the right side took origin from the dorsal aspect of the thoracic aorta just proximal to the ligamentum arteriosum on the left side.

Discussion

Twenty-two types of anatomical variation of the aortic arch and the main vessels arising from it have been described in this series. Hitherto, SAWIN and EDMONDS [1949] had described 20 variations in a much larger series of animals but these authors were mainly concerned with the relative lengths of the brachiocephalic artery and the innominate artery and did not include in their series variations in the site of origin of other vessels from the aortic arch. This therefore explains the relatively much larger number of anatomical types found in the present investigation.

Aortic arch

Of the 22 types described, only 4 fell into the category of the 'normal' aortic arch giving origin only to the brachiocephalic artery and to the left subclavian artery. This represents 11 out of 31 animals, or 35.4 %, and is a much lower figure than that of 80.6 % for Type A in the series of EDMONDS and SAWIN [1936]. However, if the two major vessels only are considered in the present series, then 22 of the 31 animals (70.9 %) had 'normal' aortic arches.

Of the 11 specimens, 8 had both a brachiocephalic artery and an innominate artery of equal length, equivalent to Type A of SAWIN and EDMONDS [1949], whereas in 1 specimen the brachiocephalic artery was shorter as described by SAWIN and EDMONDS [1949] as variation Type B. This variation was also reported by KRAUSE [1868]. The innominate was absent in 2 of these specimens.

Anomalous vessels arising from the aortic arch described here, and previously documented, include the left common artery [WHITE 1893; SMITH, 1891; EALES, 1940; PARSONS, 1902; BALDWIN, 1920] and the left vertebral artery [BALDWIN, 1920; SAWIN and EDMONDS,

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1949]. The presence of these two vessels arising from the arch was correlated with relative growth differences in these animals.

The thyroidea ima artery was described by BALDWIN [1920] as arising from the innominate artery but in 4 specimens in this series it was found to arise from the aortic arch. An anomalous superior intercostal artery was found on 15 occasions, 11 on the left side and 4 on the right, which have not hitherto been described. Another anomaly not previously described was the common trunk of the right internal mammary and right superior intercostal arteries originating from the dorsal aspect of the descending thoracic aorta in a position similar to the anomalous origin of the right subclavian artery described in the rabbit [SAWIN and EDMONDS, 1949], in the dog [DEKLEER, 1970; VITUMS, 1962] and in man [GRANT, 1956]. In one of the specimens the common trunk passed dorsally to the trachea. These, together with the thyroidea ima artery, and any other unnamed anomalous arteries of which there was only one in this series, were important to identify in the operative procedure to isolate successfully the aortic arch from the remainder of the vascular bed [ANGELL JAMES, 1971]. The total number of vessels arising from the aortic arch is normally considered to be 2, but up to 4 have been described previously [PARSON, 1902; SAWIN and EDMONDS, 1949]. In the present series, 67% of specimens had 2 or 3 vessels arising from the aortic arch, whereas 32% had 4 or more. In this latter category, 1 specimen had 5 vessels and 2 had 6.

Brachiocephalic artery

Normally, this artery gives origin to the innominate artery [SAWIN and EDMONDS, 1949] and the left common carotid. This proved to be so in 17 out of a total of 31 specimens. In the other cases the right common carotid artery and the right subclavian artery arose from the brachiocephalic artery where the innominate artery was absent, a situation also described by SAWIN and EDMONDS [1949]. On three occasions a thyroidea ima artery was observed arising from the brachiocephalic artery which was not described by them. Hence, the brachiocephalic artery had up to 4 branches arising from it.

Innominate artery

The innominate artery normally terminates in the right subclavian and right common carotid arteries, and this situation was found in 84% of specimens. In 1 specimen, the right internal mammary artery

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and the right superior intercostal artery were seen arising from the innominate artery, and these findings do not appear to have been documented previously. In confirmation of the results of BALDWIN [1920] 1 specimen had the thyroidea ima artery arising from the innominate artery. Only 2 other specimens, however, had unnamed vessels so that on the whole the innominate artery and its branches, which vary in number from 2 to 4, appear subject to less variation than other large vessels under discussion.

Subclavian arteries

BALDWIN [1920] described some subclavian arteries as of the short corona type in which the branching was near the aorta, and others, the long corona type, which branched a long way from the aorta. He found many variations but described the normal vessels arising from them as the vertebral, transverse scapular, internal mammary, and the superior intercostal arteries. This agreed with BENSLEY [1945] who also included the superficial cervical artery which BALDWIN [1920] claimed normally arose from the transverse scapular artery.

In the present series both long and short corona types were seen, but the right subclavian artery normally appeared to have only 3 or 4 vessels arising from it which included the vertebral, the superior intercostal and internal mammary arteries as well as the transverse scapular artery, before it determinated in the axillary artery. The superior intercostal artery and the internal mammary artery often arose from a common trunk and this variation was found more often on the right side than the left. The order in which the vessels arose from the subclavian arteries was also variable with the exception of the first branch which, in the majority of specimens, was the vertebral artery.

Of the two subclavian arteries, the left had the more varied anatomy both in so far as the number of branches is concerned (1–6 from the left and 3–5 from the right), and in the order the vessels arose from them. In 25 of the 31 specimens the left subclavian artery gave origin to the left vertebral artery which in the majority of cases was the first branch. In 5 specimens the superficial cervical artery arose from the left subclavian. These findings agree well with those of BALDWIN [1920].

Other abnormalities

Variations in the courses of the superior intercostal and internal mammary arteries and their tributaries as well as other anomalous

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vessels are described in this paper. Their presence complicates the dissection of the aortic arch region since many of them lie within the adipose tissue in close proximity to the nerves in this area.

This investigation has demonstrated not only the considerable variation that exists in the vasculature of the aortic arch region in the rabbit, but also in the number of anomalous vessels that are found in different specimens. The relationship of some of these vessels to the adjacent nerves, which may be seen in figs. 1–4, determined the design of a preparation for studying the physiological properties of the baroreceptors in this region and the surgical approach to the vessels for vascularly isolating the area from the circulation. The details for this are to be found elsewhere [ANGELL JAMES, 1971].

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Summary

The anatomy of the aortic arch and its branches beyond the origin of the coronary arteries was studied in 31 injected rabbits. Twenty-two anatomical variations are described and of these, only 4 fell into the category of the 'normal' aortic arch, giving origin only to the brachiocephalic and left subclavian arteries. This represents 11 out of the 31 animals, or 31.4 %. In the remainder, 3 major branches arose directly from the arch – the innominate, left common carotid and left subclavian arteries. Occasionally, up to 6 vessels originated from the aortic arch.

The brachiocephalic artery, present in 71 % of the specimens, gave origin to the innominate artery and left common carotid artery in two-thirds of them; in the remaining third the innominate artery was absent, so that the brachiocephalic artery gave origin to the right subclavian and right common carotid arteries as well as to the left common carotid artery. Up to 4 vessels arose from the brachiocephalic artery (when present) in different specimens.

The innominate artery, present in 84 % of the specimens, invariably divided into the right subclavian artery and the right common carotid artery. Few anomalous vessels were found to arise from it.

The vessels arising from the subclavian arteries were very variable, the left more than the right. The importance of the relationship between these anomalous vessels and adjacent autonomic nerves in the design of a preparation for studying the physiological properties of baroreceptors in this region are discussed.

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