Study on the Subclavian Artery and its Branches in Japanese Adults

By

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Summary: We examined the entire array of branches and the state of ramification of each branch of 144 subclavian arteries (*Su*) in 72 Japanese adults, and obtained the following findings. (1) The incidence of Type I -A(1) was 13.2%, the highest among the entire *Su* ramification. This was followed by Type I -B(1) at 9.0%, then Type I -A(2) at 6.9%, indicating considerable variation in the morphology of *Su* ramification. (2) Ontogenetic factors were implicated because of the existence of cases in which *Su* traversed the scalenus anterior muscle anteriorly (Type III: 0.7%), or was transfixed (0.7%). (3) Type 1-c was the form of thyrocervical trunk (*Ttc*) observed with the highest incidence of 31.3%. In addition, we propose that Types *a-j* (that were formed from a common trunk consisting only of the ascending cervical artery and inferior thyroid artery, and those in which another branch was included in this common trunk: 88.9%) be called *Ttc*. (4) The most common type of transverse cervical artery (*Tc*), which is formed from a common trunk consisting of superficial and deep branches, was found to be Type 1-a that branches from the first part of *Ttc*. It was observed with the highest incidence of 61.8%. Some of the superficial branches to the upper portion of the trapezius muscle that were independent and branched from *Ttc* (Types *e, f*: 2.8%), we called upper superficial branches. (5) The most frequently observed type of suprascapular artery (*Ss*) was Type *b* (38.2%), followed by Type *a* (25.7%), which branches independently from *Su*. We concluded that the sites at which *Tc* and *Ss* originate are the positions at which they traverse the brachial plexus (superior, transixed to the plexus). (6) In cases in which the supreme intercostal artery (*Is*) and the deep cervical artery (*Cp*) were separate, (Types *d-i* excluding Type *g*: 31.9%), *Is* branched from a more proximal position than *Cp*.

Formation of the human subclavian artery to an almost adult condition occurs in about 7 weeks of embryonic development.^{5, 6, 10, 26)} There have been numerous reports of substantial individual and racial differences in the position of arterial branches and the nature of their ramifications as a result of various factors that have an influence on morphosis.^{7, 12, 13, 17, 21, 27, 29, 33, 35, 44)} However, there are almost no reports of studies that have attempted to characterize and classify the ramification and positions of the entire array of branches arising from the subclavian artery. The only relevant reports in Japan were those by Adachi ('28)¹⁾ and Ouchi ('63)³⁰⁾, who described the subclavian artery ramification in Japanese adults, and that by Mori ('41)²⁸⁾, who described Japanese fetuses. However, these reports did not explain the entire subclavian artery ramification, nor determined the most common type of ramification or its incidence among the Japanese population.

With recent increase in the use of CT, MRI and angiography, it has been pointed out that an accurate understanding of the morphology of the normal sub-

clavian artery³²⁾ and detailed information about the ramification and course of arteries that branch from the subclavian artery^{12, 22)} are essential prerequisites for accurate diagnosis by these techniques of pathogenic changes in the upper limbs. Furthermore, sternocleidomastoid muscle and trapezius muscle are frequently used as a musculocutaneous flap in reconstructive surgery, but despite the fact that the nutrient artery which supplies these muscles is a branch of the subclavian artery, reports to the contrary have appeared.^{31, 40)}

For these reasons, we conducted a study to characterize and classify the entire ramification of branches arising from the subclavian artery, as well as the ramification and position of the sites of origin of the individual branches in Japanese subjects. We also determined the incidence of the different types found in the study.

Method and Materials

Materials

144 subclavian arteries of 72 Japanese adults (43 males and 29 females) were examined. The mean age of the subjects was 71.2 years (45–92 years).

Method

The entire subclavian artery and its branches were excised with care, examined in detail, and a sketch made of the sites of origin, course, and termination of each branch. We also classified the subclavian artery into the 1st part (medial to the scalenus anterior muscle), 2nd part (posterior to the muscle) and 3rd part (lateral to the muscle), based on its position relative to the scalenus anterior muscle. We named each of the arteries by following their course and distribution in the muscles.

Results

Fig. 1 shows the right subclavian artery (*Su*) and its branch ramification of a 71-year-old female (No. 315R). The vertebral artery (*Ve*) had an outer diameter of 3.1 mm, originated from the 1st part 1.5 cm lateral to the branching portion of the subclavian artery, and extended to the transverse foramen of the 6th cervical vertebra posteromedially. At a site 5 mm lateral to *Ve*, the thyrocervical trunk (*Ttc*) that originated superiorly from the 1st part immediately proximal to the medial border of the scalenus anterior muscle (*sa*), branched to form the suprascapular artery (*Ss*) at approximately 1 cm posterior to the branch. *Ss* traversed the anterior of *sa* laterally, but after passing this muscle, its direction became slightly more posterior, passing superior to the brachial plexus (*Plb*), with one branch feeding the clavicular portion of the trapezius muscle. After passing above the superior scapular transverse ligament of the scapula, *Ss* traversed behind the supraspinatus muscle, passed around the neck of the scapula, then branched to supply a fine vessel to the superior border of the posterior portion of the deltoid muscle, and another to the supraspinatus muscle ventrally. Intramuscular distribution in the trapezius muscle and deltoid muscle was equivalent to Type II-a (Takafuji⁴³) and Type 1-s (Azuma⁴) as previously reported.

The transverse cervical artery (*Tc*) branched directly from *Ttc* at a position 5 mm distal from *Ss*, then traversed the anterior *sa* laterally, passing over *Plb* to reach the lateral border of the levator scapulae muscle, where it split into a superficial branch (*Rs*) and deep branch (*Rp*). *Rs* extended to the middle

Fig. 1. Schematic drawing of the subclavian artery and its branches on the right side of a 71 year-old Japanese female (No. 315). This is the typical type (I -A(1)) in this series.

Abbreviations for Figures

- 1 : vertebral artery (*Ve*),
- 2 : internal thoracic artery (*Tin*),
- 3 : thyrocervical trunk (*Ttc*),
- 4 : inferior thyroid artery (*Tif*),
- 5 : ascending cervical artery (*Ca*),
- 6 : transverse cervical artery (*Tc*),
- 7 : suprascapular artery (*Ss*),
- 8 : costocervical trunk (*Tcc*),
- 9 : deep cervical artery (*Cp*),
- 10 : supreme intercostal artery (*Is*),
- Aa* : aortic arch,
- Ce* : external carotid artery,
- Ci* : internal carotid artery,
- Da* : dorsal aorta,
- Di* : dorsal intersegmental arteries,
- Ip* : posterior intercostal arteries,
- Rcl* : lateral costal branch (or lateral internal thoracic artery),
- Rp* : deep branch of transverse cervical artery,
- Rs* : superficial branch of transverse cervical artery,
- sa* : scalenus anterior muscle,
- Su* : subclavian artery,
- 7th* : seventh dorsal intersegmental artery.

portion of the trapezius muscle along the dorsal side of the levator scapulae muscle (superficial layer), then immediately before penetrating the muscle, split into an upper branch that supplied the upper muscle bundle (clavicular portion) and a middle branch that supplied the middle portion of the muscle (acromial portion/portion of the spine of the scapula). After branching, *Rp* supplied the rhomboid and serratus anterior muscles dorsally after passing under the ventral sides (deep layers) of the levator scapulae muscle and the rhomboid muscle along the

medial border of the scapula. In the course of this inferior passage, *Rp* sends a branch (*Blp*) to the lower portion of the trapezius muscle. *Blp* penetrates the trapezius muscle after becoming transfixed between the rhomboideus major and minor muscles. Immediately after *Tc* bifurcates, *Ttc* splits into the ascending cervical artery (*Ca*) and the inferior thyroid artery (*Tif*). *Ca* supplies this muscle with 3 fine branches during its ascending course on the anterior surface of *sa*, then penetrates the intervertebral foramen along the 4th or 5th cervical nerve. *Tif* follows an inner descending course to reach the center of the external border of the thyroid gland, supplies one fine branch to the esophagus, then descends postero-medially to supply the inferior half of the thyroid gland.

The internal thoracic artery (*Tin*) followed an inferomedial course after branching inferiorly from the 1st part of *Su* in the reflective direction from *Ttc*. It then followed a descending course approximately 1.5 cm external to the outer edge of the sternum, and supplied anterior intercostal branches and perforating branched to each intercostal space. After this, *Tin* branched to form the musculophrenic artery and the superior epigastric artery at the inferior edge of the sternum. The costocervical trunk (*Tcc*) arose from the dorsal surface of the 2nd part of *Su*, then immediately branched into the deep cervical artery (*Cp*) and the supreme intercostal artery (*Is*). *Cp*, after running dorsally sent one fine branch to the intervertebral foramen along with the 8th cervical nerve. The other branch supplied the splenius muscle after following an ascending course. *Is* sent a branch to the 1st and 2nd intercostal space after following a descending course after branching.

The following describes the sites of origin and the morphology of ramification of the subclavian artery (*Su*) and each artery that branches from it in all of the subjects examined.

1) Relation between *Su* and *sa*

Fig. 2 shows the positional relation of the subclavian artery (*Su*) to the scalenus anterior muscle (*sa*). In 142 among 144 arteries, *Su* traversed *sa* posteriorly (Type I: 98.6%), but in one case (a 76-year-old male; left side) it was transfixed to *sa* (Type II: 0.7%), and in another case (a 79-year-old male; left side) it traversed *sa* anteriorly (Type III: 0.7%).

2) *Ve*

Fig. 3 shows the site of origin and the morphology of ramification of the vertebral artery (*Ve*). Type A, in which the left vertebral artery branches directly from the aortic arch (*A*), was observed in 2 males and 3 females, a total of 5 subjects. The incidence of Type A was 6.9% by subject, and 3.5% by body side

Fig. 2. Three positional relations of the subclavian artery (*Su*) to the scalenus anterior muscle.

of appearance.

Additional classifications were combinations of the following two types (classification). Types A, 1, 2, 3, and Ax indicate the site at which the artery arose, (A) representing branching from the aortic arch, 1, 2, and 3 from the 1st, 2nd, and 3rd parts of the subclavian artery, and Ax from the axillary artery. Types represented by the letters a-q represent the nature of ramification (indicating whether or not the artery forms a common trunk with another branch) at the origin of each artery.

The most common type of *Ve* was Type a (93.1%), in which *Ve* branched independently and medially from the thyrocervical trunk (*Ttc*). A common form of Type a was Type 1-a in which branching was from the 1st part of *Su* in 129 cases or 89.6% (males: 89.5%, females: 89.7%, right: 87.5%, left: 91.7%). Type 1-d, in which *Ve* formed a common trunk with *Tif*, was also observed in 2 cases (1.4%).

3) *Tin*

The internal thoracic artery (*Tin*) followed *Ve* in showing branching from a fairly consistent position (Fig. 4). Type a showing independent branching of *Tin* was seen in 126 cases (87.5%). Type 1-a, in which formation of *Tin* from the first part of *Su*, was observed in 79.9% (males: 80.2%, females: 79.3%,

Fig. 3. Types and incidences of origin of the vertebral artery (*Ve*) classified by the site and the forming of common trunk with the other artery. For descriptive purposes, the subclavian artery was divided by the scalenus anterior muscle into 3 portions: medial to it (1st part), behind it (2nd part) and lateral to it (3rd part). In all figures of this study, additional classifications were combinations of the following two types. Types A, 1, 2, 3, and Ax indicate sites of origin for each artery, which arose from the aortic arch, the 1st part, the 2nd part and the 3rd part of the subclavian, and axillary artery, respectively; Types a~q indicate their trunk formation with the other arteries.

Fig. 4. Types of the origin of the internal thoracic artery (*Tin*) classified by their site and how they form common trunk with the other arteries. In Types b-I, c and d-II, the lateral costal branch (*Rcl*), occurred as a variational artery, arose from *Tin* which originated either alone or as a common trunk from the subclavian. These types were encountered in 3.5% of cases, and especially Type d-II *Rcl* was very rare.

right: 84.7%, left: 75.0%). There were 9 subjects (6.3%: Types d, d-I, d-II, e, f) in which *Tin* branched from *Ttc*. There were 3 unusual cases (2.1%) exhibiting Type 3-a in which *Tin* branched independently from the 3rd part. Among 5 cases (3.5%: Types b-I, c, d-II) in which a lateral costal branch (*Rcl*) arose from *Tin*, there was a Type 1-d-II subject (No. 352, 85-year-old male, left side) in which *Rcl* originated from *Tin* branching from a thyrocervical trunk (*Ttc*) consisting of the transverse cervical (*Tc*) and the suprascapular arteries (*Ss*). Moreover, in a Type 1-g subject (No. 174, 74-year-old female, right side), *Tin* originated from a common trunk consisting of *Ss* and a superficial branch (*Rs*) of *Tc*.

4) *Ttc*

As enormous variation exists in ramification of the thyrocervical trunk (*Ttc*), we based our classifi-

Fig. 5. Types of origin of the thyrocervical trunk (*Ttc*). The classification was mainly made by the common trunk of the ascending cervical (*Ca*) and inferior thyroid arteries (*Tif*) either existing or not. Type 1-c *Ttc* occurred most frequently, 31.1% of cases, and Type a was in 11.1%, in which its trunk arose alone from 1st (type 1-a: 10.4%) or 2nd parts (type 2-a) of the subclavian.

cation mainly on the ascending cervical artery (*Ca*), which supplies the spinal cord, and the inferior thyroid artery (*Tif*), which supplies the thyroid gland, as shown in Fig. 5. *Ttc* normally (94.4%) branches in an ascending direction from the 1st part immediate medial to *sa*, but in some cases (5.6%) it branched from the 2nd part immediately distal to the medial border of *sa*. The most common type observed in 45 cases (31.3%, males: 33.7%, females: 27.6%, right: 51.4%, left: 11.1%) was Type 1-c in which 4 branches (*Ca*, *Tif*, *Ss*, *Tc*) formed a common trunk branching from the 1st part. This type was observed with a higher incidence on the right side. This type included independent branching of *Tc* and *Ss* from *Ttc*, and branching of both arteries as a common trunk from *Ttc*. Another type occurring with a high incidence of 18.8% was Type 1-g in which *Ss* was absent. There were 6 cases (4.2%, including Type *d* of the *Ve* classification) in which *Tif* branched independently from *Su* (Types *k*, *l* and *m*), and 8 cases (5.6%) in which it was absent (Types *p*, *q*). In 2 cases (1.4%) *Ca* arose independently from the one (Types 1-n, 1-o), no absent of *Ca* was observed. There were also 16 cases (11.1%) in which a common trunk was formed by *Ca* and *Tif* alone (Type *a*). In 16 cases (11.1%), *Ca* and *Tif* did not form a common trunk (Types *k-q*). In the remaining cases (88.9%), these two arteries formed a common trunk or they were combined with additional arteries to form the common trunk. As a definitive definition of what constitutes the thyrocervical trunk does not exist at present, for the purpose of this study we defined it as the last-mentioned type, which is either a common trunk consisting of *Ca* and *Tif* alone, or a common trunk consisting of *Ca* and *Tif* with another branch (88.9%).

5) *Tc*

Fig. 6 shows the data related to the transverse cervical artery (*Tc*) in the 144 arteries examined in this study. As described in the subject of Fig. 1, the final regions supplied by the superficial branch (*Rs*) are the upper and middle portions of the trapezius muscle after traversing the superficial layer of the levator scapulae muscle (Refer to *a-b* and *c-d* at the upper right of Fig. 6). This *Rs* sends a branch (upper portion branch) to the upper portion and a branch (middle portion branch) to the middle portion before penetrating the muscle. Type *e* and Type *f* are cases in which the upper portion branch and the middle portion branch are separate and originate from different sites. In this report, we have given the upper portion branch (*Rs* 1) the name of upper superficial branch, and the middle portion branch (*Rs* 2), the middle superficial branch.

There were 122 cases (84.7%) in which *Tc* was

present (Types *a*, *b*, *e*). Among these, there were 93 cases (64.6%) in which *Tc* branched from *Ttc* (Type *a*). Of these 93 cases, 89 (61.8%, males: 66.3%, females: 55.2%, right: 58.3%, left: 65.3%) were Type 1-*a* in which the branch originated from the 1st part. There were 22 cases (15.3%) in which *Rs* and *Rp* branched independently (Types *c*, *d*, and *f*). However, in Type *c* (13.9%), *Rs* branched from *Ttc* (from the 1st part: 12.5%, 2nd part: 1.4%), and *Rp* branched from the subclavian artery (from the 2nd part: 4.9%, 3rd part: 8.3%, *Ax*: 0.7%). Furthermore, there was a subject (No. 174, 74-year-old female, right side) exhibiting Type 1.3-*d* in which *Rs* and *Rp* branched from the 1st and 3rd parts of *Su*, respectively. Another extremely unusual subject (No. 321, 66-year-old female, left side) exhibited Type 1.2.3-*f* in which *Rs*(1) branched from *Ttc* (branch from the 1st part) and *Rs*(2) and *Rp* branched from the 2nd and 3rd parts of *Su*. The figure shows types in which *Tc*, *Rp*, and *Rs* branching directly from *Su* are independent branches, and types in which they form a common trunk with other branches.

The figure at the bottom right of Fig. 6 shows the relation between *Tc* and the brachial plexus (*Plb*). There were 104 cases (72.2%) in which *Tc* traversed *Plb* along an ascending course (*A*), including Type *a* (excluding one case in which branching was from the 2nd part), Type *b* (Type 1-*b*) with branching from the 1st part, and 4 cases (2.8%) of Type *c* (Type 1.2-*c*) in which *Rp* branched from the 2nd part. However, *Tc* of Types *a* and *b* only traversed the scalenus anterior muscle anteriorly. In the others, *Rp* or *Tc* traversed *B-F* of *Plb*.

6) *Ss* (Fig. 7)

Type *a*, in which the suprascapular artery (*Ss*) branched independently appeared in 37 cases (25.7%, males: 26.7%, females: 24.1%, right: 27.8%, left: 23.6%). In this type, *Ss* originated from the 2nd part in 1.4%, from the 3rd part in 16.7%, and from the axillary artery (*Ax*) in 7.6%. The most commonly observed type was Type *b* seen in 55 cases (38.2%, males: 39.5%, females: 36.2%, right: 37.5%, left: 38.9%), in which *Tc* and *Ss* (equivalent to Types *c*, *k*, and *p* of the *Ttc* classification) branched from *Ttc*. The majority were Type 1-*b*, in which branching was from the 1st part. This type was observed in 53 cases (36.8%, males: 37.2%, females: 36.2%, right: 37.5%, left: 36.1%). Type *g* (equivalent to Types *b* and *b-1* of the *Tin* classification), in which *Ss* branched from *Tin* was observed in 4.2%. There were 2 cases (No. 174, right and left sides) of Type *k* in which two *Ss* were found. On both sides alike, *Ss*(1) from the 1st part traversed *sa* anteriorly, then passed over *Plb* (position *A* in the center of the

Fig. 6. Types of origin of the transverse cervical artery (*Tc*), and the frequency of the various positions of *Tc* as it passes through the brachial plexus. The left row shows some variations in the origin of *Tc*. In Type *a* (64.6% of cases) *Tc* arose directly from the thyrocervical trunk (*Ttc*), while in Type *c* the superficial branch (*Rs*) and deep branch (*Rp*) of *Tc* originated separately from *Ttc* and the subclavian, respectively. Moreover, occasionally, the branch of *Rs* (named as the upper superficial branch (*Rs*(1)) by authors) to the upper portion of trapezius muscle originated independently from *Ttc* and the branch (*Rs*(2)) to its middle portion directly from either *Rp* or the subclavian (see Types *e* and *f*, and the middle upper drawing showing the arteries supplying the muscle). Consequently, type 1.2.3. (the table on right side) intended to mean *Rs*(1), *Rs*(2) and *Rp* arise from the 1st, 2nd and 3rd parts of the subclavian, respectively.

figure) and the superior scapular transverse ligament (*Lss*). *Ss*(2), which branched from the 3rd part and from *Ax*, was transfixed to *Plb* (*C* in the center of the figure), then passed under *Lss* to reach the supraspinatus fossa. In 4 cases (2.8%), *Ss* was absent.

The lowermost figure in Fig. 7 shows the relation between the form of *Ss* and *Plb*. Similar to *Tc*, *Ss* that branched from the 1st part, usually passed over *Plb* (*A*: 64.6%) (excluding 1 case of Type 1-b, and 1 case of Type 1-c). However, *Ss* branching from the 2nd part (2 cases of Type 2-a, 2 cases of Type 2-d, 1 case of 2-e, and 1 case of 2-g) and *Ss* branching from the 3rd part (1 case of 3-a) were found to traverse *A* in a few cases. Those transfixed to *Plb* (*B*, *C*, and *D*: 32.7%) were largely *Ss* originating between the 2nd part and *Ax*, but a few exceptions were noted (Traversing *A*: 2 cases of Type 2-a, 2 cases of Type 2-d, 1 case of 2-e, 1 case of 2-g, 1 case of 3-a; transfixed to *Plb*: 1 case of Type 1-c, 1 case of Type 1-i).

7) *Tcc* (Fig. 8)

The costocervical trunk (*Tcc*) (Types *a-c*) was present in 96 cases (66.7%), which is approximately 2/3rds of the total. In most cases, *Tcc* was independent and was Type *a* originating from *Su*. Of the

Type *a* cases (65.3%, males: 66.3%, females: 63.8%, right: 73.6%, left: 56.9%), Type 1-a in which branching was from the 1st part was observed in 33 cases (22.9%, males: 27.9%, females: 15.5%, right: 9.7%, left: 36.1%), and Type 2-a in which branching was from the 2nd part was observed in 61 cases (42.4%, males: 38.4%, females: 48.3%, right: 63.9%, left: 20.8%). Type 1-a occurred mainly on the left side and Type 2-a on the right side. Separate branching (Types *d-i*) of the supreme intercostal artery (*Is*) and the deep cervical artery (*Cp*) was found in 47 cases (32.6%, males: 32.6%, females: 32.8%, right: 25.0%, left: 40.3%). *Is* branched from a position proximal to *Cp* in all but one case of Type *g*. One case (Type *j*) was found in which *Cp* was absent.

8) Entire ramification of *Su*

Fig. 9 shows our classification of the accurate branching sites and nature of common trunk formation of all the arteries arising from *Su*. We classified all of the arteries into three types (upper right of Fig. 9). Type I, which was characterized by the presence of *Ttc* formed from a common trunk consisting of *Ca* and *Tif*, was observed in 82.6% (119 cases). Type II, in which *Ttc* and *Tin* formed a common trunk, was seen in 6.3% (9 cases), and

Fig. 7. Types of origin of the suprascapular artery (*Ss*), and the frequency of the various positions as it passes through the brachial plexus. The most frequent type was found to be Type 1-b in 36.8% of the cases in which the transverse cervical artery and *Ss* arose from the thyrocervical trunk as the common trunk or independent artery. In Type *k*, 1.4%, two *Ss* existed. *Ss*(1) arose from *Ttc* which from the 1st part of subclavian, after passing over the brachial plexus it passed over the superior scapular transverse ligament; *Ss*(2) arose directly from either the 3rd part of (Type 1-3-*k*) or the axillary artery (Type 1-Ax-*k*), passing through the brachial plexus and under the ligament.

Fig. 8. Types of origin of the costocervical trunk (*Tcc*). Although in Types *a* ~ *c* (66.7%) *Tcc* as the common trunk of the supreme intercostal artery (*Is*) and deep cervical artery (*Cp*) arose from the 1st or 2nd parts of the subclavian, in Types *d* ~ *i* (32.6%) both arteries arose independently from the various positions of the subclavian, in which, except Type *g* case, *Is* located more proximal to *Cp*.

Type III, in which *Ca* and *Tif* branched independently or one of *Ca* or *Tif* was absent, was observed in 11.1% (16 cases). Since Type I appeared with the highest incidence, we classified it further as follows (Left of Fig. 9). In Type A, occurring in 31.9%, *Tc* and *Ss* branched from *Ttc* (both branching independently from *Ttc*, or branching from *Ttc* as a common trunk). In Type B, occurring in 18.8%, only *Tc* branched from *Ttc*. In Type C, occurring in 8.3%, only a superficial branch (*Rs*) of *Tc* branched from *Ttc*. In Type D, occurring in 6.9%, *Tc*(*Rs*) and *Ss* branched from *Ttc*. In Type E, occurring in 5.6%, only *Ss* branched from *Ttc*, while in Type F, occurring in 11.1%, only *Ttc* (*Ca* and *Tif*) was present.

Type I-A(1) (13.2%, males: 14.0%, females: 12.1%, right: 22.2%, left: 4.2%) exhibited the highest incidence among all of the types. In this type, *Ve*, *Ttc* and *Tin* branched from the 1st part of *Su*, while *Tcc* branched from the 2nd part. Type I-B(1) (9.0%, males: 5.8%, females: 13.8%, right: 11.1%, left: 6.9%) exhibited the next highest incidence, with *Ve*, *Ttc* and *Tin* branching from the 1st part, *Tcc* from the 2nd part, and *Ss* from the 3rd part. This was followed by Type I-A(2) (6.9%, males: 8.1%, females: 5.2%, right: 1.4%, left: 12.5%), with *Tcc* branching from the 1st part, proximally from *Tin* in 5 cases, and distal from *Tin* in 5 cases. The 4th highest incidence was shown by Type I-C(1) (5.6%, males: 4.7%, females: 6.9%, right: 9.7%, left: 1.4%), with *Ve*, *Ttc* and *Tin* branching from the 1st part, *Tcc* from the 2nd part, and *Tc*(*Rp*) and *Ss* from the 3rd part.

In these four most frequently occurring types, *Tcc* branched from the 2nd part on the right side and from the 1st part on the left side in the majority of cases, indicating the existence of a sides difference.

Discussion

The subclavian artery (*Su*) traverses the interscalene triangle dorsal to the scalenus anterior muscle (Type I of Fig. 2: 98.6%), is located ventral to the brachial plexus (*Plb*) in the interscalene triangle, traverses the scalenus anterior muscle anteriorly (Type III: 0.7%), or is transfixed to the scalenus anterior muscle (Type II: 0.7%). Type III has been reported in 4 white subjects (1.1%)^{11, 27)}, 2 negro subjects (0.3%)¹²⁾, 2 adult Japanese subjects (0.6%)¹⁾, and 2 Japanese fetuses (1.7%)²⁸⁾. Including our cases, a total of 11/1738 (0.6%) have been found, with a slightly higher incidence on the left side. Type II has been reported in 1 Japanese subject (1.0%)³⁸⁾, 7 Japanese fetuses (6.0%)²⁸⁾, and African negro subjects with a frequency of 17.2%¹⁹⁾, thus showing a significant racial difference. Although the

or 7th cervical vertebra, runs inferolaterally, then terminates above the 1st rib between the subclavian artery and the brachial plexus.³⁹⁾ The incidences of *smi* appearance reported by Stott⁴¹⁾ (39/100 sides: 39.0%), Boyd⁸⁾ (10/30 sides: 33.3%) and Serizawa³⁸⁾ (32/100 sides: 32%), are in close agreement, suggesting that overall, it appears somewhat more frequently on the right side (44/81 sides).

Serizawa reported finding 2 cases (2%) in which a portion of the muscle bundle at the lower posterior extremity of the scalenus anterior muscle had separated and ran a posterior course terminating in the superior wall of the subclavian artery. He also reported 1 case (Type II) in which a similar muscle bundle passed over the superior wall of the subclavian artery, turned posteriorly, then terminated on the 1st rib. In other words, in this case, the subclavian artery was transfixed to the scalenus anterior muscle. The former cases are of considerable interest as they appear to constitute a type intermediate between Type I (subclavian artery runs posterior to the scalenus anterior muscle) and Type II (the subclavian artery is transfixed to the scalenus anterior muscle).

Ontogenetically, the upper limb buds can be seen from the surface in the middle of the 4th week of the embryonic stage, and at the beginning of the 5th week, the brachial plexus and the main stem of the subclavian artery have already penetrated them.^{5, 10, 26)} In this period, precartilaginous of the ribs can be seen.²⁶⁾ A little later, muscle in the cervical region is formed, and the premuscle-mass that appears in the shoulder girdle differentiates, so that the form and positions of the adult muscles are largely determined by the end of the 7th week.⁵⁾ On the basis of the above-described reports, it appears that the three types of positional relation between the subclavian artery and the scalenus anterior muscle are formed between the 5th and 7th weeks of embryonic development.

Accordingly, we considered that the primordium of the scalenus anterior muscle which envelopes the subclavian artery anteroposteriorly that named Type II should be the arche type. During the course of ontogenesis, the posteriorly orientated muscle bundle normally disappears (Type I), but in some rare cases, the anteriorly orientated muscle bundle disappears and the posterior muscle bundle remains, giving rise to Type III. Moreover, cases in which a portion of the muscle bundles of the scalenus anterior muscle terminate in the superior wall of the subclavian artery are transitional type of Type I and II cases. Muscle bundles orientated posteriorly in Type II do not separate from the scalenus anterior muscle bundles, but their site of origin is shifted slightly posterior, and those arising directly from the anterior tubercles of the cervical vertebrae, we propose

constitute the scalenus minimus muscle.

Classification of the entire ramification from *Su*:

There have been numerous reports on the sites and morphology of ramification of branches from the subclavian artery (*Su*), but in all cases, descriptions have been limited mainly to only a portion of the arteries^{14, 17, 18, 21, 22, 33–35, 44)} and to variation^{9, 16, 20, 25, 36, 47)}. Hence, the sites of origin of many of the arteries have remained unclear.^{27, 29, 33, 35)} De Garis,¹³⁾ Daseler et al.,¹²⁾ Nizankowski et al.,²⁹⁾ and Adachi¹⁾ gave detailed descriptions of each of the arteries branching from *Su* in American, Polish and Japanese subjects, but they did not report the sites of origin of some of the arteries, nor classify the entire *Su*. Therefore, despite the fact that the incidence of each artery was definitively established by these reports, an overall picture of the combination of these *Su* branches was not provided. Consequently, the most commonly occurring type of overall *Su* morphology and its incidence has remained unclear.

We summarized the entire array of arteries arising from *Su*, as shown in Fig. 9 and found that among Japanese adult subjects of this study, Type I, in which the common trunk formed by the ascending cervical artery (*Ca*) and the inferior thyroid artery (*Tif*) contains branches other than the internal thoracic artery (*Tin*), appeared with the highest frequency (82.6%). Furthermore, the most commonly appearing forms of Type I were Type I -A(1) with an incidence of 13.2%, Type I -B(1) with an incidence of 9.0%, and Type I -A(2) with an incidence of 6.9%. Although differences in the classification conditions preclude from a direct comparison, Bean reported finding (in white and negro subjects) an incidence of 30% for a form of Type I -D(2) in which the costocervical trunk (*Tcc*) branched from the 2nd part, an incidence of 27% for Type I -A(1), and 22% for Type I -C(1). Daseler et al. found in their classification of branches excluding *Ca* and *Tcc* (in white and negro subjects), incidences of 46.8% for a type equivalent to Type I -D(1) (our study: 3.5%) and 25.3% for Type I -A(1), indicating a substantial difference among races. Moreover, among the four types (Types A(1), A(2), B(1), B(2)), the incidence of Type (1) in which *Tcc* arises from the 2nd part on the right side was 75.0% (24/32 sides), while the incidence of Type (2) in which *Tcc* arises from the 1st part on the left side was 86.7% (13/15 sides), showing a marked sides difference.

From these results, it can be seen that the morphology of branch ramification from the subclavian artery in our study of Japanese adults was characterized by exceptional variation.

The following is the findings of each artery.

Ve:

The incidence of Types 1-*a*, *b* and *c* (Fig. 3), in which the vertebral artery (*Ve*) arose from the 1st part of *Su* independently, was highest at 94.5%. Difference in the incidence of this type has not been found among the white,^{13, 29} negro,¹³ and Asian,^{27, 28} races. A trend appears to exist for a slightly higher incidence among Asian races of Type *A* (individual incidence of 6.9%), in which the left *Ve* branches from the aortic arch,^{7, 9, 13, 27-29} but a difference has not been found between the fetus and adult. There have also been reports of 1.4% incidence of a common trunk with *Tif* (Type *d*),^{7, 29} and rare cases in which *Tif* traverses *Ve* posteriorly.

Tin:

Type *a*, in which the internal thoracic artery (*Tin*) arises independently from *Su* have appeared with the highest incidence (87.5%), almost without variation between white (88.9%: 446/524),^{13, 22, 29} Asian (87.0%: 374/430),^{1, 27, *} and negro races (83.9%: 146/174). Furthermore, almost identical incidences of Type I -*a* (79.9%) have been reported by Bean (80%) and Daseler et al. (79.2%). Occasionally, the R. costalis lateralis (*Rcl*) has appeared in a descending course along an almost midaxillary line of the lateral wall of the thoracic cavity. This *Rcl* most commonly appeared as Type *c* (1.4%) which branches from *Tin*. Type *c* appeared with an incidence of 4.8% whites,¹³ 9.8% in negroes,¹³ 17.9% in whites and negroes combined,⁷ 11.9% in Asian adults,^{1, 27} and 19.8% in Asian fetuses,^{28, 47} indicating a slightly lower incidence in whites. In our study, we observed some rare cases of a type of *Rcl* (Type *d* -II: 0.7%) originating as a branch of *Tin* which had arisen from *Ttc*, and another type (Type *b* -I: 1.4%) originating from *Tin* which formed a common trunk with *Ss*. (The star-like symbol indicates the data from our study)

Ttc:

According to the report of Thomson (1891),⁴⁴ the thyrocervical trunk (*Ttc*) or thyroid axis which he described is our Type *c* (31.9%) formed as a common trunk by the inferior thyroid artery (*Tif*), the ascending cervical artery (*Ca*), the supra-scapular artery (*Ss*) and the transverse cervical artery (*Tc*). The incidence of this Type *c* has been reported variously to be 33.7% (326/968) in white adults,^{13, 29, 44} 15.0% (30/200) in white fetuses,²⁹ 32.2% (56/174) in negroes,¹³ 27.3% (245/899) in whites and negroes combined,^{7, 12} 38.6% (130/337) in Asian adults,^{1, 17, *} and 33.3% (38/114) in Asian fetuses,²⁸ indicating approximately equal incidences among different races. Among whites populations, higher incidences have been found in British (44.7%),⁴⁴ and American (51.0%)¹³ people, and a particularly low incidence in Polish people

(15.0%).²⁹ The incidences of Type *d*, which exhibited a common trunk formed by *Ca*, *Tif*, *Ss* and a superficial branch of the transverse cervical artery, have been reported variously to be 45.2% (524/1160) in white adults,^{13, 29, 35, 44} 67.0% (134/200) in white fetuses,²⁹ 29.3% (51/174) in negroes,¹³ 46.8% (360/770) in whites and negroes combined,¹² 11.9% (40/337) in Asian adults,^{1, 27, *} and 11.4% (13/114) in Asian fetuses.²⁸ These results show that this Type *d*, appearing in more than half of the total, is remarkably common among whites, whereas it only appears in approximately 10% of Asians, including fetuses. The incidence of Type *g*, which is a form of Type *c* lacking *Ss*, has been reported to be only 0-4% in whites and negroes,^{7, 12, 13, 29, 35, 44} in contrast to the finding of 20% in Asians,^{27, *} indicating that it is a type appearing more commonly in Asians. In our study, we found that Type *a*, which exhibits a common trunk formed by *Ca* and *Tif* only, appeared with an incidence of 11.1%, but has been little reported by other researchers. Reports of Type *a* have only been made by Röhlich,³⁵ who observed it in 4.2% (Hungarians), Adachi, who obtained an incidence of 1.7% (Japanese), and Mori who obtained an incidence of 1.8% (Japanese fetuses).

The thyrocervical artery is formed from a common trunk consisting of the above-mentioned four arteries. However, as shown in Fig. 5, there are numerous combinations of their branches, which means it is not clear exactly how many arteries are combined to form the thyrocervical artery, and a consistent definition by different researchers has not yet been obtained.

Ontogenetically, *Ca*, which supplies the spinal cord, consists of residual dorsal intersegmental arteries that supply the neural tube segmentally and a portion of their longitudinal anastomotic channels, and appears at the earliest period. This is followed by *Tif*, which is observed from the 3rd to the 7th week of embryonic development^{2, 6, 15} until the primordium of the thyroid gland is formed. By the beginning of the 7th week, *Tc* and *Ss* have extended to a pre-muscle-mass in the periphery of the scapula including the trapezius muscle, which has a form almost identical to that of the adult.^{5, 26}

On the basis of this and consideration of the derivation of the name, thyrocervical trunk, we defined the prototype of *Ttc* as a common trunk consisting only of *Ca* and *Tif* (Type *a*). We propose that all of the combinations of other arteries with this fundamental arterial trunk be termed the thyrocervical trunk (Type *a*-*j*: 88.9%), and forms in which *Tif* and *Ca* arise independently, or either one is absent (Type *k*-*q*: 11.1%) be excluded from the definition of thyrocervical artery.

Tc:

The transverse cervical artery (*Tc*) refers to a common trunk formed from a superficial branch (*Rs*) and a deep branch (*Rp*). In our classification (Fig. 6), it is equivalent to Types *a* and *b*. Usually, *Rs* is an artery that exhibits an extremely stable course, arising from *Su* then running posterolaterally and passing around the lateral border of the levator scapulae muscle to reach a superficial layer. During this course, it sends small branches and supplies the upper and middle portions of the trapezius muscle. According to the report of our previous study⁴³⁾, immediately before *Rs* penetrates this muscle, it divides to send a superior branch to the upper portion of the trapezius muscle (clavicular portion) and a middle branch to the middle portion (acromial portion) (Types *C*, *D*: 84.1%), and in some cases the superior branch may bifurcate at a site proximal to the site of *Rs* and *Rp* branching (Type *B*: 11.4%), or in rare cases, may branch independently from *Ttc* (Type *A*: 4.5%), or *Rs*(1) forms as a superior branch that arises directly and independently from *Ttc*. We named this *Rs*(1), the upper superficial branch. It has been reported appearing in rare cases by Thomson (Type *E* & *P*²: 4.6%), De Garis Type *E* & *P*²: 1.0% [whites], 5.2% [negroes]), and by Yamada.⁴⁶⁾ The type in which this artery appeared is equivalent to our Type *e* (2.1%). After branching from *Su*, *Rp* follows a posterior course around the lateral border of the levator scapulae muscle to reach the deep layer of that muscle. It follows the border between the ventral sides of the rhomboid and serratus anterior muscles along a descending course to supply both muscles. During this course, one branch is transfixed to the rhomboid muscles, becoming a branch that supplies the lower portion of the trapezius muscle. This artery follows a highly defined course that allows easy identification of the artery. In extremely rare cases, this *Rp* branches from, the 3rd part of *Su* or the 1st part of *Ax*, then is transfixed to a muscle bundle of the serratus anterior at the 1st intercostal space, runs backward on the dorsal surface of this muscle to reach the medial border of the scapula. From there it follows the above-described course (unpublished data).

From the above-described findings, it appears likely that phylogenetically, *Rs* and *Rp* constitute a different system of arteries as they are separated by a group of the intermediate external oblique muscles (levator scapulae, rhomboideus major and minor, serratus anterior muscles)⁴³⁾, with *Rs* following a course to the superficial layer and *Rp* to the deep layer of these muscles.

The most common among our cases was Type *a* (64.6%), most of which were Type 1-*a* (61.8%) with branching from the 1st part. The incidence

of this Type *a* has been reported variously to be 35.8% (495/1382) in white adults,^{13, 21, 29, 33, 34, 44)} 15.0% (30/200) in white fetuses,²⁹⁾ 37.9% (66/174) in negroes,¹³⁾ 33.6% (355/1057) in whites and negroes combined,^{7, 12, 17, 18)} 61.0% (308/505) in Asian adults,^{1, 27, 30, *)} and 57.9% (66/114) in Asian fetuses,²⁸⁾ indicating that this type is particularly common among Asians. The incidence of Type *c*, in which *Rs* arises directly from *Ttc* and *Rp* from *Su* (including a common trunk of *Rp* and other branches), has been reported to be 37.2% (241/648) in whites,^{13, 44)} 47.1% (82/174) in negroes,¹³⁾ 61.5% (571/928) in whites and negroes combined,^{12, 17, 18)} 17.6% (56/319) in Asian adults,^{27, 30, *)} and 27.2% (31/114) in Asian fetuses,²⁸⁾ indicating that this Type *c* is particularly common among whites and negroes (appearing in more than half) and less common among Asians (appearing in approximately 20%). The incidence of Type *b*, which was relatively high among Japanese subjects (16.2%: 40/247),^{30, *)} has been reported to be 7.7% (50/648) in whites,^{13, 44)} 6.3% in negroes,¹³⁾ 20.8% in whites and negroes combined,¹⁷⁾ and 4.2% in Chinese.²⁷⁾ Therefore, with the exception of the report of Huelke,¹⁷⁾ the incidence of Type *b* has been low. We also found some extremely rare cases who exhibited Types *d-f*, which have been little reported in the past. From the above-described findings, it can be seen that in the early stage of development when *Tc* is formed from the primary capillary network, there are three arteries feeding the target organs of the upper, middle, and lower portions of the trapezius muscle, each branching independently from *Su*. We consider this configuration to be the prototype (equivalent to Type *f* of Fig. 6) of the variations described below. We believe that *Rs*(1) forms a common trunk with *Ttc*. *Rs*(1), which branches from the 1st part of *Su* positioned somewhat cephalically, and *Rs*(2) traverse *sa* ventrally, and pass over *Plb* (because *Plb* is positioned caudally to these arteries). *Rp*, which arises from the 3rd part positioned somewhat caudally to these, is transfixed to *Plb* (*Plb* is located at the course of this artery), then follows a course postero-medial to the superior angle of the scapula. These arteries, similar to those supplying the gastrointestinal tract, are considered in principle, to supply their target organs via the shortest and most direct course possible at this stage of development. We believe that the positional relationships between *Plb* and these arteries are already established at this stage and retained through to the adult stage, a proposal supported by similar findings reported by other researchers.^{1, 21, 28)} These findings indicate that the site of bifurcation of these arteries from *Su* is the most important factor in determining the position of their course in relation to *Plb*. Furthermore, we

suggest that communicating anastomotic branches between these three arteries exist dorsally beyond *Plb*, and that the site and branching form of origin of *Tc* is determined by differences in the sites of disappeared origin of these three arteries, and the site of disappearance of these communicating branches. In other words, we propose that the sites of origin of *Rs*(2) and *Rp* have disappeared in Type *a*, and the site of origin of *Rs*(2) and the communicating anastomotic branches between *Rp* and *Rs*(2) have disappeared in Type *c*.

Diverse opinion exists among researchers regarding the definition of the term used as transverse cervical artery. In Type *c*, which appears with a high incidence among whites and negroes, *Rs* and *Rp* arise independently, which means that *Tc* does not exist as a common trunk formed both of these arteries, hence various names have been given to these two arteries. Numerous researchers have termed *Rs* as the superficial cervical artery,^{1, 12, 13, 28, 29, 34, 44, 46)} ascending ramus,⁷⁾ ascending branch,¹³⁾ transverse cervical artery,^{17, 18)} and superficial transverse cervical artery,^{14, 23)} and *Rp* as the transverse cervical artery,^{1, 12, 13, 29, 34)} descending ramus,⁷⁾ descending branch,¹³⁾ posterior scapular artery,^{7, 14, 44)} dorsal scapular artery,^{17, 18)} and descending scapular artery.⁴⁶⁾ Furthermore, the independent *Rs* branch to the upper portion of the trapezius muscle, which we termed the upper superficial branch, has been described as the *A. cervicalis superficialis accessoria*⁴⁶⁾ and the superficial cervical artery,^{13, 44)} similar to the name used for *Rs*. Various researchers have been using the same name (transverse cervical artery, etc.) to describe different arteries, and several names to describe the same artery, which has led to confusion in the description of this artery. For this reason, an attempt should be made at the very least, to identify each of the above-described three arteries after following their course to the region where they finally terminate, in order to ensure the consistent use of anatomical terms.

Ss:

The most common form of suprascapular artery (*Ss*) observed in our study was Type *b* (Fig. 7). The incidence of this type has been reported variously to be 33.5% (324/968) in white adults^{13, 29, 44)} 15.0% (30/200) in white fetuses,²⁹⁾ 29.9% (52/174) in negroes,¹³⁾ 19.7% (178/904) in whites and negroes combined,^{7, 12)} and 53.7% (190/354) in Asians,^{1, 27, *)} indicating a high frequency of this type among Asians. Type *c*, which appeared with a low incidence in our study, has been reported by others to have an incidence of 52.8% (603/1142) in white adults,^{13, 29, 35, 44)} 67.0% (134/200) in white fetuses,²⁹⁾ 43.7% (76/174) in negroes,¹³⁾ 59.4% (460/775) in white and negroes combined,¹²⁾ and 8.8% (19/216)

in Asians,^{27, *)} thus showing a high incidence in whites and negroes. The incidence of Type *a* branching independently from *Su*, a type observed in approximately 1/4 of our subjects, has been reported to be 6.0% (63/1048) in white adults,^{13, 29, 33, 44)} 2.5% (5/200) in white fetuses,²⁹⁾ 14.5% (59/406) in negroes,^{13, 33)} 16.6% (150/904) in whites and negroes combined,^{7, 12)} 21.2% (75/354) in Asian adults,^{1, 27, *)} and 16.7% (19/114) in Asian fetuses,²⁸⁾ thus showing an incidence in the decreasing order of Asians, negroes, and whites. The extremely rare Type *k*, in which there are two *Ss*, was found in whites by Thomson (1.5%), in negroes by De Garis (2.9%), and in the Japanese by Adachi (1.4%), the authors (1.4%), and Mori (fetuses: 3.5%), indicating the absence of any racial difference in the distribution of this type.

Although there were some exceptions, similar to the case with *Tc*, in general the relation between *Ss* and the brachial plexus was as follows. The artery arising from the 1st part passed over the plexus (*A* in Fig. 7), then followed a course over the superior scapular transverse ligament. In contrast, the artery arising from the 2nd or 3rd part was transfixed (*B-E*) to the nerve plexus, and followed a course under the ligament. As similar findings were reported by Adachi and Mori, whether or not this artery passes over or is transfixed to the brachial plexus is determined by the position at which *Ss* branches from *Su*, similar to the case with *Tc*. Furthermore, it can be surmised from the above that in the early period when *Ss* arises, two arteries exist as in Type *k*, but one of these disappears during development (normally, the more distal of the two arteries disappears).

Tcc:

The costocervical trunk (*Tcc*) is formed by a common trunk composed of the supreme intercostal artery (*Is*) and the deep cervical artery (*Cp*), and is equivalent to our Type *a*. The incidence of Type *a* has been reported variously to be 72.2% (231/320) in white adults,²⁹⁾ 73.5% (147/200) in white fetuses,²⁹⁾ 89.1% (907/1018) in white and negroes combined,^{7, 12, 13)} 73.6% (159/216) in Asian adults,^{1, *)} and 91.2% (104/114) in Asian fetuses,²⁸⁾ indicating an absence of any substantial racial difference. De Garis and Daseler reported finding almost no difference in the incidence of Types 1-*a* and 2-*a* among Type *a* cases (each was approximately 45%), but our study revealed a higher incidence of Type 2-*a* (42.9%) than that of Type 1-*a* (22.9%), and a higher incidence of Type 2-*a* on the right side and a higher incidence of Type 1-*a* on the left. In Types *d-i*, in which *Cp* and *Ia* branch independently, *Is* branched from a more proximal position than did *Cp*, except for one case of Type *g*. Since a similar

finding has been reported in a 12-mm pig embryo,⁴⁵⁾ it appears likely that in the early embryonic stage of man, who is also a species of mammal, *Is* and *Cp* branch independently (with a higher probability of *Is* being in a more proximal position than *Cp*), with a communicating branch between the two. During the course of development, Type *d* arises as a result of the communicating branch disappearing, a form observed in 5–10% in all of the races studied.^{1, 12, 13)} The remainder manifest as Type *a*, which arises by the site of origin of one of the two arteries disappearing. In our study, we found a fairly high incidence of Type *d*.

Ontogenetic Considerations:

As can be seen from the above, there is extreme variation in the sites of origin of the arteries branching from *Su*. The reason for this diversity may be that *Su* is formed through a complex development process, and that it traverses the shoulder joint, which is the most kinetic within the body.

Ontogenetically, the right and left dorsal aortae fuse⁶⁾ caudally from the 9th segment at the end of the 4th week of development (4 mm embryo),¹⁰⁾ resulting in a morphology as shown in Fig. 10. In this period, dorsal intersegmental arteries extend from the dorsal aortae towards the dorsally sited neural tube. Their main branches supply the neural tube, while a portion of branches are oriented ventrally along the body wall. There is a few divergent opinion^{2, 10)}, but in humans, the 7th dorsal intersegmental artery from the cephalic end of the embryo develops into *Su*.^{6, 15)} At the beginning of 7th week (days 44–48)^{6, 10)} the white section (the portion where the right and left sides are fused) of the right dorsal aorta shown in Fig. 10, gradually narrows and disappears. *Su* shifts cephalically with the descent of the heart which began in the 2nd month. As a result, the derivation of *Su* on the left and right sides is different, with the left *Su* forming from the 7th dorsal intersegmental artery alone, and the right *Su* forming from the right 4th aortic arch, the dorsal aorta of the 3rd–7th segments, and the 7th dorsal intersegmental artery. This developmental difference may be a cause of differences in the right and left sides.

Details of the period up to the 7th week, when the adult arterial ramification is completed, are not clear, but longitudinal communicating anastomoses appear dorsally, laterally and ventrally between the dorsal intersegmental arteries during this period. Among the dorsal anastomoses, relative to *Su* as the main axial artery, the residual postcostal anastomosis in the cephalic direction develops into *Ve*^{2, 6, 15)} and the posttransverse anastomosis becomes *Cp*.¹⁵⁾ We believe that among the precostal anastomoses, those in the caudal direction develop into *Is*^{6, 15)} and those

in the cephalic direction develop, according to Hamilton,¹⁵⁾ into the thyrocervical trunk. However, in this period, it becomes *Ca* to supply the spinal cord, after which *Tif*, *Ss* and *Tc* extend from *Ca* to their target organs (each item was studied relative to each artery). *Tin*, which is a ventral anastomotic chain,^{2, 15)} extended from the primary *Su* in an inferior direction in the earliest stage at days 4.8 (stage 25) of the incubating egg of the domestic fowl.⁴²⁾ In the pig,⁴⁵⁾ it appears at roughly the same period (12–14 mm stage) as other anastomoses, but in humans, the sites of origin of this artery and *Ca* are thought to be extremely close, suggesting that a common trunk is formed from both arteries in rare cases (Type II of Fig. 9). According to the report of Igarashi et al.,²⁰⁾ the lateral anastomotic chain develops into the lateral costal branch appearing with an incidence of 10–20%.

The diverse formation of *Su* branches appearing in adults derives from the residual state or nature of disappearance of the sites of origin of the above-described arteries and their communicating anastomoses in the initial stage of development, and this formation varies between races, individuals as well as right and left sides.

In recent years, extensive use has been made in the fields of plastic and orthopedic surgery of a musculocutaneous flap consisting of the trapezius muscle supplied by the subclavian artery and the sternocleidomastoid muscle, and a compound flap formed by combining the above-mentioned structures with the bone to which they adhere. Demergasso ('79)¹⁴⁾ reported grafting the upper and middle portions of the trapezius muscle in the restoration of large deficient portions of the oral cavity, oropharynx, hypopharynx and other structures. Our previous study⁴³⁾ reported that in all cases studied, the superficial branch of the transverse cervical artery (*Rs*) supplied almost all of this region, while only a small region (approximately 5% of the entire muscle) was supplied by the suprascapular artery (in approximately 70% of all cases studied) and the occipital artery (approximately 30% of all cases studied). Demergasso described the branch supplying the upper and middle portions as the superficial transverse cervical artery, but did not address the question of the origin of *Rs*, which supplies these regions. Therefore, it should be remembered that, as shown in the above-described Fig. 6, *Rs* arises as a branch of *Tic* from the 1st part of *Su*, in Type *c* (50–60%), which is common in whites and negroes, and in Type *a*, which is common in Asians (approximately 60%), but Types *b* and *d*, in which *Rs* arises from the 3rd part, appeared with an incidence of 10% of our cases. In the reports of Siemssen⁴⁰⁾, Ariyan³⁾, and others,^{24, 31)} who used the sterno-

cleidomastoid muscle in the deficient parts of the floor of the mouth, tongue, oropharynx, and mandible, there are incorrect references to *Tin*⁴⁰⁾ as the artery feeding the lower portion of this muscle, and that a branch from *Su* does not supply the lower portion of this muscle.³¹⁾ However, Sato et al. ('84)³⁷⁾ reported that a branch (*Ca*, *Tc* or *Ss*) from *Ttc*, supplied approximately 15% of entire region of this muscle in 75% of their subjects. On the basis of these considerations, we urge that due care be taken in the description of the ramification morphology at the site of *Ttc* origin.

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