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Typology of the arteries in the human scalenus region, with special reference to the accessory ascending cervical artery.

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Abstract

The accessory ascending cervical artery (Murakami et al., 1996), which arises from the subclavian artery and ascends between the scalenus anterior and medius muscles, was studied in 87 Japanese adult cadavers (174 sides), with special attention being given to its origin, distribution, and relationship to other arteries at the cervical or scalenus region. In 154 sides (88.5%), the accessory ascending cervical artery was found to originate from the subclavian artery behind the scalenus anterior muscle, and to branch out to the scalenus anterior and medius muscles as well as those entering the 5th and 6th intervertebral foramina along the 6th and 7th cervical nerves. This artery arose independently in 105 sides. The accessory ascending cervical artery issued off or formed a common trunk with the transverse cervical artery and/or costocervical trunk in 49 sides. In cases lacking the accessory ascending cervical artery, it was usually compensated for by the costocervical trunk and/or transverse cervical artery (18 sides). Common trunk formation with the vertebral, internal thoracic, or suprascapular arteries was not observed. The authors suggest that the accessory ascending cervical artery, the transverse cervical artery, and the costocervical trunk should be grouped into one arterial system, a system that may be a remnant of the precostal longitudinal anastomoses of intersegmental arteries of the dorsal aorta behind the scalenus anterior muscle.

KEYWORDS: accessory ascending cervical artery, transverse cervical artery, costocervical trunk, scalenus anterior muscle, subclavian artery

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Typology of the Arteries in the Human Scalenus Region, with Special Reference to the Accessory Ascending Cervical Artery

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The accessory ascending cervical artery (Murakami et al., 1996), which arises from the subclavian artery and ascends between the scalenus anterior and medius muscles, was studied in 87 Japanese adult cadavers (174 sides), with special attention being given to its origin, distribution, and relationship to other arteries at the cervical or scalenus region. In 154 sides (88.5%), the accessory ascending cervical artery was found to originate from the subclavian artery behind the scalenus anterior muscle, and to branch out to the scalenus anterior and medius muscles as well as those entering the 5th and 6th intervertebral foramina along the 6th and 7th cervical nerves. This artery arose independently in 105 sides. The accessory ascending cervical artery issued off or formed a common trunk with the transverse cervical artery and/or costocervical trunk in 49 sides. In cases lacking the accessory ascending cervical artery, it was usually compensated for by the costocervical trunk and/or transverse cervical artery (18 sides). Common trunk formation with the vertebral, internal thoracic, or suprascapular arteries was not observed. The authors suggest that the accessory ascending cervical artery, the transverse cervical artery, and the costocervical trunk should be grouped into one arterial system, a system that may be a remnant of the precostal longitudinal anastomoses of intersegmental arteries of the dorsal aorta behind the scalenus anterior muscle.

Key words: accessory ascending cervical artery, transverse cervical artery, costocervical trunk, scalenus anterior muscle, subclavian artery

We have previously reported the constant occurrence of an “accessory ascending cervical artery” arising from the subclavian artery and ascending between the scalenus anterior and medius muscles (1). Some other authors have called this artery the “deep ascending cervical artery” (2). This artery is regarded to be a remnant of the longitudinal anastomoses among the embryonic intersegmental arteries (1, 2).

Outi and his associates (3) have studied variations of the transverse cervical artery, classifying them into 3 types: type A, the transverse cervical artery (a common trunk of superficial and deep branches) arising from the thyrocervical trunk; type B, the superficial cervical artery (superficial branch) and the dorsal scapular artery (deep branch), independently originating from the thyrocervical trunk and subclavian artery, respectively; type C, the transverse cervical artery, issuing from the subclavian artery. However, their study paid little attention to the accessory ascending cervical artery, though this artery sometimes form a common trunk with the transverse cervical artery.

In present study, we investigated the accessory ascending cervical artery and other related arteries originating from the subclavian artery in the scalenus region, with special attention being paid to their compensatory relationship and the common trunk formation of their origins. A new typological diagram to interpret variations of these arteries is presented.

Materials and Methods

The cervical regions of 87 Japanese adult cadavers (Males: 47, Females: 40; 44-99 years old) were dissected during the human gross anatomy course at

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Table 1 Origin of the accessory ascending cervical artery (side)

Segment of the subclavian artery	Independently	Common trunk with				Total (%)
		CC	CC+TC	TC	TA	
Medial to SA	0	13	1	0	2	16 (9.2%)
Behind SA	105	31	2	16	0	154 (88.5%)
Lateral to SA	0	0	0	4	0	4 (2.3%)
Total (%)	105 (60.3%)	44 (25.3%)	3 (1.7%)	20 (11.5%)	2 (1.1%)	174 (100%)

SA, scalenus anterior muscle; CC, costocervical trunk; TC, transverse cervical artery or its branches; TA, thyrocervical trunk.

Okayama University Medical School in 1997 and 1998. The cadavers had been fixed by arterial perfusion with 10–20% formalin through the right or left radial artery, dehydrated with 50% ethanol, and stored in body-preservation lockers. They had neither surgical history nor pathological damage, including lymph node metastasis of cancer in their cervical regions. For convenience of comparison, figures of the cases being discussed in this paper are illustrated as they occurred on the left sides of the cadavers.

Results

General findings. The subclavian artery was found to pass between the scalenus anterior and medius muscles, except in one case in which the artery pierced the scalenus anterior muscle. The transverse cervical artery, including its main branches, was classified as either Outi's type A (96 sides, 55.2%), type B (30 sides, 17.2%), or type C (48 sides, 27.6%) (see above).

The accessory ascending cervical artery. The origins of the accessory ascending cervical artery and its common trunk formation with other arteries are summarized in Table 1. In 154 sides (88.5%), the accessory ascending cervical artery was found to originate from the subclavian artery behind the scalenus anterior muscle. Among them, the artery arose as an independent artery in 105 sides, or as a common trunk with the costocervical trunk in 31 sides, with the transverse cervical artery in 16 sides, or with both of these in 2 sides. In 69 of 174 sides (39.7%), the accessory ascending cervical artery formed a common trunk with the costocervical trunk medial to or behind the scalenus anterior muscle in 44 sides (25.3%), or with the transverse cervical artery (type B or C of Outi) behind or lateral to the scalenus anterior in 20 sides (11.5%). Rarely, the accessory ascending cervical artery was found to originate from the common trunk of the

costocervical trunk and the transverse cervical artery medial to or behind the muscle (3 sides, 1.7%), or from the thyrocervical trunk (2 sides, 1.1%). In Fig. 1, all cases are classified by combinations of the arising portions and common trunk formations of the accessory ascending artery, as well as the types of transverse cervical arteries.

The accessory ascending cervical artery, running in front of the brachial plexus, was found to branch out to the scalenus anterior and medius muscles. In some cases, it sent thin branches to the serratus anterior and levator scapulae muscles. As summarized in Table 2, this artery generally was found to branch out into the intervertebral foramens along the cervical nerves. Most of these branches ran along the 6th (122 sides) and 7th (144 sides) cervical nerves. In 5 sides, branches along the 8th cervical nerves were also observed. In addition, the ascending cervical artery branched out running along the 4th (50 sides) and 5th (65 sides) cervical nerves, though branches along the 6th cervical nerves were observed in only 4 sides. The costocervical trunk primarily gave spinal branches along the 6th (2 sides), 7th (4 sides), and 8th (51 sides) cervical nerves, respectively.

Our typological considerations regarding the origins and courses of the accessory ascending cervical artery and other related arteries are schematically presented in Fig. 2. Some interesting cases, including anomalous ones, are presented as follows (Figs. 3–10A), and are explained

Table 2 Arterial branches enter the intervertebral foramens along the cervical nerve (side)

	Ascending cervical artery	Accessory ascending cervical artery	Costocervical trunk
C4	50	1	0
C5	65	0	0
C6	4	122	2
C7	0	144	4
C8	0	5	51

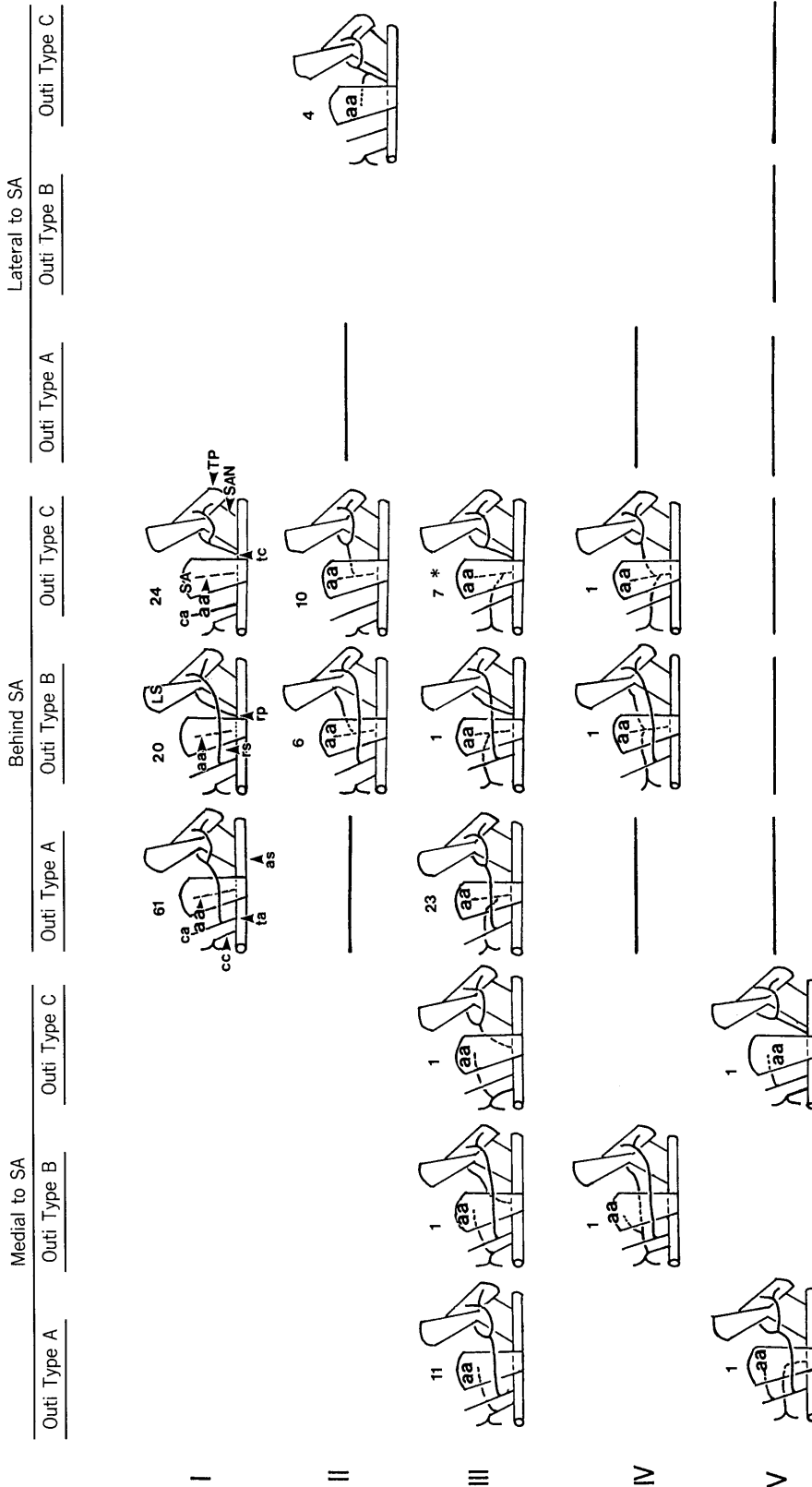


Fig. 1 The location of the common trunk where the accessory ascending cervical artery forms. Medial to SA, the common trunk arise from the subclavian artery medial to the scalenus anterior muscle; Behind SA, the common trunk arises from the subclavian artery behind the scalenus anterior muscle; Lateral to SA, the common trunk arises from the subclavian artery lateral to the scalenus anterior muscle. I, the independent accessory ascending cervical artery which doesn't form a common trunk with other arteries. Notice that in all cases the arteries were behind the SA. II, the accessory ascending cervical artery formed a common trunk with the transverse cervical artery only. III, the accessory ascending cervical artery formed a common trunk with the costocervical trunk only. IV, the accessory ascending cervical artery formed a common trunk with both the costocervical trunk and the transverse cervical artery. V, the accessory ascending cervical artery formed a common trunk with the thyrocervical trunk only. The numbers refer to each side. *Four sides of the 7 sides whose Outti's type C transverse cervical artery are behind the scalenus anterior muscle. The authors believe that the lane shown in blank area of the figure which type have not been observed in present study is impossible to exist. LS, the levator scapulae muscle; SA, scalenus anterior muscle; TP, trapezius muscle; aa, accessory ascending cervical artery; as, subclavian artery; ca, ascending cervical artery; cc, costocervical trunk; rs, deep branch of the transverse cervical artery; ta, superficial branch of the transverse cervical artery; tc, thyrocervical trunk; tc, transverse cervical artery.

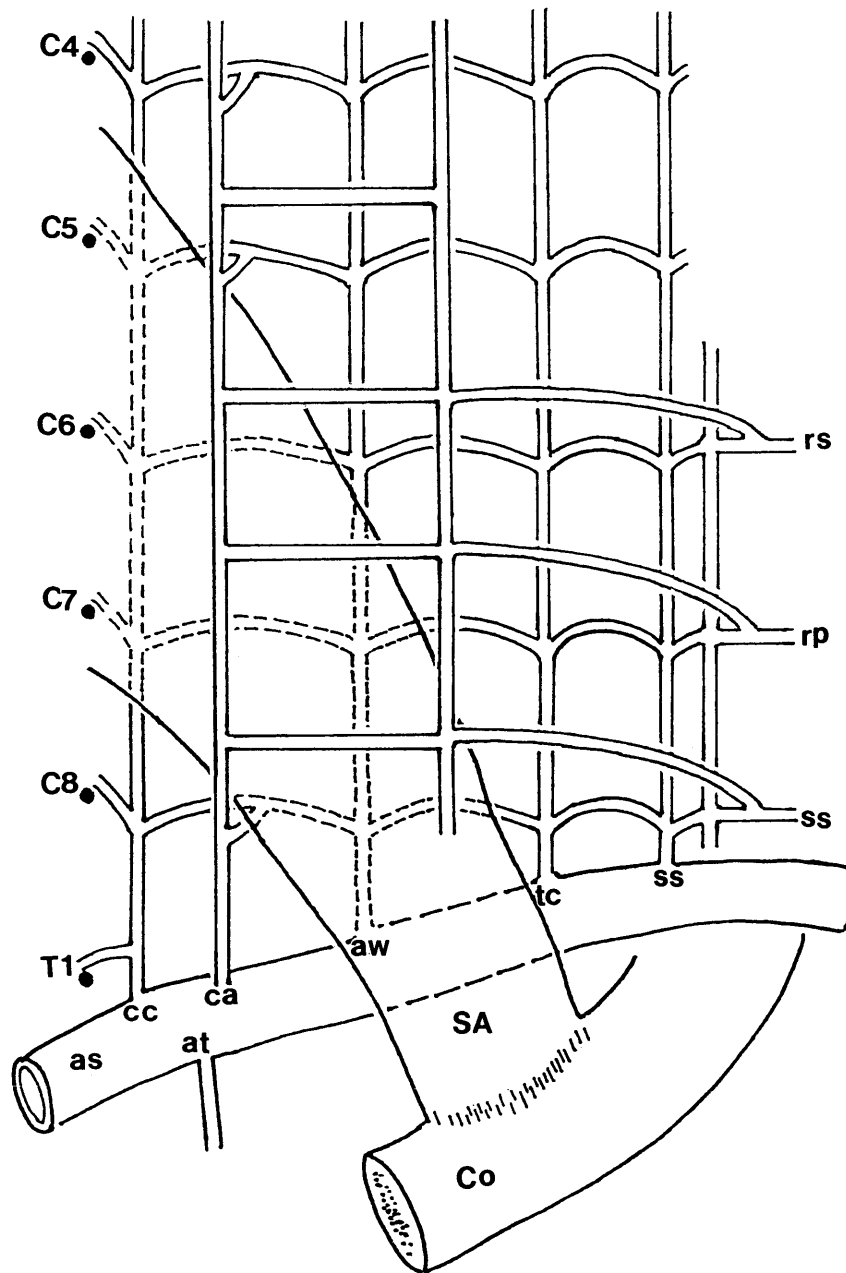


Fig. 2 Typological diagram showing the arterial system in the human scalenus region (left side). The precostal longitudinal anastomoses of the cervical intersegmental arteries include the ante-SA groups (ca) and post-SA groups (aw, cc, tc, ss). C4-C8, 4th-8th cervical nerves; Co, 1st rib; T1, 1st thoracic nerve; aw, independently originating accessory ascending cervical artery; at, internal thoracic artery; ss, suprascapular artery, see legend to Fig. 1.

using this typological schema (Figs. 3-10B).

Case 1 (Fig. 3A): A typical accessory ascending cervical artery arose independently from the subclavian artery behind the scalenus anterior muscle. It supplied the scalenus anterior and medius muscles, and exhibited

spinal branching into the intervertebral foramina along the 6th and 7th cervical nerves. The ascending cervical artery branched out along the 4th and 5th cervical nerves, and the costocervical trunk branched out along the 8th cervical nerve.

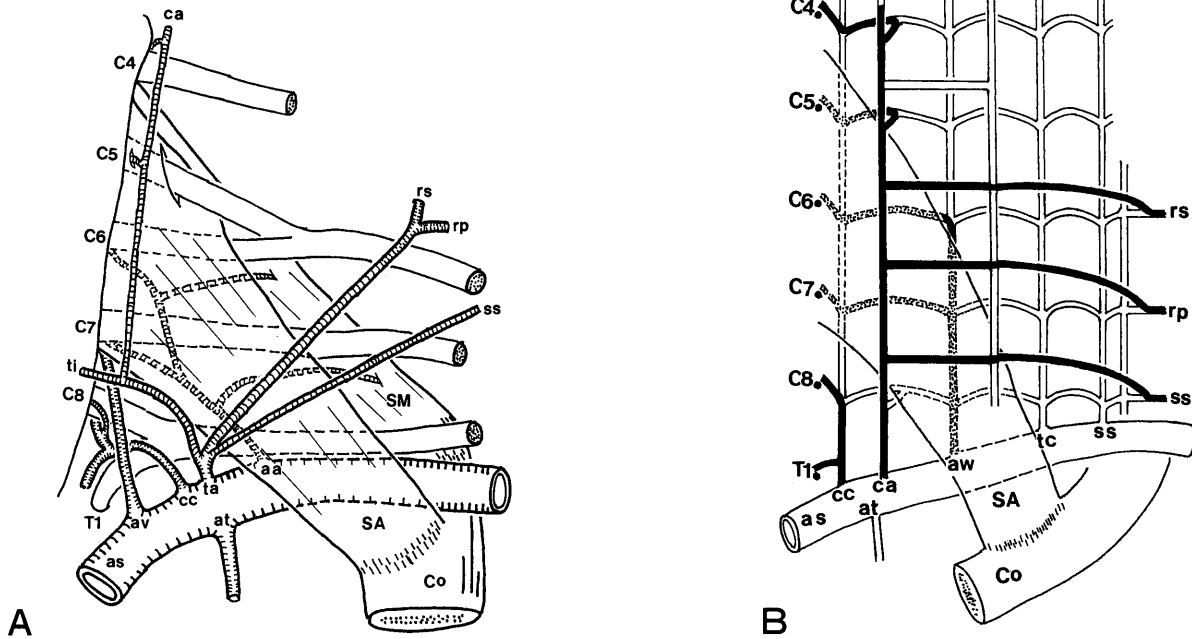


Fig. 3 A, case 1. The accessory ascending cervical artery (aa) arises independently from the subclavian artery behind the scalenus anterior muscle as a typical case. B, a typologic demonstration of case 1. SM, scalenus medius muscle; av, vertebral artery; ti, inferior thyroid artery, see legends to Figs. 1 and 2. The solid line, arteries in front of the scalenus anterior muscle; the dotted line, arteries behind the scalenus anterior muscle.

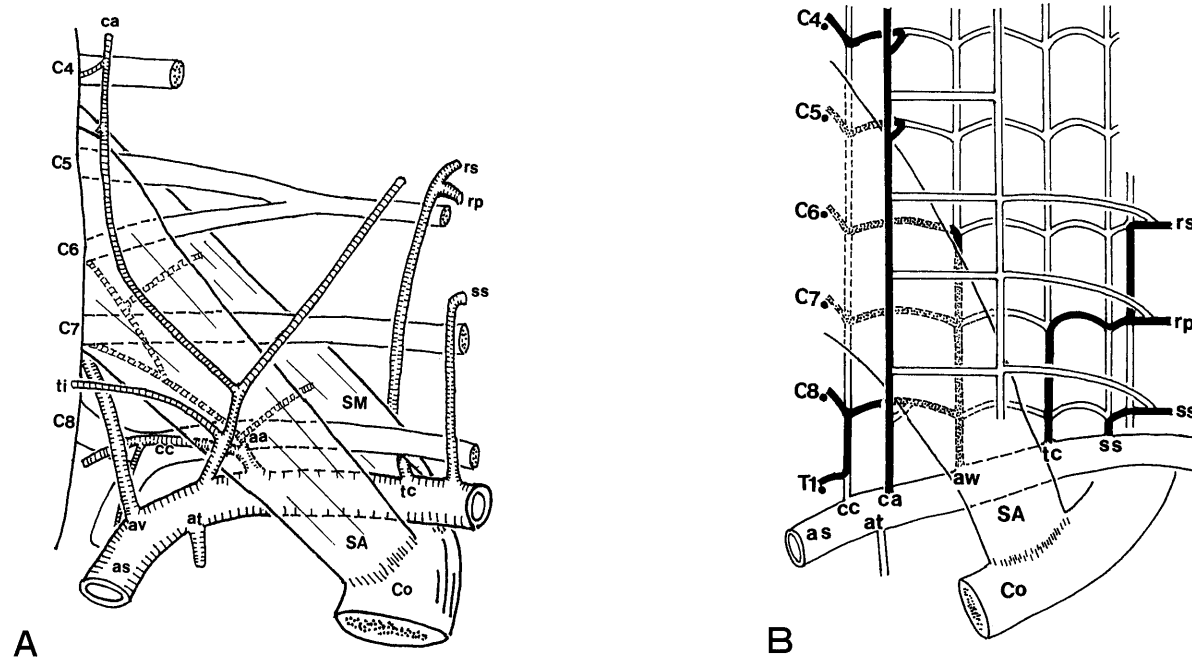


Fig. 4 A, case 2. The accessory ascending cervical artery forms a common trunk with the costocervical trunk arise from the subclavian artery behind the scalenus anterior muscle. B, a typologic demonstration of case 2. Abbreviations are same in Figs. 1, 2 and 3.

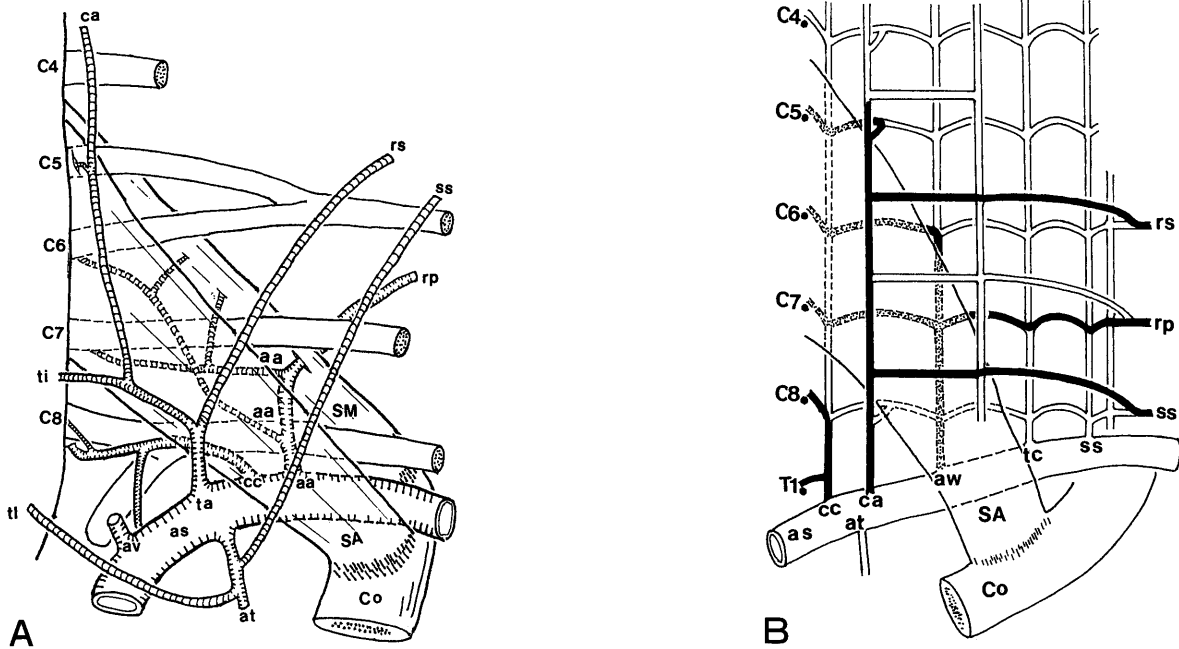


Fig. 5 A, case 3. The accessory ascending cervical artery forms a common trunk with the transverse cervical artery arising from the subclavian artery behind the scalenus anterior muscle as an Outi's type B. B, a typologic demonstration of case 3. T1, lowest thyroid artery, see legends to Figs. 1, 2 and 3.

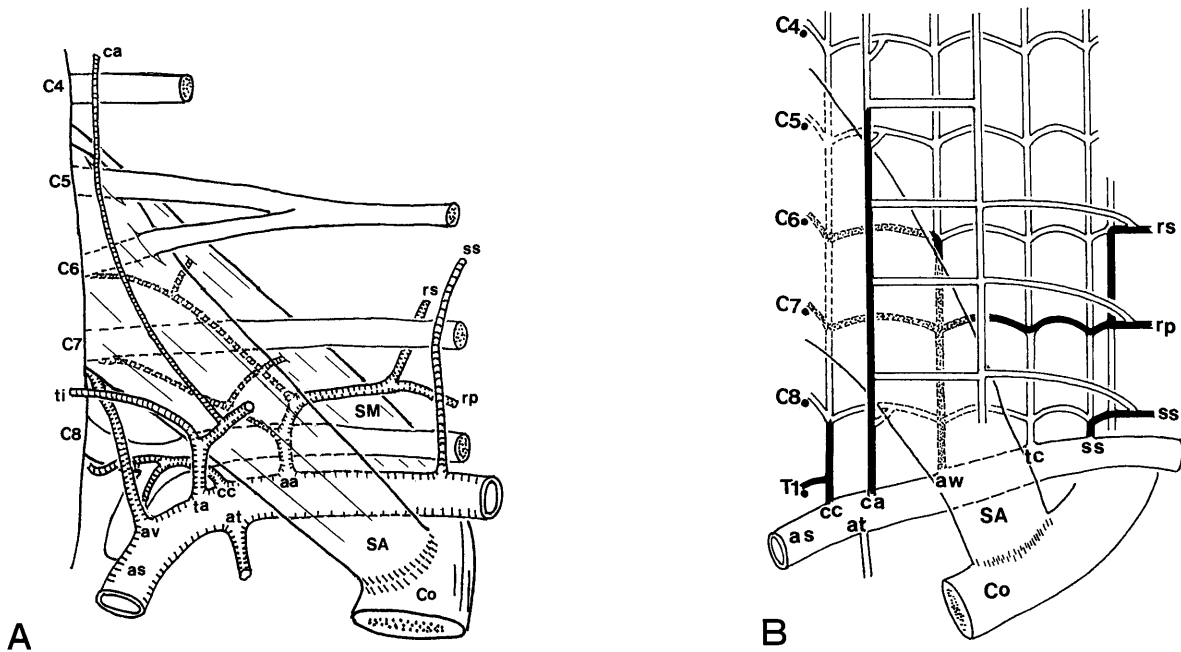


Fig. 6 A, case 4. The accessory ascending cervical artery forms a common trunk with the transverse cervical artery arising from the subclavian artery behind the scalenus anterior muscle as an Outi's type C. B, a typologic demonstration of case 4. Abbreviations are same in Figs. 1, 2 and 3.

Case 2 (Fig. 4A): The accessory ascending cervical artery, forming a common trunk with the costocervical trunk, originated from the subclavian artery behind the scalenus anterior muscle and exhibited spinal branching along the 6th and 7th cervical nerves.

Case 3 (Fig. 5A): The deep branch of the transverse cervical artery (Outi's type B) arose as a common trunk with the accessory ascending cervical artery from the subclavian artery behind the scalenus anterior muscle. After branching out along the 6th and 7th cervical nerves, it pierced the scalenus medius muscle to become the deep branch of the transverse cervical artery. The superficial branch of the transverse cervical artery was issued from the thyrocervical trunk. In this case, the suprascapular and the lowest thyroid artery originated from the internal thoracic artery.

Case 4 (Fig. 6A): The accessory ascending cervical artery, forming a common trunk with the transverse cervical artery (Outi's type C), arose from the subclavian artery. In this case, the suprascapular artery originated from the subclavian artery lateral to the scalenus anterior muscle.

Case 5 (Fig. 7A): The accessory ascending cervical artery, forming a common trunk with the costocervical

trunk, arose medial to the scalenus anterior muscle from the subclavian artery. In this case, the subclavian artery pierced the scalenus anterior muscle. The suprascapular artery originated from the axillary artery lateral to the first rib.

Case 6 (Fig. 8A): The accessory ascending cervical artery originated from a common trunk with the Outi's type C transverse cervical artery lateral to the scalenus anterior muscle. The costocervical trunk originated behind the scalenus anterior muscle.

Case 7 (Fig. 9A): A common trunk of the accessory ascending cervical artery, the costocervical trunk, and the deep branch of the Outi's type B transverse cervical artery originated from the subclavian artery medial to the scalenus anterior muscle. In this case, the vertebral artery arose from the aortic arch.

Case 8 (Fig. 10A): The accessory ascending cervical artery formed a common trunk with both the costocervical trunk and the deep branch of Outi's type B transverse cervical artery to arise from the subclavian artery behind the scalenus anterior muscle. In this case, the internal thoracic artery issued from the subclavian artery lateral to the scalenus anterior muscle and traversed anterior to the muscle.

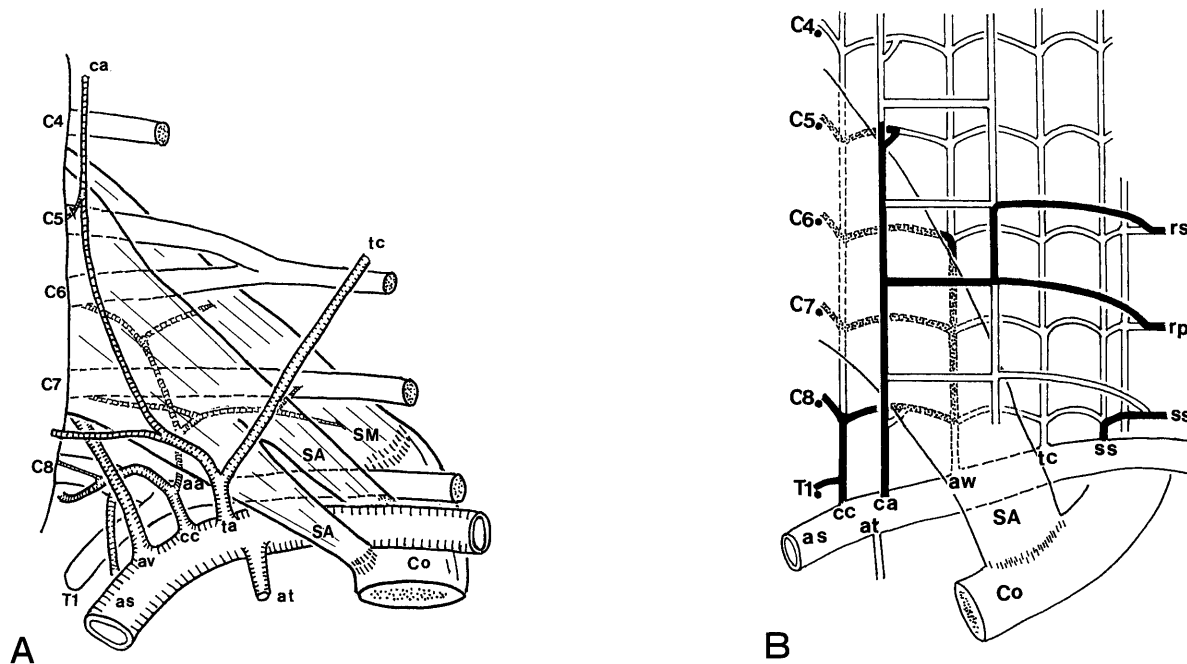


Fig. 7 A, case 5. The accessory ascending cervical artery forms a common trunk with the costocervical trunk arising from the subclavian artery medial to the scalenus anterior muscle. B, a typologic demonstration of case 5. Abbreviations are same in Figs. 1, 2 and 3.

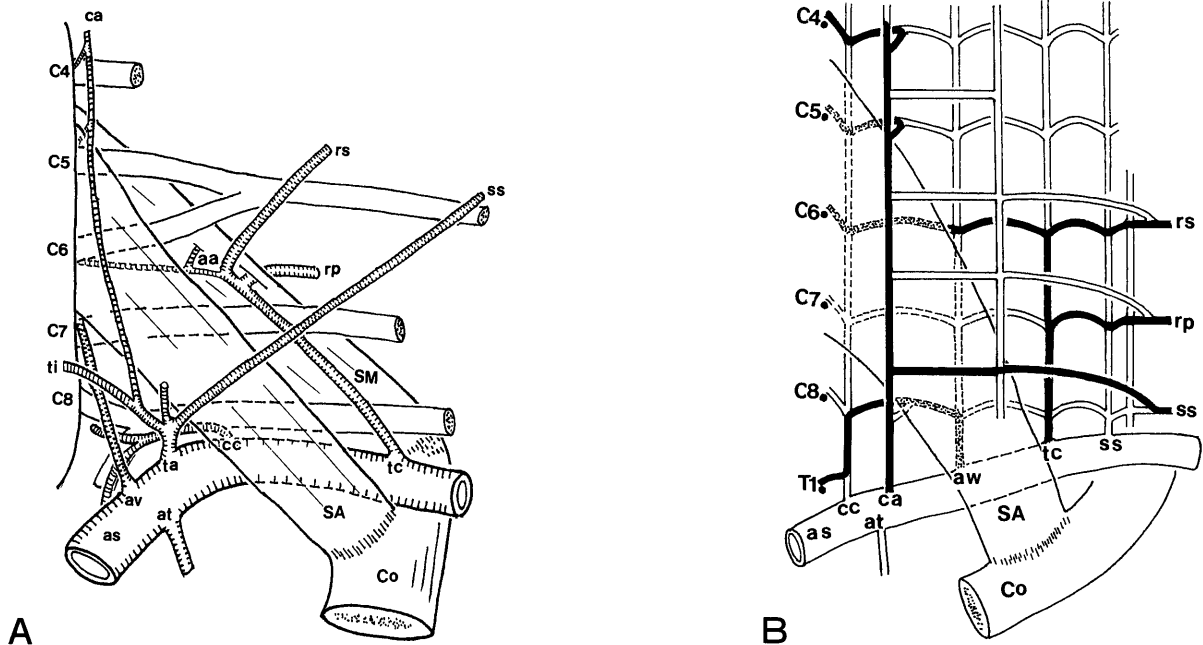


Fig. 8 A, case 6. The accessory ascending cervical artery forms a common trunk with the transverse cervical artery arising from the subclavian artery lateral to the scalenus anterior muscle. B, a typologic demonstration of case 6. Note that, in this case, "aw" appears as the costocervical artery instead of the accessory ascending cervical artery. Abbreviations are same in Figs. 1, 2 and 3.

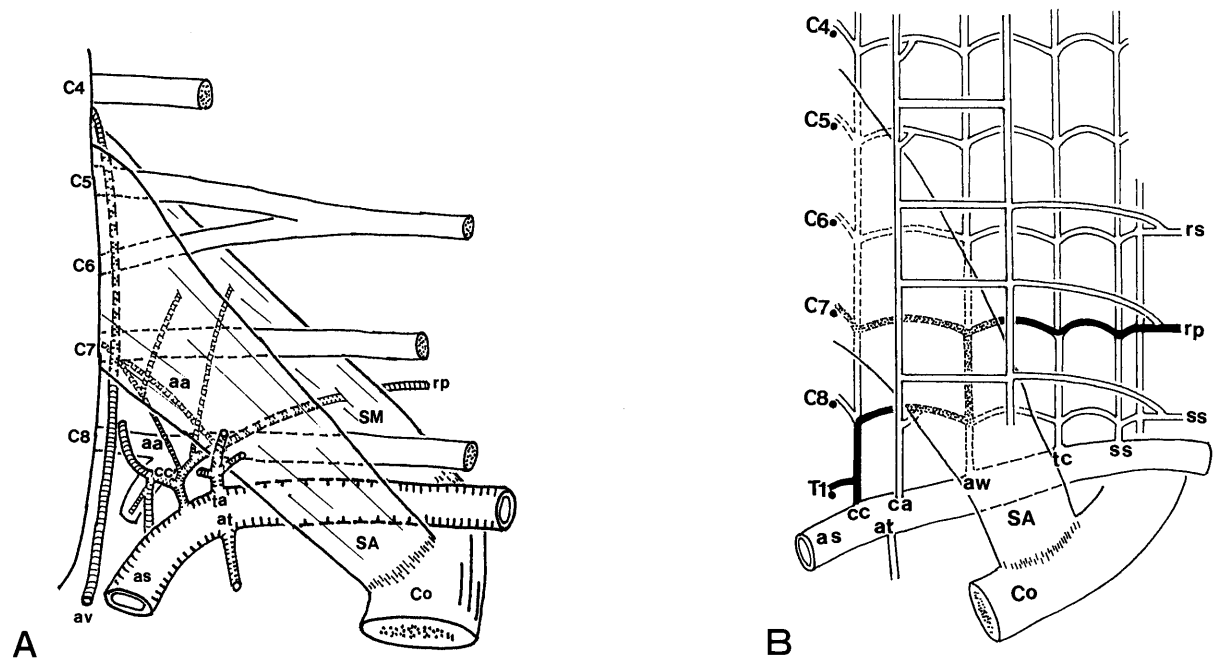


Fig. 9 A, case 7. The accessory ascending cervical artery forms a common trunk with both the transverse cervical artery and the costocervical trunk arising from the subclavian artery medial to the scalenus anterior muscle. B, a typologic demonstration of case 7. Abbreviations are same in Figs. 1, 2 and 3.

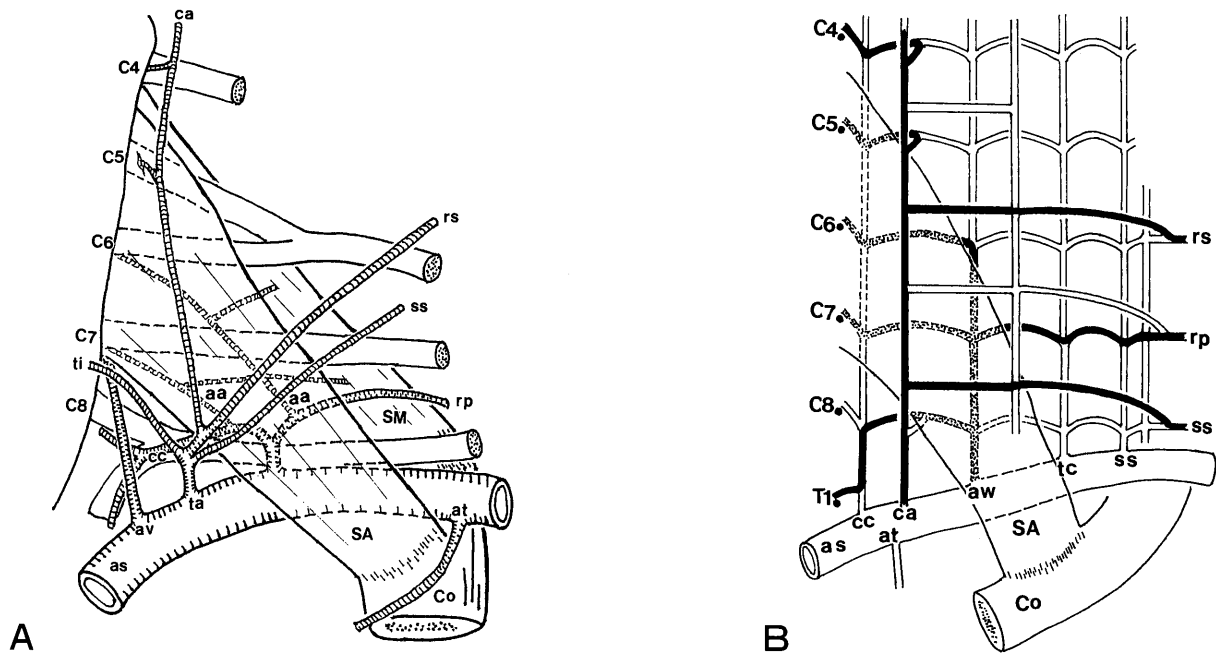


Fig. 10 A, case 8. The accessory ascending cervical artery forms a common trunk with both the transverse cervical artery and the costocervical trunk arising from the subclavian artery behind the scalenus anterior muscle. B, a typologic demonstration of case 8. Abbreviations are same in Figs. 1, 2 and 3.

Discussion

The results of the present study reconfirmed the common occurrence (88.5%) of the accessory ascending cervical artery, which originates behind the scalenus anterior muscle from the subclavian artery and runs on the brachial plexus. This finding is consistent with that of our previous investigation (1), in which this artery could be observed in 86% of total cases. The origin and course of this artery in the present study seem to correspond to vessels previously described as either an "unknown branch" (4) or a "deep ascending cervical artery" (2). In spite of its usual or even constant occurrence, this artery has remained without notice in textbooks (5-7) and in *Nomina Anatomica* (8). This oversight may have been caused by its hidden origin behind the muscle and its relatively thin diameter.

It is noteworthy that in all cases of independently or solely originating accessory ascending cervical arteries, have without exception arise behind the scalenus anterior muscle indicating that this artery takes a constant position for its origin behind the muscle. It is suggested that, when the accessory ascending cervical artery arises as a common trunk with the costocervical and/or transverse

cervical arteries behind the muscle, its origin corresponds essentially to that of the accessory ascending cervical artery. It is well known that the costocervical trunk variably arises medially in relation to the muscle or behind it from the subclavian artery (9). Such variations can also be explained as being of compensation, taking the origin of the accessory ascending cervical artery.

The accessory ascending cervical artery occasionally forms a common trunk with the transverse cervical artery. When it develops well, as previously reported by us, it becomes the Outi's type B transverse cervical artery, which penetrates the scalenus medius muscle (1). Some authors (6, 7, 10) have described in passing a similar anomaly without particular attention being paid. In the present study, we observed that the accessory ascending cervical artery can form a common trunk with not only Outi's type B but also the type C transverse cervical artery at any part of the subclavian artery. These findings suggest that the accessory ascending cervical artery may become the artery of origin of the costocervical trunk or transverse cervical artery (Outi's type B or C) behind the scalenus anterior muscle.

The present study has shown that the accessory ascending cervical artery branches out to the 6th and/or

7th cervical roots of the brachial plexus. These branches are regarded as being either proper or essential arteries derived from the original artery. When the accessory ascending cervical artery does not originate behind the muscle, these branches to the nerves issue from the costocervical or thyrocervical trunk medial to the scalenus anterior, or from the transverse cervical artery lateral to the muscle. Such compensatory cases are also regarded as common trunk formations. Our findings suggest that during the embryonic period, the accessory ascending cervical artery has anastomoses with the costocervical and thyrocervical (ascending cervical artery) trunks and the transverse cervical artery.

As discussed above, the region supplied with the accessory ascending cervical artery is characterized by branches to the 6th and 7th cervical nerves. Other cervical nerve roots receive branches from the ascending cervical artery (C5 or upper) and from the costocervical trunk (C8 or lower). These results suggest that these arteries with branches to the nerves belong to the intersegmental artery system. Embryologically, the intersegmental arteries arise from the dorsal aorta in a regular series and pass between successive somites (11). There are 2 branches off the intersegmental artery, the dorsal ramus and the ventral ramus, each of which anastomoses longitudinally to form postcostal and precostal longitudinal anastomoses, respectively (11). The dorsal postcostal longitudinal anastomoses remain as the vertebral artery and the deep cervical artery, while the ventral precostal longitudinal anastomoses remain as the ascending cervical artery and the superior intercostal artery (11, 12). As a common characteristic, all of these arteries branch out toward to the spinal cord (7, 13). As shown in the present study, the accessory ascending cervical artery also has spinal branches. Thus, this artery, which is clearly distinguished from the ascending cervical artery that passes in front of the scalenus anterior muscle, may be derived from the precostal longitudinal anastomoses.

Although both the accessory ascending cervical artery and the ascending cervical artery branch out along the cervical nerves, these 2 arteries seldom form a common trunk. Therefore, it is our proposal to classify arteries derived from the cervical precostal longitudinal anastomoses into 2 subgroups: the ante-SA group and the post-SA group, which run in front of and behind the scalenus anterior muscle, respectively (Fig. 2). This

division may be appropriate due to the development of the scalenus anterior muscle. Only the ascending cervical artery belongs to the ante-SA group, and the accessory ascending cervical artery, costocervical trunk and transverse cervical artery are included in the post-SA group.

According to the above discussions, we have created a typological diagram of the accessory ascending cervical artery and other related arteries in the human scalenus region (Fig. 2). Using this schema, all of the cases, including rare ones, can be explained (Figs. 3-10B).

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