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Variability of the Arterial Distribution to the Rotator Cuff Muscles and Its Correlation with the Diversity of Arterial Origin

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The arterial distribution to the rotator cuff muscles was studied in 14 upper extremities of Japanese cadavers and its diversity was correlated with the variable arterial origin.

The supraspinatus was supplied with arterial branches from the suprascapular artery (SPS), the infraspinatus with those from SPS and from the circumflex scapular artery (CS), and the teres minor with those from the posterior circumflex humeral artery and from CS, and the dorsal aspect of the subscapularis with those from SPS and from CS, whereas the ventral aspect of the subscapularis was supplied with branches from several variable origins. On the basis of origin and course, SPS was classified into proximal and distal types (pSPS and dSPS) and the subscapular artery was classified into superficial and deep types (sSBS and dSBS). The boundary between the distribution areas of SPS and CS in the infraspinatus and the dorsal aspect of subscapularis were variable and influenced primarily by the types of SPS with larger distribution areas of SPS in the cases of dSPS, and secondarily by the types of SBS with larger distribution areas of CS in the cases of dSBS. The kinds of branches and their distribution areas to the ventral aspect of the subscapularis were influenced by both the types of SPS and SBS.

The present study revealed the main distribution areas of arteries in the rotator cuff muscles and their variation, and predicted the weakly vascularized areas in these muscles, which corresponded well to the localization of trigger points that elicit referred pain.

Key words: artery, muscle, rotator cuff, scapula, trigger point

Abbreviations

AX Axillary artery
CS Circumflex scapula artery
dSBS Deep type of the subscapular artery
dSPS Distal type of the suprascapular artery
D-TD Thoracodorsal artery arising as a direct branch from the axillary artery
LT Lateral thoracic artery
PCH Posterior circumflex humeral artery
pSPS Proximal type of the suprascapular artery
R-AX Subscapular branches from the axillary artery
R-B Subscapular branches from the brachial artery
R-dSBS Subscapular branches from deep type of SBS
R-sSBS Subscapular branches from superficial type of SBS
SBS Subscapular artery
SPS Suprascapular artery
sSBS Superficial type of the subscapular artery
TD Thoracodorsal artery

Introduction

The rotator cuff muscles around the scapula send off the tendons which constitute the rotator cuff that stabilizes the shoulder joint. The rotator cuff is one of the most vulnerable structures in the body and is known to rupture or degenerate by aging or overuse[1)～3)]. The rotator cuff has been studied well anatomically concerning the arrangement of collagen fibers[4)～7)] or the arterial supply[8)～10)]. On the other hand, the rotator cuff muscles themselves

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have not been studied very well anatomically. However, tenderness and trigger points producing referred pain develop frequently in the rotator cuff muscles mainly due to disturbance of blood supply [11)~13)].

The arterial distribution of the rotator cuff muscles has anatomically unique features which may hinder the blood supply to the muscle. First, the distance from the origin of arteries at the subclavian artery and axillary arteries (AX) to the rotator cuff muscles is increased by the interposition of thorax in between. Second, the arteries to the rotator cuff muscles have to follow tortuous courses in order to allow extensive movement of the scapula. Third, the scapula may hinder arterial access to the muscles on the dorsal side of the scapula, namely the supraspinatus, infraspinatus, and teres minor.

The arterial supply of the skeletal muscles is not well documented in the anatomy, and most anatomy textbooks except for Gray's anatomy before the 38th edition [14)] do not mention any description of the arterial supply to the skeletal muscles. The arterial supply of the rotator cuff muscles is scarcely reported except for a few studies by Sato and his group [15) 16)]. On the other hand, the branching and courses of the subclavian artery and AX including those arteries supplying the rotator cuff muscles were reported to have extensive individual variation [17) 18)]. In the present study, we focused on the hitherto neglected distribution of the arterial branches in the rotator cuff muscles, and correlated it with the diversity of arterial origin from the subclavian artery and AX. The results are anatomically and clinically valuable, since ischemia of the rotator cuff muscles would result in various symptoms including tenderness and trigger points.

Materials and methods

In the present study, 14 upper extremities were examined from Japanese adult cadavers (9 right and 5 left shoulders; 5 males and 7 females) dissected in the gross anatomy course at the Juntendo University Faculty of Medicine in the years 2011 and 2012. After dissection of the subclavian artery and AX, the arterial branches supplying the rotator cuff muscles were identified. After dissecting out the supraspinatus, the infraspinatus, the teres minor, and the subscapularis from the scapula, the arterial branches were pursued on and in the muscles by removing muscle fibers to determine the extent of arterial distribution. Each step of dissection as well as the course and distribution of arterial branches were recorded by sketches and photographs.

Results

The ventral and dorsal aspects of the scapula were almost totally covered by the four rotator cuff muscles. The supraspinatus accommodated in the supraspinous fossa facing upward arose from the supraspinous fossa and terminated on the upper part of the greater tubercle. The infraspinatus in the infraspinous fossa which was relatively wide at the origin separated roughly into three parts, and became narrow and thick by folding and overlapping of these three parts toward the insertion on the middle part of the greater tubercle. The teres minor arose broadly from the lateral border of the scapula increasing its muscle mass toward insertion on the lower part of the greater tubercle and possessing a bipennate appearance with insertion tendon in the middle of the muscle. The subscapularis on the ventral aspect of the scapula which possessed a multipennate appearance arose broadly from the subscapularis fossa and converged toward insertion on the lesser tubercle and its lower elongation of crest.

Arterial distribution to the rotator cuff muscles

Arterial distribution to the supraspinatus

The supraspinatus in the supraspinous fossa was provided with arterial branches from the suprascapular artery (SPS). SPS arising from the subclavian artery or AX entered the supraspinous fossa via scapular notch, traversed between the muscle and scapula, and turned around the lateral edge of the base of the scapular spine to enter the infraspinous fossa. During this course SPS sent off a medial and a lateral branch to supply the supraspinatus.

Arterial distribution to the infraspinatus

The infraspinatus in the infraspinous fossa was mainly supplied by SPS from above and by the circumflex scapular artery (CS) from lateral (Figure-1). Both the arteries entered the space between the muscle and scapula, and distributed

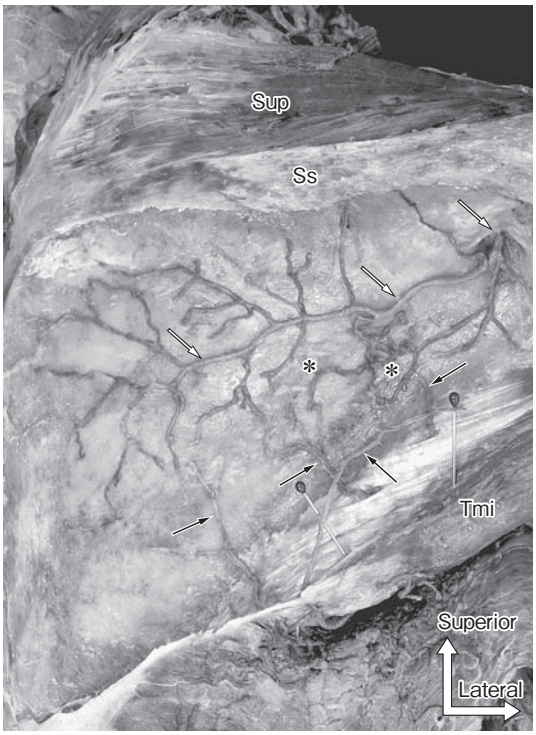

Figure-1 Photograph showing the arteries supplying the infraspinatus, after removal of the muscle from the scapula, right side. The arterial branches from the suprascapular artery (SPS, white arrows) distributed the upper and middle part, and those from the circumflex scapular artery (CS; dark arrows) distributed the lower part. The two arterial branches from CS anastomosed with SPS (asterisks). Ss, scapular spine; Sup, supraspinatus; Tmi, teres minor

the scapular surface of the muscle. After turning around the base of the scapular spine to enter the infraspinous fossa, SPS gave off branches to the upper parts of the muscle. CS arose usually by the division of the subscapular artery (SBS) arising from AX, passed through the triangular space, bifurcated into two branches either to the teres major or to the infraspinatus. The infraspinatus branch divided into a few muscular branches at the midpoint of the inferolateral border of the muscle to distribute the lower part of the muscle. Since the branches of SPS and of CS were anastomosed frequently with each other, the boundary of arterial distribution was determined by identifying the narrowest portion of the anastomosis. In two cases the boundary of distribution areas of SPS and CS was located in the supraspinatus, so that the infraspinatus was solely supplied with CS.

Arterial distribution to the teres minor

The teres minor was supplied by the branches from posterior circumflex humeral artery (PCH) in the lateral part and by branches from CS in the medial part. After passing through the triangular space, CS bifurcated into the infraspinatus branch and the teres major branch, and both branches sent off muscular branches to the teres minor. After passing through the quadrangular space, PCH gave off several muscular branches to the lateral part of the teres minor on its course to the deltoid. The branches of CS and of PCH did not anastomose with each other, so that the boundary of arterial distribution was fairly constant.

Arterial distribution to the subscapularis

The arterial supply to the subscapularis was peculiar in that the arterial branches distributed not only from the deep (dorsal) aspect toward the scapula (Figure-2), but also from the superficial (ventral) aspect toward the axilla (Figure-3). The dorsal aspect of subscapularis was supplied either with branches from SPS in the upper part or with branches from CS in the lower part. The boundary of arterial distribution was quite variable and in half of the cases the branches from SPS did not supply the subscapularis. The ventral aspect of the subscapularis was supplied with several branches of variable origin. In addition to branches from SPS distributing the uppermost part and those from CS distributing the lowest part, the branches of various origin from AX, the brachial artery, SBS, and the thoracodorsal artery (TD), the lateral thoracic artery (LT) distributed the ventral aspect of the subscapularis.

Origin and course of the arteries supplying the rotator cuff muscles

The many branches arising from the subclavian artery and AX including those distributing the rotator cuff muscles were known to be very variable in terms of their branching pattern and courses. As shown above the distribution area of arterial branches on the rotator cuff muscles was also variable. To examine the relationship between the origin and course of arteries and their distribution areas on the rotator cuff muscles, we observed the arteries from the origin at the subclavian artery and AX to the rotator cuff muscles.

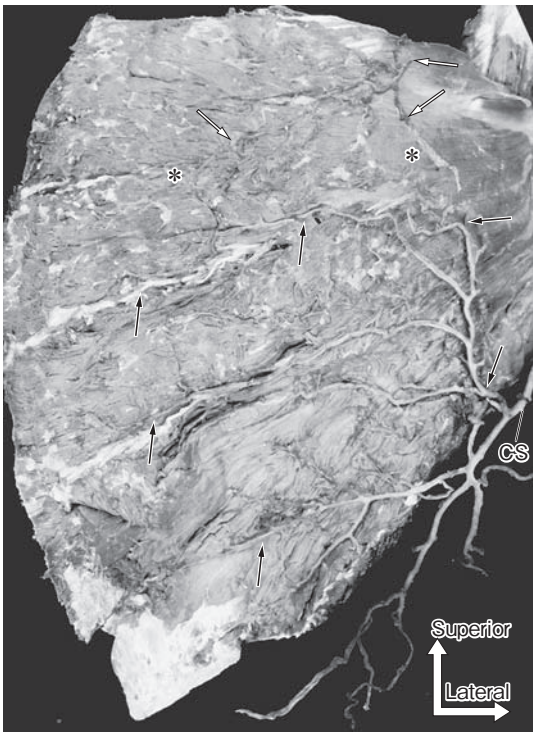

Figure-2 Photograph showing the arterial branches supplying the subscapularis on the deep (dorsal) aspect of the muscle toward the scapula after detachment of the muscle from the scapula, right side. The suprascapular artery (SPS, white arrows) distributed the upper part, and the circumflex scapular artery (CS, dark arrows) distributed the middle and lower part of the muscle. The branches from SPS and CS anastomosed with each other (asterisks)

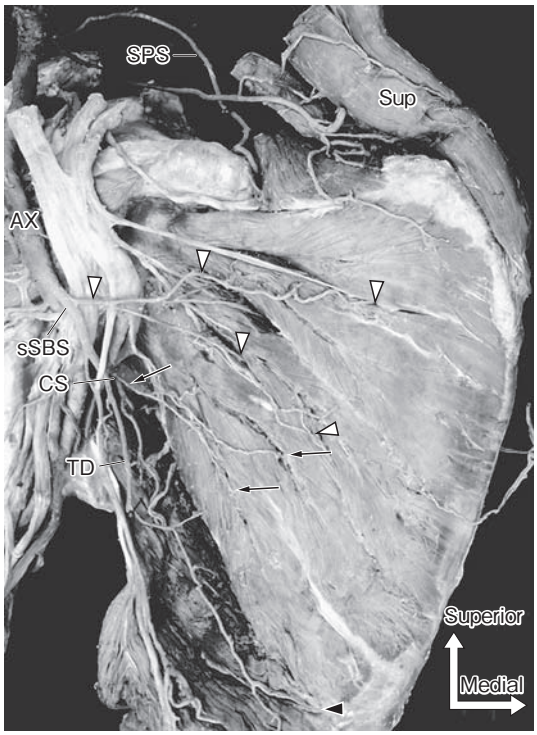

Figure-3 Photograph showing the arterial branches supplying the subscapularis on the superficial (ventral) aspect of the muscle toward the axilla, right side. The muscle was supplied by the branches from the superficial type of the subscapular artery (R-sSBS, white arrowheads) in the upper and middle part, by the circumflex scapular artery (CS, dark arrows) in the mediolateral part, and by the thoracodorsal artery (TD, dark arrowheads) in the inferolateral part. SPS, suprascapular artery; Sup, supraspinatus; AX, axillary artery; sSBS, superficial type of the subscapular artery

Two types of SPS

SPS was classified into two types on the basis of the origin as well as of the course. The proximal type of SPS (pSPS; 9 cases: Figure-4: A, B) arose from the thyrocervical trunk at the proximal part of the subclavian artery, and passed over the scapular notch above the superior transverse scapular ligament to enter the supraspinatus fossa. The distal type of SPS (dSPS; 5 cases: Figure-4: C, D) arose from AX behind the pectoralis minor, and passed through the scapular notch below the superior transverse ligament.

Types of SBS as a common trunk of TD and CS

TD arose as a continuation of SBS after branching of CS except for two cases in which TD arose as a direct branch from AX (D-TD: Figure-4: 3d, 3e). In one case, the conventional TD arising from SBS and the direct TD arising from AX were combined (Figure-4: 3c). SBS was classified into two types on the basis of location of origin at AX with regard to the brachial plexus. The superficial type of SBS (sSBS; 8 cases: Figure-4: B, D) arose from the portion of AX before or above the penetration through the two roots of median nerve. The deep type of SBS (dSBS; 6 cases: Figure-4: A, C) arose from the portion of AX after penetrating the median nerve roots.

Small branches supplying the ventral aspect of the subscapularis

Small branches arising from AX and the SBS distributed to the ventral aspect of the subscapularis. We termed these branches either as branches from AX (R-AX), as branches from superficial SBS (R-sSBS) or as branches from deep SBS (R-dSBS) depending on the origin.

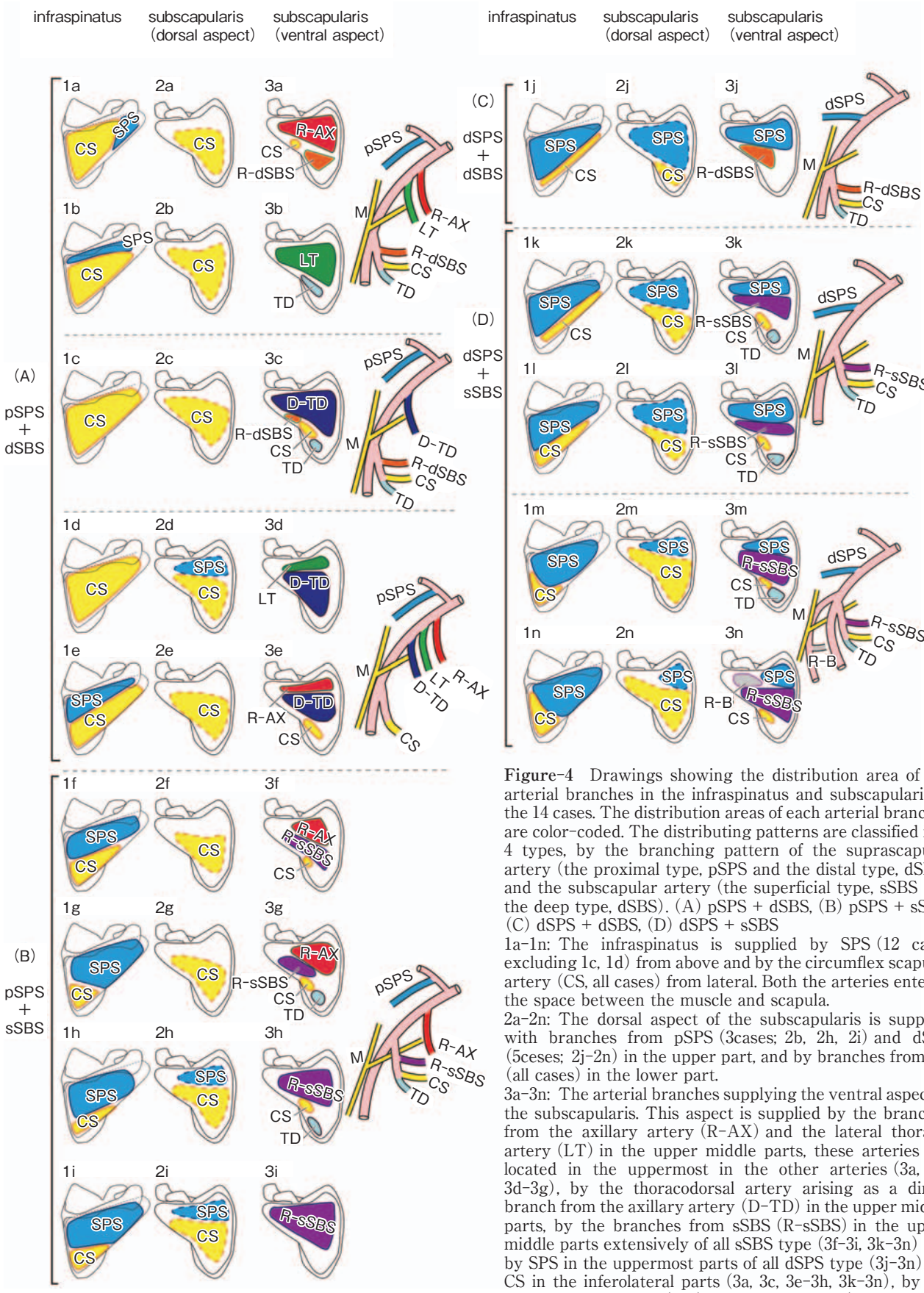

Figure-4 Drawings showing the distribution area of the arterial branches in the infraspinatus and subscapularis of the 14 cases. The distribution areas of each arterial branches are color-coded. The distributing patterns are classified into 4 types, by the branching pattern of the suprascapular artery (the proximal type, pSPS and the distal type, dSPS) and the subscapular artery (the superficial type, sSBS and the deep type, dSBS). (A) pSPS + dSBS, (B) pSPS + sSBS, (C) dSPS + dSBS, (D) dSPS + sSBS

1a-1n: The infraspinatus is supplied by SPS (12 cases excluding 1c, 1d) from above and by the circumflex scapular artery (CS, all cases) from lateral. Both the arteries entered the space between the muscle and scapula.

2a-2n: The dorsal aspect of the subscapularis is supplied with branches from pSPS (3cases; 2b, 2h, 2i) and dSPS (5ceses; 2j-2n) in the upper part, and by branches from CS (all cases) in the lower part.

3a-3n: The arterial branches supplying the ventral aspect of the subscapularis. This aspect is supplied by the branches from the axillary artery (R-AX) and the lateral thoracic artery (LT) in the upper middle parts, these arteries are located in the uppermost in the other arteries (3a, 3b, 3d-3g), by the thoracodorsal artery arising as a direct branch from the axillary artery (D-TD) in the upper middle parts, by the branches from sSBS (R-sSBS) in the upper middle parts extensively of all sSBS type (3f-3i, 3k-3n) and by SPS in the uppermost parts of all dSPS type (3j-3n), by CS in the inferolateral parts (3a, 3c, 3e-3h, 3k-3n), by the thoracodorsal artery (TD) in the lower part (3b, 3c, 3g, 3h, 3k-3m), in one case of dSPS + sSBS, by the branches from the brachial artery (R-B) in the upper part (3n). M, median nerve roots; R-dSBS, branches from d SBS

Relationship between the types of arteries and their distribution areas

Among the four rotator cuff muscles, the supraspinatus and the teres minor received constant arterial supply either from SPS or from CS and PCH without substantial variation of distribution areas. On the other hand, the arterial supply of the infraspinatus and subscapularis was considerably variable with regard to the arteries as well as their distribution areas.

Arterial distribution to the infraspinatus

The upper area of infraspinatus was supplied by SPS and the lower area by CS (Figure-4: 1a-1n). In 5 cases with dSPS, the distribution area of SPS was broad covering more than half (1j-1n). In 9 cases with pSPS, the relative distribution of SPS and CS was variable and depended on the type of SBS (1a-1i). In 4 cases with pSPS and sSBS, the distribution area of SPS was broad covering more than half (1f-1i), whereas in 5 cases with pSPS and dSBS, the distribution area of SPS was narrow or absent (1a-1e).

Arterial distribution to the dorsal aspect of subscapularis

In the dorsal aspect of subscapularis, the upper area was supplied by SPS and the lower area by CS (Figure-4: 2a-2n). The five cases with dSPS (2j-2n) received relatively rich arterial supply from SPS compared with the 9 cases with pSPS (2a-2i). In the cases with dSPS, the distribution area of SPS was more than half (3 cases: 2j-2l) or about a quarter (2 cases: 2m, 2n), whereas in the cases with pSPS, the distribution area of SPS was about a quarter (3 cases: 2d, 2h, 2i) or absent (2a-2c, 2e-2g).

Arterial distribution to the ventral aspect of the subscapularis

The ventral aspect of the subscapularis was supplied by SPS and R-sSBS, and in addition by R-AX, LT, R-dSBS, TD and CS (Figure-4: 3a-3n). In 5 cases with dSPS, the ventral aspect of the subscapularis received rich supply from SPS, which distributed the uppermost part of the muscle (3j-3n). In the other 9 cases with pSPS, SPS did not supply the ventral aspect of the subscapularis (3a-3i). In 8 cases with sSBS, the ventral aspect of the subscapularis received rich supply from R-sSBS (3f-3i, 3k-3n), which distributed the relatively upper part next to SPS and R-AX. In the other 6 cases with dSBS, the distribution area of R-dSBS was absent (3 cases: 3b, 3d, 3e) or at maximum a quarter of the ventral aspect of the subscapularis (3 cases: 3a, 3c, 3j). The distribution area of R-AX was found in 4 cases with pSPS (3a, 3e, 3f, 3g) and occupied more than half of the muscle in 2 cases (3a, 3g). The distribution area of D-TD was found in 3 cases with pSPS and dSBS, and occupied more than half of the muscle (3c-3e). The distribution area of LT was found in 2 cases with pSPS and dSBS (3b, 3d) and occupied more than half of the muscle in one case (3b). The distribution area of R-AX and LT was located in a higher position compared with that of TD and R-SBS (3a, 3b, 3d-3g).

Discussion

The muscular distribution of arteries is a relatively neglected topic in anatomy so that most of the anatomy textbooks do not describe the arterial supply to the individual muscles except for the older versions of Gray's anatomy before the 38th edition. According to the description in the 38th edition of Gray's anatomy [14], the supraspinatus is supplied by SPS and the dorsal scapular artery, the infraspinatus is supplied by SPS and CS, the teres minor is supplied by CS and PCH, and the subscapularis is supplied by small branches originating from the SPS, SBS and AX.

In a series of studies on the arterial distribution in the skeletal muscles, Sato and coworkers classified the arterial branches supplying the rotator cuff muscles in detail depending on their origin, courses, and accompanying nerve branches, and reported versatile variability of the distribution areas [15) 16)]. These studies fundamentally verified the description of arterial supply to the rotator cuff muscles in Gray's anatomy [14].

Clinical relevance of the arterial distribution to the rotator cuff muscles

On the basis of the arterial distribution to the rotator cuff muscles, we could indicate the possible risk of local ischemia in a specific region of these muscles far from the supplying arteries (Figure-5).

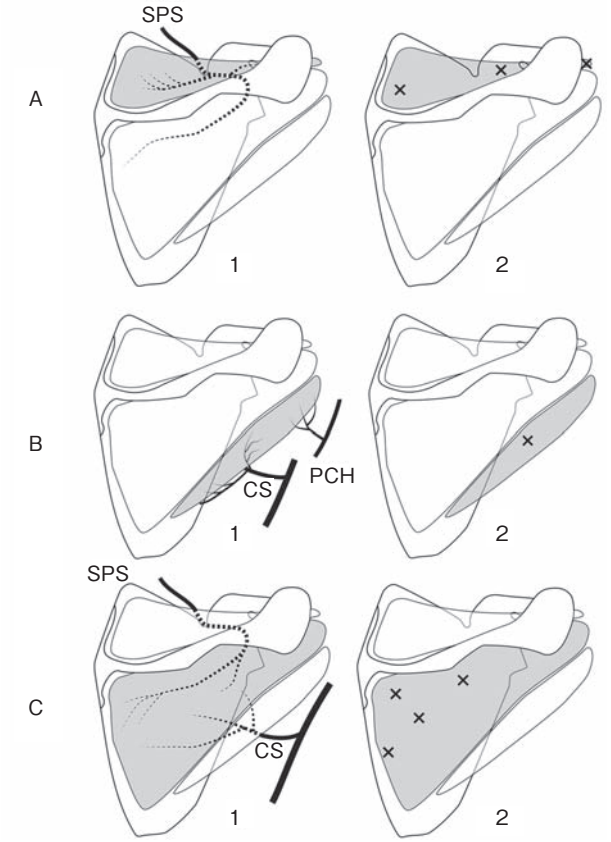

Figure-5 Correspondence between the arterial distribution and the location of trigger points in the rotator cuff muscles. A1. The suprascapular artery (SPS) runs through the central portion of the supraspinatus to send off a few medial and lateral branches to supply this muscle. The medial and lateral portions of the muscle are the periphery of arterial supply and therefore poorly vascularized. A2. The trigger points of the supraspinatus were located mainly at the medial and lateral portions of the muscle. B1. The teres minor was supplied by the circumflex scapular artery (CS) in the medial part and by the posterior circumflex humeral artery (PCH) in the lateral part. The middle of the muscle represents the border of the arterial supply, and is therefore poorly vascularized. B2. The trigger points of the teres minor were located mainly at the middle of this muscle. C1. The infraspinatus was supplied by the suprascapular artery (SPS) from above lateral corner and by the circumflex scapular artery (CS) from the lateral side. The medial part of the muscle is periphery of arterial supply and therefore poorly vascularized. C2. The trigger points of the infraspinatus were located mainly at the medial portion of this muscle. The location of trigger points was adapted from Simons *et al.* (1999) [11].

In the case of the supraspinatus muscle, the most medial and most lateral parts of the muscle were suggested to be at the highest risk because of the long distance from SPS traversing the middle of the muscle. In the case of the teres minor muscle, the middle of the muscle was suggested to be at the highest risk where the border of distribution areas of CS to the proximal part and PCH to the distal part of the muscle was located. In the case of the infraspinatus muscle, the medial portion of the muscle was suggested to be at the highest risk, the part of which was farthest from the entry point of SPS and CS.

The myofascial pain syndrome represented a chronic pain disorder in which pressure on the trigger points in the muscle caused referred pain in seemingly unrelated parts of the body [11) 19) 20)]. The energy crisis theory was proposed to explain this phenomenon which assumed that insufficient local circulation and loss of oxygen and nutrient supply caused the local hypersensitivity and pain [11)~13)]. Simons and Travell [11)] investigated the distribution of the trigger points in the body. Interestingly the distribution of trigger points in the rotator cuff muscles reported by Simons and Travell [11)] coincided very well with the region of possible risk of local ischemia predicted by our present findings (Figure-5).

In the present study, we provided anatomical evidences that the empirically determined trigger points were high risk regions of local ischemia on the basis of arterial distribution. We hope that the findings of arterial distribution in the other muscles would provide further anatomical evidence for the distribution of trigger points, and useful information for developing better methods of manipulating the tension pain and local tenderness of the skeletal muscles.

Origin and course of the arteries supplying the rotator cuff muscles

In the present study, we classified the arteries supplying the rotator cuff muscles on the basis of their origins, clarified the distribution areas of individual arteries, and correlated the variability of the origins and that of the distribution areas. The supraspinatus was mainly supplied by SPS, and in a few instances a small area at the lowest part of the supraspinatus was supplied by CS via communication between SPS and CS. The teres minor was

supplied by PCH in the lateral part and by CS in the medial part, and the boundary between the distribution areas of both the arteries at the middle of the muscle was stable among the cases examined. On the other hand, the extent of arterial supply by individual arteries to the infraspainatus and the dorsal and ventral aspects of the subscapularis was quite variable among the cases examined. The infraspinatus was supplied by SPS and CS, and the extent of distribution areas of both the arteries was variable among the cases examined. The dorsal aspect of the subscapularis was supplied by SPS and CS as well, and the extent of the distribution areas was also quite variable. The ventral aspect of the subscapularis was supplied by various branches from R-dSBS, R-AX, D-TD and LT in addition to SPS and R-sSBS, and the presence and extent of the individual distribution areas were quite variable among cases examined.

The arteries supplying the rotator cuff muscles arise from the subclavian artery and AX. It is well known that the branches of the subclavian artery and AX were quite variable both in their origin and courses. In the present study we confirmed that the origin of SPS, SBS and TD were variable among the cases examined.

Origin of SPS

As already reported in previous studies, SPS was classified depending on the origin into two types, pSPS and dSPS, which took different courses in relation to the brachial plexus and the superior transverse scapular ligament, but pursued similar courses under the supraspinatus[21)~23)]. Arising from the thyrocervical trunk, pSPS took its course above the brachial plexus, passed superficially to the superior transverse ligament, and ran deep to the supraspinatus. On the other hand, dSPS arose from AX, penetrated the brachial plexus and passed under the superior transverse ligament to enter the supraspinous fossa under the supraspinatus.

Origin of SBS

In contrast to the usual SBS arising from AX after passing through the two roots of the median nerve, six cases of variant SBS were found to arise from the portion of axially artery proximal to passing the two roots, a variant which was termed the superficial subscapular artery by Yamada[24)]. Furthermore, two cases of variant AX were found which kept ventral position to the brachial plexus, and was known as the superficial brachial artery[25)~27)]. Since these two variants were considered to have different embryonic origin from the usual types, SBS in these variant cases (sSBS) may be distinguished from the usual cases (dSBS).

Origin of TD

In the present study we found that, in addition to the usual arising of the TD from the SBS, a few exceptional cases of D-TD arose directly from AX. Furthermore in one case D-TD coexisted with the usual TD. Previous studies have reported the frequency of usual TD between 81-100%, and paucity of D-TD between 0-19%[28)~30)]. The coexistence of the usual TD and D-TD found in the present study is quite rare, and was reported as an accessory thoracodorsal artery by Saadeh[31)] and described in a monograph by Kodama[22)].

Relationship between the muscular distribution and the origin of the arteries supplying the rotator cuff muscles

We showed that the arterial distribution to the infraspinatus and the dorsal and ventral aspects of the subscapularis was variable among individuals, and had the same tendency of broader distribution area of SPS in the cases of dSPS compared with those of pSPS. In addition to this primary tendency, we found a secondary tendency in the nine cases of infraspinatus with pSPS, in which the distribution area of CS was broader in the cases of dSBS compared with those of sSBS. These findings indicate that the arterial distribution was influenced by the origin types of the supplying arteries.

The arterial distribution to the ventral aspects of the subscapularis was classified into three patterns depending the origin types of the supplying arteries. In the first type with dSPS, SPS and SBS supplied the blood to the muscle. In the second type with pSPS and sSBS, small branches from SBS (R-sSBS) mainly supplied the blood to the muscle and in addition small branches from AX (R-AX) supplied it. In the third type with pSPS and dSBS, the blood was mainly supplied by branches arising from the superficial portion of AX on the ventral side of the brachial plexus such as those from D-TD, LT, and AX itself. On the other hand, the

branches from AX and brachial artery on the dorsal side of the brachial plexus made only a limited contribution. In a study on the variation of the branches from AX, Huelke[28] found a characteristic feature of the arteries distributing the ventral aspect of the subscapularis from above to accompany the superior subscapular nerve, and reported variability of the origin of these arteries (86% of frequency) either from AX (51.6%), from SBS (21.4%), from SPS (4% or less), and from LT or the subclavian artery (4.5% or less). In a similar study on Japanese individuals, Sato and Takafuji[30] reported 100% frequency of those arteries distributing the ventral aspect of the subscapuPlaris from above with the origin either from AX (39%), from SBS (21%), and from SPS (14%). These studies were in good agreement with the findings in the present study.

The infraspinatus and the dorsal aspect of the subscapularis received blood from SPS and CS which was a major branch of SBS, and we revealed that the variation in distribution area of these arteries was associated with the variation of their origins. In the cases of pSPS arising far from the scapula, the distribution area of SPS was narrower than those of dSPS arising near the scapula. These findings would suggest that the ability of blood supply was reduced by the long distance from origin in the case of pSPS to decrease the distribution area of SPS.

It is well known that SPS arises in most cases from the thyrocervical trunk and in minor cases directly from the subclavian artery and AX. Japanese anatomists have revealed correlations between the origin of SPS and its course. Kosugi *et al.*[21] reported that the proximal type of SPS arising from the medial to the scalenus anterior muscle took a course superficial to the brachial plexus and the distal type of SPS arising behind or distal to the muscle took a course penetrating the brachial plexus. These results were confirmed by Kodama[22] and Dargaud *et al.*[23]. In addition Kodama[22] reported that the proximal type of SPS passed above the superior transverse ligament and the distal type passed below the ligament at the scapular notch. While the correlation between the origin type of SPS and its course before the scapular notch has been so far reported, in the present study we revealed for the first time that the course and distribution of SPS after the scapular notch were influenced by the origin type. As Kosugi *et al.*[21] suggested the different origins of SPS may represent embryonic differences.

In the present study we found a similar association between the origin type of SBS and its course and distribution area. The deep type (dSBS) arising from near the entry point to the infraspinatus and teres minor muscles at the lateral border of scapula supplied larger areas compared to the superficial type (sSBS) arising far from the entry point. However, the difference in the distance from the entry point between both the types of SBS was smaller than that in the case of SPS so that the influence of the origin types in SBS was minor compared with SPS.

It was noteworthy that the ventral aspect of the subscapularis muscle was supplied mainly by those branches that arose from the superficial part of AX located on the ventral side of the two roots of median nerve, such as dSPS, R-sSBS, R-AX, LT, and D-TD. On the other hand, those branches arising from the distal part of AX supplied only small areas on the ventral aspect of the subscapularis muscle in a few cases, probably because the superficial position of the subscapularis muscle relative to the distal part of AX required a recurrent course of supplying arteries.

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