ORIGINAL COMMUNICATION

Suprahyoid Neck Fascial Configuration, Especially in the Posterior Compartment of the Parapharyngeal Space: A Histological Study Using Late-Stage Human Fetuses

YUKIO KATORI,[1] TETSUAKI KAWASE,[2] KWANG HO CHO,[3]* HIROSHI ABE,[4] JOSE FRANCISCO RODRÍGUEZ-VÁZQUEZ,[5] GEN MURAKAMI,[6] AND MINEKO FUJIMIYA[7]

[1]*Division of Otorhinolaryngology, Sendai Municipal Hospital, Sendai, Japan*
[2]*Department of Otorhinolaryngology, Tohoku University School of Medicine, Sendai, Japan*
[3]*Department of Neurology, Wonkwang University School of Medicine, Institute of Wonkwang Medical Science, Jeonbuk Regional Cardiocerebrovascular Disease Center, Iksan, Korea*
[4]*Department of Anatomy, Akita University School of Medicine, Akita, Japan*
[5]*Department of Anatomy and Embryology II, Faculty of Medicine, Complutense University, Madrid, Spain*
[6]*Division of Internal Medicine, Iwamizawa Kojin-kai Hospital, Iwamizawa, Japan*
[7]*Department of Anatomy, Sapporo Medical University School of Medicine, Sapporo, Japan*

The fascial configuration in the suprahyoid parapharyngeal space was evaluated using semiserial sagittal sections of 15 late-stage human fetal heads. The prevertebral fascia covered the longus colli, longus capitis, and rectus capitis lateralis muscles, but was most evident along the longus colli muscle. The carotid sheath and its extension were located around the internal and external carotid arteries and the lower cranial nerves. The superior cervical ganglion was also inside the sheath. Even near full term, the fetal suprahyoid neck was short, with the jugular foramen and hypoglossal canal located at the posterolateral side of the oropharynx. Thus, the glossopharyngeal and accessory nerves ran across the upper part of the carotid sheath. Fasciae of the stylopharyngeus, styloglossus, and stylohyoideus muscles were attached to and joined the anterosuperior aspect of the carotid sheath. All these neurovascular and muscle sheaths are communicated with the visceral fascia covering the pharynx at multiple sites, and, together, they formed a mesentery-like bundle. This communication bundle was made narrow by the anteriorly protruding longus capitis muscle. The mesentery-like bundle was covered by the posterior marginal fascia of the prestyloid compartment of the parapharyngeal space. The external carotid artery ran on the lateral and posterior sides of the posterior marginal fascia. Consequently, the typical carotid sheath configuration was modified by muscle sheaths from the styloid process, communicated with the visceral fascia and, anteriorly, constituted the posterior margin of the prestyloid space. Clin. Anat. 26:204–212, 2013.

Key words: parapharyngeal space; deep cervical fascia; prevertebral fascia; carotid sheath; human fetuses

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*Correspondence to: Kwang Ho Cho, Department of Neurology, Wonkwang University School of Medicine, Jeonbuk Regional Cardiocerebrovascular Disease Center, Institute of Wonkwang Medical Science, 344-2, Sinyong-dong, Iksan, Jeonbuk 570-711, Republic of Korea. E-mail: neurlogy@wonkwang.ac.kr or neuro200@hanmail.net

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INTRODUCTION

The deep cervical fasciae have usually been described in the context of providing fascial spaces through which inflammation or cancer can spread (Hall, 1934; Hollinshead, 1982; Nguen et al., 1992; Nicklalus and Kelly, 1996). Around the parapharyngeal space, the prevertebral fascia, also called the prevertebral lamina, of the deep cervical fascia provides the posterior margin; the pretracheal lamina of the deep cervical fascia and the carotid sheath provide the anterior margin; and the visceral or pharyngeal fascia provide the medial margin. Most anatomical information on these structures is based on the pioneering study by Grodinsky and Hoyoke (1938), which used line-drawings of macroscopic slices of late-stage fetuses to illustrate the fascial planes. To our knowledge, however, few histological studies of the cervical fasciae have been performed, and those that have been undertaken examined specific sites (Parsons, 1910; Piffer, 1980; Honma et al., 2000; Johnson et al., 2000; Zhang and Lee, 2002; Hayashi, 2007). The prevertebral fascia may extend along the longus capitis and longus colli muscles to the cranial base or the pharyngobasilar membrane. However, we have no histological information on the suprahyoid fascial configuration to compare with the infrahyoid neck region.

The suprahyoid parapharyngeal space is usually divided into anterior and posterior compartments: the former, also known as the prestyloid space, is filled with fatty tissue, whereas the latter, also called the carotid space, contains the lower cranial nerves and the great vessels (reviewed by Chong et al., 1999). Division of the parapharyngeal space into prestyloid and poststyloid portions was first described by Hall (1934), and the posterior compartment was first called the carotid space by Harnsberger and Osborn (1991). Because the term carotid space may also refer to the carotid sheath itself (Chong et al., 1999), we did not use this term. Although the Chinese Visible Human project reported the adult prestyloid space (Li et al., 2004), we have found it difficult to identify the fascial arrangement in their photographs.

Dissection studies have suggested that the ''tensor palatini fascia'' provides a border between the anterior and posterior compartments (Curtin, 1987).

Fig. 1. Horizontal sections of a 31-week-old fetus: the inferior level. The left-hand side of the figure corresponds to the lateral side of the head and neck. Panel **A** (or **C**) is the most inferior (or superior) side of the figure. The intervals between the panels are 24 mm for panels A and **B** and 6 mm for panels B and C. Panel A displays the level of bifurcation of the common carotid artery or the lateral atlantoaxial joint, panel B shows the level of the palatine tonsil (tonsil), and panel C shows the pharyngeal insertion of the stylopharyngeal muscle. The more superior levels are shown in Figure 2: panel A and the lowest level in Figures 1 and 2. Panel A shows that the carotid sheath (triangles) and visceral or pharyngeal fascia (arrowheads) issued abundant fascial branches (indicated by a thick semicircle) toward the subcutaneous tissue (skin). Panels B and C show a large space filled with loose mesenchymal tissues (prestyloid space, open stars) behind the medial pterygoid muscle (MP). The pharyngeal fascia issued a distinct fascial branch (prestyloid space posterior fascia, arrows) extending anterolaterally along the anterior aspects of the styloglossus (SG), stylopharyngeus (SP), and levator veli palatini (LVP) muscles. A connection is evident between the visceral fascia and neurovascular sheaths (thick semicircles in panels B and C). The prevertebral fascia (black stars) covers the anterior aspect of the rectus capitis lateralis (RCL), longus capitis (LC), and longus colli (LCO) muscles. All panels are at the same magnification (scale bar in panel A). OA, occipital artery. **Common abbreviation for figures: APA, ascending pharyngeal artery; C1 (C2), first (second) cervical vertebra or cervical spinal nerve; CPI, constrictor pharyngis inferior muscle; CPM, constrictor pharyngis medius muscle; CT, crycotyroideus muscle; DP, digastricus muscle posterior belly; ECA, external carotid artery; HB, hyoid bone; HG, hyoglossus; ICA, internal carotid artery; ICN, internal carotid nerve; IJV, internal jugular vein; LA, lingual artery; LC, longis capitis muscle; LCO, longus colli muscle; LN, lymph nodes; LVP, levator veli palatini muscle; NG, nodosa ganglion or the inferior vagal ganglion; OCC, occipital bone; PP, palatopharyngeus muscle; PTT, pharyngotympanic tube; PX, pharynx; RC, Reichert cartilage (perspective styloid process); RCA, rectus capitis anterior muscle; RCL, rectus capitis lateralis muscle; SCG, superior cervical ganglion; SH, stylohyoideus muscle; SG, styloglossus muscle; SM, sternocleidomastoideus muscle; SMG, submandibular gland; SP, stylopharyngeus muscle; STA, superior thyroid artery; TC, thyroid cartilage; TG, thyroid gland; TH, tyrohyoideus muscle; TVP, tensor veli palatini muscle; IX, glossopharyngeal nerve; X, vagus nerve; XI, accessory nerve; XII, hypoglossal nerve.**

Fig. 2. Horizontal sections of a 31-week-old fetus: the superior level. The specimen is identical to that shown in Figure 1. The left-hand side of the figure corresponds to the lateral side of the head and neck. Panel **A** is 11 mm superior to Figure 1C, and panel **B** is 7 mm superior to panel A. Panel A shows the accessory nerve (IX) running laterally to the sternocleidomastoideus muscle (SM). Panel B includes the pharyngotympanic tube (PTT) near its pharyngeal opening. Panel B, the highest level shown in Figures 1 and 2, corresponds to the level of the atlanto-occipital joint. Panels A and B show the prestyloid space (open stars) on the lateral side of the pharynx. The prestyloid space posterior fascia (arrows) is distant from the tensor veli palatini (TVP) muscle. The carotid sheath (triangles) issues branches to the accessory and glossopharyngeal nerves and joins the stylopharyngeus muscle sheath (panel A). The pharyngeal fascia (arrowheads) attaches to the prevertebral fascia (black stars) in panel B. Because of the anteriorly protruding longus capitis (LC) muscle, the connection between the visceral fascia and neurovascular sheaths becomes narrower (thick semicircle). The asterisk in panel B indicates connective tissue covering the inferior aspect of the external auditory meatus. All panels were prepared at the same magnification (scale bar in panel A). MA, maxillary artery; OA, occipital artery; PG, parotid gland; V3, mandibular nerve root.

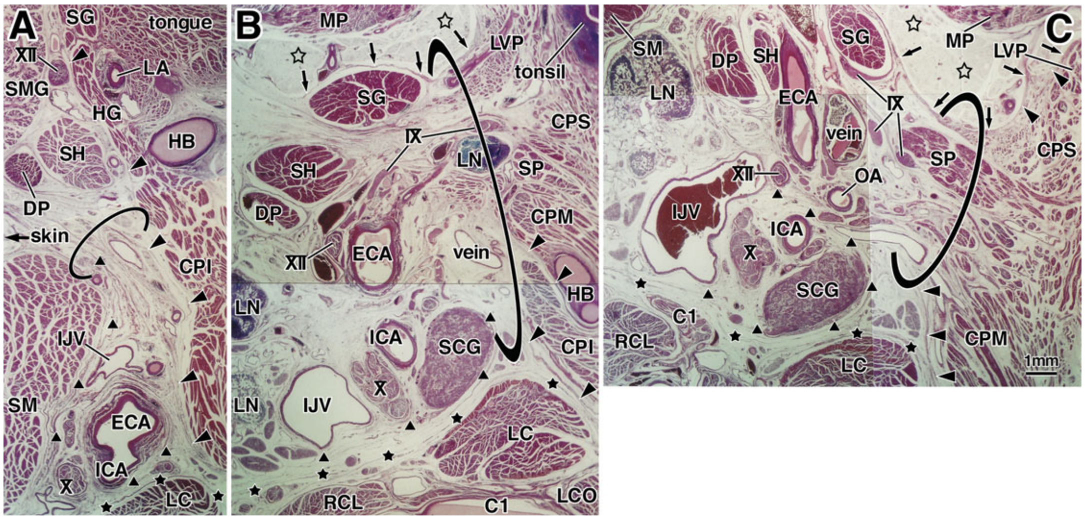

Fig. 1.

Because the marginal fascia is not restricted along the surface of the tensor veli palatini muscle, it was termed ''the tensor-vascular-styloid fascia'' based on MRI observations (Shin et al., 2001). Thus, in contrast to the infrahyoid neck, in which the pretracheal lamina and carotid sheath cover the parapharyngeal space (see above), there may be another, anterior covering of the parapharyngeal space in the suprahyoid neck, and the key structure may be the ''tensor'' veli palatini muscle. The ''tensor-vascular-styloid fascia'' (see above) is unlikely to continue, at the lower side, to the pretracheal lamina (a fascia of the infrahyoid muscles), because the latter continues to the submandibular triangle in front of the cervical viscera (Hollinshead, 1982) and because the pretracheal lamina has not been defined above the omohyoideus muscle at the lateral site. It remains unclear whether the carotid sheath continues superiorly to the tensor-vascular-styloid fascia or whether the fascia continues to the pharyngeal fascia covering the mediolaterally extended oropharynx.

To better understand the suprahyoid parapharyngeal space, it is necessary to use a new viewpoint other than the classical concept of the deep cervical fascia, that is, a configuration comprising three laminae (prevertebral, pretracheal, and superficial) and one sheath (carotid sheath). At 9–12 weeks, the prevertebral (or alar) fascia develops as a definite fascial connection between the bilateral longus colli muscles or between the adventitial layers of the bilateral common carotid arteries (Miyake et al., 2010). Thus, at least in the infrahyoid neck, each of these fasciae has an embryological background or ''anlage.'' The carotid sheath seems to be established later than 20–25 weeks, and, even at this late stage, whether it is clear or unclear varies among

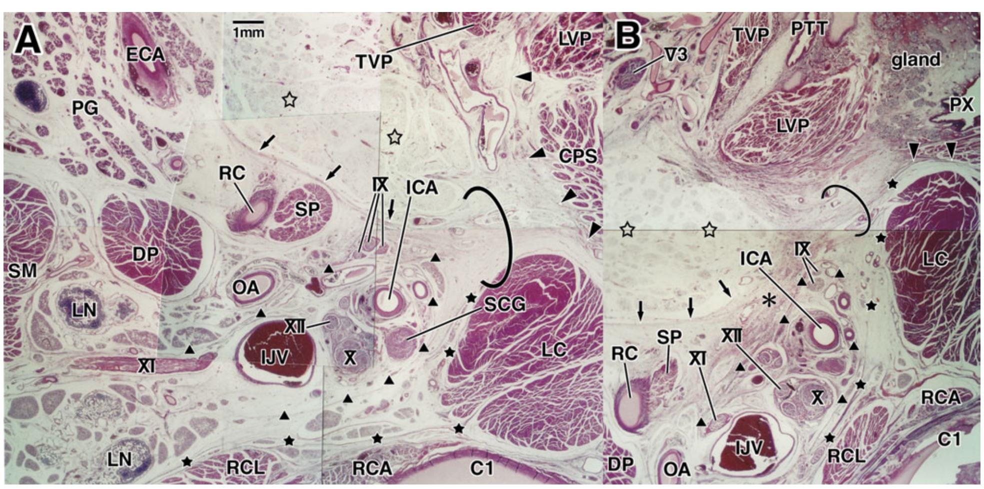

Fig. 2.

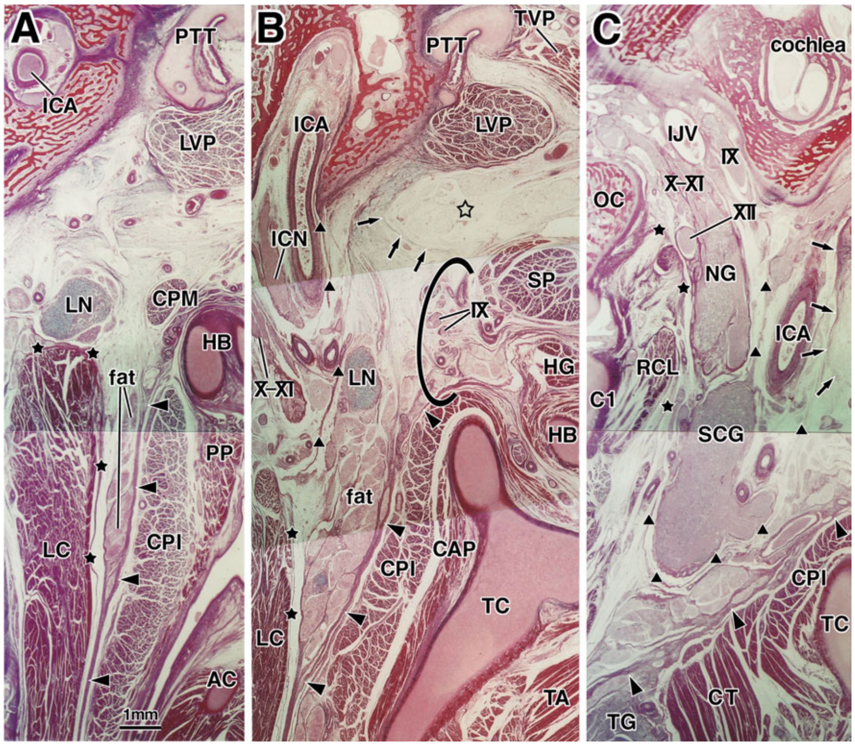

Fig. 3.

specimens and sites. Because less is known about the suprahyoid cervical fasciae, we have examined fetal topohistology along and around the suprahyoid parapharyngeal space. To determine the morphology most similar to that of adults, late fetal specimens were assessed.

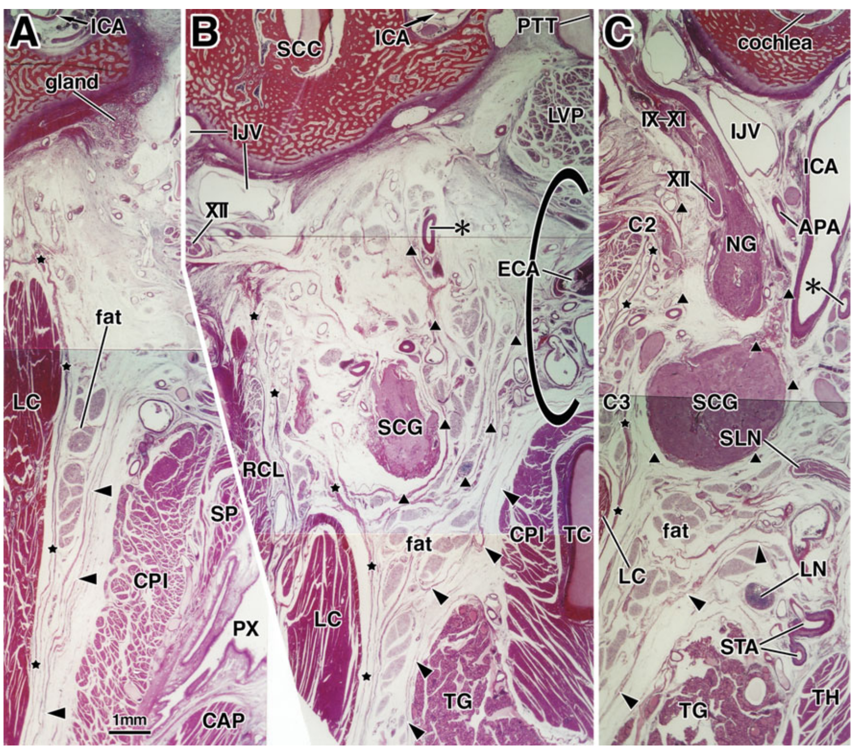

Fig. 4.

MATERIALS AND METHODS

We examined paraffin-embedded sections of 15 late stage fetuses (28–37 weeks of gestation; crown-rump length, 220–320 mm). Three of these heads had been prepared for horizontal sections and the other 12 for sagittal sections. All specimens were part of the large collection maintained at the Embryology Institute of the Universidad Complutense, Madrid, and were the products of urgent abortion, miscarriages, or ectopic pregnancies managed at the Department of Obstetrics of the University. The donated fetuses were fixed in 10% v/v formalin solution and stocked in the same solution for more than 3 months. After trimming of the tissue mass, the left or right side of each head was decalcified in 5% v/v nitric acid. The study protocol was approved by the ethics committee of the university. The study was performed in accordance with the provisions of the Declaration of Helsinki 1995 (as revised in Edinburgh 2000).

In each section, we sought to include large areas from the pharynx (medial) to the sternocleidomastoideus muscle (lateral), from the middle ear and occipital condyle (superior) to the thyroid cartilage (inferior), and from the medial pterygoid muscle (anterior) to the vertebrae (posterior). The pharyngotympanic tube was also included in this area. For sagittal sections, we prepared 100–150 sections, each of thickness 10 μm and at intervals of 0.5 mm from one side of each head after bisection. The horizontal sections were prepared at intervals of 1.0 mm. Most sections were stained with hematoxylin and eosin, while some were subjected to silver impregnation or Masson Trichrome staining. Identification of fetal structures around the Meckel and Reichert cartilages was based on our recent observations (Rodríguez-Vázquez et al., 1992, 2006, 2011a,b; Katori et al., 2011a,b) of the areas overlapping with those of the present study.

RESULTS

Horizontal Sections

Horizontal sections were examined in the superoinferior levels between the hyoid bone and the inferior opening of the carotid canal in the temporal bone. When the sectional plane was slightly tilted, the carotid canal opening and the jugular foramen were observed behind the external auditory meatus or the middle ear. Thus, the most superior part of the carotid sheath was isolated from the visceral and prevertebral fasciae. Sagittal sections (see below) were more useful than horizontal sections for identifying the most superior carotid sheath. In contrast, communications between the visceral fascia and the neurovascular sheath were easily identified in horizontal sections.

Even at the level of the hyoid bone, the carotid \sheath does not enclose the entire internal carotid artery, internal jugular vein, and vagus nerve but was evident around the artery and nerve. The common, internal, and external carotid arteries were surrounded by thick adventitial tissue, in contrast to the internal jugular vein and its thick tributaries. The superior cervical ganglion was also enclosed by the sheath (Fig. 1). The carotid sheath extended superomedially along the external carotid artery and its branches (Figs. 1 and 2). Likewise, the sheath extended medially along the glossopharyngeal and hypoglossal nerves (Fig. 2) and laterally along the accessory nerve. Thus, although they were fragmented, multiple neurovascular sheaths were continuous with the carotid sheath.

The medially extending neurovascular sheaths were attached to and joined a fascia covering each of the three muscles (i.e., the styloglossus, stylopharyngeus, and stylohyoideus muscles) attached to the primitive styloid process or Reichert cartilage. The neurovascular sheaths also approached or attached to the visceral fascia covering the pharynx

Fig. 3. Sagittal sections of a 30-week-old fetus. The left-hand side of the figure corresponds to the posterior side of the head and neck. Panel **A** (or **C**) is the most medial (or lateral) side of the figure. The intervals between panels are 8 mm for panels A and **B** and 5 mm for panels B and C. A visceral or pharyngeal fascia (arrowheads) is separated by the fatty tissue from the prevertebral fascia (black stars). However, at the lower site, the visceral fascia is fused with the prevertebral fascia. Neurovascular sheaths (black triangles) are evident along the superior cervical ganglion (SCG) and the nodosa ganglion (NG). On the anterior side of the internal carotid artery (ICA) and the lower cranial nerves (IX–XII), a definite fascia (prestyloid space posterior fascia, arrows) extends almost horizontally along the stylopharyngeus muscle (SP). Note the tensor veli palatini (TVP) muscle distant from the posterior fascia (panel B). The fascia separates loose mesenchymal tissue (the prestyloid space; open star in panel B) from the great vessels and lower cranial nerves. A connection between the visceral fascia and neurovascular sheaths (thick semicircle in panel B) is located on the inferior side of the prestyloid space. All panels were prepared at the same magnification (scale bar in panel A). AC, arytenoids cartilage; CAP, cricoarytenoideus posterior muscle; TA, thyroarytenoideus muscle.

Fig. 4. Sagittal sections of a 33-week-old fetus. The left-hand side of the figure corresponds to the posterior side of the head and neck. Panel **A** (or **C**) is the most medial (or lateral) side of the figure. Intervals between panels are 10 mm for panels A and **B** and 7 mm for panels B and C. The pharyngeal fascia (arrowheads) is separated by the fatty tissue from the prevertebral fascia (black stars). Between these two fasciae (panel B), another fascia is observed running across the fatty tissue to the joint neurovascular sheaths (black triangles). The sheath is not evident even along the ganglia (SCG, NG). A connection between the visceral fascia and neurovascular sheaths is indicated by a thick semicircle in panel B. All panels were prepared at the same magnification (scale bar in panel A). CAP, cricoarytenoideus posterior muscle; SCC, semicircular canal of the inner ear.

(i.e., the pharyngeal fascia). Conversely, the pharyngeal fascia issued abundant branches to join the neurovascular sheaths along the facial and lingual arteries, along the stylohyoideus and digastric muscles and along branches of the vagus and glossopharyngeal nerves. In particular, at sites in which the styloglossus and stylopharyngeus muscles penetrated or inserted into the pharyngeal wall, the pharyngeal fascia issued a distinct branch extending anterolaterally along the anterior aspects of these two muscles (Fig. 1B and 1C). Because of these multiple fascial communications between the visceral fascia and carotid sheath, a mesentery-like bundle was formed almost along the mediolateral axis (Fig. 1B and 1C). However, when the longus capitis muscle became thicker and protruded more anteriorly in the superior level, the mesentery-like connection became narrower (Fig. 2). The anterior margin of the mesentery-like bundle corresponded to the posterior margin of a large space filled with loose mesenchymal tissues, that is, the prestyloid space. Thus, the posterior marginal fascia of the prestyloid space provided the anterior margin of the suprahyoid neurovascular bundle. It was not connected with the ''tensor'' veli palatini muscle but with the ''levator'' veli palatini muscle (Figs. 1B and 2B). The prestyloid space extended anteriorly to the medial pterygoid muscle, but the fascia covering this muscle could not be determined.

At the level of the hyoid bone, the pretracheal lamina of the deep cervical fascia was not seen in front of the great vessels. Rather, the visceral fascia as well as the carotid sheath issued thin fasciae to the subcutaneous tissue (Fig. 1A). The posterior aspect of the pharyngeal fascia was evident along the constrictor pharyngis muscles (Fig. 1A and 1B). The carotid sheath was easily distinguished from the prevertebral lamina of the deep cervical fascia at any level although, sometimes, they were fused. For simplicity, we will use the term ''prevertebral fascia.'' This fascia covered the anterior aspect of the rectus capitis lateralis, longus capitis, and longus colli muscles. Because the longus capitis muscle showed significant anterior protrusion, in contrast to the flat surfaces of the other two muscles, the prevertebral fascia issued a thick branch into the space between the longus colli and capitis muscles or between the longus capitis and rectus capitis muscles (Figs. 1B and 2B).

Sagittal Sections

The suprahyoid neck was short along the superoinferior axis, possibly because of the short supero-inferior length of the occipitovertebral junction: the length of the corresponding junction area was shorter than that of the larynx. The hyoid body was located at the levels of the occipital condyle and atlas, whereas the thyroid cartilage was located at the levels of the atlas and axis (Figs. 3 and 4). The bifurcation of the common carotid artery was at the level of the atlas. Thus, the jugular foramen and the hypoglossal canal were located on the posterolateral side of the greater horns of the hyoid bone or the oropharynx.

The lower cranial nerves first ran together anteriorly, changing directions in the parapharyngeal space; that is, the vagus nerve ran inferiorly, the glossopharyngeal and hypoglossal nerves anteroinferiorly, and accessory nerve laterally. Thus, the upper continuation of the carotid sheath was penetrated by these nerves (Figs. 3B and 4C). In contrast, the internal carotid artery, as a continuation of the common carotid artery, took an almost straight course to the temporal bone. A neurovascular sheath was more evident along the internal carotid artery and nerve near the temporal bone than along the internal jugular vein and lower cranial nerves near the jugular foramen.

The posterior marginal fascia of the prestyloid space was located on the anterosuperior side of the great vessels and lower cranial nerves (Fig. 3B). Although the external carotid artery and glossopharyngeal nerve approached the posterior fascia, they did not penetrate it but ran alongside its posterior and lateral aspects. A mesentery-like fascial connection between the carotid sheath and pharyngeal fascia appeared as a thinner bundle than in horizontal sections (Figs. 3B and 4B). The posterior fascia of the prestyloid space corresponded to the superior margin of the mesentery-like fascial connection, although it was identified as the ''anterior'' margin in horizontal sections. The fascia approached the covering fascia of the levator veli palatini muscle (not the ''tensor'' veli), with both fusing when the medial site of the prestyloid space became too small or thin (Figs. 3A and 4B). The tensor veli palatini muscle was separated from the posterior fascia of the prestyloid space by a mass of the levator veli palatini muscle (Fig. 3B).

The prevertebral fascia covered the anterior aspects of the longus capitis, longus colli, and rectus capitis lateralis muscles, but it was more evident along the anterior surface of the longus colli than along the longus capitis. The fascia became thicker along the upper part of the longus capitis (Figs. 3A and 4A) or near the pharyngobasilar membrane (not shown). The pharyngeal and prevertebral fasciae were separated by fatty tissue, although the amount of the latter varied among specimens. The pharyngeal and prevertebral fasciae were fused in 3 of the 15 specimens at the lower site behind the thyroid cartilage (Fig. 3). In sagittal sections, the lateral margin of the carotid sheath covered the nodosa and superior cervical ganglia, and it attached to or joined both the prevertebral and pharyngeal fasciae (Figs. 3C, 4B, and 4C).

DISCUSSION

We have histologically evaluated the fascial configuration in and around the suprahyoid parapharyngeal space. Because the hyoid body in adults is located at the levels of the third and fourth cervical vertebrae (Standring, 2005), the difference in the length of the suprahyoid neck in adults and fetuses corresponded to the lengths of three to four vertebrae. Because of the densely packed structures, the short neck emphasized the mediolateral fascial connections between the carotid sheath and the visceral or pharyngeal fascia. The posterior marginal fascia of the prestyloid space (i.e., the anterior compartment of the parapharyngeal space) corresponded to the anterior margin of the mediolateral fascial connections. However, the short neck may underestimate interruptions of the superior extension of the carotid sheath by the lower cranial nerves as well as by branches of the external carotid artery. Actually, we failed to demonstrate a circular fascial configuration surrounding the entirety of the internal carotid artery, internal jugular vein, and lower cranial nerves. Conversely, to our knowledge, this study was the first to demonstrate a mesentery-like neurovascular bundle between the carotid sheath and pharynx. Thus, similar to ''subperitoneal neurovascular bundles'' (mesentery-like bundles enclosed by a visceral fascia), such as the mesorectum (Standring, 2005; Mirilas and Skandalakis, 2010), the lateral ligament of the rectum (Kinugasa et al., 2007), and the neurovascular bundle in the urologic system of males (Takenaka et al., 2004), this concept can be applied to the overall connections between the upper pharynx and carotid sheath. Figure 5 shows a schematic representation of the mesentery-like bundle for the pharynx and its topographical relationship to the posterior marginal fascia of the prestyloid space.

Notably, we found that the fascia covering the ''levator,'' not the ''tensor,'' veli palatini muscle was continuous with the inferior and posterior marginal fasciae of the prestyloid space (i.e., the anterior compartment of the parapharyngeal space). Instead, the tensor veli palatini muscle is likely to contribute to the formation of the ''anterior'' border of the prestyloid space because of its location adjacent to the medial pterygoid muscle. Moreover, the tensor veli palatini fascia likely joins the pharyngeal or visceral fascia when the muscle attaches to the constrictor pharyngis superior muscle near the pterygoid hamulus. However, our findings conflict with those showing that a fascia of the ''tensor'' veli palatini muscle divides the parapharyngeal space into anterior and posterior compartments (Curtin, 1987; Shin et al., 2001). The ''tensor veli palatini fascia'' has been reported to divide the upper part of the prestyloid space into an anterolateral compartment containing fat and a deep part of the parotid gland and a posteromedial compartment containing the cartilaginous part of the Eustachian tube, internal carotid artery, internal jugular vein, and lower cranial nerves (Maheshwar et al., 2004), a finding that differs from ours. We found that the border between these compartments was not the tensor veli palatini fascia but a distinct fascia originating from a fascia covering the levator veli palatini muscle, extending along the anterior aspects of the styloglossus and stylopharyngeus muscles and joining the pharyngeal fascia, thus corresponding to an anterosuperior margin of the mesentery-like neurovascular bundle between the carotid sheath and upper pharynx.

A basic factor for the development of fascial structures consists of mechanical stress to bundle collagen fibers, irrespective of whether or not the fascia is a remnant of a transiently appearing structure during fetal development (Hayes, 1950). Similarly, the early developing longus colli muscle creates traction on the prevertebral fascia, whereas the anteriorly protruding longus capitis muscle disturbs the prevertebral fascial configuration (Miyake et al., 2010). Thus, along the longus capitis muscle, the fatty tissue was likely to separate the prevertebral from the visceral fascia as well as to push the mesentery-like neurovascular bundle to narrow its uppermost part. In contrast, our findings suggested that the styloglossus and stylopharyngeus muscles contributed to the formation of a distinct marginal fascia of the prestyloid space (or a septum between the anterior and posterior compartments of the parapharyngeal space). This posterior fascia was not found during early stages of

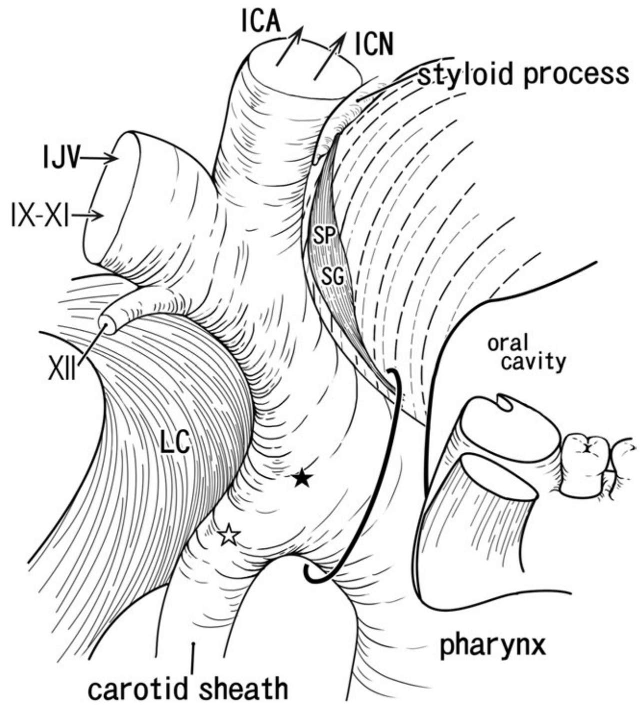

Fig. 5. Schematic representation of the suprahyoid fascial configuration. The neurovascular sheaths for (1) the internal carotid artery (ICA) and nerve (ICN) to the carotid canal of the temporal bone; (2) the internal jugular vein (IJV), glossopharyngeal nerve, vagus nerve, and accessory nerve (IX–XI) to and from the jugular foramen; (3) the hypoglossal nerve (XII), and (4) a mesentery-like band to the upper pharynx (indicated by a semicircle) meet the carotid sheath behind the mandibular angle. Because of the anterior protrusion, the longus capitis (LC) muscle narrows the meeting site. The styloglossus (SG) and stylopharyngeus (SP) muscles extend along the anterior margin of the mesentery-like band. A distinct fascia (the posterior marginal fascia of the prestyloid fat or space, dotted lines) joins the anterior aspect of the neurovascular sheath complex. The bifurcation of the carotid artery is located in a lower level (open star) in fetuses, but it seems to be in the meeting site of the neurovascular sheath (black star) in adults.

TABLE 1. Correspondence of Layers Between Terms for Head and Neck Fasciae

Classical terms in the neck (deep to superficial)	Recent terms in the head
Preverterbral lamina, continues to the head	Prestyloid space-related fasciae[a]
Visceral or pharyngeal fascia, continues to the head	
Carotid sheath, continues to the head	Mesentery-like bundle[b]
Pretracheal lamina, ends at the hyoid or mandible	(Partly, masticatory muscle layer)
Superficial lamina, ends at the mandible	(Subcutaneous layer of the face)

[a]The posterior marginal fascia of the prestyloid compartment (defined in the present study): tensor palatine fascia (Curtin, 1987); tensor-vascular-styloid fascia (Shin et al., 2001).
[b]The mesentery-like bundle or band communicating between the pharyngeal fascia and the carotid sheath: It is postulated in the present study as an analogy of fasciae around the pelvic viscera.

development, during which Reichert cartilage develops as two independent segments (Rodríguez-Vázquez et al., 2006). Thus, the fascia is unlikely to be a remnant of the embryological structure, such as a missing intermediate segment of the Reichert cartilage.

The schematic representations of Perlemuter and Waligora (1971) showed the muscle sheath connecting the styloid process and pharynx. This sheath, in association with (1) the parotid gland capsule, (2) the visceral or pharyngeal fascia, and (3) the medial pterygoid muscle fascia, formed a quadrangular space containing the glossopharyngeal nerve course and the palatine tonsil. However, the sheaths of the styloglossus and stylopharyngeus muscles may not be continuous with the sheath on the posterior belly of the digastric muscle, because the stylohyoideus also originates from the styloid process. However, the digastric and stylohyoideus muscles were separated from the posterior marginal fascia of the prestyloid space. The developmental process of the digastric and stylohyoideus muscles is quite different from that of the styloglossus and stylopharyngeus muscles (Katori et al., 2011b). Moreover, the posterior marginal fascia of the prestyloid space extended along the anterior aspect of the latter two muscles, but did not include the entire muscle sheath. Thus, rather than mechanical stress from the contraction of the styloglossus and stylopharyngeus muscles, the fatty tissue behind the medial pterygoid muscle provided the prestyloid space, possibly in association with the posteriorly expanding pterygoid muscle, a process similar to the formation of the renal fascia, which requires increased mass of the kidney (Matsubara et al., 2009). Consequently, the space or content seems to develop first and the fascia second. In fact, the prestyloid space has been shown to be a distinct mass of fatty tissue (reviewed by Wolfram-Gabel et al., 1997).

Finally, we found that the carotid sheath and visceral fascia appeared to issue fascial branches toward the subcutaneous tissue at the level of the hyoid bone. Because of the absence of the omohyoideus muscle, which supports the pretracheal lamina of the deep cervical fascia, there is no surface covering the front of the carotid sheath. Conversely, the mandible, submandibular gland, and sternocleidomastoideus muscle cover the deep structures at more superior levels. Thus, the deep fasciae seem to communicate with skin ligaments at the carotid triangle or trigonum caroticum. We tried to prepare a table for comparison between the classical terms and new terms described in this study. However, any of classically defined neck fasciae (the prevertebral, pretracheal, and superficial laminae) do not exactly correspond to the new terms such as the mesentery-like bundle and the posterior marginal fascia of the prestyloid compartment. Thus, depending on the layers or depth of the fascial structure, we arranged each of the new terms (Table 1).

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