The Anatomy of the Fasciae of the Face and Neck with Particular Reference to the Spread and Treatment of Intraoral Infections (Ludwig's) that Have Progressed into Adjacent Fascial Spaces

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Descriptions of the fasciae of the lower half of the face and of the adjacent cervical fasciae have long been puzzling and descriptively much too complex. For this reason, medical students, young medical and dental practitioners, and at times even senior surgeons frequently do not understand the anatomy of the cervicofacial fasciae, which plays such an important role in the spread and subsequent final localization of primary intraoral infections. This article attempts to simplify the descriptions of these fasciae, in particular, their sites of origin and insertion.

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COLLIER AND YGLESIAS,[1] Grodinsky and Holyoke,[2] Grodinsky,[3] Levitt,[4] and others have added to our knowledge of this region.

According to Levitt:[4]

> The confusion in the descriptions of the cervical fascia is due to two major reasons: (1) great difficulties exist in the anatomical dissection of the fascial spaces since false spaces are crested and true spaces are obliterated: (2) artificial grouping and classification of spaces for descriptive purposes is difficult and greatly reflects the emphasis of the author. Both pure anatomists and surgically oriented clinicians have described these fasciae from their own points of view, each one stressing what he feels to be important from the level of his particular interests, thus creating different opinions on the subject.

Certainly, a simplified and accurate knowledge of the facial and cervical fasciae is of great importance in the proper understanding of the treatment of cervical infections. This is true because it is the facial and cervical fasciae that both direct and limit the spread of such infections.

The fasciae of the neck are grossly divided into two separate layers: the superficial fascia and the deep fascia. The superficial fascia is actually a component of the fatty subcutaneous tissue. The more complicated deep fascia is divided into three primary layers: investing fascia, visceral fascia, and prevertebral and paravertebral fascia. These three layers envelop those structures of the neck that lie deep to the potential superficial space that lies deep to the superficial fascia but superficial to the superficial layer of the deep fascia.

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Superficial Fascia

The superficial fascia of the head and the neck is a sheet of fatty subcutaneous tissue that clothes the head and neck and descends to the thorax, the shoulders, and the axilla. As it covers the anterior and lateral segments of the neck, it is thinner and less well marked than on the face.

Over the posterior segments of the neck the superficial fascia is thick and fibrous and is adherent to the deep fascia. Over the anterior and lateral surfaces of the neck it is a relatively loose fascial layer and contains a variable amount of fat, which is greater in children and women, giving the neck a more rounded and less angular appearance. The superficial fascia that covers the face and head is very thick, and as it covers the muscles of expression of the lower and middle regions of the face it is tightly attached to the underlying muscular structures. However, at the level of the eyelids, the fascia is loosely attached around the orbicularis oculi muscles.

Over the lower region of the face, the anteriolateral surfaces of the neck, and the superior anterior thorax, the superficial fascia splits to enclose the platysma muscle, which thus becomes an integral part of this fascia. The platysma varies in thickness from 1–4 mm, usually being thicker and more developed in men than in women. The platysma muscle arises from the fascia covering the superior portions of the pectoralis major and deltoid muscles. Its fibers run superiorly, cross the clavicle, and cover the anterolateral region of the neck. The fibers continue

to run superiorly and cross the mandible, with some fibers inserting into this bone during their ascent. Other fibers insert into the skin and subcutaneous tissues of the lower part of the face, whereas others blend with the muscles about the angle and lower segment of the mouth. Occasionally some fibers insert about the zygomatic and the orbicularis oculi muscles. The platysma is supplied by the cervical branch of the facial nerve. The platysma is often called "the surgeon's friend," since a good closure of this muscle after neck surgery prevents the skin and subcutaneous tissues from attaching to the mobile visceral structures lying deep to the superficial layer of the deep neck fascia, preventing the unsightliness of a "mobile scar."

Deep to the superficial cervical fascia and its enclosed platysma muscle lies a well-defined potential fascial cleft or space that separates the superficial fascia from the deep cervical fascia. This space allows free movement of the skin and superficial fascia on the deeper structures of the anterolateral neck, and it also serves as an excellent cleavage plane during dissection in this area. Within this potential space lie a number of important cervical structures. Running vertically, inferior to the lateral segment of the space, is the descending cervical branch of the facial nerve, which innervates the platysma muscle. It is placed far enough laterally so that it seldom is injured in neck surgery. The mandibular branch of the facial nerve also lies in the superficial fascial cleft. It descends into the upper lateral region of the neck from a plane deep to the stylomandibular ligament, descends to about 1–1.5 cm below the level of the inferior border of the transverse ramus of the mandible, and then moves anteriorly, paralleling the ramus while lying inferior to it. The nerve leaves the neck at the level of the anterior border of the masseter muscle, crosses the body of the mandible, and runs to the lateral commissure of the mouth. The cervical course of the nerve lies in the pathway of most suprahyoid incisions, and it must be identified and reflected along with the overlying skin and subcutaneous tissue flap when transverse suprahyoid incisions are made. Also lying within the subcutaneous fascial cleft are the three supraclavicular nerves: anterior supraclavicular nerve, mid supraclavicular nerve, and posterior supraclavicular nerve. They supply cutaneous sensation to the shawl area of the shoulder and must be searched for when incisions are made in the neck just above the lateral third of the clavicle.

The submental area, placid, inferior to the symphysis menti and superior to the body of the hyoid bone, contains a plexus of small venules that lie between the superficial fascia and the superficial layer of the deep fascia. At the level of the upper border of the hyoid bone these veins coalesce to form the right and left anterior jugular veins that run inferiorly in the subcutaneous cleft as far as the level of the midportion of the thyroid cartilage, at which point they leave the subcutaneous cleft by piercing the superficial layer of the deep cervical fascia. The external jugular vein that forms just inferior to the inferior border of the parotid gland at the level of the angle of the jaw, runs obliquely inferior in the neck in the subcutaneous cleft. The vein is formed by the junction of the posterior branch of the posterior facial vein with the posterior auricular vein and several small retromandibular veins. In its inferior course, the external jugular vein crosses the body of the sternocleidomastoid muscle in an oblique fashion in a medial to lateral direction. It leaves the cleft by perforating the superficial layer of the deep cervical fascia just superior to the middle third of the clavicle and ends in the subclavian vein just lateral to the anterior scalene muscle. As the external jugular vein lies on the sternocleidomastoid muscle it is separated from the muscle by the investing layer of the deep cervical fascia. The transversely placed anterior cutaneous nerve of the neck also lies in the subcutaneous fascial cleft and runs transversly in the midneck. There are a few relatively unimportant lymph nodes that also lie within the superficial fascial cleft.

The Deep Cervical Fascia

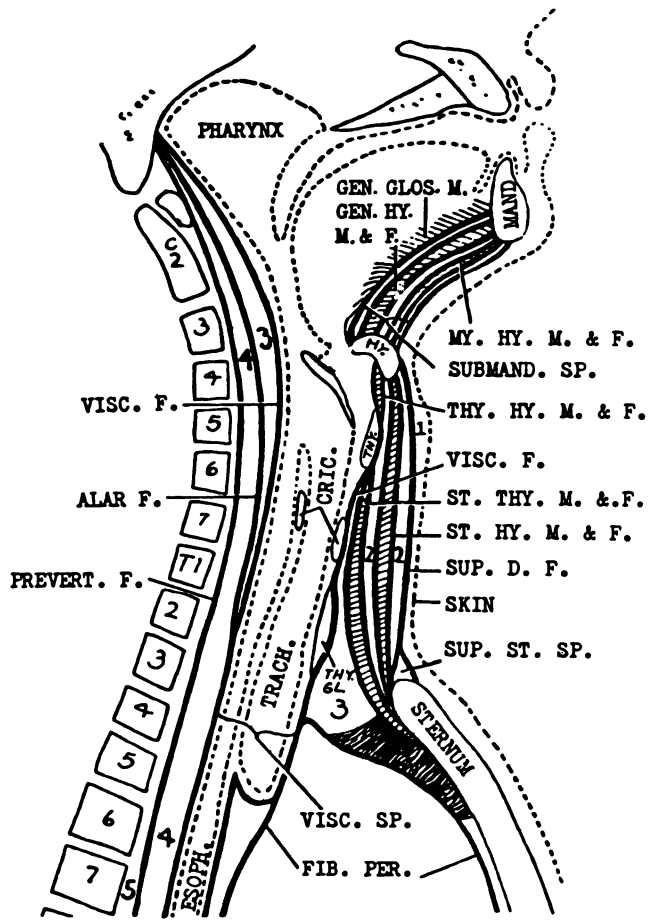
For purposes of description the deep cervical fascia may be divided into three major categories: (1) the superficial layer of the deep fascia or the investing layer, (2) the middle or visceral fascia, and (3) the deep or prevertebral and paravertebral fascia. Because the neck is essentially a junctional area between the head and the thorax, the three divisions of the deep cervical fascia join in the formation of various spaces and fascial clefts, some of which lead from the neck to the neighboring oral cavity and parotid gland to the axilla. A knowledge of these associations between the cervical spaces *per se* and the head and axillary spatial areas is of great importance in order to properly anticipate and treat the spread of cervical infections by surgical means.

The Investing Fascia of the Neck

The investing fascia of the neck (superficial layer of the deep cervical fascia) is really the "mother" of the cervical fasciae, since all of the major deep cervical fasciae develop as septa from it (Figs. 1–3).[7] It is a well-defined fascial layer that completely surrounds the neck and extends superiorly onto the face and inferiorly into the axilla. In its dorsal to ventral course it invests the sternocleidomastoid muscle, the trapezius muscle, and the cervical group of erector muscles of the spine as well as the submandibular and parotid salivary glands.

The investing fascia is attached posteriorly to the spinous processes of all of the cervical vertebrae. The investing fascia begins its lateral and anterior progress as a single sheath, from which a group of septa depart to sheath

FIG. 1. Fasciae of head and neck in midsagittal section. (From Grodinsky M. Ludwig's angina, retropharyngeal abscess and other deep abscesses of the head and neck. JAMA 1940; 114:18–22.) **Key to Figures 1–3.** ALAR F., alara fascia; AX. SP., axillary space; ARYT, arytenoid cartilage; A. AOR., ascending aorta; BR. PL., brachial plexus; CLVA, clavicle; CORAC., coracoid process; CRIC., cricoid cartilage; C.C.A., common carotid artery; CONST. PHAR. SUP. M., superior pharyngeal constrictor muscle; D. D. PECT. F., deep layer of deep pectoral fascia; DELT. M., deltoid muscle; DIG. ANT. M., digastric muscle, anterior belly; DIG. POST M., digastric muscle, posterior belly; E.C.A., external carotid artery; E. MAX. A., external maxillary artery; EPIGL., epiglottis; ESOPH., esophagus; EUST. TUBE, eustachian tube; GEN. GLOS. M., genioglossus muscle; GEN. HY. M., geniohyoid muscle; GLOT., glottis; HY., hyoid bone; HY. GLOS. M., hypoglossus muscle; I.C.A., internal carotid artery; I.J.V., internal jugular vein; LEV. VEL. PAL. M., levator veli palatini muscle; LAT. PHARYNG. SP., lateral pharyngeal space; L.A., lingual artery; L.N., lingual nerve; MAND., mandible; MASTIC. SP., masticator space; MAST. PROC., mastoid process; MAX. S., maxillary sinus; MY. HY. M., mylohyoid muscle; OCCIP. BONE, occipital bone; OM. HY. M., omohyoid muscle; PAROT. GL., parotid gland; PECT. MAJ. M., pectoralis major muscle; P.F.V., posterior facial vein; PREVET. F., prevertebral fascia; PT. INT. M., internal pterygoid muscle; PT. EXT. M., external pterygoid muscle; PHR. N., phrenic nerve; SCAL. F., scalenus fascia; SCAL. ANT. M., scalenus anterior muscle; SCAL. MED. M., scalenus medius muscle; SCAL. POST. M., scalenus posterior muscle; ST., sternum; SCAP., scapula; SUP. D. F., superficial layer of deep fascia; SUP. D. PECT. F., superficial layer of deep pectoral fascia; SUBMAND. SP., submandibular space; SUP. ST. SP., suprasternal space; SUBMAX. GL., submaxillary gland; ST. CL. M., sternocleidomastoid muscle; ST. HY. M., sternohyoid muscle; ST. THY. M., sternothyroid muscle; STY. HY. M., stylohyoid muscle; STY. GLOS. M., styloglossus muscle; STY PHAR. M., stylopharyngeus muscle; SUBCLAV. M., subclavius muscle; SYM., sympathetic trunk; TEMP. M., temporalis muscle; THY., thyroid cartilage; THY. GL., thyroid gland; TRACH., trachea; TEN. VEL. PAL. M., tensor veli palatini muscle; TRAP. M., trapezius muscle; THY. HY. M., thyrohyoid muscle; VISC. F., visceral fascia; VISC. SP., visceral space; V. N., vagus nerve; ZYG., zygoma.



the underlying trapezius muscle and cervical erector muscles of the spine. The investing fascia reaches the anterior border of the trapezius muscle as a single lamella. At this point a septum joins with another septum from the contralateral side and forms the prevertebral fascia. The investing fascia then continues on a ventral and lateral course, and crosses the supraclavicular triangle as a single fascial layer. At the posterior border of the sternocleidomastoid muscle the investing fascia splits and sheathes this muscle, and then at the anterior border of the sternocleidomastoid muscle it becomes a single layer of fascia that joins the investing fascia of the contralateral side of the neck in the midline of the cervical area of the neck.

The investing fascia attaches superiorly and inferiorly as it covers the anterolateral areas of the neck and face. In the anterior region of the midline of the neck, the investing fascia runs superiorly from its attachment to the hyoid bone to insert into the symphysis menti and the medial segment of the inferior border of the transverse ramus of the mandible. In so doing, the fascia roofs the submental division of the suprahyoid area. As the fascia covers the anterior bellies of the digastric muscles it becomes attached to their sheaths. As a result of the attachments of the investing fascia to the superior border of the hyoid bone, to the inferior border of the transverse ramus of the mandible, to the symphysis menti, and to the anterior sheaths of the digastric muscles, a closed submental space is formed. Collections of blood, pus, and/or serous fluid in this space are trapped and may only with great difficulty pass laterally beneath the anterior belly of the digastric muscle that is tightly applied to the underlying mylohyoid muscle. This lateral pathway is the only escape route for a submental collection of fluid to reach the more lateral reaches of the suprahyoid area, which has a direct connection with the floor of the mouth.

Lateral to the anterior belly of the digastric muscle, the investing fascia roofs the submandibular area in a complex fashion. The investing fascia is tightly connected inferiorly to the greater cornu of the hyoid bone. The fascia is connected superiorly to the lateral two thirds of the inferior border of the transverse ramus of the mandible. As the investing fascia runs laterally after its attachment to the anterior belly of the digastric muscle it splits to enclose the submandibular salivary gland, an occupant of the submandibular space that lies on the underlying hyoglossus muscle. The enclosing fascial sheath is separated from the true capsule of the gland by a fascial cleft. The deep portion of the sheath after investing the submandibular

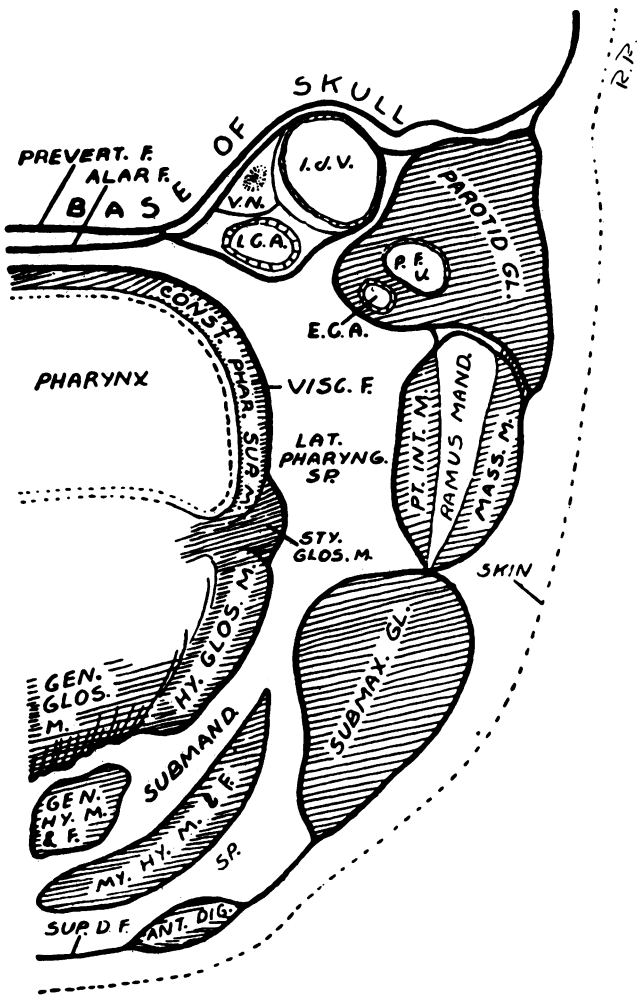


FIG. 2. Fasciae of head and neck. Oblique anteroposterior section showing the relation of the submandibular space to the lateral pharyngeal space. (Adapted from Grodinsky M. Ludwig's angina, retropharyngeal abscess and other deep abscesses of the head and neck. JAMA 1940; 114:18–22.) (see Key beneath Fig. 1).

gland joins the sheaths of the underlying stylohyoid muscle and posterior digastric muscle to form a fascial ligament that runs from the angle of the mandible to the styloid process of the temporal bone. The lower pole of the parotid gland rests on this ligament, called the stylomandibular ligament, which separates the gland from the most lateral segment of the submandibular area.

The two divisions of the investing fascia that have split to enclose the submandibular gland join again at the lateral border of the gland and run laterally a short distance further to the region of the angle of the mandible, where they split again to form the superficial and deep capsules of the parotid gland. The superficial layer of the fascial parotid capsule is called the parotideomasseteric fascia, and is tough and thick and closely attached to the superficial substance of the parotid. It terminates superiorly by attaching to the anterior border of the zygomatic arch. The deep layer of fascia is quite thin and is only loosely attached to the deep surface of the gland. It terminates along the posterior border of the zygomatic arch. After sheathing the parotid gland, the two layers of the superior segment of the investing fascia join again and continue laterally as a very strong fascia that splits to enclose the sternocleidomastoid muscle before attaching to the external auditory meatus and the mastoid process of the temporal bone. At this point the two layers become continuous with the investing layer of fascia covering the dorsal surface of the neck.

The infrahyoid segment of the investing fascia is of interest because it splits in the inferior anterior neck into a superficial layer and a deep layer. In the anterior region of the midline of the neck the investing fascia is attached superiorly to the inferior surface of the body of the hyoid bone. It then descends as a single layer as far as the junction of the upper- and midthird of the thyroid cartilage. At this level, the investing fascia splits into a superficial layer and a deep layer, the layers corresponding in position to the superficial and deep layers of the investing fascia as they split to enclose the sternocleidomastoid muscle. The split gradually widens in a ventral-dorsal direction as the fascia descends, so that when it terminates at the base of the neck the superficial layer is able to insert into the anterior superior surface of the sternum and the anterior border of the clavicle, whereas the deep layer ter-

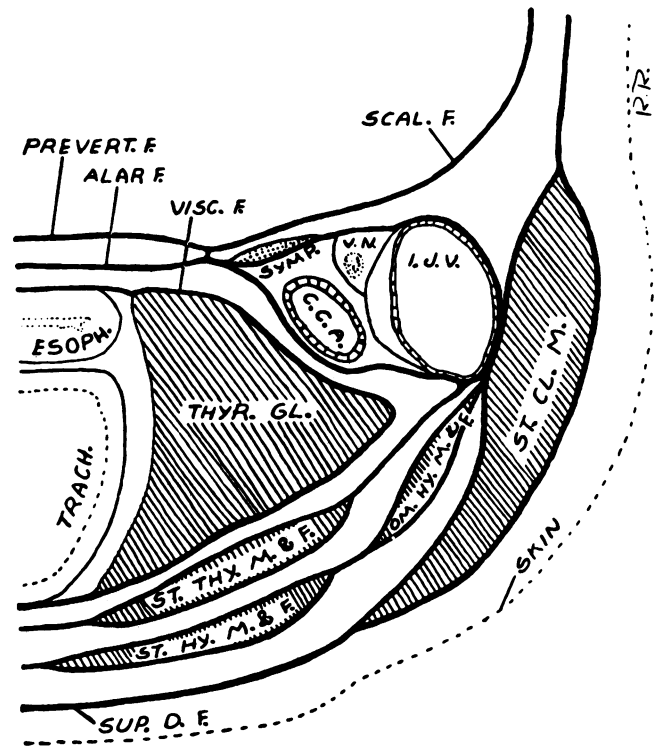


FIG. 3. Fasciae of the neck. Transverse section approximately at the level of the sixth cervical vertebrae. (Adapted from Grodinsky M. Ludwig's angina, retropharyngeal abscess and other deep abscesses of the head and neck. JAMA 1940; 114:18–22.) (see Key beneath Fig. 1).

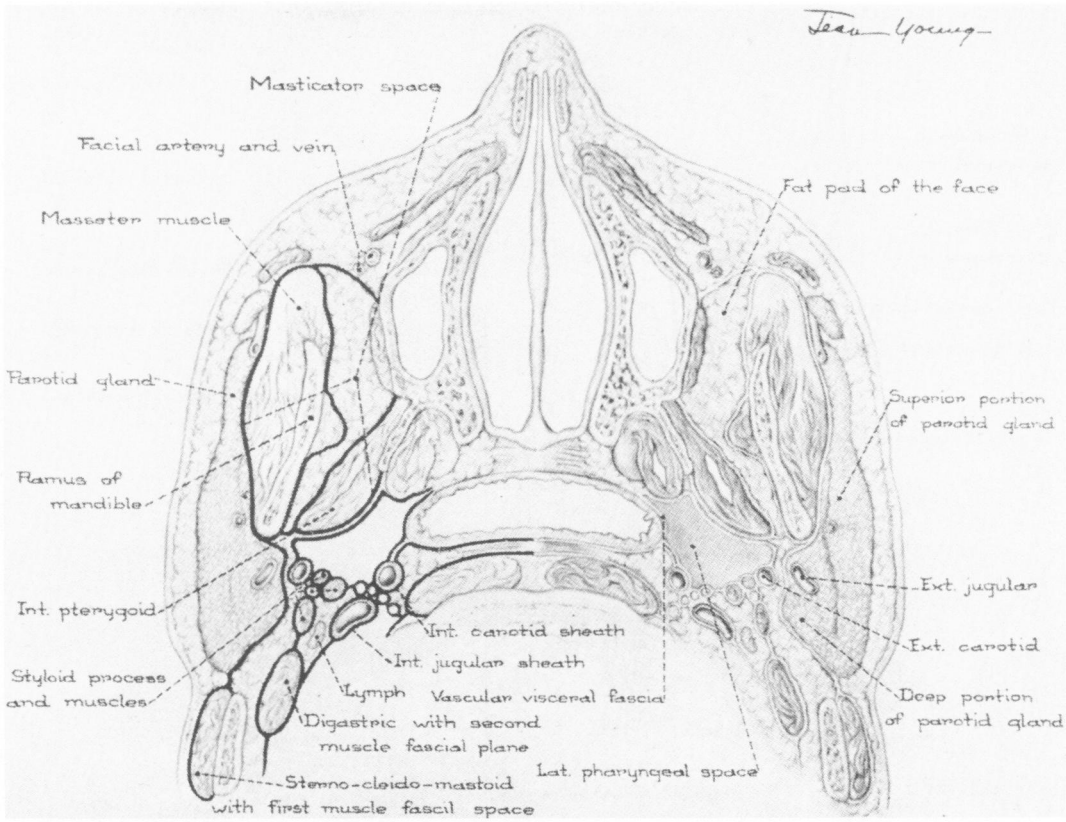


FIG. 4. Horizontal plane of the fasciae of the head and neck and potential anatomical spaces.

minates by inserting into the posterior superior border of the sternum and the posterior border of the clavicle.

The two anterior jugular veins that have descended into the subcutaneous cleft superficial to the investing fascia suddenly pierce the superficial layer of the split investing fascia and come to lie in the space between the superficial and deep layers of this fascia. The two anterior jugular veins connect across the midline of the neck about 2 cm above the sternum.

At the lateral region where the investing fascia covers the supraclavicular triangle of the neck it again appears as a single layer that is so closely applied to the underlying prevertebral fascia that these two fasciae appear to be one.

The Middle or Visceral Fascia

The middle or visceral fascia, often erroneously called the pretracheal fascia, sheathes the viscera of the neck, all of which lie deep to the investing fascia and superficial to the deep or prevertebral fascia (Figs. 1–3). The cervical viscera include the pharynx, esophagus, larynx, trachea, thyroid, parathyroid glands, and the great vessels of the neck. Additionally, the visceral fascia sheathes those strap muscles that are attached to the hyoid bone and the thyroid cartilage.

The middle fascia is derived from the investing fascia, and is given off as the investing fascia that covers the deep surface of the sternocleidomastoid muscle. At their sites of origin, the multiple septa of the middle fascia are thin and difficult to dissect, but as they approach the viscera and muscle bodies that they sheath, they thicken greatly and become a strong anatomic entity. Most investigators divide the middle cervical fascia into three categories: the middle cervical fascia *per se,* the cervical visceral fascia, and the carotid sheath.

The middle cervical fascia. The middle cervical fascia forms the sheaths of the two layers of infrahyoid muscles and, as a consequence, comprises three laminae. All three laminae are attached to the hyoid bone. At the lateral border of the omohyoid muscle, the superficial lamina and deep lamina fuse into one layer. The middle cervical fascia forms a continuous sheet of fascia across the midline of the neck, lying deep to the investing fascia but superficial to the visceral lamina of the middle cervical fascia. A fascial cleft is present just dorsal to its deep surface between the visceral lamina of the middle cervical fascia and the visceral fascia. The muscular division of the middle cervical fascia attaches inferiorly to the sternum, clavicle, and anterior scapula.

The cervical visceral fascia. The visceral division of the middle cervical fascia forms the false capsule of the thyroid gland and the sheaths of the respiratory and digestive tubes in the neck. The visceral division is continuous with the fascia that covers the trachea and the esophagus in the mediastinum, and it seems to form a relatively closed space around these viscera as they rise into the neck to

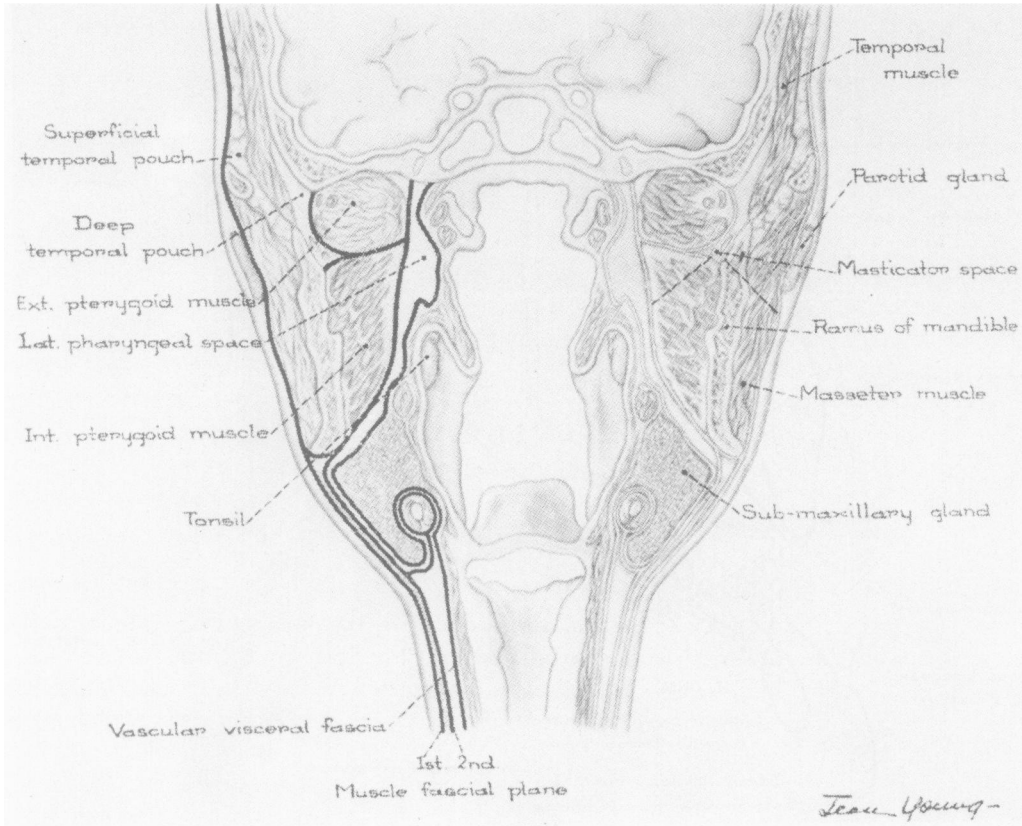


FIG. 5. Frontal plane of the fasciae of the head and neck and potential anatomical spaces.

become the larynx and the pharynx. The thyroid gland is enclosed within this same compartment. The visceral fascial compartment runs superiorly as far as the base of the skull to which it is attached. It is also attached superiorly to the fascia of the superior constrictor of the pharynx, the pharyngeal aponeurosis, the mandible, and the pterygomandibular raphe. The portion of the visceral fascia that lies posterior to the pharynx and covers the constrictor muscles of the pharynx and the buccinator muscle extends from the base of the skull to the level of the cricoid cartilage and is called the buccopharyngeal fascia.

The carotid sheath. The carotid sheath is a pipe-like fibrous sheath that surrounds the common carotid artery, the internal jugular vein, and the vagus nerve (Figs. 2–4). It has a group of attachments to structures sheathed by the investing, middle, and deep fasciae of the neck. It is attached medially to the visceral fascia via the alar fascia, along the midposterior surface of the pharynx from the base of the skull to the level of vertebra C7. The sheath is attached dorsally to the prevertebral fascia along the line of the lateral borders of the investing fascia as it covers the deep surface of the sternocleidomastoid muscle. The carotid sheath is attached medially to the middle cervical fascia along the lateral border of the sternothyroid muscle. The sheath connects superiorly with the fascia, covering the posterior belly of the digastric muscle and the stylohyoid muscle. At the base of the neck the sheath receives contributions from all layers of the cervical fasciae in the neck. Within the carotid sheath there are separate individual sheaths for its three main occupants. The cervical sympathetic trunk lies dorsal to the carotid sheath in a fascial lamina derived from the deep surface of the posterior wall of the sheath.

The Deep Cervical Fascia (the Prevertebral Fascia)

The deep layer of the deep cervical fascia comprises two layers: the prevertebral layer and the alar layer (Figs. 1–3). This fascia encloses the posterior half of the neck that lies deep to the trapezius muscle. The great vessels of the neck, the hypopharynx, the cervical esophagus, and the cervical sympathetic chain lie ventral to this fascia, and the longus colli, the longus capitis, and the three scalene muscles lie dorsal to it. Also lying dorsal to this fascia is the phrenic nerve.

The prevertebral layer of the deep cervical fascia lies just anterior to the cervical vertebral bodies, thus lying directly on the longus colli and longus capitis and also on the anterior longitudinal ligament of the vertebral column. It runs inferiorly as far as the midthoracic region of the neck. It extends laterally as far as the tips of the transverse processes of the cervical vertebrae with which it fuses. It continues posterolaterally in the neck, sheathing the erector muscles of the spine and scalene muscles, and finally

attaches posteriorly to the spines of the cervical vertebral bodies. It is related laterally to the second segment of the subclavian artery. At this point it gives origin to the axillary sheath.

The alar layer of the deep cervical fascia lies just ventral to the prevertebral fascia and just dorsal to the visceral layer of the middle cervical fascia. It extends across the midline of the neck from the tip of one transverse process to the tip of the contralateral process, and then passes ventrolaterally to attach to the medial, lateral, and dorsal walls of the carotid sheath. It rises superiorly to the base of the skull and it terminates inferiorly at the base of vertebra T2, where it fuses with the visceral fascia. It is of clinical importance because it bounds the anterolateral segment of the cervical retropharyngeal space, separating the space from the pharyngomaxillary space.

The axillary sheath. The axillary sheath is a lateral and inferior extension of the prevertebral fascia that sheathes the anterior scalene muscle. The subclavian artery rises into the lower medial neck from its origin dorsal to the sternoclavicular joint. It then proceeds laterally and dorsally until it reaches the medial border of the anterior scalene muscle that lies dorsal to the prevertebral fascia. The artery pierces the prevertebral fascia at this point and comes to lie dorsal to the anterior scalene muscle. As it pierces the prevertebral fascia, the artery draws a sheathing of the fascia about itself and carries it as its arterial sheath inferiorly into the axilla and then as far distally as the midarm. This sheet of prevertebral fascia also becomes the sheath of the brachial plexus and the subclavian vein as they move laterally and inferiorly behind the clavicle, across the first rib, and down into the axilla.

The Potential Fascial Spaces of the Lower Face and Neck

The Pharyngomaxillary Space

The pharyngomaxillary space is also referred to as the peripharyngeal space, the parapharyngeal space, and the lateral pharyngeal space (Figs. 2, 4, 5). It is a triangular-shaped pocket with the base placed superiorly at the base of the skull and its apex is at the level of the hyoid bone. The pharyngomaxillary space is bounded superiorly by the base of the skull and the sphenoid bone, inferiorly by the superior surface of the hyoid bone, ventrally by the pterygomandibular raphe, dorsally by the prevertebral fascia, laterally by the investing fascia as it covers the internal pterygoid muscle, by the deep surface of the parotid gland and by the mandible, and medially by the visceral layer of the deep fascia as it covers the superior constrictor muscle of the pharynx (buccopharyngeal fascia). The presence of the styloid process of the temporal bone divides the pharyngomaxillary space into a ventral or prestyloid compartment and a dorsal or poststyloid compartment. The poststyloid compartment contains the carotid sheath and the glossopharyngeal nerve and the hypoglossal nerve. The prestyloid compartment is in close proximity to the tonsillar fossa. The space communicates dorsally with the retropharyngeal space, whereas it communicates laterally with the parotid and masticator spaces. The prestyloid compartment communicates posteriorly with the carotid sheath and its contents.

The Submandibular Space

The submandibular space is a conglomerate of two spaces, the sublingual space and the submaxillary space. From a clinical standpoint, these two spaces function as one space because of their free intercommunication and their common clinical signs and symptoms. The submaxillary space may be further divided into a central submental space and two lateral submaxillary spaces. The entire submandibular space is tightly bounded anteriorly and laterally by the attachment of the investing fascia to the mandible, superiorly by the mucous membrane of the floor of the mouth, inferiorly by the attachment of the tightly applied investing layer of the deep cervical fascia to the hyoid bone and the posterior belly of the digastric muscle, and directly inferiorly by the hyoid bone. It is this space that is primarily involved in "Ludwig's angina."

The sublingual space. The sublingual space lies superior to the mylohyoid muscle. It is bounded superiorly by the mucous membrane of the floor of the mouth, anteriorly and anterolaterally by the inner margin of the mandible, posteriorly by the intrinsic musculature of the base of the tongue, and inferiorly by the mylohyoid muscle. An extension of the dorsal surface of the submaxillary (submandibular) salivary gland surrounds the excretory duct of that gland as it enters the sublingual space from the submaxillary space via the cleft between the lateral border of the mylohyoid muscle and the medial border of the hyoglossus muscle (mylohyoid cleft). This cleft also transmits the lingual and hypoglossal nerves, a relatively large branch of the facial artery, and some lymphatics that reach the neck from the sublingual area. The sublingual space contains the sublingual salivary gland, whose posterior rim is in intimate contact with the intraoral extension of the submaxillary gland. Thus a wide spatial pathway exists between the floor of the mouth and the suprahyoid region of the neck.

The submaxillary space. The submaxillary space is bounded superficially by the superficial layer of the deep cervical fascia (investing fascia), floored by the mylohyoid and hyoglossus muscles, bounded inferiorly by the hyoid bone and the posterior belly of the digastric muscle, and bounded superiorly by the inferior border of the transverse ramus of the mandible. The space is divided into an anterior or submental division and two lateral and posterior divisions by the presence of the anterior bellies of the digastric muscle. Infections may spread from one division

of the space to the other, deep to the anterior belly of the digastric muscle. Infection of the two spaces may spread posteriorly along the styloglossus muscle into the pharyngomaxillary space and continue to spread into the loose areolar tissue of the retropharyngeal space, and then further inferiorly into the superior mediastinum.

Parotid Space

The parotid space is the result of the splitting of the investing fascia at the level of the stylomandibular ligament to enclose the parotid gland within a superficial capsule and a deep capsule (Figs. 2, 4). The superficial capsule is thick and strong, and running from it into the superficial lobe of the parotid gland are multiple connective tissue septa that hold the external glandular capsule tightly to the underlying glandular tissue. Therefore, no fascial space exists between the gland and its superficial capsule, and glandular infections of the superficial parotid lobe do not pierce the thick superficial capsule. The deep capsule of the dorsal lobe gland, however, is thin and infections in the gland can easily pass through this capsule into the pharyngomaxillary space that lies just deep to the gland. Passage of infections into this space and then into the posterior mediastinum is one of the feared complications of parotitis. The strong fascial band that is the stylomandibular ligament effectively separates the parotid space from the submaxillary space.

The Masticator Space

The masticator space lies lateral and anterior to the pharyngomaxillary space. It contains the masseter muscle, the two pterygoid muscles, the ramus and the posterior surface of the body of the mandible, the tendon of insertion of the temporalis muscle, and the inferior alveolar vessels and nerves. It is bounded by the superficial layer of the deep cervical fascia that splits as it passes around the mandible and the superficial lamina of the investing fascia that makes up the sheath of the masseter muscle and attaches it to the zygoma. The deep lamina of the investing fascia forms the sheath of the two pterygoid muscles. The two laminae join again into a single sheet of fascia around the anterior and posterior borders of the body of the mandible. The masticator space is closed at all of its borders except the superior one, where it communicates deep to the zygomatic arch with the temporal space that lies both superficial and deep to the temporalis muscle. The temporal space is limited superficially by the attachment of the thick external temporal fascia to the zygoma and the temporal ridge. The temporal space contains the internal maxillary or deep facial artery and many of the divisions of the mandibular branch of the trigeminal nerve.

The Retropharyngeal Space

The retropharyngeal space (posterior visceral space) lies between the middle layer of the deep cervical fascia, which sheathes the pharynx and the esophagus anteriorly and laterally, and the alar layer of the deep cervical fascia posteriorly (Figs. 1–3). It extends from the base of the skull to the superior mediastinum, at about the level of vertebra T2, at which point the alar layer of the deep cervical fascia joins with the middle layer of the deep cervical fascia. Infections in this space can spread inferiorly into both the anterior and posterior divisions of the superior mediastinum. Infections in this space can also break through the alar fascia and enter the space between the alar fascia and the prevertebral fascia, whence they can extend inferiorly into the posterior mediastinum as far as the diaphragm. The space is extremely important in the diagnosis and treatment of deep neck infections.

The Anterior Visceral Space (Pretracheal Space—Previsceral Space)

The visceral compartment of the neck is made up of the loose areolar tissue that surrounds the thyroid gland, the trachea, and the esophagus (Figs. 1, 3). All three structures are sheathed by the middle or visceral layer of the middle cervical fascia. The visceral compartment is divided into two segments by a thick connective tissue band that extends laterally from the esophageal wall to the carotid sheath. The anterior compartment, called the anterior visceral space, surrounds the trachea and abuts posteriorly against the ventral wall of the esophagus. It is limited superiorly by the hyoid bone. The anterior visceral space is surrounded by the visceral fascia, and extends in a ventral-dorsal direction from just deep to the ribbon muscles to the retropharyngeal portion of the visceral compartment. It reaches from the superior border of the thyroid cartilage to the anterior superior mediastinum at the level of vertebra T4. There is continuity between the anterior and posterior visceral spaces at the level of the superior segments of the trachea, esophagus, and thyroid gland (above the level of the inferior thyroid artery). The most common cause of infections that reach this space is perforation of the ventral pharyngeal or esophageal walls due to foreign body trauma or endoscopy.

Treatment of Infection in the Sublingual and Submandibular Fascial Spaces (Ludwig's Angina)

The treatment of infections that involve the deep fascial spaces of the neck is primarily medical, with surgical treatment used only for those complications that demand operative intervention. The complications include the need for surgical drainage of pus under tension, respiratory complications secondary to the presence of the infection, erosion of sizable cervical blood vessels secondary to the

presence of the infectious process, and internal jugular vein thrombosis. Surgical intervention for reasons other than the above is looked upon as meddlesome and will hinder rather than help the treatment of the diseased areas.

It should be emphasized that the primary pathologic finding in deep neck space infections is cellulitis that involves the connective tissues, fasciae, and muscles in and about the spaces, which frequently results in early gangrene of the tissues in question. The gangrene results in a serosanguineous, putrid infiltration of the cervical tissues, usually with little or no frank pus present. The process spreads by continuity rather than by lymphatic extension. It is a well-established surgical principle, as true today as it was 50 years ago, that cellulitic areas should not be incised. They should be treated by systemic and local therapeutic measures so that the cellulitis will resolve or, failing resolution, will localize into a discrete abscess that should then be incised and completely drained. Incision into a cellulitic area compounds the pathologic process and allows the entrance of additional microorganisms, over and above those that caused the initial infection. In addition, incision also tends to break down the natural defense systems in the body.

Treatment of an infection in a deep cervical space should primarily consist of specific antibiotic therapy to combat the infection. In more than 80% of infections in deep cervical spaces, *Streptococcus hemolyticus* in pure or mixed cultures is found. Additionally, *Diplococcus pneumoniae,* enterococci, *Staphylococcus aureus,* and pathogenic anerobes are often present. Large doses of a broad-spectrum antibiotic should be given as soon as cellulitis is suspected. A spiking fever with chills calls for repetitive blood cultures, and the antibiotic used should then be varied with the bacterial findings in the blood cultures. Massive hot compresses applied to the involved area of the neck and hot saline gavages given hourly to the oral cavity give some symptomatic relief and also help to localize infection if the cellulitic process is one that will not completely resolve. Upper cervical infections cause difficulty in swallowing; therefore, it is important that the patient's fluid and electrolyte balance are maintained using intravenous (I.V.) therapy. Additionally, antibiotics can be administered by I.V. therapy.

Maintenance of a Proper Airway

Maintenance of a proper airway is of the upmost importance in the treatment of Ludwig's angina. Asphyxiation is the most frequent cause of death in this disease. The asphyxia is caused by either pressure obstruction of the central air passage of the neck or impairment of the mechanisms that control respiration. It is believed that the asphyxiation in the latter case is caused by paralysis of the medullary respiratory center, and two components have been suggested to be the responsible factors. One factor is acapnia caused by hyperventilation due to persistent shallow, rapid respiration; the second factor is hypersensitivity of the carotid sinus pressure receptors caused by the adjacent inflammatory process, although the studies of Tschiasshy[5] and Elliott and Weisengreen[6] do not support the latter contention. Whatever the cause of asphyxiation, tracheotomy is imperative as soon as breathing becomes shallow and rapid in any patient with Ludwig's angina. Tracheotomy should be carried out regardless of the absence of audible or visible signs of mechanical airway obstruction. The great number of late emergency tracheotomies that become necessary in Ludwig's angina should be a warning for the surgeon to perform the procedure electively, early in the disease. Tracheotomy has the added advantage of allowing the surgeon to carry out any manipulative or operative procedure under deep general anesthesia without having to pass an endoscopic tube through a compressed superior airway. As previously noted, most cases of Ludwig's angina will regress and become quiescent under vigorous antibiotic and local supportive therapy. In fact, probably not more than one in 20 patients will need surgery in this era of improved treatment of acute infections.

Surgery

Surgery had been used to treat this condition even before the time of Ludwig. However, during the last quarter of the 19th century its use became much more popular and it was regarded as the optimal therapeutic procedure. Many cervical approaches of surgery were used. Because pus was not usually present, surgeons varied their approaches in an effort to find and drain the often elusive or nonexistent pocket of pus. Additionally, multiple approaches were often used, both intraoral and cervical, particularly when the disease had advanced from the suprahyoid area to other deep cervical spaces. Currently, a variety of surgical approaches have been used and a generally accepted standard method of approach does not exist. Median longitudinal cervical incisions as well as transverse incisions are used, and occasionally a combination of both is advocated. Additionally, the cutting of various cervical muscles has been advocated, and some surgeons recommend the removal of the submaxillary salivary gland because the removal of the gland speeds the regression of the infectious process.

It is my own belief that a procedure that is based on the degree of development of the pathologic process, leaves a relatively nondisfiguring scar on the neck, and allows for complete decompression of the fascial space or spaces involved is the most advantageous procedure.

Before operation, the surgeon must be sure that there is pus under tension in an involved cervical space. The decision to operate may be a difficult one to make. It should be based on the patient's general condition, the

advancement of local and general symptoms, and the appearance of pitting edema over the region suspected. In such a patient the surgeon will more often than not find pus under tension as a result of examination. Under no circumstances should the surgeon incise an area of cellulitis in order to determine the presence of pus. If no pus is found the surgeon should discontinue operation after decompression of the fascial limits of the incised area.

Any patient ill enough to require surgical intervention should have tracheostomy performed either before or at operation. General anesthesia should be used and administered through the tracheotomy tube. Such anesthesia allows the surgeon to perform an adequate anatomic dissection in an unhurried fashion.

The aim of surgery for Ludwig's angina is the relief of tension, not the search for pus, which often is not even found at autopsy. Two anatomic structures are chiefly responsible for cervical tension, which is responsible for the crippling and toxic effects of Ludwig's angina. The first structure is the strong layer of investing fascia that covers the three suprahyoid spaces (the right and left submandibular spaces and the submental space). The second structure is the mylohyoid muscle that forms all of the submental floor and the anterior one third of the submandibular floor and that separates the cervical space from the sublingual space. The relief of tension can only be done by the division of both of these fascial and muscular structures at right angles to the line of their individual fibers.

A transverse skin incision is made on the side of the major involvement at a point about 2 cm below the transverse ramus of the mandible, extending from the angle of the mandible to the midline of the neck. The superficial fascia and the platysma muscle are divided carefully across the line of their fibers so as not to injure the mandibular branch of the facial nerve. The suprahyoid portion of the investing fascia is exposed. This fascia is cut transversely and freed from its dorsal attachments. The submental branch of the facial artery is exposed and ligated. Ligation of the main trunk of the facial artery can usually be avoided with this incision. The fascia enclosing the submaxillary salivary gland is freed at the angle between the anterior and posterior bellies of the digastric muscle, and the submaxillary gland, thus mobilized, is retracted laterally. There is no reason to remove the submaxillary salivary gland. The mylohyoid muscle is then divided at right angles to the line of its fibers. Once the mylohyoid muscle is cut, a wide gap appears between the two segments of the muscle. The mucous membrane of the floor of the mouth that covers the sublingual area, may or may not be divided, depending on the degree of tension put on it by the process deep to it. Certain procedures are avoided, including cutting the geniohyoid muscle and digastric muscle, as well as removing the submaxillary salivary gland. The geniohyoid muscle and the anterior bellies of the digastric muscle open the mouth and support the hyoid bone and the larynx. As Ludwig[8] has pointed out, the submaxillary salivary gland is seldom, if ever, a part of the inflammatory process and should not be removed. However, its fascia, a derivative of the investing fascia, should be completely freed from surrounding structures, particularly where it encloses the lower pole of the gland.

Since the immediate submandibular spaces communicate with the parapharyngeal space superior to the body of the styloglossus muscle, and the deeper visceral spaces of the neck (retroesophageal, paravisceral, vascular, and pretracheal) are in wide-open communication with the mediastinal spaces of the thorax, the spread of superior cervical infection such as Ludwig's angina into the deep neck spaces is a complication to be carefully watched for. Mediastinitis should be avoided if possible.

The paravisceral spaces are accessed by an incision through the investing fascia of the neck. In the upper region of the neck the spaces are entered medial to the sternocleidomastoid muscle, whereas in the lower region of the neck they are entered lateral to the sternocleidomastoid muscle. Incisions to drain the vascular division of the visceral spaces of the neck are made just behind the anterior border of the sternocleidomastoid muscle. The muscle is easily exposed after cutting the sheath of the superficial lamella. The muscle is then retracted medially or laterally as needed for the proper exposure, and its deep muscle sheath is also incised. The vascular space is then exposed.

Once the cervical space or spaces in question have been opened and drained of their pus, care having been taken to break up any loculations, soft-rubber Penrose drains are inserted into the spaces and a large, soft-pressure dressing is applied to the neck.

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