ANATOMY

ANTERIOR CERVICAL TRIANGLE (FIG. 2.1)

The boundaries are:

- Lateral: sternocleidomastoid muscle
- Superior: inferior border of the mandible
- Medial: anterior midline of the neck

This large triangle may be subdivided into four more triangles: submandibular, submental, carotid, and muscular.

Submandibular Triangle

The submandibular triangle is demarcated above by the inferior border of the mandible and below by the anterior and posterior bellies of the digastric muscle.

The largest structure in the triangle is the submandibular salivary gland. A number of vessels, nerves, and muscles also are found in the triangle.

For the surgeon, the contents of the triangle are best described in four layers, or surgical planes, starting from the skin. It must be noted that severe inflammation of the submandibular gland can destroy all traces of normal anatomy. When this occurs, identifying the essential nerves becomes a great challenge.

Roof of the Submandibular Triangle

The roof—the first surgical plane—is composed of skin, superficial fascia enclosing platysma muscle and fat, and the mandibular and cervical branches of the facial nerve (VII) (Fig. 2.2).
Figure 2.1. The subdivision of the anterior triangle of the neck (By permission of JE Skandalakis, SW Gray, and JR Rowe. *Am Surg* 45(9):590–596, 1979).

Figure 2.2. The roof of the submandibular triangle (the first surgical plane). The platysma lies over the mandibular and cervical branches of the facial nerve (By permission of JE Skandalakis, SW Gray, and JR Rowe. *Am Surg* 45(9):590–596, 1979).
It is important to remember that: (1) the skin should be incised 4–5 cm below the mandibular angle, (2) the platysma and fat compose the superficial fascia, and (3) the cervical branch of the facial nerve (VII) lies just below the angle, superficial to the facial artery (Fig. 2.3).

The mandibular (or marginal mandibular) nerve passes approximately 3 cm below the angle of the mandible to supply the muscles of the corner of the mouth and lower lip.

The cervical branch of the facial nerve divides to form descending and anterior branches. The descending branch innervates the platysma and communicates with the anterior cutaneous nerve of the neck. The anterior branch—the ramus colli mandibularis—crosses the mandible superficial to the facial artery and vein and joins the mandibular branch to contribute to the innervation of the muscles of the lower lip.

Injury to the mandibular branch results in severe drooling at the corner of the mouth. Injury to the anterior cervical branch produces minimal drooling that will disappear in 4–6 months.
The distance between these two nerves and the lower border of the mandible is shown in Fig. 2.3.

Contents of the Submandibular Triangle

The structures of the second surgical plane, from superficial to deep, are the anterior and posterior facial vein, part of the facial (external maxillary) artery, the submental branch of the facial artery, the superficial layer of the submaxillary fascia (deep cervical fascia), the lymph nodes, the deep layer of the submaxillary fascia (deep cervical fascia), and the hypoglossal nerve (XII) (Fig. 2.4).

It is necessary to remember that the facial artery pierces the stylomandibular ligament. Therefore, it must be ligated before it is cut to prevent bleeding after retraction. Also, it is important to remember that the lymph nodes lie within the envelope of the submandibular fascia in close relationship with the gland. Differentiation between gland and lymph node may be difficult.

The anterior and posterior facial veins cross the triangle in front of the submandibular gland and unite close to the angle of the mandible to form the common facial vein, which empties into the internal jugular vein near the greater cornu of the hyoid bone. It is wise to identify, isolate, clamp, and ligate both of these veins.

The facial artery—a branch of the external carotid artery—enters the submandibular triangle under the posterior belly of the digastric muscle and under the stylohyoid muscle. At its entrance into the triangle it is under the subman-

Figure 2.4. The contents of the submandibular triangle (the second surgical plane). Exposure of the superficial portion of the submandibular gland (By permission of JE Skandalakis, SW Gray, and JR Rowe. Am Surg 45(9): 590–596, 1979).
dibular gland. After crossing the gland posteriorly, the artery passes over the
mandible, lying always under the platysma. It can be ligated easily.

**Floor of the Submandibular Triangle**

The structures of the third surgical plane, from superficial to deep, include the
mylohyoid muscle with its nerve, the hyoglossus muscle, the middle constrictor
muscle covering the lower part of the superior constrictor, and part of the
styloglossus muscle (Fig. 2.5).

The mylohyoid muscles are considered to form a true diaphragm of the floor
of the mouth. They arise from the mylohyoid line of the inner surface of the man-
dible and insert on the body of the hyoid bone into the median raphe. The nerve to
the mylohyoid, which arises from the inferior alveolar branch of the mandibular
division of the trigeminal nerve (V), lies on the inferior surface of the muscle.
The superior surface is in relationship with the lingual and hypoglossal nerves.

**Basement of the Submandibular Triangle**

The structures of the fourth surgical plane, or basement of the triangle, include
the deep portion of the submandibular gland, the submandibular (Wharton’s)
duct, lingual nerve, sublingual artery, sublingual vein, sublingual gland, hypoglossal nerve (XII), and the submandibular ganglion (Fig. 2.6).

The submandibular duct lies below the lingual nerve (except where the nerve
passes under it) and above the hypoglossal nerve.
Lymphatic Drainage of the Submandibular Triangle

The submandibular lymph nodes receive afferent channels from the submental nodes, oral cavity, and anterior parts of the face. Efferent channels drain primarily into the jugulodigastric, jugulocarotid, and jugulo-omohyoid nodes of the chain accompanying the internal jugular vein (deep cervical chain). A few channels pass by way of the subparotid nodes to the spinal accessory chain.

Submental Triangle (See Fig. 2.1)

The boundaries of this triangle are:

- Lateral: anterior belly of digastric muscle
- Inferior: hyoid bone
- Medial: midline
- Floor: mylohyoid muscle
- Roof: skin and superficial fascia

The lymph nodes of the submental triangle receive lymph from the skin of the chin, the lower lip, the floor of the mouth, and the tip of the tongue. They send lymph to the submandibular and jugular chains of nodes.
Carotid Triangle (See Fig. 2.1)

The boundaries are:
- Posterior: sternocleidomastoid muscle
- Anterior: anterior belly of omohyoid muscle
- Superior: posterior belly of digastric muscle
- Floor: hyoglossus muscle, inferior constrictor of pharynx, thyrohyoid muscle, longus capitis muscle, and middle constrictor of pharynx
- Roof: investing layer of deep cervical fascia

Contents of the carotid triangle: bifurcation of carotid artery; internal carotid artery (no branches in the neck); external carotid artery branches, e.g., superficial temporal artery, internal maxillary artery, occipital artery, ascending pharyngeal artery, sternocleidomastoid artery, lingual artery (occasionally), and external maxillary artery (occasionally); jugular vein tributaries, e.g., superior thyroid vein, occipital vein, common facial vein, and pharyngeal vein; and vagus nerve, spinal accessory nerve, hypoglossal nerve, ansa hypoglossi, and sympathetic nerves (partially).

Lymph is received by the jugulodigastric, jugulocarotid, and jugulomohyoid nodes and by the nodes along the internal jugular vein from submandibular and submental nodes, deep parotid nodes, and posterior deep cervical nodes. Lymph passes to the supraclavicular nodes.

Muscular Triangle (Fig. 2.1)

The boundaries are:
- Superior lateral: anterior belly of omohyoid muscle
- Inferior lateral: sternocleidomastoid muscle
- Medial: midline of the neck
- Floor: prevertebral fascia and prevertebral muscles; sternohyoid and sternothyroid muscles
- Roof: investing layer of deep fascia; strap, sternohyoid, and cricothyroid muscles

Contents of the muscular triangle include: thyroid and parathyroid glands, trachea, esophagus, and sympathetic nerve trunk.

Remember that occasionally the strap muscles must be cut to facilitate thyroid surgery. They should be cut across the upper third of their length to avoid sacrificing their nerve supply.
POSTERIOR CERVICAL TRIANGLE (FIG. 2.7)

The posterior cervical triangle is sometimes considered to be two triangles—occipital and subclavian—divided by the posterior belly of the omohyoid muscle or, perhaps, by the spinal accessory nerve (see Fig. 2.7); we will treat it as one.

The boundaries of the posterior triangle are:

- Anterior: sternocleidomastoid muscle
- Posterior: anterior border of trapezius muscle
- Inferior: clavicle
- Floor: prevertebral fascia and muscles, splenius capitis muscle, levator scapulae muscle, and three scalene muscles
- Roof: superficial investing layer of the deep cervical fascia

Contents of the posterior cervical triangle include: subclavian artery, subclavian vein, cervical nerves, brachial plexus, phrenic nerve, accessory phrenic nerve, spinal accessory nerve, and lymph nodes.

The superficial occipital lymph nodes receive lymph from the occipital region of the scalp and the back of the neck. The efferent vessels pass to the

Figure 2.7. The posterior triangle of the neck. The triangle may be divided into two smaller triangles by the omohyoid muscle (By permission of JE Skandalakis, SW Gray, and JR Rowe. Anatomical Complications in General Surgery. New York: McGraw-Hill, 1983).
deep occipital lymph node (usually only one), which drains into the deep cervical nodes along the spinal accessory nerve.

■ FASCIAE OF THE NECK

Our classification of the rather complicated fascial planes of the neck follows the work of several investigators. It consists of the superficial fascia and three layers that compose the deep fascia.

Superficial Fascia

The superficial fascia lies beneath the skin and is composed of loose connective tissue, fat, the platysma muscle, and small unnamed nerves and blood vessels (Fig. 2.8). The surgeon should remember that the cutaneous nerves of the neck and the anterior and external jugular veins are between the platysma and the deep cervical fascia. If these veins are to be cut, they must first be ligated. Because of their attachment to the platysma above and the fascia below, they do not retract; bleeding from them may be serious. For all practical purposes, there is no space between this layer and the deep fascia.

Deep Fascia

Investing, Anterior, or Superficial Layer (Figs. 2.9 and 2.10)

This layer envelops two muscles (the trapezius and the sternocleidomastoid) and two glands (the parotid and the submaxillary) and forms two spaces (the supraclavicular and the suprasternal). It forms the roof of the anterior and posterior cervical triangles and the midline raphe of the strap muscles.

Figure 2.8. The superficial fascia of the neck lies between the skin and the investing layer of the deep cervical fascia (By permission of JE Skandalakis, SW Gray, and JR Rowe. Anatomical Complications in General Surgery. New York: McGraw-Hill, 1983).
2. Neck

Figure 2.9. Diagrammatic cross section through the neck below the hyoid bone showing the layers of the deep cervical fascia and the structures that they envelop (By permission of JE Skandalakis, SW Gray, and LJ Skandalakis. In: CG Jamieson (ed), Surgery of the Esophagus, Edinburgh: Churchill Livingstone, 19–35, 1988).

**Pretracheal or Middle Layer**

The middle layer of the deep fascia splits into an anterior portion that envelops the strap muscles and a posterior layer that envelops the thyroid gland, forming the false capsule of the gland.

**Prevertebral, Posterior, or Deep Layer**

This layer lies in front of the prevertebral muscles. It covers the cervical spine muscles, including the scalene muscles and vertebral column anteriorly. The fascia divides to form a space in front of the vertebral bodies, the anterior layer being the alar fascia and the posterior layer retaining the designation of prevertebral fascia.

**Carotid Sheath**

Beneath the sternocleidomastoid muscle, all the layers of the deep fascia contribute to a fascial tube, the carotid sheath. Within this tube lie the common carotid artery, internal jugular vein, vagus nerve, and deep cervical lymph nodes.
Figure 2.10. Diagrammatic cross section of the neck through the thyroid gland at the level of the sixth cervical vertebra showing the fascial planes, muscles, and vessels that may be encountered in an incision for thyroidectomy (By permission of JT Akin and JE Skandalakis. Am Surg 42(9):648–652, 1976).
**2. Neck**

**Buccopharyngeal Fascia**
This layer covers the lateral and posterior surfaces of the pharynx and binds the pharynx to the alar layer of the prevertebral fascia.

**Axillary Fascia**
This fascia takes its origin from the prevertebral fascia. It is discussed in Chap. 3.

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**SPACES OF THE NECK**

There are many spaces in the neck defined by the fasciae, but for the general surgeon the visceral compartment is the most important; be very familiar with its boundaries and contents.

The boundaries of the visceral compartment of the neck are:

- **Anterior:** pretracheal fascia
- **Posterior:** prevertebral fascia
- **Lateral:** carotid sheath
- **Superior:** hyoid bone and thyroid cartilage
- **Posteroinferior:** posterior mediastinum
- **Anteroinferior:** bifurcation of the trachea at the level of the fifth thoracic vertebra

Contents of the spaces of the neck include: part of esophagus, larynx, trachea, thyroid gland, and parathyroid glands.

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**LYMPHATICS OF THE NECK/RIGHT AND LEFT THORACIC DUCTS**

The overall anatomy of the lymphatics of the head and neck may be appreciated from Table 2.1 and Fig. 2.11.

The thoracic duct originates from the cisterna chyli and terminates in the left subclavian vein (Fig. 2.12). It is approximately 38–45 cm long. The duct begins at about the level of the second lumbar vertebra from the cisterna chyli or, if the cisterna is absent (about 50% of cases), from the junction of the right and left lumbar lymphatic trunks and the intestinal lymph trunk. It ascends to the right of the midline on the anterior surface of the bodies of the thoracic vertebrae. It crosses the midline between the seventh and fifth thoracic vertebrae to lie on the left side, to the left of the esophageal wall. It passes behind the great vessels at the level of the seventh cervical vertebra and descends slightly to enter the left subclavian vein (see Fig. 2.12). The duct may have multiple entrances to the vein, and one or more of the contributing lymphatic trunks may enter the subclavian or the jugular vein independently. It may be ligated with impunity.
### Table 2.1 Lymph nodes and the lymphatic drainage of the head and neck

<table>
<thead>
<tr>
<th>Location</th>
<th>From</th>
<th>To</th>
</tr>
</thead>
<tbody>
<tr>
<td>Superior horizontal chain:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Submental nodes</td>
<td>Submental triangle</td>
<td>Skin of chin, lip, floor of mouth, tip of tongue</td>
</tr>
<tr>
<td>Submandibular nodes</td>
<td>Submandibular triangle</td>
<td>Submental nodes, oral cavity, face, except forehead and part of lower lip</td>
</tr>
<tr>
<td>Preauricular (parotid) nodes</td>
<td>In front of tragus</td>
<td>Lateral surface of pinna, side of scalp</td>
</tr>
<tr>
<td>Postauricular (mastoid) nodes</td>
<td>Mastoid process</td>
<td>Temporal scalp, medial surface of pinna, external auditory meatus</td>
</tr>
<tr>
<td>Occipital node</td>
<td>Between mastoid process and external occipital protuberance</td>
<td>Back of scalp</td>
</tr>
<tr>
<td>Vertical chain:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Posterior cervical (posterior triangle) nodes</td>
<td>Subparotid nodes, jugular chain, occipital, and mastoid area</td>
<td>Supraclavicular and deep cervical nodes</td>
</tr>
<tr>
<td>Superficial</td>
<td>Along external jugular vein</td>
<td></td>
</tr>
<tr>
<td>Deep</td>
<td>Along spinal accessory nerve</td>
<td></td>
</tr>
<tr>
<td>Intermediate (jugular) nodes</td>
<td></td>
<td>All other nodes of the neck</td>
</tr>
<tr>
<td>Jugulocarotid (subparotid) nodes</td>
<td>Angle of mandible, near parotid nodes</td>
<td></td>
</tr>
<tr>
<td>Location</td>
<td>From</td>
<td>To</td>
</tr>
<tr>
<td>-----------------------------------------------</td>
<td>-----------------------------------------</td>
<td>-----------------------------------------</td>
</tr>
<tr>
<td>Jugulodigastric (subdigastric) nodes</td>
<td>Junction of common facial and internal jugular veins</td>
<td>Palatine tonsils</td>
</tr>
<tr>
<td>Jugulocarotid (bifurcation) nodes</td>
<td>Bifurcation of common carotid artery close to carotid body</td>
<td>Tongue, except tip</td>
</tr>
<tr>
<td>Jugulo-omohyoid (omohyoid) nodes</td>
<td>Crossing of omohyoid and internal jugular vein</td>
<td>Tip of tongue</td>
</tr>
<tr>
<td>Anterior (visceral) nodes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Parapharyngeal nodes</td>
<td>Lateral and posterior wall of pharynx</td>
<td>Deep face and esophagus</td>
</tr>
<tr>
<td>Paralaryngeal nodes</td>
<td>Lateral wall of larynx</td>
<td>Larynx and thyroid gland</td>
</tr>
<tr>
<td>Paratracheal nodes</td>
<td>Lateral wall of trachea</td>
<td>Thyroid gland, trachea, esophagus</td>
</tr>
<tr>
<td>Prelaryngeal (Delphian) nodes</td>
<td>Cricothyroid ligament</td>
<td>Thyroid gland, pharynx</td>
</tr>
<tr>
<td>Pretracheal nodes</td>
<td>Anterior wall of trachea below isthmus of thyroid gland</td>
<td>Thyroid gland, trachea, esophagus</td>
</tr>
<tr>
<td>Inferior horizontal chain:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Supraclavicular and scalene nodes</td>
<td>Subclavian triangle</td>
<td>Axilla, thorax, vertical chain</td>
</tr>
</tbody>
</table>


Figure 2.12. The thoracic duct and main left lymphatic trunks. Trunks are variable and may enter the veins with the thoracic duct or separately (By permission of JE Skandalakis, SW Gray, and JR Rowe. Anatomical Complications in General Surgery. New York: McGraw-Hill, 1983).
The right lymphatic duct is a variable structure about 1 cm long formed by the right jugular, transverse cervical, internal mammary, and mediastinal lymphatic trunks (Fig. 2.13). If these trunks enter the veins separately, there is no right lymphatic duct. When present, the right lymphatic duct enters the superior surface of the right subclavian vein at its junction with the right internal jugular vein and drains most of the right side of the thorax.

The thoracic duct collects lymph from the entire body below the diaphragm, as well as from the left side of the thorax. Lymph nodes may be present at the caudal end, but there are none along its upward course. Injury to the duct in supraclavicular lymph node dissections results in copious lymphorrhea. Ligation is the answer.

ANATOMY OF THE THYROID GLAND

The thyroid gland consists typically of two lobes, a connecting isthmus, and an ascending pyramidal lobe. One lobe, usually the right, may be smaller than the other (7% of cases) or completely absent (1.7%). The isthmus is absent in about 10% of thyroid glands, and the pyramidal lobe is absent in about 50% (Fig. 2.14). A minute epithelial tube or fibrous cord—the thyroglossal duct—almost always extends between the thyroid gland and the foramen cecum of the tongue.
The thyroid gland normally extends from the level of the fifth cervical vertebra to that of the first thoracic vertebra. It may lie higher (lingual thyroid), but rarely lower.

**Capsule of the Thyroid Gland**

The thyroid gland has a connective tissue capsule which is continuous with the septa and which makes up the stroma of the organ. This is the *true* capsule of the thyroid.

External to the true capsule is a well-developed (to a lesser or greater degree) layer of fascia derived from the pretracheal fascia. This is the *false* capsule, *perithyroid sheath*, or *surgical capsule*. The false capsule, or fascia, is not removed with the gland at thyroidectomy.

Figure 2.14. Normal vestiges of thyroid gland development. None are of clinical significance, but their presence may be of concern to the surgeon (By permission of JE Skandalakis, SW Gray, and JR Rowe. *Anatomical Complications in General Surgery*. New York: McGraw-Hill, 1983).
The superior parathyroid glands normally lie between the true capsule of the thyroid and the fascial false capsule. The inferior parathyroids may be between the true and the false capsules, within the thyroid parenchyma, or lying on the outer surface of the fascia.

**Arterial Supply of the Thyroid and Parathyroid Glands**

Two paired arteries, the superior and inferior thyroid arteries, and an inconstant midline vessel—the thyroid ima artery—supply the thyroid (Fig. 2.15).

The superior thyroid artery arises from the external carotid artery just above, at, or just below the bifurcation of the common carotid artery. It passes downward and anteriorly to reach the superior pole of the thyroid gland. Along part of its course, the artery parallels the external branch of the superior laryngeal nerve. At the superior pole the artery divides into anterior and posterior...
branches. From the posterior branch, a small parathyroid artery passes to the superior parathyroid gland.

The inferior thyroid artery usually arises from the thyrocervical trunk, or from the subclavian artery. It ascends behind the carotid artery and the internal jugular vein, passing medially and posteriorly on the anterior surface of the longus colli muscle. After piercing the prevertebral fascia, the artery divides into two or more branches as it crosses the ascending recurrent laryngeal nerve. The nerve may pass anterior or posterior to the artery, or between its branches (Fig. 2.16). The lowest branch sends a twig to the inferior parathyroid gland. On the right, the inferior thyroid artery is absent in about 2% of individuals. On the left, it is absent in about 5%. The artery is occasionally double.

Figure 2.16. Relations at the crossing of the recurrent laryngeal nerve and the inferior thyroid artery. (a–c) Common variations. Their frequencies are given in Table 2.2. (d) A nonrecurrent nerve is not related to the inferior thyroid artery. (e) The nerve loops beneath the artery (By permission S Tzinas, C Droulias, N Harlaftis, et al. Am Surg 42(9):639–644, 1976).
The arteria thyroidea ima is unpaired and inconstant. It arises from the brachiocephalic artery, the right common carotid artery, or the aortic arch. Its position anterior to the trachea makes it important for tracheostomy.

**Venous Drainage**

The veins of the thyroid gland form a plexus of vessels lying in the substance and on the surface of the gland. The plexus is drained by three pairs of veins (Fig. 2.17):

- The superior thyroid vein accompanies the superior thyroid artery.
- The middle thyroid vein arises on the lateral surface of the gland at about two-thirds of its anteroposterior extent. No artery accompanies it. This vein may be absent; occasionally it is double.
- The inferior thyroid vein is the largest and most variable of the thyroid veins.

Figure 2.17. The venous drainage of the thyroid gland. The inferior thyroid veins are quite variable (By permission S Tzinas, C Droulias, N Harlaftis, et al. *Am Surg* 42(9):639–644, 1976).
Recurrent Laryngeal Nerves (Figs. 2.16 and 2.18)

The right recurrent laryngeal nerve branches from the vagus as it crosses anterior to the right subclavian artery, loops around the artery from posterior to anterior, crosses behind the right common carotid, and ascends in or near the tracheoesophageal groove. It passes posterior to the right lobe of the thyroid gland to enter the larynx behind the cricothyroid articulation and the inferior cornu of the thyroid cartilage.

The left recurrent laryngeal nerve arises where the vagus nerve crosses the aortic arch, just distal to the origin of the left subclavian artery from the aortic arch. It loops under the ligamentum arteriosum and the aorta, and ascends in the same manner as the right nerve. Both nerves cross the inferior thyroid arteries near the lower border of the middle third of the gland.

In about 1% of patients, the right recurrent nerve arises normally from the vagus, but passes medially almost directly from its origin to the larynx without looping under the subclavian artery. In these cases, the right subclavian artery arises from the descending aorta and passes to the right behind the esophagus. This anomaly is asymptomatic, and the thyroid surgeon will rarely be aware of it prior to operation. Even less common is a nonrecurrent left nerve in the presence of a right aortic arch and a retroesophageal left subclavian artery.

In the lower third of its course, the recurrent laryngeal nerve ascends behind the pretracheal fascia at a slight angle to the tracheoesophageal groove. In the middle third of its course, the nerve may lie in the groove or within the substance of the thyroid gland.

The vulnerability of the recurrent laryngeal nerve may be appreciated from Table 2.2.

Exposure of the Laryngeal Nerves

The recurrent laryngeal nerve forms the medial border of a triangle bounded superiorly by the inferior thyroid artery and laterally by the carotid artery. The nerve can be identified where it enters the larynx just posterior to the inferior cornu of the thyroid cartilage. If the nerve is not found, a nonrecurrent nerve should be suspected, especially on the right.

In the lower portion of its course, the nerve can be palpated as a tight strand over the tracheal surface. There is more connective tissue between the nerve and the trachea on the right than on the left. Visual identification, with avoidance of traction, compression, or stripping the connective tissue, is all that is necessary.

The superior laryngeal nerve arises from the vagus nerve just inferior to its lower sensory ganglion just outside the jugular foramen of the skull. The nerve passes inferiorly, medial to the carotid artery. At the level of the superior cornu of the hyoid bone it divides into a large, sensory, internal laryngeal branch and
Figure 2.18. The course of the recurrent laryngeal nerve at the level of the thyroid gland in 102 cadavers. In about one-half of the cases, the nerve lay in the groove between the trachea and the esophagus. (Top) Lateral view. (Bottom) Cross-sectional view (By permission of JE Skandalakis, C Droulias, N Harlaftis, et al. *Am Surg* 42(9):629–634, 1976).

a smaller, motor, external laryngeal branch, serving the cricothyroid muscle and the cricopharyngeus. The point of division is usually within the bifurcation of the common carotid artery (Fig. 2.19).
The internal laryngeal branch is rarely identified by the surgeon (Fig. 2.20). The external laryngeal branch, together with the superior thyroid vein and artery, passes under the sternothyroid muscles, posterior and medial to the vessels. The nerve then passes beneath the lower border of the thyrohyoid muscle to continue inferiorly to innervate the cricothyroid muscle.

**Remember:**

✓ The results of injury to the recurrent laryngeal nerve and the external branch of the superior laryngeal nerve are as follows:

- **Unilateral recurrent nerve injury.** The affected vocal cord is paramedian owing to adduction by the cricothyroid muscle. Voice is preserved (not unchanged).

- **Unilateral recurrent and superior laryngeal nerve injury.** The affected cord is in an intermediate position, resulting in hoarseness and inability to cough. The affected cord will move toward the midline with time. Voice improves, but improvement is followed by narrowing of the airway. Tracheostomy becomes necessary.

Postoperative hoarseness is not always the result of operative injury to laryngeal nerves. From 1 to 2% of patients have a paralyzed vocal cord prior to thyroid operations. Researchers at the Mayo Clinic examined 202 cases of vocal cord paralysis, of which 153 (76%) followed thyroidectomy, 36 (18%) were of various known etiologies, and 13 (6%) were of idiopathic origin. We strongly advise the general surgeon to perform a mirror laryngoscopy prior to thyroidectomy.

We believe that the patient should be told that in spite of all precautions, there is a possibility of some vocal disability following thyroidectomy.

A sympathetic ganglion can be confused with a lymph node and removed when the surgeon operates for metastatic papillary carcinoma of the thyroid. In one of our patients, the inferior cervical and first thoracic ganglia were fused.

### Table 2.2  Recurrent laryngeal nerve vulnerability

<table>
<thead>
<tr>
<th>Cause of vulnerability</th>
<th>Percent encountered</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lateral and anterior location</td>
<td>1.5–3.0</td>
</tr>
<tr>
<td>Tunneling through thyroid tissue</td>
<td>2.5–15.0</td>
</tr>
<tr>
<td>Fascial fixation</td>
<td>2.0–3.0</td>
</tr>
<tr>
<td>Arterial fixation</td>
<td>5.0–12.5</td>
</tr>
<tr>
<td>Close proximity to inferior thyroid vein</td>
<td>1.5–2.0+</td>
</tr>
</tbody>
</table>

Data from Chang-Chien Y. Surgical anatomy and vulnerability of the recurrent laryngeal nerve. *Int Surg* 1980; 65:23
to form a nodelike structure that was removed. The surgeon must identify any apparent lymph node related to the vertebral artery and fixed in front of the transverse process of the seventh cervical vertebra.

Figure 2.19. Branching of the superior laryngeal nerve and the carotid arteries. (a) The internal branch crosses the external carotid artery above the origin of the lingual artery. (b) The internal branch crosses below the origin of the lingual artery. (c) The nerve divides medial to the external carotid artery (By permission of C Droulias, S Tzinas, N Harlaftis, et al. *Am Surg* 42(9):635–638, 1976).
Injury to the cervical sympathetic nerve results in Horner’s syndrome: (1) constriction of the pupil, (2) partial ptosis of the upper eyelid, (3) apparent enophthalmos, (4) dilatation of the retinal vessels, and (5) flushing and drying of the facial skin on the affected side.

Persistent Remnants of the Thyroglossal Duct

The foramen cecum of the tongue and the pyramidal lobe of the thyroid gland are normal remnants of the thyroglossal duct. Between these structures is a very small epithelial tube, usually broken in several places. Occasionally these epithelial fragments hypertrophy, secrete fluid, and form cysts. Drainage or aspiration of these cysts is futile and often results in formation of a fistula, usually infected.

All fragments of the duct, the foramen cecum, and the midportion of the hyoid bone should be removed (Sistrunk procedure). Recurrence of the cyst is the result of failure to remove the entire duct or the central portion of the hyoid bone.
ANATOMY OF THE PARATHYROID GLANDS

The parathyroid glands are usually found on the posterior surface of the thyroid gland, each with its own capsule of connective tissue. They are occasionally included in the thyroid capsule, or one of them may even follow a blood vessel deep into a sulcus of the thyroid.

Extreme locations are very rare, although glands have been found as high as the bifurcation of the carotid artery and as low as the mediastinum. In practice, the surgeon should start at the point at which the inferior thyroid artery enters the thyroid gland. The superior parathyroid glands will probably lie about 1 in. above it, and the inferior parathyroid glands will probably lie 1/2 in. below it. If the inferior gland is not found, it is more likely to be lower than higher.

It is not uncommon to have more or fewer than four parathyroid glands.

Blood Supply

The inferior thyroid artery is responsible in most cases for the blood supply of both the upper and lower parathyroid glands (see material on arterial supply of thyroid and parathyroid glands).

ANATOMY OF THE TRACHEA

The trachea, together with the esophagus and thyroid gland, lies in the visceral compartment of the neck. The anterior wall of the compartment is composed of sternothyroid and sternohyoid muscles. It is covered anteriorly by the investing layer of the deep cervical fascia and posteriorly by the prevertebral fascia (Fig. 2.9). The trachea begins at the level of the sixth cervical vertebra. Its bifurcation is at the level of the sixth thoracic vertebra in the erect position, or the fourth to fifth thoracic vertebrae when supine.

Vascular System

The chief sources of arterial blood to the trachea are the inferior thyroid arteries. At the bifurcation, these descending branches anastomose with ascending branches of the bronchial arteries.

Small tracheal veins join the laryngeal vein or empty directly into the left inferior thyroid vein.

The pretracheal and paratracheal lymph nodes receive the lymphatic vessels from the trachea.
Nervous System

The trachealis muscle and the tracheal mucosa receive fibers from the vagus nerve, recurrent laryngeal nerves, and sympathetic trunks. Small autonomic ganglia are numerous in the tracheal wall.

Anatomic Landmarks

The usual site of a tracheostomy is between the second and fourth or third and fifth tracheal rings. Several structures are encountered. The platysma lies in the superficial fascia and is absent in the midline. The anterior jugular veins may lie close to the midline; more importantly, they may be united by a jugular venous arch at the level of the seventh to eighth tracheal rings in the suprasternal space of Burns.

The investing layer of deep cervical fascia is encountered when the superficial fascia is reflected. Deep to the investing fascia are the sternohyoid and sternothyroid muscles. These muscles lie between the investing layer and the pretracheal fascia on either side of the midline.

Within the visceral compartment under the pretracheal fascia, the isthmus of the thyroid gland will be found, except that in 10% it is absent. A thyroid ima artery is possible, as well as a suspensory ligament of the thyroid and a levator thyroid muscle in, or close to, the midline.

■ PAROTID GLAND (FIG. 2.21)

Relations of the Parotid Gland

The parotid gland lies beneath the skin in front of and below the ear. It is contained within the investing layer of the deep fascia of the neck, called locally the parotid fascia, and the gland can be felt only under pathological conditions.

The boundaries are:

■ Anterior: masseter muscle, ramus of mandible, and medial pterygoid muscle
■ Posterior: mastoid process, sternocleidomastoid muscle, and posterior belly of the digastric muscle and facial nerve
■ Superior: external auditory meatus, and temporomandibular joint
■ Inferior: sternocleidomastoid muscle and posterior belly of digastric muscle
■ Lateral: investing layer of deep cervical fascia, skin, and platysma muscle
■ Medial: investing layer of deep cervical fascia, styloid process, internal jugular vein, internal carotid artery, and pharyngeal wall
From the anterolateral edge of the gland, the parotid duct (Stensen’s) passes lateral to the masseter muscle and turns medial at the anterior margin of the muscle. The duct pierces the buccinator muscle and enters the oral cavity at the level of the upper second molar tooth.

**Structures Traversing the Parotid Gland**

**Facial Nerve**

There is a superficial lobe and a deep lobe of the gland; the branches of the facial nerve run between them. In contrast, some anatomists visualize the gland as essentially unilobular, with the branches of the facial nerve enmeshed within the gland tissue with no cleavage plane between nerve and gland. The view that one may accept does not change the actual surgical procedure.

The main trunk of the facial nerve enters the posterior surface of the parotid gland about 1 cm from its emergence from the skull through the stylomastoid foramen, about midway between the angle of the mandible and the cartilaginous ear canal (Fig. 2.21). At birth the child has no mastoid process; the stylo-mastoid foramen is subcutaneous.
About 1 cm from its entrance into the gland, the facial nerve typically divides to form five branches: temporal, zygomatic, buccal, mandibular, and cervical. In most individuals, an initial bifurcation called the pes anserinus forms an upper temporofacial and a lower cervicofacial division, but six major patterns of branching, based on a series of simple to complex arrangements, have been distinguished.

**Arteries**

The external carotid artery enters the inferior surface of the gland and divides at the level of the neck of the mandible into the maxillary and superficial temporal arteries. The latter gives rise to the transverse facial artery. Each of these branches emerges separately from the superior or anterior surface of the parotid gland (Fig. 2.22).

**Veins**

The superficial temporal vein enters the superior surface of the parotid gland. It receives the maxillary vein to become the retromandibular vein. Still within the gland, the retromandibular vein divides. The posterior branch joins the posterior auricular vein to form the external jugular vein. The anterior branch
emerges from the gland to join with the facial vein, thereby forming the common facial vein, a tributary to the internal jugular (Fig. 2.23). Remember, the facial nerve is superficial, the artery is deep, and the retromandibular vein lies between them.

**Lymphatics**

The preauricular lymph nodes in the superficial fascia drain the temporal area of the scalp, upper face, lateral portions of the eyelids, and the anterior pinna. Parotid nodes within the gland drain the gland itself, as well as the nasopharynx, nose, palate, middle ear, and external auditory meatus. These nodes, in turn, send lymph to the subparotid nodes and eventually to the nodes of the internal jugular vein and spinal accessory chains (Table 2.1).

**Great Auricular Nerve**

The great auricular nerve reaches the posterior border of the sternocleidomastoid muscle and, on the surface of the parotid gland, follows the course of the external jugular vein. It is sacrificed at parotidectomy. Injury to this nerve results in numbness in the preauricular region, lower auricle, and the lobe of the ear, but it disappears after 4–6 months.
**Auriculotemporal Nerve**

The auriculotemporal nerve, a branch of the mandibular division of the trigeminal cranial nerve, traverses the upper part of the parotid gland and emerges with the superficial temporal blood vessels from the superior surface of the gland. Within the gland, the auriculotemporal nerve communicates with the facial nerve.

Usually, the order of the structures from the tragus anteriorly is the following: auriculotemporal nerve, superficial temporal artery and vein, and temporal branch of the facial nerve. The auriculotemporal nerve carries sensory fibers from the trigeminal nerve and motor (secretory) fibers from the glossopharyngeal nerve.

Injury to the auriculotemporal nerve produces Frey’s syndrome, in which the skin anterior to the ear sweats during eating (“gustatory sweating”).

**Parotid Bed**

Complete removal of the parotid gland reveals the following structures (the acronym VANS may be helpful in remembering them):

- **One Vein**: internal jugular
- **Two Arteries**: external and internal carotid
- **Four Nerves**: glossopharyngeal (IX), vagus (X), spinal accessory (XI), and hypoglossal (XII) (Fig. 2.24)
- **Four anatomic entities starting with S**: styloid process, and styloglossus, stylopharyngeus, and stylohyoid muscles

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**Figure 2.24.** Lateral view of the structures in the left carotid sheath at the base of the skull. The posterior belly of the digastric is shown in dotted outline. The hypoglossal nerve (not shown) hooks around the vagus and appears between the artery and the vein below the lower border of the digastric (By permission of RJ Last. *Anatomy: Regional and Applied*. Baltimore: Williams & Wilkins, 1972).
IDENTIFICATION OF THE FACIAL NERVE

The main trunk of the facial nerve is within a triangle bounded by the mastoid process, the external auditory meatus, and the angle of the mandible. The lower tip of the mastoid process is palpated and a fingertip is placed on the lateral surface pointing forward. The trunk of the facial nerve will be found deep and anterior to the center of the fingertip.

Remember:

✓ The stem of the nerve lies between the parotid gland and its fascia, deep in front of the mastoid, and medially at the midpoint between the mandibular angle and the cartilaginous ear canal. The stylomastoid foramen and the facial nerve are subcutaneous.

The facial nerve and its branches are in danger during parotidectomy. The facial trunk is large enough for anastomosis of the cut ends, should this be necessary.

BRANCHIAL CLEFT SINUSES AND CYSTS

Anatomy of Branchial Remnants

Fistulas

Fistulas are patent duct-like structures that have both external and internal orifices. Cervicoaural fistulas extend from the skin at the angle of the jaw, and may open into the external auditory canal. These fistulas lie anterior to the facial nerve. They are remnants of the ventral portion of the first branchial cleft (Fig. 2.25).

Lateral cervical fistulas almost always arise from the ventral portion of the second branchial cleft and pouch. They originate on the lower third of the neck on the anterior border of the sternocleidomastoid muscle. The path is upward through the platysma muscle and deep fascia. Above the hyoid bone the track turns medially to pass beneath the stylohyoid and the posterior belly of the digastric muscle, in front of the hypoglossal nerve, and between the external and internal carotid arteries. It enters the pharynx on the anterior surface of the upper half of the posterior pillar of the fauces (Fig. 2.26a). It may open into the supratonsillar fossa or even into the tonsil itself.

Sinuses

External sinuses are blindly ending spaces that extend inward from openings in the skin. Internal sinuses are blindly ending spaces that extend outward from openings in the pharynx.
External sinuses usually arise at the anterior border of the sternocleidomastoid muscle and end in a cystic dilatation (Fig. 2.26b). Internal sinuses are usually asymptomatic and hence undetected.

**Cysts**

Cysts are spherical or elongated spaces lying in the track of a branchial pouch or cleft and have no communication with the pharynx or skin.

Superficial cysts lie at the edge of the sternocleidomastoid muscle. Deeper cysts lie on the jugular vein or in the bifurcation of the carotid artery (Fig. 2.26c). These are of branchial cleft origin and are lined with stratified squamous epithelium. Cysts on the pharyngeal wall deep to the carotid arteries are usually of branchial cleft origin. They are lined with ciliated epithelium unless inflammatory or pressure changes have occurred (Fig. 2.27).

The external and internal carotid arteries just above the bifurcation of the common carotid artery are especially prone to injury while performing excision of the branchial remnants, because a second-cleft cyst or the path of a second-cleft fistula will lie in the crotch of the bifurcation.

**Remember:**

✓ A first-cleft sinus or cyst passes over or under the facial nerve below and anterior to the ear. The cyst may displace the nerve either upward or
downward. While removing the cyst, the surgeon must be careful to protect the nerve.

✓ Several nerves will be found above the pathway of a second-cleft or second-pouch branchial fistula:

- Mandibular and cervical branches of the facial nerve
- Spinal accessory nerve, which may be injured when trying to free a cyst or fistulous tract from the sternocleidomastoid muscle
- Descendens hypoglossi—superior root of the ansa cervicalis—which may be cut with impunity
- Hypoglossal nerve (the fistula crosses the nerve above the bifurcation of the common carotid artery)
- Superior laryngeal nerves
- Vagus nerve, which lies parallel to the carotid artery. (The fistula crosses the nerve near the level of the carotid bifurcation.)
Figure 2.27. Incomplete closure of the second branchial cleft or pouch may leave cysts. Type I, superficial, at the border of the sternocleidomastoid muscle. Type II, between the muscle and the jugular vein. Type III, in the bifurcation of the carotid artery. Type IV, in the pharyngeal wall. Types I, II, and III are of second-cleft origin; Type IV is from the second pouch. M = sternocleidomastoid muscle; V = jugular vein; A = carotid artery (By permission of JE Skandalakis, SW Gray, and JR Rowe. Anatomical Complications in General Surgery. New York: McGraw-Hill, 1983).
Diagnosis of nonthyroid neck masses follows a well-marked pathway. With a little rounding of the figures, an easily remembered rule is apparent:

**Rule of 80**
- 80% of nonthyroid neck masses are neoplastic.
- 80% of neoplastic neck masses are in males.
- 80% of neoplastic neck masses are malignant.
- 80% of malignant neck masses are metastatic.
- 80% of metastatic neck masses are from primary sites above the clavicle.

In addition, the probable diagnosis may be based on the average duration of the patient’s symptoms:

**Rule of 7**
- Mass from inflammation has existed for 7 days.
- Mass from a neoplasm has existed for 7 months.
- Mass from a congenital defect has existed for 7 years. However, acquired immune deficiency syndrome (AIDS) perhaps changes these rules a little.

**PAROTIDECTOMY**

Position the head and prepare the skin as in thyroid surgery, but uncover the lateral angle of the eye and the labial commissure. Sterilize the external auditory canal. Use intravenous antibiotic of choice.

**Step 1. Incision:** Inverted T or modified Y (Figs. 2.28 and 2.29)

*Inverted T:* Make a vertical preauricular incision about 3 mm in front of the ear with downward curved extension at the posterior angle of the mandible. Make a transverse curved incision 3 cm below the mandible with posterior extension close to the mastoid.

*Modified Y:* Make vertical pre- and postauricular incisions that unite approximately at the angle of the mandible, forming a Y which again meets a transverse incision 3 cm below the mandible.
Make a deep incision into the superficial cervical fascia (anteriorly, fat and platysma; posteriorly, fat only).

**Step 2.** Formation of flaps (Fig. 2.30).
Carefully elevate skin and fat using knife, scissors, and blunt dissection upward, medially, laterally, downward, and posteriorly.
For the upper flap, provide traction upward and medially on the dissected skin, and laterally toward the external auditory canal. Form the lower flap by dissection of the skin downward and posteriorly toward the mastoid process.

Figure 2.28. Modified Y incision.

Figure 2.29. Inverted T-incision.
Remember:
✓ Sacrifice the great auricular nerve and the posterior facial vein. Both are very close to and topographicoanatomically situated in the vicinity of the lower flap and the lower parotid border.

Step 3. Facial nerve identification (Fig. 2.31)

a. Place the distal phalanx of the left index finger on the mastoid, pointing to the eye of the patient.
b. Carefully incise the parotid fascia and further mobilize the superficial part of the parotid.
c. Insert a hemostat between the mastoid and the gland and bluntly spread the gland medially.
d. The stem of the nerve will always be found at a depth of less than 0.5 cm. If there is any doubt whether the nerve has been identified, use electrical stimulation.
e. Exert upward traction on the superficial lobe and, with a curved hemostat, begin dissection over the nerve.
f. Identify all five branches.

Step 4. Resection of the superficial lobe (Fig. 2.32).
With gentle traction of the gland and further anterior nerve dissection toward the periphery of the gland, totally mobilize and resect the superficial lobe. As the dissection is carried toward the ends of the branches of the facial nerve, Stensen’s duct will be encountered and should be ligated and divided.

Step 5. Resection of the deep lobe (Fig. 2.33)

The following anatomical entities should be kept in mind:
- Pterygoid venous plexus
- External carotid artery
- Maxillary nerve
- Superficial temporal nerve
- Posterior facial vein

All the above should be ligated. Pterygoid venous plexus bleeding may be stopped by compression. Do not go deep: remember VANS (see “Parotid Bed” earlier in this chapter). Remove the deep lobe carefully, working under the facial nerve by the piecemeal dissection technique. Obtain good hemostasis.
Figure 2.32. Resection of the superficial lobe.

Figure 2.33. Resection of the deep lobe.
Radical Parotidectomy (Fig. 2.34)

Excise the parotid in toto, as well as the facial nerve and the regional lymph nodes; also, if necessary, perform ipsilateral radical neck dissection.

Autologous graft microanastomosis should be considered for reconstruction of the facial nerve. The greater and lesser occipital nerves can serve as donors.

Remember:

✓ Try to save zygomatic marginal branches if possible. If not, use microanastomosis end to end.

Insert a Jackson–Pratt drain through a lower stab wound. To close the wound, use interrupted 3-0 Vicryl for platysma and fat, and interrupted 6-0 nylon for skin.

RESECTION OF SUBMAXILLARY GLAND (FIGS. 2.1, 2.2, 2.3, 2.4, 2.5, AND 2.6)

POSITION AND PREPARATION: As in parotidectomy. The upper half of the face should be covered, but the labial commissure should be uncovered.

INCISION: Make a transverse incision 3 cm below the lower border of the mandible. Incise the superficial fascia from the anterior border of the sternocleidomastoid muscle (SCM) to 2–3 cm from the midline (Fig. 2.35).
Remember:
✓ The two branches of the facial nerve (mandibular and cervical) are under the platysma and the deep fascia of the submaxillary gland. Identify and protect them. Apply retractors carefully.

Surgical Field in View:
- Superior: inferior border of mandible
- Inferior: digastric and stylohyoid muscles
- Medial: mylohyoid muscle
- Lateral: sternocleidomastoid muscle
- Center: deep cervical fascia covering the gland

The common facial vein, its anterior tributary, or its posterior tributary is now in view close to the sternocleidomastoid muscle. Continue to observe the marginal branch of the facial nerve, which is superficial to the facial vessels (occasionally at a lower level).

Remember:
✓ There are lymph nodes outside the capsule close to the vessels. With benign disease, removal of these is not necessary.

Step 1. Ligate the facial vessels (Fig. 2.36).

Step 2. With curved hemostat, separate inferiorly the gland from the digastric muscle (Fig. 2.37).
Resection of Submaxillary Gland

Figure 2.36. Exposure of common facial artery, vein, and nerve.
Remember:

✓ The hypoglossal nerve is located very close to the digastric tendon and is accompanied by the lingual vein and, deeper, by the external maxillary artery. Both vessels should be ligated carefully. Elevate the mylohyoid muscle to expose the deep part of the submaxillary gland. Separate the gland slowly. Just under the gland and cephalad to it, the following anatomical entities are in view: lingual nerve, chorda tympani, submaxillary ganglion, and Wharton’s duct.

Step 3. Ligate and cut Wharton’s duct. Protect the lingual nerve (Fig. 2.38). Continue blunt dissection.

Step 4. Insert Jackson–Pratt drain and close in layers.
Caution: Avoid injury to the mandibular, hypoglossal, and lingual nerves.

THYROIDECTOMY

Step 1. Position
  a. Put the patient in semi-Fowler position.
  b. Patient’s neck should be hyperextended.
  c. Place small pillow at the area of the upper thoracic spine, beneath the shoulders.
  d. Place a doughnut support under the head.
Step 2. Preparation of skin
a. Use Betadine or any other solution of the surgeon’s choice.
b. Be sure the chin and long axis of the body are aligned at the midline.
c. With 2-0 silk, mark the location of the incision, two fingerbreadths above the sternal notch.
d. Use a knife to mark very superficially the middle and edges of the previously marked location of the incision.

Step 3. Incise the low collar symmetrical mark of the skin, carrying out the incision through the superficial fascia (subcutaneous fat and platysma). Establish good hemostasis by electrocoagulation or ligation using silk (Figs. 2.39 and 2.40).
Step 4. Formation of flaps (Fig. 2.41)
By blunt dissection, elevate the upper flap to the notch of the thyroid cartilage and the lower flap to the jugular (sternal) notch. Use Mahorner’s, Murphy’s, or other self-retaining retractors.

Step 5. Opening of the deep fascia (Figs. 2.42 and 2.43)
The opening is accomplished by a longitudinal midline incision along the raphe of the strap muscles, which is actually the deep fascia.
Step 6. Elevation of the strap muscles (Figs. 2.44, 2.45, and 2.46)

The sternohyoid muscles are easily elevated, but the thyrohyoid and sternothyroid muscles are attached to the false thyroid capsule and should be separated carefully to avoid injuring the gland and causing
Figure 2.44. Sternohyoid muscles.

Figure 2.45. Breaking of attachments.
bleeding. In extremely rare cases, when the thyroid gland is huge, section of the strap muscles becomes necessary. Divide them at the proximal (upper) one-third to avoid paralysis due to injury of the ansa hypoglossi (C1, C2, C3, and XII).

The sternohyoid muscles are the most superficial, and the sternothyroid and thyrohyoid are underneath. For practical purposes, the thyrohyoid is an upward continuation of the sternothyroid.

**Step 7.** Exposure and mobilization of the gland

With all strap muscles elevated and retracted, the index finger of the surgeon is gently inserted between the thyroid and the muscles (Fig. 2.45). A lateral elevation is also taking place, occasionally using all the fingers except the thumb. It not only breaks the remaining muscular or pathological attachments, but enables the surgeon to appreciate the gross pathology of the gland in toto. Occasionally the strap muscles should be divided (Figs. 2.46 and 2.47).

The anatomy of the normal and the abnormal must be studied carefully regarding size, extension, consistency, and fixation of the gland. Is a pyramidal lobe present? How thick is the isthmus? Are a Delphian node and other lymph nodes present? If so, excision of the Delphian node and perhaps one or two of the other palpable lymph nodes is in order. Frozen section should follow.

**Step 8.** Total lobectomy (Figs. 2.48, 2.49, and 2.50)

a. Retract the lobe medially and anteriorly by special clamps or deep sutures outside the lesion.

b. Ligate the middle thyroid vein.
Figure 2.47. Lateral elevation.

Figure 2.48. Exposure.
Thyroidectomy

Figure 2.49. Retraction.

Figure 2.50. Ligation.
c. Identify the recurrent laryngeal nerve by blunt dissection into the tracheoesophageal groove.
d. Identify and protect the parathyroids.
e. Ligate the inferior thyroid artery. Superior and inferior pole vessels may also be divided with the Ligasure or Harmonic scalpel.
f. Ligate the lower pole vessels.
g. Carefully ligate the upper pole. Perform en masse ligation, thereby ligating the superior thyroid artery, or, if possible, prepare the artery above the pole and ligate.
h. Dissect the lobe from the trachea by dividing the gland between straight mosquitoes. With 3-0 silk, suture ligate the tissue that is clamped over the trachea. Alternatively the Harmonic Scalpel can be used with the same effect.
i. If the pyramidal lobe is present, ligate its most distal part and remove it together with the lobe. Send the specimen to the lab for frozen section.
j. Ligate the isthmus, if present.
k. Obtain meticulous hemostasis.

Step 9. Subtotal thyroidectomy.
Apply multiple hemostats at the thyroid parenchyma and partially transect the gland. Use 4-0 silk suture ligature for suture ligation of the thyroid parenchyma and surface veins. If possible, approximate the segment to the trachea. Both upper pole remnants or the tracheoesophageal remnant should weigh approximately 5–6 g.

■ PARATHYROIDECTOMY

Step 1. The following steps are a strategy for finding abnormal parathyroid locations.
a. Perform preoperative CT angiogram (CTA) to identify parathyroid adenoma.
b. Explore the superior surface of the thyroid gland. Ligate the middle thyroid veins, retract the lobe medially and anteriorly, and expose the recurrent laryngeal nerve.
c. Dissect the superior anterior mediastinum as far as possible, with special attention to the thymus or its remnant behind the manubrium.
d. Explore the region above the upper pole of the thyroid gland as far as the hyoid bone.
e. Explore the retroesophageal, retropharyngeal, and retrosternal spaces.
f. Perform subtotal thyroidectomy.
g. Confirm removal of parathyroid adenoma via intraoperative parathyroid monitoring.

h. Further explore the mediastinum at a second operation. This should be done only after the pathology report on thymus and thyroid tissue has been received and no parathyroid tissue is reported.

Remember:
✓ The best anatomical landmark is the inferior thyroid artery.
✓ The most useful instrument for palpation is the distal phalanx of the index finger.

Step 2. In the patient with a localized gland identified by CTA, the incision is made directly over the gland between the sternocleidomastoid muscle and the strap muscles. In a patient with hyperplasia, remove 3½ glands. The remaining ½ gland can be left in situ or implanted into the sternocleidomastoid muscle. In any case, cryopreserve a parathyroid for reimplantation in case the patient becomes hypoparathyroid. When a patient is explored for a suspected adenoma, the healthy glands will be smaller than normal. If a parathyroid adenoma has been identified by CTA, it is not necessary to identify all the glands. After removal of the enlarged gland, there should be at least a 50 % reduction in the PTH level. If the PTH level does not show a significant decrease, then the presence of a second and possibly a third adenoma should be investigated. Always send adenomas for frozen section. If the gland is determined to be malignant, the surrounding tissue should be removed.

Step 3. Reconstruction
Insert a Penrose or a Jackson–Pratt drain. Close the midline and the superficial fascia, approximating the marked points and avoiding dogears. Closure of the skin is up to the surgeon: use subcuticular sutures with Steri-strips, interrupted 6-0 nylon, or clips. Remember to check the vocal cords as soon as the endotracheal tube has been removed.

**THYROID REOPERATION**

Step 1. Carefully read the patient’s previous operating report.
Step 2. Inspect vocal cords.
Step 3. Incise through the previous scar, but add 1–2 cm on each side laterally.
Step 4. Make flaps as in thyroidectomy.
Step 5. Identify the sternocleidomastoid muscle; incise, dissect, and elevate its medial border.

Step 6. Carefully elevate the strap muscles.

Step 7. There are two ways to reexplore the thyroid: from the periphery (this anatomically intact area has less scar tissue) to the center, and from the midline/isthmic area to the periphery.
   a. From the periphery to the center  
      Most likely, the virgin area after thyroid surgery is the area corresponding to the medial border of the sternocleidomastoid. The best anatomical landmark is the proximal part of the inferior thyroid artery, since the distal was probably ligated. Any white, thin, cordlike structure should be protected, since this is probably the recurrent laryngeal nerve. If in doubt, stop the dissection in this area and try to find the nerve at the cricothyroid area above, or at the supraclavicular area below. The most virgin area is just above the clavicle, and the least virgin (if total lobectomy was performed previously) is the cricothyroid area. The parathyroids will be found above and below the inferior thyroid artery. The remnants of the thyroid glands will be found in the tracheoesophageal groove or in the area of the upper thyroid pole.
   b. From the midline/isthmic area to the periphery  
      The anatomical area to be explored with this procedure is the tracheoesophageal groove, in the hope that the recurrent laryngeal nerve is somewhere in the vicinity. Small curved mosquito or Mixter clamps may be used for elevation of the thyroid remnants, location of the nerve, and location of the parathyroids.

If reexploration is performed for malignant disease, then a modified radical neck dissection is in order. In the modified procedure the sternocleidomastoid muscle and the internal jugular vein are preserved. The recurrent nerve also should be saved; it should be sacrificed only if it is fixed to the tumor.

■ PARATHYROID REOPERATION

Step 1. Read about normal and abnormal locations of parathyroids.

Step 2. Carefully read the patient’s previous operating report and pay special attention to:
   a. Number of parathyroids removed.
   b. Sites (right or left).
c. Together with the radiologist, study all possible results of techniques for localization (ultrasonography, CTA, MRI, sestamibi scan, selective venous catheterization with parathyroid hormone immunoassay evaluation, digital subtraction angiography).

Step 3. Reexplore the neck as in thyroidectomy.

Step 4. Locate and mark the inferior thyroid artery.

Step 5. Protect the recurrent laryngeal nerve.

Step 6. Palpate the “certain” location and all possible locations of parathyroid glands, such as tracheoesophageal groove, retropharyngeal, retroesophageal, retrocarotid, anterior mediastinum (thymus), posterior mediastinum, middle mediastinum (pericardium) within the carotid sheath, suprathyroid, infrathyroid, intrathyroid, and posterior triangle.

Step 7. Remove the tumor. A patient diagnosed with hyperplasia probably has one gland or only 1/2 of the fourth gland (if the patient has only four glands) with hyperplastic or adenomatous changes. Perform a total parathyroidectomy and transplant multiple pieces (1 mm in diameter) of the adenoma or the hyperplastic gland into the biceps muscle, being sure to mark the location. If there is an adenoma that was not found previously, remove it. If the frozen section is determined to be malignant, the surrounding tissue should be removed.

THYROGLOSSAL DUCT CYSTECTOMY (FIG. 2.51)

Position and prepare as for thyroidectomy.

Step 1. Make a transverse incision over the cyst. Incise the superficial fascia (fat and platysma) and mark the skin at the midline to facilitate good closure. Formation of flaps: the upward elevation reaches the hyoid bone and extends cephalad 1–2 cm. Elevate the lower flap almost to the isthmus of the thyroid gland. One self-retaining retractor is enough to keep the field open. Open the deep fascia in a longitudinal fashion.

Step 2. Dissect the cyst and isolate it with a small hemostat and plastic scissors (Fig. 2.52). The involved anatomical entities depend upon the location of the cyst (Fig. 2.53): suprathyroid (rare), hyoid (common), and infrathyroid or suprasternal (rare). (Knowledge of the embryology plays a great role here.)
Figure 2.51. Various locations of thyroglossal duct cysts. (A) In front of the foramen cecum. (B) At the foramen cecum. (C) Above the hyoid bone. (D) Below the hyoid bone. (E) In the region of the thyroid gland. (F) At the suprasternal notch. About 50% of the cysts are located at (D), below the hyoid bone (by permission of GE Ward, JW Hendrick, and RG Chambers. Surg Obstet Gynecol 89:728, 1949).

Figure 2.52. Dissection of cyst.
Remember:

✓ The embryologic path of descent of the thyroid gland (from the foramen cecum to the manubrium sterni).

✓ The thyroglossal duct (a midline cordlike formation) travels, in most cases, through the hyoid bone.

✓ The anatomical entities involved in most of the cases are:
  - Foramen cecum
  - Thyroid membrane
  - Mylohyoid muscle
  - Geniohyoid muscle
  - Genioglossus muscle
  - Sternohyoid muscle
  - Anterior belly of digastric muscle

✓ The mylohyoid is fixed to the hyoid bone above; the sternohyoid is fixed to the hyoid bone below.

✓ Occasionally, the anterior belly of the digastric muscle may partially cover the hyoid bone laterally.

✓ The geniohyoid is between the thyroid membrane and the mylohyoid.

Step 3. Take special care of the hyoid bone and tract. Clean the central part of the hyoid bone, but be sure to leave some cuffs of sternohyoid and mylohyoid attached to the bone, as well as some cuffs of the underlying geniohyoid and genioglossus attached to the cephalad tract (Fig. 2.54). Insert a curved hemostat under the central part of the hyoid bone. With heavy scissors or small bone cutter, cut the bone on both sides. Continue upward dissection bilaterally to the midline where the tract is located. The thyrohyoid membrane is now exposed (Fig. 2.55).

Step 4. The foramen cecum also requires special attention. The anesthesiologist’s index finger is inserted into the patient’s mouth, elevating the foramen cecum. With continuous cephalad dissection, the surgeon reaches the foramen cecum by palpating the finger of the
anesthesiologist just under the thyrohyoid membrane. Excise the foramen cecum in continuity and close the defect with figure-of-eight 4-0 chromic catgut or any other absorbable suture. Drainage is up to the surgeon. Establish good hemostasis. Irrigate with normal saline (Fig. 2.56).

**Step 5.** Reconstruction. Perform midline approximation of the mylohyoid and sternohyoid with interrupted sutures as for thyroid operation.

**Note:**

✓ In the case of a sinus without cyst, follow the same steps.
EXCISION OF BRANCHIAL CLEFT CYST OR FISTULA

Step 1. Above a cyst, make a small transverse incision; around a sinus, make an elliptical incision. Multiple incisions will be necessary if the cyst or sinus is low (Fig. 2.57).

Step 2. Separate and elevate the sternocleidomastoid muscle, always using the medial border (Fig. 2.58).

Step 3. Visualize the carotid sheath and hypoglossal nerve (Fig. 2.59).
2. Neck

Figure 2.58. Exposure of fistulous tract.

Figure 2.59. Excision of fistula inset: structures of surgical field.
Step 4. Continue dissection of the cyst or sinus cephalad toward the pharyngeal wall.

Step 5. Excise the minute pharyngeal wall if pathology exists.

### RADICAL NECK DISSECTION

**Overview**

A radical neck dissection must be planned as a curative procedure. It involves complete excision of the primary lesion, together with all nonessential structures and their lymph nodes, collecting lymph trunks, fascia, and fat. The bed of a radical neck dissection is bounded superiorly by the inferior border of the mandible, inferiorly by the clavicle, posteriorly by the anterior border of the trapezius muscle, and anteriorly by the midline.

Lymphatic tissue must be removed as completely as possible. Nonlymphatic tissue falls into three categories: (1) structures that can be sacrificed with impunity, (2) structures whose sacrifice is controversial, especially for cosmetic reasons, and (3) structures that must be preserved unless directly invaded by cancer. Structures in these categories are listed in Table 2.3.

**Anatomical Elements**

**Superficial Cervical Fascia**

The anterior cutaneous nerves and the supraclavicular nerves must be sacrificed. The platysma muscle should be preserved.

**Deep Cervical Fascia**

The deep cervical fascia must be removed as completely as possible, since lymph nodes and lymphatic vessels are largely distributed in the connective tissue between the layers of the fascia. The carotid sheath and the internal jugular vein also should be sacrificed.

**Anterior Triangle**

- Submental triangle: Remove the entire contents.
- Submandibular triangle: Remove the submaxillary gland and lymph nodes.
- Carotid triangle: Remove the internal jugular vein. High ligation of the vein is facilitated by removal of the lower pole of the parotid gland. The great auricular nerve and all superficial branches of the cervical nerves should be cut. All lymph nodes along the internal jugular vein must be removed. The final result is shown in Fig. 2.60.
<table>
<thead>
<tr>
<th>Structures</th>
<th>May be sacrificed</th>
<th>Controversial</th>
<th>Must be preserveda</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organs</td>
<td>Submaxillary gland, lower pole of parotid gland</td>
<td>None</td>
<td>Thyroid gland, parathyroid glands</td>
</tr>
<tr>
<td>Muscles</td>
<td>Omohyoid, sternocleidomastoid</td>
<td>Platysma, digastic, stylohyoid</td>
<td>All other muscles</td>
</tr>
<tr>
<td>Vessels</td>
<td>External jugular vein, facial artery and vein, superior thyroid artery, lingual artery</td>
<td>Internal jugular vein</td>
<td>External carotid artery, internal carotid artery, subclavian artery and vein, thoracic duct</td>
</tr>
<tr>
<td>Nerves</td>
<td>Anterior cutaneous C2–C3, supraclavicular C3–C4, ansa hypoglossi, great auricular nerve</td>
<td>Spinal accessory nerve</td>
<td>Mandibular branch of facial nerve, superior laryngeal nerve, recurrent laryngeal nerve, facial nerve, lingual nerve, hypoglossal nerve, phrenic nerve, vagus nerve, cervical sympathetic nerve, carotid sinus nerves, brachial plexus, nerves to rhomboid and serratus muscles</td>
</tr>
</tbody>
</table>

Posterior Triangle

Remove all tissue above the spinal accessory nerve without injury to the nerve. With blunt dissection, free the nerve from the underlying tissue. Ligate the external jugular vein close to the subclavian vein, and transect the sternocleidomastoid and omohyoid muscles.

The area beneath the spinal accessory nerve is the “danger zone” of Beahrs. It contains a number of structures that must be saved if possible: the nerves to rhomboid and serratus muscles, the brachial plexus, the subclavian artery and vein with the anterior scalene muscle between, and the phrenic nerve. The object of dissection in this area is to remove completely the transverse...
Deep to the sternocleidomastoid muscle and posterolateral to the internal jugular vein, the thoracic duct on the left and the right lymphatic duct on the right lie in a mass of areolar connective tissue. They should be preserved if possible; if they have been injured, ligate.

Between the jugular vein and the carotid artery lies the ansa cervicalis, which innervates the strap muscles of the neck. This nerve is on or in the carotid sheath medial to the internal jugular vein. It may be cut with impunity.

**Procedure**

Position and prepare as in parotidectomy.

**Step 1. Incision (Figs. 2.61, 2.62, and 2.63)**

Make a T-incision with the horizontal part extending from the midline to the submastoid area approximately 3 cm below the inferior border of the mandible and the vertical part extending from the midpoint of the horizontal down to 1 cm above the clavicle. Alternative incisions are the H type, the I type, or one shaped like an H lying on its side (lazy H).

*The upper flap of the horizontal part.* Incise the superficial fascia (fat and platysma) by deepening the skin incision and elevate the upper flap. The anterior facial vessels are located at the upper part of the flap snaking in front of the mandible. The mandibular (inferior horizontal) and spinal accessory chains of lymph nodes (see Fig. 2.11).
Figure 2.62. Development of upper flap.

Figure 2.63. Dissection of submental and submandibular triangles.
and cervical branches of the facial nerves are located superficially to these vessels. Protect both nerves, especially the marginal branch, by careful dissection and isolation. If necessary, the cervical branch may be cut. Elevate the anterior facial vessels, then clamp, divide, and ligate them.

Detach the deep cervical fascia from the mandible and push it downward bluntly, including the submental area and the submaxillary gland, fat, and lymph nodes. Occasionally, the lower pole of the parotid is removed below the disappearing point of the marginal branch. Then, in this procedure, the contents of the submental and submandibular triangles are dissected as well as the lower pole of the parotid.

**Vertical incision and formation of flaps.** To form flaps, deepen the existing skin incision. Prepare the anterior neck triangle and elevate the anterior flap to the midline and the posterior flap to the anterior border of the trapezius muscle. The sternocleidomastoid muscle is essentially in the middle of the surgical field.

**Step 2.** Exploration of the posterior triangle (Fig. 2.64)

The following anatomical entities should be identified:

- Spinal accessory nerve
- External jugular vein
- Cervical nerves (not shown)
- Brachial plexus (between anterior and middle scalene) (not shown)
- Phrenic nerve (resting on the anterior scalene) (not shown)

All but the spinal accessory nerve are under the “carpet” (the splitting of the deep fascia) of the floor of the posterior triangle.

Carefully ligate the external jugular vein close to the subclavian vein while protecting the other four entities listed above. The upper part of the posterior triangle is cleaned by blunt dissection, pushing fibrofatty tissue and lymph nodes cephalad.

**Step 3.** After elevating and protecting the anatomical entities of the carotid sheath, carefully transect the clavicular and sternal insertions of the sternocleidomastoid muscle.

The next step is a low division of the omohyoid behind the sternocleidomastoid muscle. Continue cleaning the floor of the posterior triangle (Figs. 2.65 and 2.66).

**Step 4.** Open the anterior wall of the carotid sheath, ligate the internal jugular vein close to the clavicle, and remove the sheath together with the vein and all fibrofatty tissue in the vicinity. Protect the phrenic nerve, and ligate the transverse scapular and transverse cervical arteries and the
right or left thoracic ducts as required. Proceeding upward, remember the posterior belly of the digastric muscle is an excellent anatomical landmark. Just underneath are internal and external carotid arteries; the internal jugular vein, which should be ligated; cranial nerves (X, XI, XII); and the sympathetic chain (Fig. 2.67).

**Step 5.** Working now at the anterior triangle, avoid cutting the external branch of the superior laryngeal nerve. Ligate the branches of the external carotid artery. Protect and save the hypoglossal nerve. Continue to work on both the submental and the submandibular triangles. Ligate the submaxillary duct, but protect and save its fellow traveler, the lingual nerve. Spare the submaxillary ganglion. Establish good hemostasis (Fig. 2.68).

**Step 6.** Remove the specimen en bloc (Fig. 2.69). Figure 2.60 shows the surgical field after removal of the specimen.
Figure 2.65. Transection of omohyoid muscle.

Figure 2.66. Exploration of overlying fascia.
Note:

✓ Under certain circumstances, such as thyroid cancer, a modified radical neck dissection or central neck dissection may be more appropriate than the radical dissection.

TRACHEOSTOMY

Step 1. Position: semi-Fowler; hyperextension of the neck; small pillow at the area of the upper thoracic spine beneath the shoulders; doughnut support under the head.

Step 2. Preparation of skin: use Betadine or any other solution of surgeon’s choice.

Be sure that chin and long axis of the body are aligned at the midline. Mark the location of the incision with 2-0 silk, two fingerbreadths above the sternal notch.

With a knife, mark very superficially the middle and edges of the previously marked location of the incision.
Use of an endotracheal tube is a wise step.

**Step 3.** In children, make a vertical incision to avoid injury of the arteries and veins located under the anterior border of the sternocleidomastoid muscle.

In adults, use vertical or transverse incision and proceed as in thyroid surgery (Fig. 2.70).

**Step 4.** Locate the thyroid isthmus. The inferior thyroid vein and thyroid ima artery should be ligated (Fig. 2.71).

**Step 5.** Clean the anterior wall of the trachea below the isthmus.
Remember:
✓ Dissection too deep toward the superior mediastinum will injure the jugular venous arch, and dissection too lateral will injure the vessels of the carotid sheath. The thyroid isthmus should be retracted or cut between clamps for more tracheal room.

Step 6. Immobilize and elevate the anterior tracheal wall using a hook at the lower border of the cricoid cartilage.

Step 7. Make a vertical incision through the second or third tracheal ring or form a window at the anterior tracheal wall by removing the anterior central segment of the two rings (Fig. 2.72).

Remember:
✓ Be careful when you incise the trachea. The posterior wall of the trachea is not protected, so injury to the esophagus is an obvious risk.
✓ Protect the cricoid cartilage and first tracheal ring to avoid postoperative tracheal stenosis.

Step 8. Spread the tracheal opening with a tracheal spreader. Insert a Hardy–Shiley tracheostomy tube as the endotracheal tube is slowly backed out (Fig. 2.73).

Step 9. With umbilical tape, secure the tube around the patient’s neck. Pack iodoform in the subcutaneous tissue around the tracheostomy tube.
Figure 2.73. Tracheal opening.
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