# Chapter 92: Neck Dissection

**Jesus E. Medina, Nestor M. Rigual**

The treatment of the neck in patients with squamous cell carcinoma of the upper aerodigestive tract and other neoplasms of the head and neck region continues to be one of the most controversial issues in head and neck oncology. The evolution of the treatment of the neck, in time, is a good example of how the quest of clinicians to maximize tumor control and minimize morbidity to each patient has led to the diversification of what is considered appropriate surgical removal of the regional lymph nodes and continues to be a stimulus to refine the combined use of surgery, radiation therapy, and chemotherapy.

Today, it is not possible to address the subject of neck dissection and limit the discussion to any one operation. It is clear that a number of different cervical lymph node dissections are being used for the surgical treatment of the neck in patients with cancer of the head and neck region. This has created a problem of nomenclature and a problem of confusion about the role that each one of these operations has in the surgical treatment of the neck in patients with cancer. Whereas the former problem can be solved by adopting a logical classification of neck dissections, such as the one recently endorsed by the American Academy of Otolaryngology and Head and Neck Surgery (Robbins, 1991), the latter remains far from a scientific resolution. As Ward (1990) has pointed out, "It is a sad commentary on our scientific efforts that most approaches to the management of the N0 neck are based on empiricism". The effectiveness of the different neck dissections currently used by head and neck surgeons in the USA and abroad has not been demonstrated by properly controlled, prospective, randomized studies. The use of these operations, including the radical neck dissection, is based on information gathered mostly through retrospecive sources. Nevertheless, this information cannot and should not be disregarded. Not only does it represent the experience of many dedicated head and neck surgeons, but also it is likely to remain for an indefinite time as the only foundation for our clinical practice in the treatment of the neck.

This chapter provides the reader with a succinct discussion of the current classification of neck dissections and the rationale, indications, results, and surgical technique of the most commonly used neck dissections.

## Classification of Neck Dissections

The need to standardize the nomenclature referring to the different cervical lymph node dissections is obvious. To classify neck dissections, we must first adopt a common nomenclature for the lymph node groups of the neck. The diagrammatic division of the lymph nodes of the neck used at Memorial Sloan-Kettering Cancer Center (Fig. 92-1) is ideal for this purpose because it is simple and has been refined by long-standing use. Region I contains the submental and submandibular triangles. Regions II, III, and IV include the lymph nodes along the internal jugular vein and those nodes found within the fibroadipose tissue located medial to the sternocleidomastoid muscle. These regions are divided into equal thirds. Region II corresponds to the upper third and includes the upper jugular and jugular digastric nodes and the upper posterior cervical nodes, which are found in close proximity to the spinal accessory nerve. Regions III and IV are divided at the point that the omohyoid muscle crosses the internal jugular vein. Region IV includes the lower jugular lymph nodes as well as the scalene and supraclavicular lymph nodes that are located deep to the lower third of the sternocleidomastoid muscle. Region V includes the contents of the posterior cervical triangle.

A rational classification of neck dissections must take into account primarily the lymph node groups of the neck that are removed and secondarily the anatomic structures that may be preserved, such as the spinal accessory nerve and the internal jugular vein. From these two points of view, there are essentially three anatomic types of neck dissections: comprehensive, selective, and extended (Medina, 1989).

*Comprehensive* neck dissections consist of the removal of all lymph node regions (I to V) of one side of the neck. Included in this category are the radical neck dissection and those modifications of the radical neck dissection that were developed with the intention of reducing the morbidity of this operation by preserving one or more of these structures: the spinal accessory nerve, the internal jugular vein, or the sternocleidomastoid muscle. These operations are truly modifications of the original radical neck dissection and can be referred to as *modified radical neck dissections.*

The three neck dissections that can be included in this category are outlined in the box. They differ from each other only in the number of neural, vascular, and muscular structures that are preserved. Therefore they can be subclassified into type I, in which only "one" structure, the spinal accessory nerve, is preserved; type II, in which "two" structures, the spinal accessory nerve and the internal jugular vein, are preserved; and type III, in which all "three" structures, the spinal accessory nerve, the internal jugular vein, and the sternocleidomastoid muscle, are preserved. This last neck dissection corresponds to the "functional neck dissection" popularized by Bocca.

The *selective* neck dissections consist of the removal of only the lymph node groups that are at highest risk of containing metastases according to the location of the primary tumor, preserving the spinal accessory nerve, the internal jugular vein, and the sternocleidomastoid muscle. There are three different neck dissections that can be included in this category:

1. The "lateral neck dissection" consists of the en bloc removal of nodal regions II, III, and IV.

2. The supraomohyoid neck dissection and the expanded supraomohyoid neck dissection consist of en bloc removal of nodal regions I, II, and III. The expanded supraomohyoid dissection includes, in addition, the nodes in region IV.

3. The "posterolateral neck dissection" consists of the removal of the suboccipital and retroauricular lymph node groups and nodal regions II, III, IV, and V.

The *extended* neck dissections are any of the neck dissections described above "extended" to include either lymph node groups that are not routinely removed, such as retropharyngeal or paratracheal, or structures that are not routinely removed, such as the carotid artery or the levator scapulae.

## Documentation of Neck Dissections

***

## Radical Neck Dissection

### *Definition*

This operation is defined as the en bloc removal of the lymph node-bearing tissues of one side of the neck, from the inferior border of the mandible to the clavicle and from the lateral border of the strap muscles to the anterior border of the trapezius. Included in the resected specimen are the spinal accessory nerve, the internal jugular vein, and the sternocleidomastoid muscle (Fig. 92-4).

### *Rationale*

The first description of this systemic en bloc removal of the lymphatics of the neck was published by Crile in 1906. The operation he described has come to be known as the radical neck dissection. Crile believed that removing the internal jugular vein was essential because of the intimate relation of this structure with the lymph nodes of the neck. He also believed that an en bloc removal of the primary tumor and the lymphatic system of the neck should be carried out in a manner similar to the Halstead operation for cancer of the breast and that interruption of the normal lymph flow by metastases in a lymph node would cause further tumor dissemination to occur in any direction. In his opinion a less radical, "incomplete operation" disseminates and stimulates the growth of tumor. Interestingly, the drawings that illustrate his publication indicate that the spinal accessory nerve and the anse hypoglossi were preserved. The routine removal of the spinal accessory nerve was advocated later by Blair and Brown (1933), who believed that the nerve should be removed to decrease operating time and increase the certainty of total neck node removal of the cervical lymph nodes. It was Martin (1951), however, who in the 1950s championed the concept that a cervical lymphadenectomy for cancer was not adequate unless all the lymph node-bearing tissues of one side of the neck were removed and that this was not possible unless the spinal accessory nerve, the internal jugular vein, and the sternocleidomastoid muscle were included in the resection. In fact, he categorically stated that "any technique that is designed to preserve the spinal accessory nerve should be condemned unequivocally". Like Crile, Martin (1951) believed that it was not possible to completely remove the lymphatic of the neck without resecting the internal jugular vein because of the close association of the lymphatics in this area with the vein walls.

Removal of the sternocleidomastoid muscle is clearly necessary when the muscle is involved by tumor as well as when the metastases are large and, in some instances, when they are located in multiple regions of the neck. Removal of this muscle unquestionably facilitates access to the jugular vein and the removal of the lymph node-bearing tissues of the neck. However, removing the muscle is no longer justified for ease of dissection or exposure alone.

Although most head and neck surgeons today would agree that a radical neck dissection is not indicated in the absence of palpable cervical metastases (that is, in the treatment of the N0 neck), it has been argued recently that the radical neck dissection should continue to be the only dissection of the lymph nodes performed in patients with cancer of the head and neck. The proposed rationale for this recommendation is that the radical neck dissection is an anatomically well-delineated operation and thus it is easy to reach. Further, having only one operation to select, "surgeons who perform dissections of the neck occasionally, who are not comfortable with the indications for neck dissections and the subtleties of metastatic disease of the neck, are more likely to perform a timely operation if that operation is predictable and easy" (DeSanto and Beahrs, 1988). If such reasoning was ever valid, its validity is dissipating as more residents and fellows are being eductaed about the subtleties of head and neck cancer and are being trained to perform other cervical lymphadenectomies properly.

### *Indications*

The radical neck dissection is indicated when there are multiple clinically obvious cervical lymph node metastases, particularly when they involve the lymph nodes of the posterior triangle of the neck and these are found to be closely related to the spinal accessory nerve. A radical neck dissection is also indicated when there is a large metastatic tumor mass or there are multiple matted nodes in the upper portion of the neck. In such instances it is unwise to preserve the sternocleidomastoid or the internal jugular or to dissect the spinal accessory nerve and risk entering the tumor.

### *Results*

The rate of recurrence in the neck reported for patients who have undergone a radical neck dissection that yielded histologically tumor-free lymph nodes varies from 3% to 7% (DeSanto et al, 1985; Leemans et al, 1990). The recurrence rate in the ipsilateral side of the neck following therapeutic radical neck dissection (that is, a dissection done in the presence of clinically and histologically positive nodes) ranged from 20% to 71% (Strong, 1969). This variability is in part due to the inclusion, in some series, of cases in which the primary tumor was not controlled. In addition, a number of factors have been identified that are associated with an increased likelihood of recurrence in the neck following radical neck dissection. Therefore an appropriate analysis of the results of radical neck dissection must take these factors into account.

The presence of tumor spread beyond the capsule of a lymph node is the most important prognostic factor regarding recurrence in the neck after neck dissection in patients with squamous cell carcinoma of the upper aerodigestive tract. Johnson et al (1981), Snow et al (1986), and Carter et al (1985) have shown that the recurrence rate in the neck after radical neck dissection is significantly higher when extracapsular spread of tumor is demonstrated. Further, Carter et al (1985) found that only the presence of macroscopic extracapsular extension is associated with a higher risk of recurrence in the neck (44%), whereas the presence of microscopic extracapsular spread was associated with a recurrence rate (25%) similar to that associated with intracapsular nodal metastases (32%). Although these differences were not statistically significant, they point out the need to quantitate extracapsular spread in order to better delineate the prognostic significance of this factor.

The number of lymph nodes involved by tumor has been found to correlate with frequency of tumor recurrence in the neck and survival. In a study of 179 patients treated by neck dissection at the University of Alabama, patients with four or more involved nodes had a significantly worse 4-year survival than patients with only one node involved ($p < 0.001$) (O'Brien et al, 1986). Similarly, Snow et al (1986) have shown that patients who have four or more histologically positive nodes and extracapsular spread have a significantly greater likelihood ($p < 0.01$) of developing distant metastases (> 60%) than patients who have one histologically positive node and extracapsular spread (< 30%).

The prognostic importance of the level of nodal involvement in the nack has been emphasized by Strong (1969). In a series of 204 patients treated by radical neck dissection alone at Memorial Hospital in New York, he observed a recurrence rate in the neck of 36.5% in patients with histologically positive nodes in one level in the neck and 71% in patients with positive nodes in multiple levels.

Finally, the efficacy of a therapeutic radical neck dissection must be considered in relationship to the adjuvant use of radiation therapy. The value of combining surgery and radiation therapy in the treatment of the N+ neck remains controversial, since it has not been elucidated in a prospective, randomized study. In a review of 1192 neck dissections done at the Mayo Clinic, DeSanto et al (1985) reported no difference in the probability of recurrence in the neck patients with N2 neck disease treated by neck dissection alone, preoperative radiation, postoperative radiation, or "miscellaneous" radiation. On the other hand, several investigators have reported a reduction in neck recurrences by the addition of radiation therapy to radical neck dissection (Leemans et al, 1990; Strong, 1969; Vikram et al, 1984). It would appear from the information available in the literature that the combined use of radical neck dissection and radiation can decrease recurrences in the ipsilateral side of the neck and prevent recurrence in the contralateral side in patients with cervical lymph node metastases who have combinations of poor prognostic factors, that is, multiple histologically positive nodes, extracapsular spread of tumor, and positive nodes at multiple levels in the neck.

### *Surgical technique*

**Selection of incision.** To avoid complications such as wound breakdown, skin flap necrosis, and exposure of the carotid artery following neck dissection, it is essential to place the incisions properly, being mindful of the vascular anatomy of the skin flaps to be created. The results of an elegant study of the anatomy of the blood vessels of the skin of the neck by Freeland and Rogers (1975) suggest that the incisions that are most likely to safeguard the blood supply to the skin flaps are the superiorly based apronlike incision from mastoid to mentum designed by Latyschevsky and Freund (1960) for combined neck dissection with intraoral procedures (Fig. 92-5, A) and the apronlike incision described by Freund (1967) to be used when a neck dissection is performed in conjunction with a laryngectomy (see Fig. 92-5, B). The Y incision of Crile and the double Y incision of Martin et al (1951) jeopardize the blood supply to the inferior and middle skin flaps, respectively, and suffer from placing a trifurcate incision over the carotid artery (see Fig. 92-5, C and D). Babcock and Conley's modification (1966) of the Schobinger incision creates a long anteromedial flap, the tip of which may necrose as a result of the limited ascending blood supply (see Fig. 92-5, E); care must be taken to place the descending limb of this incision approximately 2 to 3 cm behind the carotid. A more posterior placement of this incision jeopardizes the viability of the lateral and superior portion of the flap. The MacFee double transverse incision (1960) transects the ascending and descending blood supply to the central portion of the flap (see Fig. 92-5, F). This flap, however, usually fares well even in the previously irradiated patient.

**Skin flap elevation.** Using skin hooks, the skin is retracted perpendicularly to the plane of dissection and adequate countertraction permits an expedient and bloodless elevation of the skin flaps along a subplatysmal plane. When a large tumor mass is present in the upper jugular region or in the submandibular region, it may be advisable to leave the platysma attached to it. In such cases the elevation of the flaps is performed in a plane immediately superficial to the platysma muscle.

**Identification of ramus mandibularis.** Identification of the ramus mandibularis is essential to perform an adequate excision of the lymph nodes in the submandibular triangle (Fig. 92-6, A). The practice of ligating the anterior facial vein low in the submandibular triangle and retracting it superiorly, to "protect the ramus mandibularis", can also result in elevation of the prevascular and retrovascular lymph nodes and thus preclude their appropriate removal. To remove these lymph nodes thoroughly the nerve is exposed about 1 cm in front and below the angle of the mandible by incising the superficial layer of the deep cervical fascia that envelops the submandibular gland, immediately above the gland, in a direction parallel to the direction of the nerve. The incised fascia is then gently pushed superiorly, exposing the nerve that lies deep to it but superficial to the adventitia of the anterior facial vein. The submandibular prevascular and retrovascular lymph nodes are usually in close proximity to the nerve and must be carefully dissected away from it. As this is done, the facial vessels are exposed and divided (see Fig. 92-6, A).

**Upper dissection.** The lax connective tissue between the inferior border of the mandible and the submandibular gland is incised, exposing the mylohyoid muscle. At the angle between the anterior belly of the digastric and the mandible, the submental vessels must be ligated and divided. Posteriorly, near the angle of the mandible, the nerve to the mylohyoid and its accompanying blood vessels must similarly be divided between clamps and ligated. The fibrofatty tissue of the submandibular triangle is dissected off the anterior bellies of the digastric muscles and the mylohyoid. Then the fascia is dissected off the anterior belly of the digastric muscle and the specimen is retracted posteriorly, removing the fibrofatty tissue containing lymph nodes lateral to the mylohyoid muscle. When the dissection reaches the posterior border of the mylohyoid, this is retracted anteriorly, exposing three structures that run forward in a parallel direction but in different planes. These are, from superficial to deep, the lingual nerve, the submandibular gland duct, and the hypoglossal nerve. The submandibular ganglion is divided, as is the submandibular gland duct. This allows easy dissection of the contents of the submandibular triangle in a posterior direction over the hyoglossal muscle. The hypoglossal nerve and the vena comitans are left undisturbed. Ligation of the facial artery as it crosses under the posterior belly of the digastric completes the dissection of the submandibular triangle.

When a node is present in the upper jugular area and its size requires excision of the anterior portion of the parotid gland to ensure adequate margins around it, it is advisable to follow the ramus mandibularis posteriorly and incise the parotid having the nerve under direct vision, rather than the recommended practice of incising the parotid along the line between the angle of the mandible and the tip of the mastoid process, without visualizing the nerve. As the tail of the parotid gland is transected the posterior facial vein and the greater auricular nerve are ligated and divided (see Fig. 92-6, B).

The sternocleidomastoid muscle is then incised at its insertion in the mastoid process. The fibrofatty tissue medial to the muscle is incised, exposing the splenius capitis and the levator scapulae muscles (see Fig. 92-6, B). During this step of the operation it may be necessary to ligate the occipital artery or branches of it as it courses posteriorly. Depending on the location and the extent of the tumor in the neck it may be necessary to include the posterior belly of the digastric in the dissected specimen. In that case the digastric muscle is divided near the mastoid tip. If this muscle is preserved, the dissection continues by dividing, over a hemostat, the connective tissue immediately below its inferior border. After this is done, gentle inferior traction of the specimen allows identification of the hypoglossal nerve, the upper end of the internal jugular vein, and the spinal accessory nerve.

**Posterior dissection.** The dissection is continued posteriorly and inferiorly along the anterior border of the trapezius muscle. The spinal accessory nerve and the transverse cervical vessels are divided as they cross the anterior border of the trapezius muscle. The fascia and fibrofatty tissue containing lymph nodes are dissected, from superior to inferior, in a plane immediately lateral to the fascia of the splenius and the levator scapulae muscles (see Fig. 92-6, C). At this point in the operation it is essential, unless the extent of the disease in the neck precludes it, to preserve the branches of the cervical plexus that innervate the levator scapulae muscle. The levator scapulae is innervated by two or three branches of the fourth and fifth cervical nerves. From their origin in the cervical plexus, these nerves run in an inferolateral direction to reach the levator in its middle third. Through most of their course, these short nerves are located deep to the fascia of the levator. Therefore to identify and preserve them during a radical neck dissection the plane of dissection in this area of the meck must be kept superficial to the fascia of the levator.

**Inferior dissection.** The sternocleidomastgoid muscle and the superficial layer of the deep cervical fascia are incised along the superior border of the clavicle. The external jugular vein is divided and ligated, and the omohyoid muscle is likewise divided (Fig. 92-6, D). After the fascia has been incised, the fibrofatty tissue in this region is gently pushed in an upward direction, exposing the brachial plexus, the scalenus anticus muscle, and the phrenic nerve. Posteriorly, the dissection is continued to join the previous dissection along the anterior border of the trapezius. In this area of the neck, multiple veins must be diligently ligated and divided. The specimen is then dissected forward off the scalenus medius, the brachial plexus, and the scalenus anticus (see Fig. 92-6, D). The cutaneous branches of the cervical plexus are exposed, and they are ligated and divided. The dissection continues medially, exposing the vagus nerve, the common carotid artery, and the internal jugular vein (see Fig. 92-6, E).

In this area of the neck the surgeon must deal with the thoracic duct, which is located to the right of and behind the left common carotid artery and the vagus nerve. From here it arches upward, forward, and laterally, passing behind the internal jugular vein and in front of the anterior scalene muscle and the phrenic nerve. It then opens into the internal jugular vein, the subclavian vein, or the angle formed by the junction of these two vessels. The duct is anterior to the thyrocervical trunk and the transverse cervical artery. Precise knowledge of these anatomic relationships is important to avoid injuring the duct in the course of a neck dissection. It is even more important when the surgeon is called on to search for and repair a chyle leak during or at any time after a neck dissection. To prevent a chyle leak the surgeon must also remember that the thoracic duct may be multiple in its upper end and that at the base of the neck it usually receives a jugular trunk, a subclavian trunk, and maybe other minor lymphatic trunks, which must be individually ligated or clipped. If the thoracic duct and tributary lymphatic vessels are clearly seen they are serially ligated and divided. Otherwise, the soft tissues lateral to the carotid and the internal jugular vein, in this area of the neck, are serially divided between hemoclips to avoid creating a chyle leak.

The internal jugular vein can be divided either superiorly or inferiorly, depending on the location of the disease in the neck. If the tumor mass is located low in the jugulodigastric region or in the midjugular region, the internal jugular vein is first ligated and divided superiorly. The dissection then continues in an inferior direction, separating the specimen from the vagus nerve, the carotid, and the superior thyroid vessels. The medial limit of the dissection is marked by the strap muscles. If, on the other hand, the disease is located high in the jugulodigastric region, especially if the tumor is extensive and may require removal of the external carotid artery or the hypoglossal nerve, the internal jugular vein is divided inferiorly and the dissection is carried in a superior direction along the common carotid artery. By doing so, mobilization of the surgical specimen allows easier dissection of it from the internal carotid artery and, if possible, the external carotid and the hypoglossal nerve.

Closure of the incision is usually performed in two layers; the first layer aproximates the platysma anteriorly and the subcutaneous tissue laterally, and the second one approximates the skin. One or two suction drains are left in place. Care must be taken not to allow the drains to rest immediately over the carotid artery or in the area of the thoracic duct. We do not use bulky or pressure dressings.

## Modified Radical Neck Dissections

### Modified radical neck dissection with preservation of spinal accessory nerve (type I)

#### *Definition*

A modified radical neck dissection with spinal accessory nerve preservation is defined as the en bloc removal of the lymph node-bearing tissues of one side of the neck, from the inferior border of the mandible to the clavicle and from the lateral border of the strap muscles to the anterior border of the trapezius, preserving the spinal accessory nerve. The internal jugular vein and the sternocleidomastoid muscle are included in the resected specimen (Fig. 92-7).

#### *Rationale*

For many years since its description the radical neck dissection was the only procedure accepted for the surgical treatment of the neck in patients with squamous cell carcinoma of the head and neck, staged N0 or otherwise. During this time, however, the following observations compelled different surgeons to explore and develop alternative cervical lymph node dissections:

1. The morbidity associated with the radical neck dissection, especially the shoulder disability that results from the resection of the spinal accessory nerve, and to a lesser extent

the cosmetic deformity that results from this operation, particularly when it is done on both sides of the neck.

2. The realization that in many instances the spinal accessory nerve is not in close proximity to the nodes grossly involved by tumor and that its preservation does not compromise the oncologic soundness of the operation.

### *Indications*

A modified radical neck dissection with preservation of the spinal accessory nerve is accepted by virtually every head and neck surgeon as an adequate operation for the elective treatment of the neck in patients with squamous cell carcinoma of the upper aerodigestive tract. It should be noted, however, that the necessity to perform such an extensive operation in patients with an N0 neck is now being questioned (vide infra). Currently, the main role for this type of neck dissection appears to be in the surgical treatment of the neck in selected patients with clinically obvious lymph node metastases. An increasing number of surgeons are advocating preserving the spinal accessory nerve whenever it is not directly involved by tumor, regardless of the number, size, and location of the involved lymph nodes. Obviously then the decision to preserve the spinal accessory nerve and thus the indication for this type of neck dissection become a delicate intraoperative judgment call. Much like the current philosophy about preservation of the facial nerve during surgery for parotid tumors, the spinal accessory nerve can be preserved whenever there is a clearly identifiable, not an artificially created, plane of dissection between the tumor and the nerve.

### *Results*

Dargent and Papillon in 1945 and Skolnik et al in 1967 were among the first to advocate preservatin of the spinal accessory nerve during radical neck dissections performed in patients without palpable lymph node metastases. Subsequently, Roy and Beahrs (1969), Carenfelt and Eliasson (1980), and others (Brandenburg and Lee, 1981; Chu and Strawitz, 1978; Pearlman et al, 1982) reported preserving the spinal accessory nerve not only in elective radical neck dissections but also in selected cases with palpable metastases. The results obtained by these authors are summarized in Table 92-1. The reader must realize that these results represent a mixture of patients who were treated with surgery alone and patients who were treated with surgery and preoperative or postoperative radiation. Nonetheless, the recurrence rates following elective modified radical neck dissections of this type (4% to 7%) are similar to those observed with the radical neck dissection (3% to 7%). When the operation was used for the treatment of patients with clinically palpable nodes the reported recurrence rates range from 5% to 20%. Chu and Strawitz (1978) analyzed their recurrence rates further according to whether the lymph nodes removed (which were clinically palpable in all cases) were histologically positive or negative and found that the recurrence rates were 12.% and 0%, respectively.

### *Surgical technique*

Knowledge of the surgical anatomy of the spinal accessory nerve is essential in performing this operation. Below the jugular foramen, the external branch of the spinal accessory nerve is located medial to the digastric and stylohyoid muscles and lateral or immediately posterior to the internal jugular vein. Then it runs obliquely downward and backward to reach the medial surface of the sternocleidomastoid muscle near the junction of the superior and middle thirds of it (between two and three finger breadths below the tip of the mastoid). Although the nerve can continue its downward course entirely medial to the muscle, more commonly it traverses the cleidomastoid bundle of it and appears in the posterior border of the muscle, near the point where the greater auricular nerve turns around it (Erb's point). From there it runs through the posterior triangle of the neck and crosses the anterior border of the trapezius muscle approximately 2 cm above the superior border of the clavicle. Three anatomic characteristics of this portion of the nerve are relevant in the course of a neck dissection. First, the relationship of the spinal accessory nerve and Erb's point (the point where the greater auricular nerve turns around the posterior border of the sternocleidomastoid muscle) is not constant enough to be used as a good reference for the initial identification and exposure of the spinal accessory. Frequently the spinal accessory exits the sternocleidomastoid muscle above the level of Erb's point. Further, in this area of the neck the nerve is located deeply and can be confused with other cutaneous branches of the cervical plexus. Second, the spinal accessory nerve is located rather superficially as it courses through the mid and low posterior triangle of the neck and can be easily injured while elevating the posterior skin flaps. Third, the nerve does not enter the trapezius muscle as it reaches the anterior border of it, but it courses along the deep surface of the muscle in close relationship with the transverse cervical vessels. Therefore isolation of the nerve to the level of the anterior border of the trapezius does not ensure its preservation during surgical dissection below this point, particularly in a bloody operative field.

The position of the patient on the operating and the incisions used for this type of neck dissection are similar to those described for the radical neck dissection. After the flaps have been elevated, the spinal accessory nerve is exposed as it crosses the anterior border of the trapezius. Then, in a manner similar to the dissection of the facial nerve during a parotidectomy, the nerve is exposed through the posterior triangle, incising the fascia and fatty tissue over a hemostat. This type of dissection is continued through the upper portion of the sternocleidomastoid muscle, exposing the nerve in its entire course through the neck. The nerve is then carefully dissected from the underlying tissues. To accomplish this, one or more branches to the sternocleidomastoid must be divided.

Alternatively, the nerve can be identified high in the neck, medial to the posterior belly of the digastric, where it is located either lateral or immediately posterior to the internal jugular vein. From there the nerve is exposed and isolated in a downward direction through the sternocleidomastoid muscle and through the posterior triangle of the neck. Regardless of the approach used to expose the nerve, care must be taken to avoid cutting through any lymph nodes. This is easier to accomplish when bleeding is kept to a minimum by using the electrocautery for dissection.

After the spinal accessory nerve has been isolated, the operation proceeds in exactly the same manner as the radical neck dissection.

## Functional, conservative, or conservation neck dissection (type III)

### *Definition*

This operation consists of the en bloc removal of the lymph node-bearing tissues of one side of the neck, including lymph nodes at levels I to V, preserving the spinal accessory nerve, the internal jugular vein, and the sternocleidomastoid muscle. The submandibular gland may or may not be removed (Fig. 92-8).

### *Rationale*

To understand the rationale for this type of neck dissection, the surgeon must possess a working knowledge of the anatomy of the fascial compartments of the neck. The deep cervical fascia of the neck is divided into three layers: superficial, middle, and deep (Fig. 92-9). The superficial or investing layer surrounds the entire neck. It arises from the vertebral spinous processes and the ligamentum nuchae and encircles the entire neck to attach itself again to the spinous processes on the opposite side. This fascia divides to enclose the trapezius muscle. At the anterior border of this muscle, the two layers fuse into a single layer that crosses the posterior triangle of the neck. It divides again to surround the inferior belly of the omohyoid muscle and the sternomastoid muscle. At the lateral border of the strap muscles it sends fibers between them before fusing in front of them as it extends onto the other side of the neck. This fascia also envelops the submandibular and parotid glands.

The middle layer of the deep cervical fascia, also called the visceral fascia, surrounds the visceral structures of the anterior portion of the neck. The deep layer of the deep cervical fascia or prevertebral fascia surrounds the deep muscles of the neck. Among them it covers the splenius capitis, the levator scapulae, and the scalene muscles. It extends onto the other side of the neck, covering the prevertebral muscles.

The carotid sheath encircling the jugular vein, common carotid artery, and vagus nerve is formed by all the layers of the deep cervical fascia. The carotid sheath originates superiorly at the jugular foramen where it attaches to the skull base. It then follows the course of the vessels traversing the anterior cervical triangle and extending inferiorly into the thoracic inlet.

The rationale for this type of neck dissection has been eloquently discussed by Suarez (1963). As a result of his observations in necropsy and surgery specimens of patients with cancer of the larynx and hypopharynx, he pointed out that the lymph nodes of the neck "were always found in the fibrofatty tissue either away or near blood vessels, particularly veins, with which they have a relationship of vicinity, but do not form part of the adventitia of the same". He also observed that the cervical lymph nodes "are not located within the muscular aponeurosis of the glandular capsule, for example, the sternocleidomastoid muscle or the submandibular gland, but they are found within the parotid cell". More importantly, he stated that he "could never find a direct communication or anastomosis (of the lymphatics draining the larynx and hypopharynx) with the lymphatics of the surrounding muscles or their fascia of insertion". Consequently, he felt that it was oncologically sound to remove the lymph node-bearing fibrofatty tissue of the neck without removing the sternocleidomastoid muscle, the submandibular gland, and the internal jugular vein. He demonstrated that this was technically feasible and reported his experience with 271 operations of this kind. In 1954 Miodonski in

Poland reported his experience with the same concept. This operation was later popularized by Bocca who coined the terms *functional, conservative,* and *conservation neck dissection* to designate it and expanded its use to patients with palpable, nonfixed lymph node metastases (Bocca and Pignataro, 1967; Bocca et al, 1980).

It was Bocca et al (1980) who emphasized that the muscular and vascular aponeuroses of the neck define compartments filled with fibroadipose tissue and that the lymphatic system of the neck, contained within these compartments, can be excised in an anatomic block by stripping the fascia off the muscles and vessels. They also pointed out that, with the exception of the vagus nerve that is contained within the carotid sheath, the nerves of the neck do not follow the aponeurotic compartment distribution. Whereas the phrenic nerve and the brachial plexus are partially within the compartment, the hypoglossal and the spinal accessory nerves run across compartments. However, Bocca and others (Bocca et al, 1980; Calearo and Teatini, 1983) believe that unless these nerves are directly involved by tumor, they can be dissected free and preserved.

### *Indications*

This operation is widely accepted, particularly in Europe, as the neck dissection of choice for the treatment of the N0 neck in patients with squamous cell carcinoma of the upper aerodigestive tract, especially when the primary tumor is located in the larynx or hypopharynx. In those cases the nodes in the submandibular triangle are at low risk of containing metastases and do not need to be removed. Molinari et al (1980), Lingeman et al (1977), and Gavilan and Gavilan (1989) feel that this operation is also indicated for the treatment of the neck in stage N1, when the metastatic nodes are mobile and no greater than 2.5 to 3 cm. Bocca et al (1980), on the other hand, believe that the indications for this type of modified radical neck dissection are almost the same as those of the radical neck dissection, with the only contraindication to its use being the presence of node fixation.

A modified radical neck dissection with preservation of the eleventh nerve, the internal jugular vein, and the sternocleidomastoid muscle is currently the operation of choice for patients with differentiated carcinoma of the thyroid who have palpable lymph node metastases in the lateral compartments of the neck (Block et al, 1990).

### *Results*

The reported results obtained with this operation by several surgeons are shown in Table 92-2. The results reported by Molinari et al (1980) and by Gavilan and Gavilan (1989) correspond only to patients with carcinoma of the larynx; whereas all of Molinari's patients were treated with surgery alone, almost half of Gavilan's received postoperative radiation. Bocca et al (1984) included an unknown number of patients previously treated with radiation. The majority of patients included in the studies of Lingeman et al (1977) and Calear and Teatini (1983) also received preoperative or postoperative radiation. A somewhat more meaningful retrospecitve analysis of the effectiveness of this modified radical neck dissection has been presented by Byers (1986), who studied 260 neck dissections of this kind performed by the surgeons at the MD Anderson Cancer Center. The results of this study are shown in Table 92-3.

### *Surgical technique*

The position of the patient on the operating room table and the surgical incisions are similar to those recommended for the radical neck dissection. The elevation of the cervical flaps and the identification of the ramus mandibularis are carried out in the manner described for the radical neck dissection. Likewise, the dissection of the submental and submandibular triangles is performed with the same technique (see Fig. 92-10, A).

Once the dissection of the submandibular triangle is completed, the dissection is carried out in a posterior direction, identifying and preserving the hypoglossal nerve and the superior thyroid vessels. During this portion of the operation, the upper end of the internal jugular vein and the spinal accessory nerve can also be identified below the posterior belly of the digastric muscle (see Fig. 92-10, A).

The next step in the operation consists of dissecting the fascia of the sternocleidomastoid muscle, beginning at the posterior border of the muscle and proceeding in an anterior direction (see Fig. 92-10, B). Although removal of the external jugular vein and the greater auricular nerve may make the subsequent dissection easier and faster, it is often possible to preserve the greater auricular nerve and occasionally the external jugular vein. The dissection of the fascia of the sternocleidomastoid muscle continues around the anterior border of the muscle and onto its medial surface. Retracting the muscle laterally, the spinal accessory nerve is identified as it enters the muscle, at about the level of the junction of its upper and middle thirds. The fibrofatty tissue overlying the spinal accessory nerve is carefully divided, exposing the nerve between its exist at the jugular foramen and its entrance into the sternocleidomastoid muscle. The dissection proceeds above and behind the spinal accessory nerve, where the fibrofatty tissue containing lymph nodes is dissected from the splenius capitis and the levator scapulae muscles. The dissected tissues from this area of the neck are later brought forward under the spinal accessory nerve (see Fig. 92-10, C). Below the level of the nerve, the cutaneous branches of the cervical plexus are divided as they cross the posterior border of the sternocleidomastoid muscle.

At this point the dissection of the posterior triangle begins by identifying the spinal accessory nerve either at the point where it exits from under the sternocleidomastoid muscle or, more easily, as it courses in an oblique direction through the posterior triangle of the neck. Using very gentle traction on the nerve, the spinal accessory nerve is freed from the surrounding tissues using a scalpel. With the nerve isolated, the fascia and fibroadipose tissues are incised along the anterior border of the trapezius muscle. This tissue that contains lymph nodes is then dissected in an anterior direction off the splenius, the levator scapulae, and the scalenus medius muscles (see Fig. 92-10, D).

The superficial layer of the deep cervical fascia is then incised along the superior border of the clavicle, between the posterior border of the sternocleidomastoid muscle and the anterior border of the trapezius. The external jugular vein is divided between clamps, and the omohyoid muscle is transected. The fibrofatty tissue in this area is then gently pushed in a superior direction, identifying the proper plane of dissection, superficial to the fascia of the scalenus medius, the brachial plexus, the scalenus anticus, and the phrenic nerve. The contents of the posterior triangle of the neck, now completely freed, can be brought forward under the spinal accessory nerve (see Fig. 92-10, D) and then under the sternocleidomastoid muscle (see

Fig. 92-10, E).

The dissection continues in an anterior direction, dividing the inferior cutaneous branches of the cervical plexus (see Fig. 92-9, F). Finally, the specimen is dissected sharply from the vagus nerve, the carotid artery, and the internal jugular vein. To avoid injury to the thoracic duct, the dissection in the anterior inferior area of the neck, lateral to the internal jugular vein and the common carotid artery, is carried out carefully as is described in the radical neck dissection. The dissection of the specimen off the internal jugular vein continues superiorly toward the upper portion of the neck that was previously dissected, completing the operation (see Fig. 92-10, F).

## Selective Neck Dissection

Selective neck dissections consist of the selective en bloc removal of only the lymph node groups that, depending on the location of the primary tumor, are most likely to contain metastases.

The supraomohyoid neck dissection consists of the removal of nodal regions I, II, and III. When the nodes in region IV are removed in addition, we refer to the operation as an expanded supraomohyoid neck dissection (Fig. 92-11).

The "lateral neck dissection" consists of the en bloc removal of nodal regions II, III, and IV (Fig. 92-12).

The "posterolateral neck dissection" consists of the removal of the suboccipital and retroauricular lymph node groups and nodal regions II, III, IV, and V (Fig. 92-13).

### *Rationale*

In the 1960s the surgeons at the MD Anderson Hospital modified the concept of the radical neck dissection by selectively removing only those lymph node groups that, based on the location of the primary tumor, were at highest risk of containing metastases (Jesse et al, 1978). Although preservation of functional and cosmetically relevant structures were also primary goals in the development of these operations, their current use is predicted on the following concepts: en bloc removal of the nodes at highest risk for metastases is anatomically justified; it has the same therapeutic value and provides the surgeon with the same staging information as the more extensive radical and modified radical neck dissections; and it is associated with less postoperative morbidity (Medina and Byers, 1989).

The topographic distribution of cervical lymph node metastases appears to be predictable in patients with previously untreated squamous cell carcinoma of the head and neck. The anatomic studies by Rouvière (1938) and Fisch and Siegel (1964) have demonstrated that the lymphatic drainage of the mucosal surfaces of the head and neck region follows relatively constant and predictable routes. The clinical study of Lindberg in 1972 demonstrated that the lymph node groups most frequently involved in patients with carcinomas of the oral cavity are the jugulodigastric and midjugular nodes. In addition, the nodes in the submandibular triangle are frequently involved in patients with carcinoma of the floor of the mouth, anterior oral tongue, and buccal mucosa. Further, these tumors frequently metastasize to both sides of the neck, and they can skip the submandibular and jugulodigastric nodes, metastasizing first to the midjugular nodes. This study also demonstrated that in the absence of metastases to the first echelon nodes, tumors of the oral cavity and oropharynx rarely involve the low jugular and posterior cervical nodes. Similar findings have been reported by Skolnik (1976), who, in a study of radical neck dissection specimens, found no metastasis in the nodes of the posterior triangle of the neck in radical neck dissection specimens, regardless of the site of the primary tumor and the presence or absence of metastases in the jugular nodes. Perhaps the most compelling evidence supporting the predictability of nodal metastases from squamous cell carcinomas of the upper aerodigestive tract has been recently presented by Shah (1990). In a retrospective study of 1119 radical neck dissections, he found that tumors of the oral cavity metastasized most frequently to the neck nodes in levels I, II, and III, whereas carcinomas of the oropharynx, hypopharynx, and larynx involved mainly the nodes in levels II, III, and IV.

The concept of staging the neck is important in patients whose primary tumors are amenable to treatment with surgery alone but are highly likely to produce metastases to the cervical lymph nodes. Patients who have large T2N0 and T3N0 squamous cell carcinomas of the oral cavity and faucial arch region are excellent examples of this situation. Since the probability of lymph node metastases is high in the majority of these patients, a radical neck dissection may only have the value of a staging procedure, the results of which determine whether postoperative radiation therapy is necessary. If the lymph nodes are histologically negative or only microscopic foci of metastases are found in one or two nodes at the primary echelon of lymphatic drainage, no further therapy is indicated and the patient is treated with surgery alone. However, in order to make this decision with confidence, all the lymph nodes at risk of containing metastases must be evaluated. This requires dissecting both sides of the neck in patients with lesions of the anterior tongue and floor of the mouth, with the attendant morbidity of a bilateral radical neck dissection. On the other hand, if the nodal metastases are multiple or the tumor extends beyond the capsule of a lymph node, a radical neck dissection alone is associated with a high incidence of recurrence in the neck (Johnson et al, 1981; Strong, 1969). In these situations the addition of postoperative radiation therapy results in better regional control of the disease (Vikram et al, 1984). Those who advocate the use of selective neck dissections believe that these operations, designed to remove en bloc only the lymph node groups that are most likely to contain metastases, provide the surgeon with the same staging information as the more extensive comprehensive neck dissections.

The dysfunction of the trapezius muscle produced by selective neck dissections is minimal and, unlike that produced by the radical neck dissection, is usually temporary and reversible (Remmler et al, 1986; Sobol et al, 1985).

### *Indications*

The supraomohyoid neck dissection is indicated in the surgical management of patients with squamous cell carcinoma of the oral cavity staged T2 to T4 N0 or TxN1 when the palpable node was less than 3 cm, clearly mobile, and located in either level I or II. The procedure is performed in both sides of the neck in patients with cancers of the anterior tongue and floor of the mouth. This type of dissection is performed when an elective neck dissection is indicated in the management of patients who have squamous cell carcinoma of the lip or skin of the midportion of the face and when these lesions are associated with clinically discrete, single metastases to the submental or submandibular nodes. A bilateral dissection is performed when the lesion is located at or near the midline. A supraomohyoid neck dissection is performed in conjunction with a parotidectomy in patients with squamous cell carcinoma, Merkel cell carcinoma, and selected stage I melanomas (thickness between 1.5 and 3.99 mm) located in the cheek and zygomatic regions of the face.

The lateral neck dissection is indicated in patients with tumors of the larynx, oropharynx, and hypopharynx staged T3 to T4N0 or N1 or T1N1 when the palpable node is located in level I or II. Since the lymphatic drainage of these regions is such that metastases are frequently bilateral, the operation is often done on both sides of the neck.

The posterolateral neck dissection is indicated in the treatment of melanomas, squamous cell carcinomas, or other skin tumors with metastatic potential such as the Merkel cell carcinomas that originate in the posterior and posterolateral aspects of the neck and the occipital scalp. It is rarely indicated in the treatment of squamous cell carcinoma of the upper aerodigestive tract.

### *Results*

The effectiveness of the supraomohyoid and the lateral neck dissections in the treatment of the N0 and N1 neck in patients with squamous cell carcinoma of the upper aerodigestive tract has been evaluated recently in a prospective study in which the indications for the operations, the surgical technique, and the indications for postoperative radiation were standardized (Medina and Johnson, 1991). The overall recurrence rates observed in the dissected side of the neck, at 2 years, with the primary tumor under control, were 3.4% when the lymph nodes removed were histologically negative and 12.5% when multiple positive nodes or extracapsular invasion was found. The results obtained with the supraomohyoid by Medina and Johnson (1991) at the University of Oklahoma and Byers (1986) at the MD Anderson Cancer Center are shown in Table 92-4. Spiro et al (1988) have recently reported the Memorial Hospital experience with the supraomohyoid neck dissection. They observed a recurrence rate of 5% in patients with histologically negative nodes. This figure, however, refers to patients who were treated with and without postoperative radiation. Among 43 dissections in which histologically positive nodes were found, 9 recurrences were observed (21%). Not all of the patients in this group received postoperative radiation, which may in part explain why the rate of recurrence is higher than that reported by Byers (1986) and Medina and Johnson (1991).

### *Surgical technique*

A unilateral supraomohyoid neck dissection is usually performed through an apronlike incision that extends from the mastoid tip to the mandibular sypmhysis (Fig. 92-14). The lowest point of the incision is usually located at the level of the thyrohyoid membrane. This incision can be extended into a lip-splitting incision and, if a more extensive dissection of the neck is indicated by the surgical findings, a descending limb can be easily added for exposure. Occasionally, it is necessary to excise a scar from a previous lymph node biopsy. In that case a modification of the Schobinger incision is used. To perform a bilateral dissection an apronlike incision is made from mastoid to mastoid overlying the thyrohyoid membrane (Fig. 92-15).

A superior flap is elevated in a subplatysmal plane up to the inferior border of the mandible. The marginal mandibular branch of the facial nerve is identified and preserved unless it is grossly involved by tumor. Similarly, the greater auricular nerve and the external jugular vein are preserved during the elevation of the flap (Fig. 92-16, A). An inferior flap is elevated usually to about 1 inch above the clavicles. However, elevation of the flap can be carried down to the level of the clavicles, if necessary.

The prevascular and retrovascular lymph nodes in the submandibular region are usually seen through the fascia that envelops the submandibular gland. They are carefully displaced inferiorly after the facial vessels are divided. Removal of these lymph nodes is of utmost importance when the primary tumor is located in the lateral floor of the mouth, alveolar ridge, and buccal mucosa.

The dissection begins in the submental triangle. The tissue at the apex of the triangle is grasped with a hemostat to exert gentle traction inferiorly, and the fibrofatty tissue in the area is separated from the anterior belly of the digastric muscles and the mylohyoid (see Fig. 92-16, A). Retracting the specimen laterally, the fascia overlying the anterior belly of the digastric and the strap muscles is elevated. An important menuver at this point in the operation is to retract the anterior belly of the digastric to expose and remove a lymph node or nodes located lateral to the mylohyoid muscle. The contents of the submandibular triangle are separated from the mandible, exposing the nerve to the mylohyoid, which is transected. The mental vessels must be ligated at the angle formed by the mandible and the anterior belly of the digastric. Then the mylohyoid muscle is retracted anteriorly, exposing the lingual nerve, the submandibular gland duct, and the hypoglossal nerve. These structures run parallel to each other, although they are located in different planes. Division of the submandibular ganglion and duct allows mobilization of the specimen posteriorly to expose the hyoglossus muscle and the facial artery as it appears under the posterior belly of the digastric. The fascia overlying the posterior belly of the digastric and the omohyoid is incised, developing an envelope along the entire length of both muscles (see Fig. 92-16, B). As the dissection is continued below the digastric and posterior to the omohyoid, all the fibroadipose tissue in this area is removed, preserving the hypoglossal nerve and the superior thyroid vessels. As the dissection is carried inferiorly, the fascia of the omohyoid muscle is included with the specimen, thus outlining the anteroinferior limit of the dissection (see Fig. 92-16, C).

Next, the posterior segment of the dissection begins by incising the fascia along the anterior border of the sternocleidomastoid muscle. With the fascia retracted anteriorly, the dissection is carried around the muscle up to the point where the spinal accessory nerve enters it. The spinal accessory nerve is carefully dissected free from the surrounding tissues. Above the level of the nerve, the splenius capitis and the levator scapulae muscles are dissected clean. The fibroadipose tissue containing lymph nodes from this area is brought forward, underneath the spinal accessory nerve (see Fig. 92-16, D). Below this level the posterior limit of the dissection is marked by the cutaneous branches of the cervical plexus, which are preserved. A block of nodal and adipose tissue is thus formed, and it is dissected anteriorly (see Fig. 92-16, E). The dissection is carried along the vagus nerve, the common and internal carotid arteries, and the internal jugular vein. The inferior limit of the dissection is usually the omohyoid muscle as it crosses forward, lateral to the internal jugular vein. However, if a node is found in this area that appears to be involved by tumor, the omohyoid is divided and the lymph nodes and adipose tissue anterior to the scalene muscles and the brachial plexus (cervical nodes at level IV) are included in the specimen. In that case the operation is called "extended supraomohyoid dissection".

Finally, the common facial vein is divided and the surgical specimen is removed, or it is reflected toward the midline, beginning the dissection on the opposite side (see Fig. 92-16, D). When the dissection is completed, only a small amount of lymph-node bearing tissue remains in the posteroinferior aspect of the neck.

## Extended Neck Dissections

Any of the neck dissections described above can be extended to remove either lymph node groups or vascular, neural, or muscular structures that are not routinely removed in a neck dissection.

A neck dissection may be extended to remove the retropharyngeal lymph nodes in one or both sides when the primary tumor originates in the pharyngeal walls. Ballantyne (1964) found a 44% incidence of retropharyngeal node involvement in a group of patients with carcinomas of the pharyngeal wall that were treated surgically. Tumors of the base of the tongue, tonsil, soft palate, and retromolar trigone can also spread to these lymph nodes when they involve the lateral or posterior walls of the oropharynx.

Similarly, to remove all the lymph nodes at risk of containing metastases in patients with transglottic and subglottic carcinoma, carcinoma of the cervical esophagus and trachea, and thyroid carcinomas, a neck dissection must be extended to include the paratracheal and pretracheal lymph nodes. Failure to do this is probably the most common cause of stomal recurrences.

On the other hand, adequate removal of a metastatic tumor in the neck may dictate the need to extend a neck dissection to resect structures such as the hypoglossal nerve, the levator scapulae muscle, or the carotid artery.

Controvery still exists about the advisability of resecting the common or the internal carotid artery. Some surgeons feel that it is not justified to resect these arteries in patients with squamous cell carcinoma of the upper aerodigestive tract because of the associated morbidity and because the prognosis of patients with disease in the neck that is extensive enough to warrant such a resection is dismal (Byers and Ballantyne, 1985). Moore and Baker (1955), for example, observed a mortality rate of 30% and a cerebral complication rate of 45% among patients who underwent carotid artery ligation. It should be noted that these figures included both elective and emergency ligation. In a study of 28 patients who had tumors grossly excised by "peeling" them off the carotid artery, Kennedy et al (1977) found that only 18% of them developed a recurrence in the neck without distant metastases. This observation led the authors to state that only this small group of patients may have benefited by carotid resection. Goffinet et al (1985) have reported encouraging results in patients with large cervical metastases attached to the carotid artery who were treated by resection of the tumor and intraoperative iodine-125 seed-Vicryl suture implants over the remaining carotid. Tumor control was obtained in the neck in 77% of the patients; however, only 15% of them were alive and free of disease at 1 year.

There are, on the other hand, surgeons who advocate resecting the common or the internal carotid when the extent of the disease dictates it. They feel that current methods of assessing adequacy of cerebral circulation based on the contralateral carotid system allow better preoperative patient selection. This, coupled with improved techniques for vascular and soft tissue reconstruction, has made it possible to resect the carotid with acceptable morbidity. McCready et al (1989) recently reported their observations in 16 patients who underwent carotid artery resection for the treatment of advanced carcinomas of the head and neck. Only two patients (12%) developed postoperative cerebrovascular complications, and seven patients (45%) were free of disease at 1 year. Other have reported similar results (Biller et al, 1988; Urken et al, 1986). Patients with frank involvement of the carotid wall whose preoperative evaluation indicates intolerance to carotid ligation should have carotid resection and reconstruction. Saphenous vein grafts are preferred over prosthetic grafts for reconstruction, and if the skin has been heavily radiated or a portion of the skin over the carotid is resected a myocutaneous flap should be used to cover the graft (Olcott et al, 1981; Sobol et al, 1985).

## Sequelae of Neck Dissection

The most notable sequela observed in patients who have undergone a radical neck dissection is related to the removal of the spinal accessory nerve. The resulting denervation of the trapezius muscle, one of the most important shoulder abductors, causes destabilization of the scapule with progressive flaring of it at the vertebral border (drooping of the scapula as well as lateral and anterior rotation of it). The loss of the trapezius function decreases the patient's ability to abduct the shoulder above 90 degrees at the shoulder (see Fig. 92-14 and 92-15). These physical changes result in the recognized shoulder syndrome of pain, weakness, and deformity of the shoulder girdle that is commonly associated with the radical neck dissection.

In the past few years it has been debated in the literature whether there is a significant difference in postoperative shoulder function following a radical neck dissection and the modifications of the radical neck dissection that preserve the spinal accessory nerve. Using patient questionnaires, Schuller et al (1983) compared symptomatology and the ability to return to their preoperative employment of patients who underwent either a radical neck dissection or a modified radical neck dissection. Although they found no statistically significant difference between the two groups, Sterns and Shaheen (1981) and others (Short et al, 1984; Weitz et al, 1982), using similar methods, found that the majority of patients who had a nerve-sparing procedure did not have postoperative pain or shoulder dysfunction.

Only recently, objective data regarding shoulder dysfunction following neck dissection have been gathered prospectively. Leipzig et al (1983) studied 109 patients who had undergone various types of neck dissection, utilizing preoperative and postoperative observations of shoulder movement made by the surgeons who rated the degree of shoulder dysfunction. They concluded that any type of neck dissection may result in impairment of function of the shoulder. They noted, however, that dysfunction occurred more frequently among those patients in whom the spinal accessory nerve was extensively dissected or resected.

In 1985, Sobol et al performed a prospective study in which preoperative and postoperative measures of shoulder range of motion were compared. In addition, postoperative electromyograms were obtained in some patients. Shoulder range of motion was better in patients who underwent a nerve-sparing procedure than in patients who had a radical neck dissection. However, the type of nerve-sparing procedure was found to have an influence on the degree of shoulder disability. Patients who had undergone a modified radical neck dissection, in which the entire length of the nerve was dissected, had no significantly better shoulder range of motion than those patients who had a radical neck dissection 16 weeks after surgery. However, patients who underwent a supraomohyoid neck dissection, in which there is less extensive dissection of the spinal accessory nerve, performed significantly better ($p > 0.05$) than either of the other two groups, in terms of both shoulder range of motion and electromyographic (EMG) findings on the trapezius muscle. Interestingly, at 16 weeks postoperatively, moderate to severe EMG abnormalities were noted in as many as 65% of the patients in whom the spinal accessory nerve was dissected in its entire length (modified radical neck dissection). Although no severe abnormalities were noted in the group undergoing a supraomohyoid neck dissection, 22% of them showed moderate abnormalities. Several patients from each group had repeat studies at approximately 1 year following surgery. Unlike what happened in the patients who had a radical neck dissection, patients in whom the nerve was spared showed clear evidence of improvement in all parameters studied.

A more recent prospective study by Remmler et al (1986) also revealed that patients who had a nerve-sparing procedure had a significant but temporary spinal accessory nerve dysfunction. In this study, preoperative strength, range of motion measures, and electromyography of the trapezius muscle were compared to postoperative measures obtained at 1, 3, 6, and 12 months. The groups studied consisted of patients undergoing nerve-sparing procedures and those who had the nerve resected. Most of the patients in the nerve-sparing group had supraomohyoid neck dissections. Patients who underwent radical neck dissection had a significant decrease in trapezius muscle strength and had denervation of the trapezius muscle on EMG at 1 month; these parameters did not improve with time. Interestingly, patients in the nerve-sparing group had a small but significant reduction in trapezius muscle strength and evidence of trapezius muscle denervation at 1 and 3 months, which improved by 12 months.

The last three studies have provided evidence that even procedures that involve minimal dissection of the spinal accessory nerve can result in shoulder dysfunction. Although this appears to be reversible, it behooves us to make every effort to avoid undue trauma to the nerve, particularly stretching it, during any neck dissection in which the nerve is preserved. Further, it is imperative that every patient who undergoes a neck dissection be questioned about the function of the shoulder and evaluated by a physical therapist early in the postoperative period. Should any deficit be detected, the patient should be properly counselled and coached to ensure proper rehabilitation of the shoulder.

## Complications of Neck Dissection

In addition to the various medical complications that can occur following any surgical procedure in the head and neck region, a number of surgical complications can be related solely or in part to the neck dissection. If we follow the course of a patient who has undergone a neck dissection as part of the surgical treatment of a cancer of the head and neck region, the following complications can occur.

## Air leaks

Circulation of air through a wound drain is a common complication usually encountered during the first postoperative day. The point of entrance of air may be located somewhere along the skin incision. However, if the drains are connected to suction in the operating room near the completion of the wound closure, such an air leak usually becomes apparent then and can be corrected. Other points of entrance may not become apparent until after surgery, when the position of the neck changes or the patient begins to move. The typical example of this situation is the improperly secured suction wound drain that gets displaced, exposing one or more of the drain vents. A similar situation occurs frequently when a lateral trapezius flap is used in conjunction with a neck dissection. The slightest movement of the should can produce an air leak into the neck wound through the extensive donor defect, even after meticulous tacking of the skin edges to the underlying tissues and painstaking suturing of a skin graft. We have learned to prevent this problem by using an adhesive vinyl drape applied over the defect and surrounding skin to seal any possible air leak, instead of the bolster of gauze traditionally used to immobilize the skin graft.

Air leaks with potentially more serious consequences are those that occur through a communication of the neck wound with the tracheostomy site or through a mucosal suture line. In these cases it is very likely that, in addition to air, contaminated secretions are circulated through the wound. Thus early identification of the site of leakage is desirable. This may not be a simple task and to correct it may require revision of the wound closure in the operating room.

## Bleeding

Postoperative hemorrhage usually occurs immediately after surgery. External bleeding through the incision, without distortion of the skin flaps, often originates in a subcutaneous blood vessel. In most instances, this can be readily controlled by ligation or infiltration of the surrounding tissues with an anesthetic solution containing epinephrine. On the other hand, pronounced "swelling" or "ballooning" of the skin flaps in the immediate postoperative period, with or without external bleeding, must be attributed to a hematoma in the wound. If a hematoma is detected early, "milking" the drains may occasionally result in evacuation of the accumulated blood and resolve the problem. However, if this is not accomplished immediately or if blood reaccumulates quickly, it is best to return the patient to the operating room and explore the wound under sterile conditions, evacuate the hematoma, and control the bleeding. Attempting to do this in the recovery room or at the bedside may be ill advised, because lighting may be inadequate, surgical equipment improvised, and sterile conditions precarious. Failure to recognize or to manage properly a postoperative hematoma may predispose the patient to the development of a wound infection. Although bulky, "pressure" dressings may be useful in curtailing postoperative edema, they do not prevent hematomas and may, in fact, delay their recognition.

## Chylous fistula

In a recent review of 823 neck dissections performed by the surgeons at Memorial Hospital, which included removal of the lymph nodes in level IV, Spiro et al (1990) found that 14 patients (1.9%) developed a chyle fistula. In this and other studies (Crumley and Smith, 1976), a chylous leakage was identified and apparently controlled intraoperatively in the majority of patients who develop a postoperative chylous fistula. These observations behoove the surgeon not only to avoid injury to the thoracic duct proper, but also to ligate or clip any visualized or potential lymphatic tributaries in the area of the thoracic duct. This may be accomplished with relative ease if the operative field is kept bloodless when dissecting in this area of the neck. Further, as soon as the dissection of this area is completed, and again before closing the wound, the area is observed for 20 or 30 seconds, while the anesthesiologist increases the intrathoracic pressure. Even the smallest leak of chylous material must be pursued seriously until it is arrested. Direct clamping and ligating may be difficult and sometimes counterproductive because of the fragility of the lymphatic vessels and the surrounding fatty tissue. Hemoclips are ideal to control a source of leakage that is clearly visualized. Otherwise, it is preferable to use suture ligatures with pliable material, such as No. 50 silk, that are tied over a piece of hemostatic sponge to avoid tearing.

Despite the surgeon's best efforts to avoid it, a postoperative chylous fistula occurs after 1% to 2% of neck dissections (Crumley and Smith, 1976; Strong, 1969). Management of this complication depends on the time of onset of the leak and the amount of chyle drainage in a 24-hour period, as well as on the physician's ability to prevent accumulation of chyle under the skin flaps. When the daily output of chyle exceeds 600 mL, especially when the chyle fistula becomes apparent immediately after surgery, conservative closed wound management is not likely to succeed. In such cases, we prefer early surgical exploration before the tissues exposed to chyle become markedly inflamed and before the fibrinous material that coats these tissues becomes adherent, obscuring and jeopardizing important structures such as the phrenic and the vagus nerves.

Chylous fistulas that become apparent only after enteral feedings are resumed, and particularly those that drain less than 600 mL of chyle in 1 day, are initially managed conservatively with closed wound drainage, pressure dressings, and low-fat nutritional support.

## Facial/cerebral edema

Synchronous bilateral radical neck dissections, in which both internal jugular veins are ligated, can result in the development of facial edema, cerebral edema, or both. The facial edema, which can sometimes be dramatically severe, appears to be caused by a mechanical problem of venous drainage. This usually resolves to a variable extent with time, as collateral circulation is established. Facial edema appears to be more common and more severe in patients who had previous radiation to the head and neck as well as in those patients in whom the resection includes large segments of the lateral and posterior pharyngeal walls. We have been able to prevent massive facial edema by preserving at least one external jugular vein whenever a bilateral radical neck dissection is anticipated. The external jugular is usually separated from the tumor in the neck by the sternocleidomastoid muscle and can be dissected free between the tail of the parotid and the subclavian vein.

The development of cerebral edema may be at the root of the impaired neurologic function and even coma that can occur after bilateral radical neck dissection. Ligation of the internal jugular veins leads to increased intracranial pressure (Royster, 1953; Sugarbaker and Wiley, 1951). It has been shown experimentally that the increased cerebral venous pressure that occurs as a result of ligating both internal jugular veins in dogs is associated with inappropriate secretion of antidiuretic hormone (ADH) (McQuarrie, 1977). It can then be speculated that the resulting expansion of extracellular fluids and dilutional hyponatremia aggravate the cerebral edema and create a visious cycle. In practice, these observations behoove the surgeon and the anesthesiologist to curtail the administration of fluids during and after bilateral radical neck dissections (Wenig and Heller, 1987). Further, perioperative management of fluid and electrolytes in these cases should not be guided solely by the patient's urine output, but by monitoring of central venous pressure, cardiac output, and serum and urine osmolarity.

### Blindness

Blindness after bilateral neck dissection is a rare but catastrophic complication. To this date there have been five cases reported in the literature (Marks et al, 1990). In one report, histologic examination revealed intraorbital optic nerve infarction, suggesting intraoperative hypotension and severe venous distension as possible etiologic factors (O'Brien et al, 1986).

### Emergency: carotid artery rupture

The most feared and most commonly lethal complication after surgery in the neck is the exposure and rupture of the carotid artery. Therefore every effort must be made to *prevent* it. If the skin incisions have been designed properly, very seldom does the carotid become exposed in the absence of a salivary fistula. Fistula formation and flap breakdown are more likely to occur in the presence of malnutrition, diabetes, infection, and prior radiation therapy, which impair healing capacity and compromise vascular supply. Faced with any of these risk factors, the surgeon must employ flawless surgical techniques in the closure of oral and pharyngeal defects. The use of perioperative antibiotics and, more importantly, the use of free and pedicled vascularized flaps, which provide skin for closure of mucosal defects and variably bulky muscle that can protect the carotid, have rendered nearly obsolete the use of "protective" measures such as dermal grafts, levator scapulae muscle flaps, and controlled pharyngostomes.

Management of the exposed carotid depends on the likelihood of rupture, based on the length of the exposed segment, the condition of the surrounding tissues, and the size of the oropharyngocutaneous fistula. Large cutaneous defects or large, high-output fistulas in previously irradiated patients are not likely to heal by secondary intention in a timely manner. The likelihood of rupture of the carotid in these conditions is extremely high. Therefore an attempt should be made to repair the defect and cover the carotid using well vascularized tissue, early, before the vessel has been irreversibly damaged. Whenever the carotid is exposed, it is advisable to take "carotid precautions", that is, warning and instructing nursing personnel and house staff about the possibility of a carotid rupture, the site of potential rupture, and the steps to be taken in the event of bleeding; having compatible blood available; and keeping appropriate surgical instruments at the bedside.

When a carotid rupture occurs, it is usually possible to stop the bleeding with manual pressure, while blood and fluids are administered to restore and maintain the patient's blood pressure. Only then is the patient taken to surgery. Attempts to repiar the area of rupture are futile. Introduction of Fogarty catheters through the area of rupture is helpful in controlling the bleeding temporarily, while the artery is exposed and ligated proximally and distally to the area of rupture.