Herbert Chen *Editor*

Illustrative Handbook of General Surgery

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Herbert Chen
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Contributors

Cameron D. Adkisson, MD Division of Endocrine Surgery, Department of Surgery, University of Pittsburgh, Pittsburgh, PA, USA

Jacquelynn D. Arbuckle, MD Department of Surgery, University of Wisconsin School of Medicine and Public Health, Madison, WI, USA

Jocelyn F. Burke, MD Department of General Surgery, University of Wisconsin Hospital and Clinics, Madison, WI, USA

Guilherme M. Campos, MD, FACS Division of Bariatric and Gastrointestinal Surgery, Department of Surgery, Virginia Commonwealth University, Richmond, Virginia, USA

Clifford S. Cho, MD Department of Surgery, University of Wisconsin School of Medicine and Public Health, Madison, WI, USA

Marquita Renee Decker, MD, MPH Department of Surgery, University of Wisconsin Hospital and Clinics, Madison, WI, USA

Dina M. Elaraj, MD, FACS Department of Surgery, Section of Endocrine Surgery, Northwestern University Feinberg School of Medicine, Chicago, IL, USA

Alain Elian, MD Department of Surgery, University of Wisconsin, University of Wisconsin School of Medicine and Public Health, Madison, WI, USA

Abbey L. Fingeret, MD Department of General Surgery, New York-Presbyterian Hospital, Columbia University Medical Center, New York, NY, USA

Division of Gastrointestinal and Endocrine Surgery, Department of Surgery, College of Physicians and Surgeons of Columbia University, New York, NY, USA

Laura E. Fischer, MD, MS Department of Surgery, University of Wisconsin, University of Wisconsin School of Medicine and Public Health, Madison, WI, USA

Department of General Surgery, University of Wisconsin Hospitals and Clinics, Madison, WI, USA

Luke M. Funk, MD, MPH Department of Surgery, University of Wisconsin School of Medicine and Public Health, University of Wisconsin, Madison, WI, USA

Department of Surgery, University of Wisconsin Hospitals and Clinics, Madison, WI, USA

Michael J. Garren, MD Department of Surgery, University of Wisconsin, Madison, WI, USA

Jacob A. Greenberg, MD, EdM Department of Surgery, University of Wisconsin Hospital and Clinics, Madison, WI, USA

Rebecca Gunter, MD Department of General Surgery, University of Wisconsin Hospital and Clinics, Madison, WI, USA

Nicholas A. Hamilton Department of General Surgery, Washington University, St. Louis, MO, USA

William G. Hawkins Department of General Surgery, Washington University, St. Louis, MO, USA

Department of Surgery, Washington University in St Louis, St Louis, MO, USA

Charles P. Heise, MD, FACS Department of Surgery, University of Wisconsin Hospital and Clinics, Madison, WI, USA

University of Wisconsin School of Medicine and Public Health, Madison, WI, USA

Mary Beth Henry, RN, MS, CS, APNP Department of Surgical Oncology, University of Wisconsin Health System, Madison, WI, USA

Sara E. Holden, MD Department of General Surgery, University of Wisconsin Hospital and Clinics, Madison, WI, USA

Gregory D. Kennedy, MD, PhD Department of Surgery, University of Alabama at Birmingham, Birmingham, AL, USA

Jad Khoraki, MD Department of Surgery, University of Wisconsin School of Medicine and Public Health, Madison, WI, USA

James A. Lee, MD Department of Endocrine Surgery, New York-Presbyterian Hospital, Columbia University Medical Center, New York, NY, USA

Division of Gastrointestinal and Endocrine Surgery, Department of Surgery, College of Physicians and Surgeons of Columbia University, New York, NY, USA

Christina W. Lee, MD Department of Surgery, University of Wisconsin School of Medicine and Public Health, Madison, WI, USA

Charles M. Leys, MD, MSCI Department of General Surgery, University of Wisconsin Hospital and Clinics, Madison, WI, USA

Ryan A. Macke, MD Section of Thoracic Surgery, Division of Cardiothoracic Surgery, Department of Surgery, University of Wisconsin, University of Wisconsin School of Medicine and Public Health, Madison, WI, USA

David M. Melnick, MD, MPH Department of Surgery, University of Wisconsin School of Medicine and Public Health, Madison, WI, USA

Clinton T. Morgan, MD, PhD Department of Surgery, University of Wisconsin, University of Wisconsin School of Medicine and Public Health, Madison, WI, USA

Lilah F. Morris, MD Department of Surgery, Northwest Medical Center, Northwest Allied General Surgery, Tucson, AZ, USA

Heather B. Neuman, MD, MS Department of Surgery, University of Wisconsin School of Medicine and Public Health, Madison, WI, USA

Francesco Palazzo, MD, FACS Department of Surgery, Thomas Jefferson University, Philadelphia, PA, USA

Christina M. Papageorge, MD Department of Surgery, University of Wisconsin Hospital and Clinics, Madison, WI, USA

Terrah J. Paul Olson, MD Department of General Surgery, University of Wisconsin Hospital and Clinics, Madison, WI, USA

Scott N. Pinchot Department of Surgery, University of Wisconsin, Madison, WI, USA

Matthew R. Porembka Section of HPB Surgery, Department of Surgery, Washington University in St Louis, St Louis, MO, USA

Charlotte Rabl, MD, FACS Department of Surgery, Paracelsus Medical University, Salzburg, Austria

Andrew J. Russ, MD Department of Surgery, University of Tennessee Graduate School of Medicine, University of Tennessee Medical Center, Knoxville, TN, USA

M. Shirin Sabbaghian, MD Riverside Surgical Group, Department of Surgery, Lexington Medical Center, Columbia, SC, USA

Surgical Oncology and General Surgery, Private Practice, Louisiana State University Health Sciences Center, Suite D Crowley, LA, USA

Sarah C. Schaefer, MS, ANP-BC Department of Surgery, University of Wisconsin School of Medicine and Public Health, Madison, WI, USA

Patrick J. Shabino, MD Department of Surgery, University of Wisconsin, Wisconsin School of Medicine and Public Health, Madison, WI, USA

Wen T. Shen, MD, MA Endocrine Surgery Section, Department of Surgery, University of California, San Francisco, UCSF Medical Center—Mount Zion, San Francisco, CA, USA

Stanley B. Sidhu, PhD, FRACS Endocrine Surgery Unit, University of Sydney, St. Leonards, NSW, Australia

Endocrine Surgery Unit, University of Sydney and RNSH, St. Leonards, NSW, Australia

Department of Endocrine and Oncologic Surgery, Royal North Shore Hospital, St. Leonards, NSW, Australia

Rebecca S. Sippel, MD Department of General Surgery, University of Wisconsin School of Medicine and Public Health, Madison, WI, USA

Sarah E. Smith, RN, MS, ANP-BC, APNP Department of General Surgery, University of Wisconsin, University of Wisconsin-Madison, Madison, WI, USA

Jennifer G. Steiman, MD Department of Surgery, University of Wisconsin, Madison, WI, USA

Steven M. Strasberg Section of HPB Surgery, Department of Surgery, Washington University in St Louis, St Louis, MO, USA

Cord Sturgeon, MD, MS Department of Surgery, Section of Endocrine Surgery, Northwestern University Feinberg School of Medicine, Chicago, IL, USA

Insoo Suh, MD Endocrine Surgery Section, Department of Surgery, University of California, San Francisco, UCSF Medical Center—Mount Zion, San Francisco, CA, USA

Lauren J. Taylor, MD Department of Surgery, University of Wisconsin Hospital and Clinics, Madison, WI, USA

Sarah E. Tevis, MD Department of General Surgery, University of Wisconsin, Madison, WI, USA

Allan Tsung, MD Division of Hepatobiliary and Pancreatic Surgery, UPMC Liver Cancer Center, Montefiore Hospital, University of Pittsburgh Medical Center, Pittsburgh, PA, USA

Sharon M. Weber Department of Surgery, University of Wisconsin, Madison, WI, USA

Lee G. Wilke, MD Department of Surgery, University of Wisconsin Hospital and Clinics, Madison, WI, USA

Jennifer B. Wilson, PA Department of General Surgery, University of Wisconsin Hospital and Clinics, Madison, WI, USA

Jason T. Wiseman, MD, MSPH Department of Surgery, University of Wisconsin School of Medicine and Public Health, Madison, WI, USA

Department of Surgery, University of Wisconsin Hospitals and Clinics, Madison, WI, USA

Michael W. Yeh, MD Department of Surgery, Section of Endocrine Surgery, UCLA David Geffen School of Medicine, Los Angeles, CA, USA

Linwah Yip, MD, FACS Division of Endocrine Surgery, Department of Surgery, University of Pittsburgh, Pittsburgh, PA, USA

Division of Endocrine Surgery, University of Pittsburgh School of Medicine, Pittsburgh, PA, USA

Nisar A. Zaidi, MD Endocrine Surgical Unit, University of Sydney, Royal North Shore Hospital, St Leonards, NSW, Australia

Part I
Endocrine Surgery

Rebecca S. Sippel

Chapter 1
Total Thyroidectomy and Thyroid Lobectomy

Insoo Suh and Wen T. Shen

Abstract The key to a safe thyroidectomy is to dissect in the correct cervical planes using absolutely meticulous, bloodless technique. This optimizes the surgeon's ability to identify and preserve delicate perithyroidal structures such as the recurrent laryngeal nerve and parathyroid glands, as well as minimize the risk of life-threatening postoperative neck hematoma. This chapter describes the technique of a conventional thyroidectomy performed via an anterior cervical incision. An overview of preoperative workup and postoperative care is also included.

Keywords Thyroid • Thyroidectomy • Thyroid nodule • Thyroid cancer • Goiter • Hyperthyroidism • Hypothyroidism • Recurrent laryngeal nerve • Parathyroid

I. Suh, MD • W.T. Shen, MD (✉)
Endocrine Surgery Section, Department of Surgery,
UCSF Medical Center – Mount Zion, University of California,
San Francisco, Campus Box 1674, San Francisco,
CA 94115, USA
e-mail: insoo.suh@ucsf.edu; wen.shen@ucsfmedctr.org

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Indications

The indications for thyroidectomy encompass a wide spectrum of thyroid disorders, but the majority fall under three categories:

1. Hyperthyroidism or thyroiditis refractory to nonsurgical management [1, 2]
2. goiters with or without local compressive symptoms [3, 4], and
3. thyroid nodules and cancers [5].

The decision to perform a total thyroidectomy versus unilateral lobectomy or other more limited procedure depends on the underlying disease, the patient's clinical profile, suspicion of intraoperative recurrent laryngeal nerve injury, and in some instances on surgeon or patient preference.

Preoperative Preparation

All patients undergoing thyroidectomy should have preoperative biochemical thyroid function tests as well as a neck ultrasound with fine-needle aspiration biopsies of suspicious nodules [6]. Depending on the type and extent of disease, selected patients may require further imaging studies such as CT, MRI, thyroid scintigraphy, and endoscopy [7]. Patients should ideally be euthyroid at the time of operation, either with antithyroid medication and/or Lugol's solution for hyperthyroidism or exogenous thyroid hormone supplementation for hypothyroidism.

Preoperative laryngoscopy must be performed on any patient with hoarseness or a prior history of neck operations in order to assess preoperative vocal cord function. Preanesthetic evaluation should be a routine step prior to any procedure requiring general anesthesia.

Positioning and Anesthesia

Most thyroidectomies are performed under general anesthesia with endotracheal intubation. The patient is placed supine in a 20° reverse Trendelenburg position, with both arms tucked. The neck is extended by placing a beanbag or soft roll behind the scapulae and a foam ring under the head. This places the thyroid in a more anterior position. The head must be well-supported to prevent neck hyperextension and postoperative posterior neck pain.

The use of intraoperative nerve monitoring (IONM) for recurrent laryngeal nerve (RLN) function has become increasingly common in many endocrine surgical practices despite ongoing controversy over the true effectiveness of IONM in reducing the incidence of RLN injury and vocal cord palsy [8]. Proponents of IONM use cite its value in, among other things, tracing the anatomic course of nerves (particularly for challenging situations such as reoperations), more sensitively detecting injury in the intraoperative setting, and enabling the detection of vagal and superior laryngeal nerve function. If the use of IONM is planned, an appropriate endotracheal tube with contact electrodes for the vocal cords is used, and grounding and return surface electrodes are applied per the individual manufacturer's instructions. The remainder of this chapter will assume and describe the use of IONM during the relevant steps of the operation.

We routinely perform a bilateral superficial cervical anesthetic block with 0.25 % bupivacaine, as this provides excellent anesthesia in the postoperative setting [9]. In addition, prior to surgical prep, we routinely perform our own intraoperative neck ultrasound in order to (1) confirm the findings of the preoperative study, (2) identify any new findings, and (3) assess the overall anatomy of the gland to facilitate incision placement and operative planning. The surgical area is prepared with 1 % iodine or chlorhexidine and sterilely draped.

Description of Procedure

In general, thyroid operations should be performed in a bloodless field so that vital structures can be identified. Bleeding obscures the normal color of the parathyroids and RLN, placing these important structures at greater risk for injury. If bleeding does occur, application of manual pressure is the preferred hemostatic maneuver; vessels should be clamped only if they are precisely identified, or shown to not be in close proximity to the RLN.

A centrally placed, 4–5 cm Kocher transverse incision is made typically 1 cm caudad to the cricoid cartilage, paralleling the normal skin lines of the neck (Fig. 1.1). The incision is

FIGURE 1.1 Skin incision. The pen marks, from top to bottom, denote the thyroid cartilage, cricoid cartilage, and suprasternal notch, respectively. A centrally placed, 4–6 cm Kocher transverse incision is made 1 cm caudad to the cricoid cartilage, paralleling the normal skin lines of the neck (*white dotted line*)

extended through the platysma, and subplatysmal flaps are raised, first cephalad to the level of the thyroid cartilage and then caudad to the suprasternal notch. Five straight Kelly clamps placed on the dermis of each flap aid in retraction for this dissection.

In a cancer operation, dissection of the thyroid gland is generally begun on the side of the suspected tumor, since problems with the dissection on this side (e.g. concern for RLN injury) could allow the surgeon the option to perform a less-than-total thyroidectomy on the contralateral side in order to avoid bilateral injury and resultant complications. One exception is the large bulky tumor, in which case the surgeon may choose to resect the contralateral side first in order to more easily mobilize the larger lobe.

The strap muscles are separated in the midline via an incision through the superficial layer of the deep cervical fascia starting at the suprasternal notch and extending cephalad to the thyroid cartilage. On the side of the suspected tumor, the more superficial sternohyoid is separated from the deeper sternothyroid muscle by blunt dissection, proceeding laterally until the ansa cervicalis is visible at the lateral border of the sternothyroid muscle. The sternothyroid is then dissected from the underlying thyroid capsule until the middle thyroid vein is encountered laterally. The thyroid is retracted anteromedially, and the carotid sheath and strap muscles are retracted laterally. A peanut sponge can be used to facilitate retraction and exposure of the area posterolateral to the thyroid. The middle thyroid vein is optimally exposed for division at this time (Fig. 1.2). For those that use IONM, a pre-RLN dissection vagus signal (denoted V1) is obtained by stimulating the vagus nerve which is typically located posterolateral to the carotid.

In the case of thyroid lobectomy, the isthmus is usually divided early in the dissection to facilitate mobilization. The isthmus is clamped and divided lateral to the midline, taking care to not leave residual tissue anterior to the

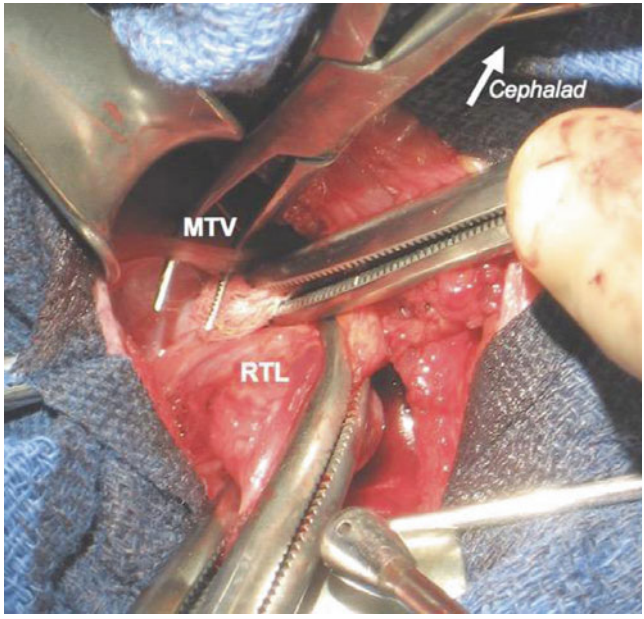

FIGURE 1.2 Identification of the middle thyroid vein (MTV). On this side, the right thyroid lobe (RTL) is retracted antero-medially to expose the MTV, which is isolated in preparation for division and ligation

trachea to minimize the chances of hypertrophy of the thyroid remnant. Energy sealing devices such as the Ligasure (Covidien, New Haven, CT) or Harmonic scalpel (Ethicon, Cincinnati, OH) are useful for dividing the thyroid parenchyma in a hemostatic manner; alternatively, the isthmus can be divided with a scalpel between clamps and the thyroid remnant oversewn at the cut edge. The pyramidal lobe, present in 80 % of patients, drapes cephalad over the anterior midline just right or left of the cricoid cartilage, and can extend as superiorly as the hyoid bone. It is dissected until it tapers into a fibrous band, divided, and ligated.

The superior pole is dissected mostly in a blunt fashion with a small peanut sponge on a clamp. The dissection is carried out superolaterally and posteriorly, with countertraction of the thyroid inferomedially. This exposes the superior thyroid vessels, as well as some connective tissue lateral to the superior pole. These tissues are carefully mobilized below the level of the cricothyroid muscle, since the RLN passes through Berry's ligament and dive deep to the inferior constrictor muscle at the level of the cricoid cartilage. The superior pole is similarly separated from the cricothyroid muscle medially with gentle blunt sweeping (into the so-called avascular space of Reeve). The superior pole vessels are dissected, double- or triple-clamped, and ligated (Fig. 1.3); again, the use of energy sealing devices may augment or replace manual ligation. They are then divided close to the surface of the thyroid in order to prevent injury to the external branch of the superior laryngeal nerve as it traverses the anterior surface of the cricothyroid muscle. Division of these vessels allows for easy sweeping of the remaining filmy tissues away from the posterior aspect of the superior pole via blunt dissection. The superior parathyroid gland is often identified behind the superior pole during this dissection, at the level of the cricoid cartilage (Fig. 1.3).

The mobilization of the lateral and inferior aspects of the thyroid lobe includes the definitive identification of the inferior parathyroid gland (Fig. 1.4). With the inferior thyroid lobe retracted anteromedially and the carotid sheath laterally, dissection should proceed cephalad along the lateral edge of the thyroid. Fatty and lymphatic tissues immediately adjacent to the thyroid are swept laterally with a peanut sponge, and small vessels are ligated with clips. The inferior parathyroid is usually encountered during this lateral mobilization, and care must be taken to not transect any tissues in this area until these vital structures are identified. The location of the inferior parathyroid gland is less constant than that of the superior gland, but it is invariably located anterior

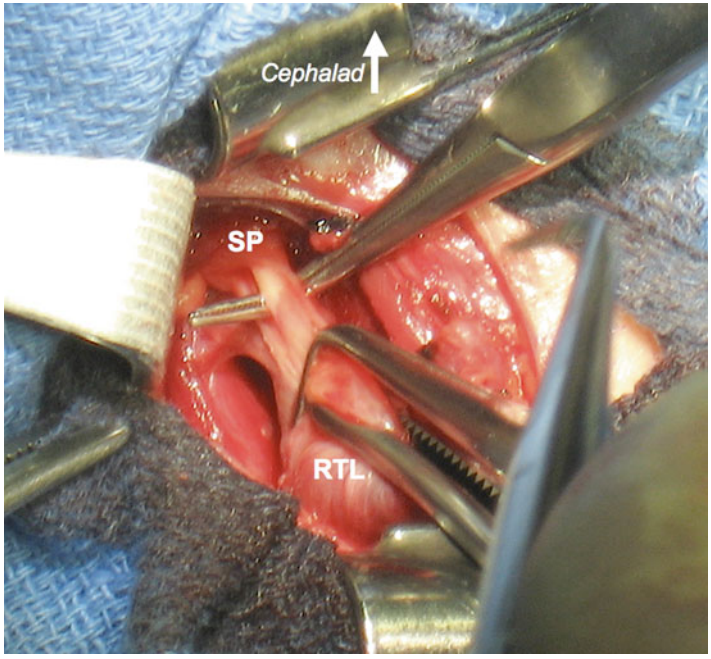

FIGURE 1.3 Dissection of the superior pole (*SP*). In the image, counter-traction of the right thyroid lobe (*RTL*) infero-medially exposes the SP vessels, which are individually skeletonized, clamped, and ligated

to the RLN and inferior to the inferior thyroid artery as it crosses the RLN. In its "normal" location, it is often adherent to the posterolateral surface of the inferior lobe. All normal parathyroid glands should be carefully swept away from the thyroid on as broad a vascular pedicle as possible to prevent devascularization, since this would necessitate autotransplantation of the gland.

Once the superior pole and inferior aspect of the lobe are dissected and mobilized, the majority of the gland aside from its tracheal attachments and ligament of Berry can be delivered out of the incision with anteromedial retraction. This

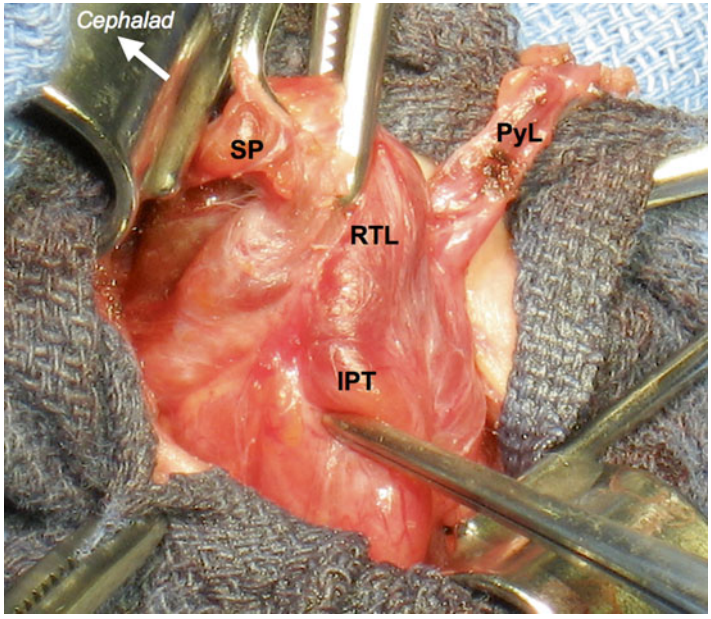

FIGURE 1.4 Identification of the inferior parathyroid (*IPT*). After the superior pole (*SP*) has been dissected and mobilized, the right thyroid lobe (*RTL*) is retracted supero-medially to begin the inferior pole dissection. The IPT is often variable in position, but is invariably anterior to the recurrent laryngeal nerve. The pyramidal lobe (*PyL*) is also seen medially

judicious retraction (either with a finger or with an atraumatic sponge) is imperative for controlled dissection and protection of the RLN. Care must be taken not to use excessive force, which may place the nerve under stretch and increase the risk of injury. The course of the right and left RLN can vary considerably. The left RLN is usually situated deeper and more medially, running in the tracheoesophageal groove, while the right RLN takes a more superficial and oblique course and may pass either anterior or posterior to the inferior thyroid artery. Two commonly-used rules of thumb are used for RLN identification: (1) it is located within

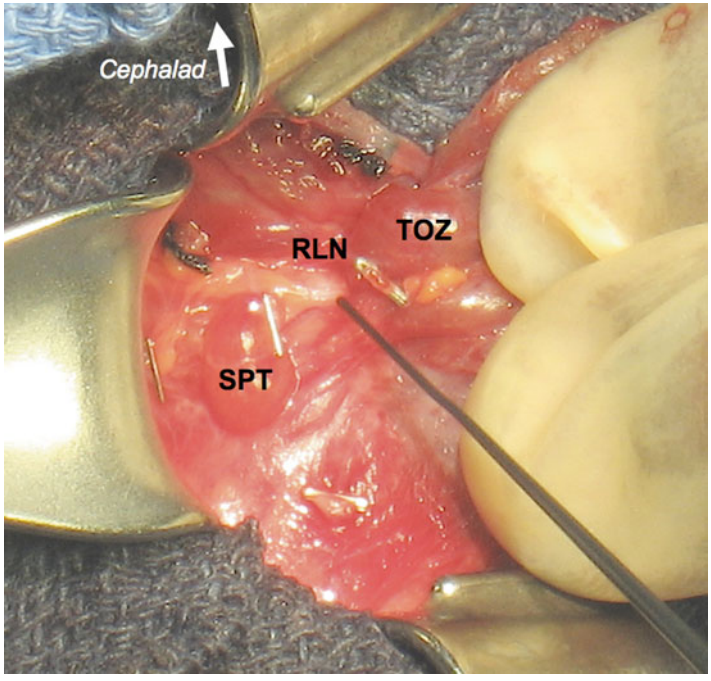

FIGURE 1.5 Identification of the superior parathyroid gland (*SPT*) and recurrent laryngeal nerve (*RLN*). The SPT is usually posterolateral to the RLN (shown here with the nerve monitoring probe), at the level of the cricoid cartilage. The right thyroid lobe, including the tubercle of Zuckerkandl (*TOZ*), is retracted medially for optimal exposure of the RLN

1 cm anteromedial to the superior parathyroid, at the level where the nerve crosses the inferior thyroid artery; and (2) its course through the ligament of Berry is also situated just posteromedial to a small posterolateral protuberance of the thyroid lobe known as the tubercle of Zuckerkandl (Fig. 1.5). Once the nerve is dissected and visually identified, the IONM may be used to obtain an initial signal (denoted R1).

Once the parathyroids and RLN are identified and preserved, the remainder of the thyroid is easily dissected in a

more superficial plane off of the trachea. Occasionally, the course of the RLN at the ligament of Berry is intimately associated with the thyroid tissue at the tubercle of Zuckerkandl; in these circumstances, it would be appropriate to leave a small amount of thyroid tissue behind in the interest of protecting the nerve. The entire thyroid lobe should now be completely freed.

Meticulous hemostasis is obtained, and post-resection RLN and vagus signals (denoted R2 and V2, respectively) are confirmed with the IONM system. If a total thyroidectomy is to be performed, the same steps described above apply for the contralateral lobe.

For closure, the sternothyroid and sternohyoid muscles are re-approximated with 3-0 absorbable sutures, with a small opening left in the midline at the suprasternal notch to allow any blood to exit. The platysma layer is approximated with similar sutures, and the skin is closed with a 4-0 subcuticular monofilament absorbable suture.

Postoperative Care

Though relatively uncommon in experienced centers, significant complications can occur after thyroidectomy, including RLN injury, hypoparathyroidism, bleeding and neck hematoma leading to life-threatening airway compromise, injury to the external branch of the superior laryngeal nerve, infection, seroma, and keloid formation. Because of the small but serious risk of neck hematoma, postoperative patients are usually admitted overnight to the hospital ward for observation. They are positioned in a low Fowler position with the head and shoulders elevated 10–20° for the first 6–12 postoperative hours, in order to maintain negative pressure in the veins. Eating is resumed within 4 h. For patients who have undergone bilateral exploration, serum calcium levels are measured 6 h after operation and again the next morning; a serum phosphorus level is also measured at the latter time point. Since calcium levels may not nadir for several days after

surgery, a parathyroid hormone level may be obtained postoperatively to help assess the risk of hypocalcemia. Patients who have undergone unilateral first-time exploration do not require biochemical evaluation. Oral calcium supplements are administered for signs of biochemical and/or symptomatic hypocalcemia.

The vast majority of patients are discharged on the first postoperative day; they are given a prescription for thyroid hormone supplementation if the procedure was more extensive than a lobectomy, and are instructed to take calcium tablets for symptoms of hypocalcemia. Most patients can return to work or full activity within 1 week. They are seen in the outpatient clinic within 2 weeks after discharge, at which time further management is discussed in light of the pathology findings as well as the results of any relevant follow-up laboratory evaluation.

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Chapter 2
Central Neck Dissection

Dina M. Elaraj and Cord Sturgeon

Abstract The central compartment of the neck, also known as level VI, is bounded by the carotid arteries laterally, the hyoid bone superiorly, and the suprasternal notch or innominate artery inferiorly. Papillary thyroid cancer, derived from follicular cells, and medullary thyroid cancer, derived from parafollicular cells, commonly metastasize to the cervical lymph nodes. Therapeutic central neck dissection for papillary thyroid cancer is clearly indicated, while routine prophylactic central neck dissection for papillary thyroid cancer is controversial. Pre-operatively, all patients should undergo comprehensive neck ultrasound with fine needle aspiration biopsy of any suspicious lymph nodes. To perform a central neck dissection, the patient is positioned supine with the neck extended. Total thyroidectomy is performed in the standard fashion. The thin fascial layer overlying the recurrent laryngeal nerve is incised and the nerve then dissected away from the fibrofatty lymph node-bearing tissue of the paratracheal space extending from the point of the

D.M. Elaraj, MD, FACS (✉) • C. Sturgeon, MD, MS, FACS
Department of Surgery, Section of Endocrine Surgery,
Northwestern University Feinberg School of Medicine,
676 N St Clair St., Suite 650, Chicago,
IL 60611, USA
e-mail: delaraj@nm.org; csturgeo@nm.org

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nerve's insertion into the criocthyroid muscle superiorly to the thoracic inlet inferiorly and between the carotid arteries laterally. The pretracheal tissue is dissected inferiorly to the suprasternal notch. The lower parathyroid gland is frequently devascularized during this procedure and should be autotransplanted if its blood supply is in doubt. Drains are not usually necessary. Patients are usually discharged home the following day.

Keywords Papillary thyroid cancer • Medullary thyroid cancer • Delphian lymph node • Lymph node metastases • Central neck dissection • Level 6 lymph nodes

Indications

Lymph nodes in the neck are classified by their location (Levels I-VI). Level VI, also known as the central compartment of the neck, is bounded by the carotid arteries laterally, the hyoid bone superiorly, and the suprasternal notch or innominate artery inferiorly [1, 2]. It contains the Delphian (precricoid), pretracheal, and paratracheal lymph nodes. Level VII nodes, although not technically located in the neck, are often included when describing lymph node groups/levels in the neck. They are located in the anterior superior mediastinum between the suprasternal notch and brachiocephalic vessels, and lymph nodes in Level VII can be resected en bloc with those in Level VI [1]. Some references define the inferior boundary of the central neck as the innominate artery on the right and the corresponding axial plane on the left [2]. If using this definition, the level VII lymph nodes superior to the innominate artery will be included in level VI.

Thyroid cancer is classified by cell of origin. Differentiated thyroid cancers of follicular cell origin include papillary, follicular, and Hürthle cell cancers.

Medullary thyroid cancer is derived from the calcitonin-producing parafollicular cells and has a different biology than cancers of follicular cell origin. Eighty percent of thyroid cancers are of the papillary subtype, which first metastasize to the cervical lymph nodes [3]. Medullary thyroid cancer also tends to first metastasize to the cervical lymph nodes [4]. Follicular and Hürthle cell cancers have a propensity for hematogenous metastases and rarely spread to cervical lymph nodes.

Lymph node metastases from papillary and medullary thyroid cancer are very common, and they have been observed to have an adverse impact on prognosis, with the possible exception of patients with papillary thyroid cancer who are younger than 45 years [5]. Cervical nodal metastases usually occur in a stepwise fashion, first involving lymph nodes of the ipsilateral central neck, then involving lymph nodes of the ipsilateral lateral neck (Levels II-IV), followed by lymph nodes on the contralateral side. Skip metastases, while unusual, can occur.

Central neck dissection for differentiated thyroid cancer is clearly indicated when central compartment lymph nodes are grossly involved with cancer. This is termed therapeutic central neck dissection. Therapeutic central neck dissection is also indicated if an enlarged or suspicious lymph node in the central neck is found to contain metastatic thyroid cancer on frozen section analysis. The role of routine, prophylactic central neck dissection for papillary thyroid cancer is controversial. The American Thyroid Association (ATA) guidelines and the National Comprehensive Cancer Network (NCCN) guidelines both recommend considering routine prophylactic central compartment neck dissection for patients with papillary thyroid cancer [5, 6]. The possible benefit to reducing cancer recurrence, however, must be balanced with the possible increased risk of morbidity associated with this procedure [7]. In contrast to papillary thyroid cancer, routine, bilateral prophylactic central neck dissection is recommended in the treatment of medullary thyroid cancer [4].

Preoperative Preparation

All patients with a diagnosis of thyroid cancer should have a preoperative ultrasound of the central and lateral compartments of the neck, with fine needle aspiration biopsy of any suspicious lymph nodes [5, 6]. If positive in the lateral neck, then the patient will require a modified radical neck dissection in addition to total thyroidectomy and central neck dissection.

Position

The patient is positioned supine on the operating table with the neck extended and the arms tucked at the sides. A beanbag or shoulder role is used to help extend the neck. A foam ring is helpful to pad the head and hold it in place. All pressure-points are padded. Semi-Fowler's or reverse Trendelenberg positioning is helpful to decompress the veins in the neck.

Description of Procedure

A curvilinear incision is made in a natural neck crease overlying the thyroid isthmus and carried through the subcutaneous tissue and platysma. Subplatysmal flaps are raised superiorly to the notch in the thyroid cartilage and inferiorly to the sternal notch. The strap muscles are separated vertically in the midline in an avascular plane. It is usually not necessary to divide the strap muscles for exposure. Total thyroidectomy is then performed in the standard fashion. Once the thyroid has been removed, the lymph nodes in the central compartment of the neck can then be addressed. The Delphian (precricoid) lymph node is located overlying the cricothyroid membrane and is often encountered and resected during the dissection of the thyroid isthmus and pyramidal lobe (if present).

Central compartment lymph node dissection involves resection of the fibrofatty lymph node-bearing tissue in the paratracheal and pretracheal spaces. The boundaries of this dissection are:

1. Hyoid bone – superiorly
2. Carotid artery – laterally
3. Midportion of the anterior trachea – medially
4. Suprasternal notch or innominate artery – inferiorly
5. Prevertebral fascia – deep

Structures at risk during this dissection include the parathyroid glands (particularly the lower glands) and the recurrent laryngeal nerves.

The technique of central compartment lymph node dissection first starts by defining the medial and lateral boundaries of the dissection [8]. A distinction can also be made between unilateral central neck dissection, which includes the precricoid/prelaryngeal, pretracheal, and unilateral paratracheal lymph nodes, and bilateral central neck dissection, which adds dissection of the contralateral paratracheal space [2]. Medially, the fibrofatty tissue overlying the trachea is incised to the level of the suprasternal notch, exposing the anterior surface of the trachea. Laterally, the medial border of the carotid artery is dissected down to the prevertebral fascia. The thin fascial layer overlying the recurrent laryngeal nerve is then opened along its length and the nerve dissected away from the fibrofatty tissue of the central neck and gently retracted laterally. This dissection, which can usually be done sharply, extends from the point of the nerve's insertion into the cricothyroid muscle superiorly to the thoracic inlet inferiorly. Figure 2.1 illustrates the left recurrent laryngeal nerve partially dissected out at the beginning of the central neck dissection. The fibrofatty lymph node-bearing tissue of the paratracheal space is then taken off the prevertebral fascia in a cephalad-to-caudad and lateral-to-medial fashion, lastly freeing it from the trachea and esophagus. Figure 2.2 illustrates the appearance of the left central neck at the conclusion of the dissection and Fig. 2.3 shows the

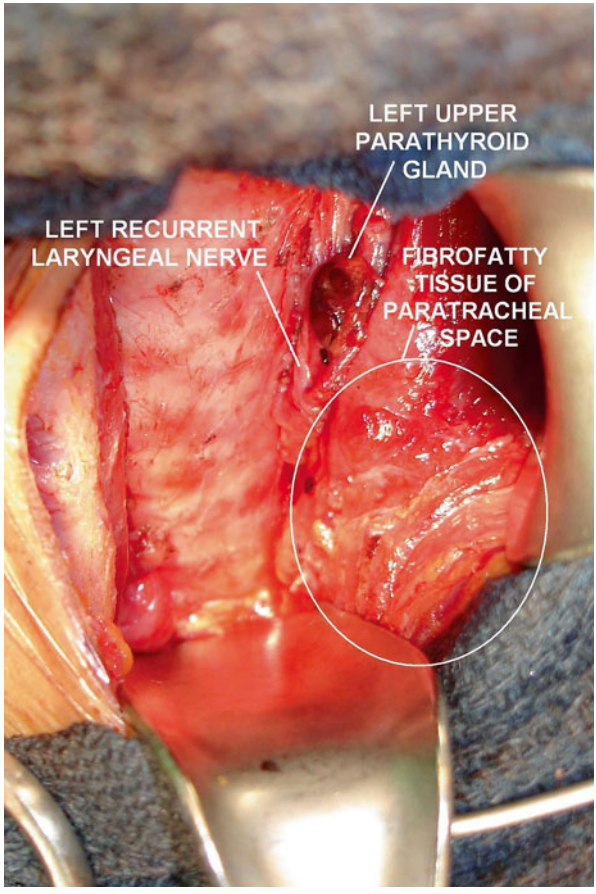

FIGURE 2.1 Left central neck dissection. The left recurrent laryngeal nerve is partially dissected, and the left upper parathyroid gland is visible in its normal position posterior to the nerve. The fibrofatty lymph node-bearing tissue of the paratracheal space is seen within the ellipse

resected specimen. Care must be taken to preserve the upper parathyroid gland on its vascular pedicle. The lower parathyroid gland is frequently devascularized during a formal central

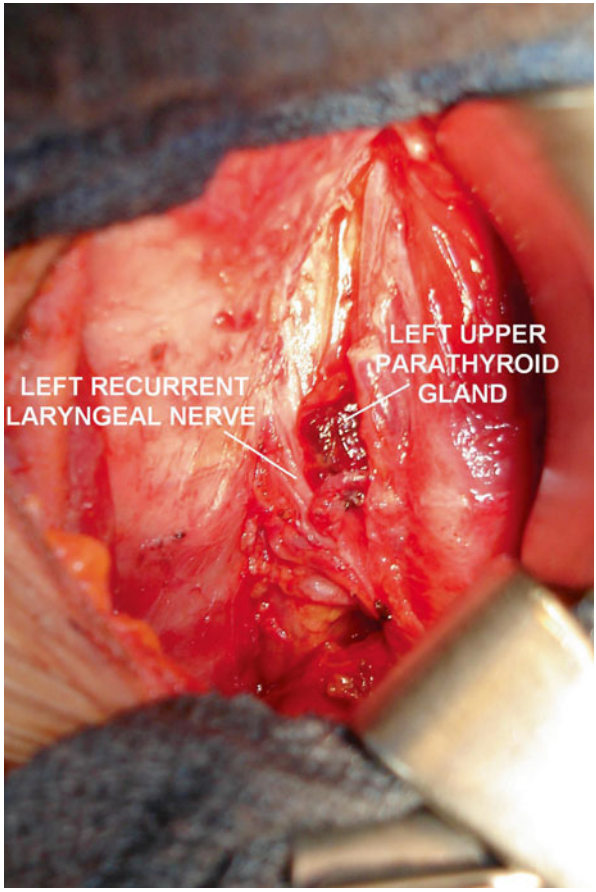

FIGURE 2.2 Left central neck dissection. The left recurrent laryngeal nerve has been skeletonized, and the fibrofatty lymph-node bearing tissue of the central neck has been removed

compartment neck dissection and should be autotransplanted if its blood supply is threatened. Hemostasis is assured and closure is performed in the standard fashion. Drains are usually not necessary.

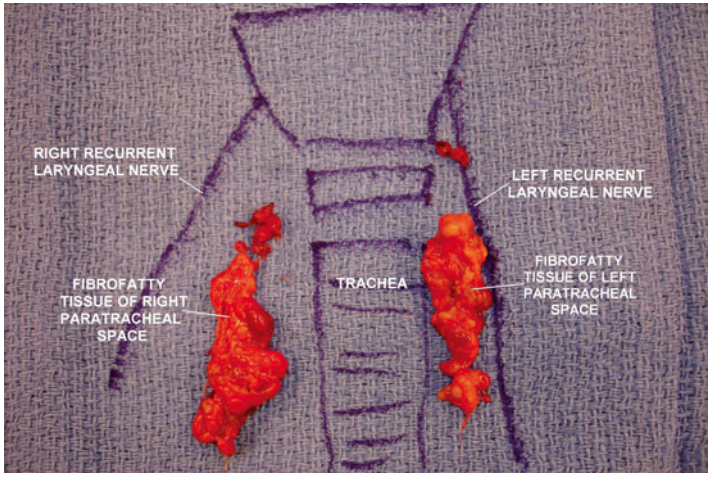

FIGURE 2.3 Post-resection specimens from a patient who required bilateral central neck dissections

Bulky central compartment nodal metastases that invade the recurrent laryngeal nerve should be managed based on the histology of the primary tumor and preoperative vocal cord function. Papillary thyroid cancer should be "shaved off" a functioning recurrent laryngeal nerve in an attempt to preserve vocal cord function on that side, and these patients should receive postoperative adjuvant radioactive iodine. Because there are no good adjuvant treatment options for patients with medullary thyroid cancer, invasion of the recurrent laryngeal nerve may require en-bloc resection of a segment of the nerve. Primary reanastomosis, nerve graft reconstruction, or anastomosis to the ansa cervicalis can be performed to preserve muscle bulk on that side.

Postoperative Care

Patients are observed in the hospital overnight. The head of the bed is elevated 30°. Clear liquids are given initially, and the diet advanced as tolerated. Recurrent laryngeal nerve function is assessed clinically by evaluating voice quality and aspiration

of thin liquids. A serum calcium and parathyroid hormone level is checked the morning after surgery, or sooner if there are symptoms of hypocalcemia. Oral calcium supplementation is given to patients at risk of perioperative hypocalcemia.

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Chapter 3
Modified Radical Neck Dissection

Cord Sturgeon and Dina M. Elaraj

Abstract All patients with a diagnosis of thyroid cancer should have a complete preoperative ultrasound of the central and lateral compartments of the neck, with a clear documentation of the description and location of suspicious lymph nodes using the standard nomenclature. Fine needle aspiration biopsy of suspicious lymph nodes should be performed preoperatively in order to guide the extent of surgery. Papillary and medullary thyroid cancers frequently metastasize to the cervical lymph nodes. Thyroid cancer nodal metastases are best treated with formal compartmental clearance. For metastatic thyroid cancer within the lateral neck, the authors perform a formal nodal clearance of levels IIA, III, IV, and VB. The standard nomenclature, preoperative preparation, steps of the dissection, and postoperative care are described.

Keywords Neck dissection • metastatic thyroid cancer • surgical technique

C. Sturgeon, MD, MS (✉) • D.M. Elaraj, MD
Department of Surgery, Section of Endocrine Surgery,
Northwestern University Feinberg School of Medicine,
676 North Saint Clair Street, Suite 650, Chicago,
IL 60611, USA
e-mail: csturgeo@nmh.org; delaraj@nmh.org

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Indications

The neck is divided into seven lymph node-bearing compartments, the nomenclature of which was originally described by the Memorial Sloan Kettering Head and Neck Service [1] and has been standardized and modified several times by the Committee for Neck Dissection Classification of the American Head and Neck Society and the American Academy of Otolaryngology-Head and Neck Surgery [2–4]. The seven nodal compartments are defined as follows:

I. Submental (IA) and submandibular (IB) triangle nodes.
II. Upper third jugular nodes located between the skull base and the hyoid bone. This compartment is subdivided into IIA (anterior) and IIB (posterior) based on the relationship to the spinal accessory nerve (CN XI).
III. Middle third jugular nodes located between the hyoid bone and the cricoid cartilage.
IV. Lower third jugular nodes located between the cricoid cartilage and the clavicle.
V. Posterior triangle nodes located between the anterior border of the trapezius muscle, the posterior border of the sternocleidomastoid muscle (SCM), and the clavicle. This group is subdivided into spinal accessory (VA) and supraclavicular (VB) nodes by a horizontal plane defined by the lower border of the cricoid cartilage.
VI. Central neck nodes located between the carotid sheaths extending from the hyoid bone to the suprasternal notch.
VII. Upper mediastinal nodes located between the suprasternal notch and the innominate artery.

The radical neck dissection, as originally described by Crile in 1906, entailed removal of all of the node-bearing tissue in Levels I–V along with the SCM, internal jugular vein and CN XI. The radical neck dissection is not considered a standard operation for thyroid cancer. Numerous modifica-

tions of the original operation have been described, however, that do have a significant role in the surgical management of thyroid cancer [5]. A "modified radical neck dissection" (MRND) is defined as an operation that involves the preservation of one or more non-lymphatic structures that were routinely removed in the radical neck dissection, but still results in the formal compartmental clearance of levels I–V [3]. Some experts have referred to an operation that formally clears compartments I–V and preserves the SCM, CN XI, and internal jugular vein as a "functional neck dissection". Expert guidelines would classify a procedure as a "selective neck dissection" (SND) when one or more of the lymph node levels is preserved during a formal neck dissection, and is usually depicted in the medical record as SND with the levels removed following in parentheses [2, 3]. An "extended neck dissection" is defined as a neck dissection that includes the removal of additional lymph node groups or structures beyond those included in the radical neck dissection.

The term "therapeutic neck dissection" implies that nodal metastases are clinically apparent at the time of the neck dissection. The terms "prophylactic neck dissection" or "elective neck dissection" imply that there are no clinical or radiographic findings to suggest that there are nodal metastases at the time of the dissection.

Papillary and medullary thyroid cancers frequently metastasize to the cervical lymph nodes. Thyroid cancer nodal metastases are best treated with formal compartmental clearance. There is no role for the selective removal of individual metastatic lymph nodes ("berry picking") [6]. For metastatic thyroid cancer, the authors perform a formal nodal clearance of levels IIA, III, IV, and VB, and in the text that follows we will refer to clearance of these node-bearing regions as a MRND. We recognize that some authors include levels I and IIB, and may perform a more extensive clearance of level V than what is described herein [2]. The SCM, internal jugular vein and CN XI are preserved, except in rare cases of directly invasive thyroid cancers, where a decision can be made to sacrifice one of these structures to allow resectability.

Therapeutic MRND is indicated for biopsy-proven lateral neck metastases from thyroid cancer [6–8]. Prophylactic MRND is not indicated in the treatment of patients with papillary thyroid cancer. The role and extent of prophylactic MRND in the treatment of medullary thyroid cancer (MTC) is controversial, with some authors advocating prophylactic MRND based on clinical parameters and intraoperative findings [9, 10]. The National Comprehensive Cancer Network recommends considering prophylactic ipsilateral MRND in the treatment of MTCs that are ≥1 cm (>0.5 cm if Multiple Endocrine Neoplasia [MEN] 2B) or with adjacent central compartment metastases [11], while other consensus guidelines for the treatment of patients with MEN recommend MRND for patients with MEN 2 only if there is clinical or radiographic evidence of involved lymph nodes in the lateral neck [12]. The 2009 American Thyroid Association (ATA) guidelines on the management of medullary thyroid cancer recommend dissection of the lateral neck including levels IIA, III, IV and V for patients with clinically apparent lateral neck nodal metastases [13]. It should also be noted that a minority of members on the ATA panel favored prophylactic ipsilateral MRND when lymph node metastases were present in the adjacent central compartment [13].

Preoperative Preparation

All patients with a diagnosis of thyroid cancer should have a complete preoperative ultrasound of the central and lateral compartments of the neck, with a clear documentation of the description and location of suspicious lymph nodes using the standard nomenclature described above. Fine needle aspiration biopsy of suspicious lymph nodes should be performed in order to guide the extent of surgery [6]. The patency of both internal jugular veins should be assessed and documented. A thorough neurologic examination should be done to assess the baseline function of the nerves at risk during

MRND. Preoperative laryngeal exam is recommended in cases of voice alteration or for revision surgery, although many clinicians perform this routinely to evaluate baseline vocal cord function in thyroid cancer patients. Patients should be counseled on the risks, benefits and alternatives to the proposed procedure(s), and the details of the discussion and the patient's understanding thereof should be documented.

Description of Procedure

The neck is extended and the head turned to expose the lateral aspect of the neck. A beanbag or shoulder role is used to help extend the neck. A foam ring is helpful to pad and immobilize the head. The patient is placed in semi-Fowler's position to decompress the neck veins. The entire neck extending from the chin, corner of the mouth, and pinna of the ear, laterally to the shoulders, and down onto the upper chest is prepped and draped. In order to visually assess the function of the marginal mandibular branch of the facial nerve, the corner of the mouth can be kept visible with the use of clear sterile draping.

Many skin incisions have been described for the MRND [14]. An incision from the mastoid process carried inferiorly along the posterior border of the SCM, then curved medially in a Langer's line towards the midline yields excellent exposure with an acceptable cosmetic result. For simplicity, only the MRND through this hemi-apron or "hockey-stick" incision will be described herein.

The skin is marked in the proposed line of the incision and infiltrated with 1 % lidocaine with epinephrine to allow for sharp dissection in a relatively bloodless field. The skin, subcutaneous tissues and platysma are incised sharply. Subplatysmal flaps are raised sharply towards the midline, taking care to preserve the greater auricular nerve and external jugular vein as the dissection proceeds over the surface of the SCM. The marginal mandibular nerve is preserved at the medial aspect of the subplatysmal flap.