

VOLUME I



# CUMMINGS OTOLARYNGOLOGY

Head and Neck Surgery

EIGHTH EDITION



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HOWARD W. FRANCIS  
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GOLOGY



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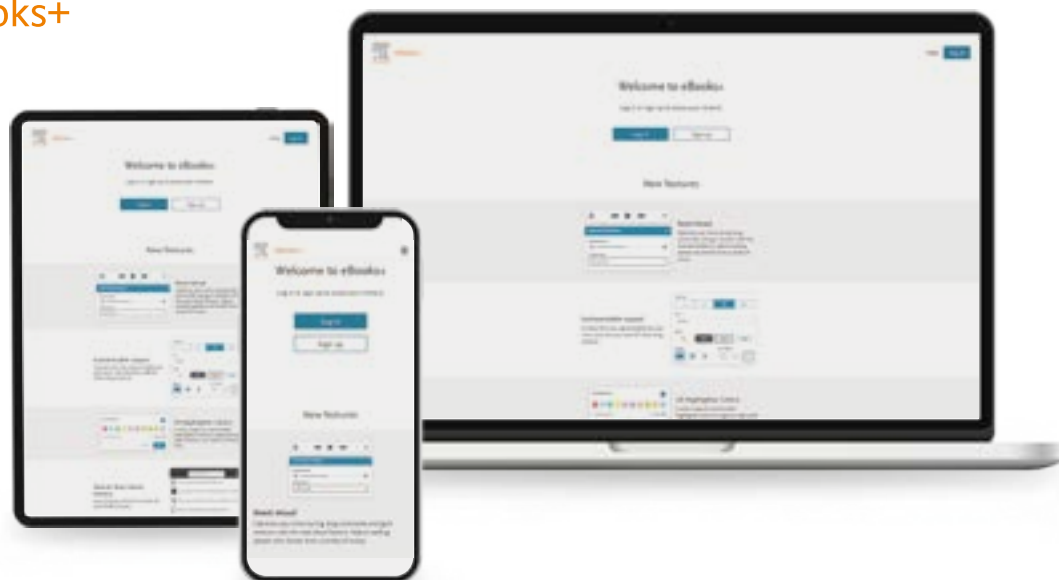
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CUMMINGS  
**OTOLARYNGOLOGY**

Head and Neck Surgery

# CUMMINGS OTOLARYNGOLOGY

## Head and Neck Surgery

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# Preface

As with all specialties, otorhinolaryngology–head and neck surgery continues to evolve with our ability to understand the immune response to cancer and other disorders, the introduction of targeted therapies that unlock the genetic basis of disease, and advances in technology across the spectrum of surgical therapy. In response, the eighth edition of *Cummings Otolaryngology: Head and Neck Surgery* has added 11 new chapters in addition to expanding the archive of narrated video clips. A total of 115 video clips (an increase from 73) are cited in the text with links to Elsevier eBooks+. Most importantly, the Cummings text continues to reflect the knowledge, experience, and wisdom of the field's most committed authors and contemporary thought leaders.

This eighth edition has many new topics as we try to keep pace with the rapidly evolving field of facial plastic surgery. We have new chapters covering the areas of gender-affirming surgery; fat grafting and transfers; the latest advances in facial reanimation; the newest trends in rhinoplasty, including dorsal preservation surgery; and additional focus on nonsurgical techniques with lasers, injectables, and new energy devices. Chapters have updated images and video content that greatly enhance learning opportunities.

A lot has happened in rhinology since the last edition, and this is reflected in significant updates of all chapters. Some have completely new authorship, resulting in radically changed content such as the imaging chapter. Elsewhere, many new experts have been added to topics, such as for the orbit, cerebrospinal fluid leaks, and benign sinonasal tumors. The wealth of new evidence and consensus documents is highlighted in significant revisions throughout and includes the impact of COVID on olfaction, our increasing understanding of the pathophysiology and management of chronic rhinosinusitis, and the impact of biologic agents.

Updates to the otology and skull base section reflect progress in our understanding of the basis of ear disease and the approach to clinical management. The presentation of several topics in this section has been updated, reorganized, and even rewritten, such as Chapter 147: Cochlear Transduction and Peripheral Auditory Pathology. The addition of videos and consolidation of detailed information into tables and key points have further made this section more accessible to the contemporary learner and practitioner.

The pediatric section includes a new chapter on pediatric voice disorders. In addition, reflecting the importance of obstructive sleep apnea (OSA) persisting after adenotonsillectomy, there is a new chapter that adds information on complex pediatric OSA in addition to nonobstructive sleep disorders. There is expanded content on pediatric trauma and also on infant feeding and swallowing. Finally, there is a new chapter on understanding and evaluating genetics and genomics in pediatric otolaryngology

that provides a general overview to complement the chapter on genetics of hearing loss.

Changes in the epidemiology, science, novel staging, and treatment of HPV-related head and neck cancer are detailed in updated chapters. Updated chapters also highlight computer-simulated and modeled dentomandibular reconstruction and advances in the technology and approaches to transoral surgery for upper aerodigestive tract tumors. A new chapter on immunology in the treatment of head and neck cancer has also been included.

We continue to keep the text concise yet representative of the major and notable developments in the field. As with the last edition, the eighth edition features access to the Elsevier eBooks+ website, which includes enhanced text and images from the book, a full reference list for each chapter, as well as videos demonstrating ACGME (Accreditation Council for Graduate Medical Education) Key Indicator Procedures, and more. The video component provides residents and practitioners with the opportunity to visualize and better understand the critical elements of these core procedures. There is also a 29-slide deck of labeled temporal bone sections arranged in series, providing a valuable educational resource for understanding ear anatomy.

Our goal is to further the education of those currently associated with otorhinolaryngology and head and neck surgery and to provide a foundation for the next generation to follow. We are committed to presenting the leading edge of practice arising from new data and schools of thought. We acknowledge that some readers, authors, and editors may find certain topics controversial and the interventions described at odds with their personal beliefs. While the technical aspects of each chapter are excellent, the evidence base for safe delivery of care is evolving. We are always guided, however, by our goal to disseminate current best knowledge, understanding it may change in future.

Our editorial team welcomes some new senior editors and has expanded to also include a new panel of associate editors: Charles Limb, Cherie-Ann Nathan, Carole Fakhry, Samuel Oyer, and Devyani Lal. This team and our contributing authors continue to have worldwide representation, thus reflecting the global contributions to the field. Through the combined effort of all contributors, the eighth edition will continue to be the definitive resource and reference for our specialty.

**Howard W. Francis**  
**Bruce H. Haughey**  
**Alexander T. Hillel**  
**Marci M. Lesperance**  
**Valerie J. Lund**  
**Stephen S. Park**  
**K. Thomas Robbins**

# Acknowledgments

As the outgoing senior editor, I am privileged to mark the end of my career with the planning and preparation of this eighth edition of *Cummings Otolaryngology: Head and Neck Surgery*. I am grateful to Howard Francis for bringing this project to completion as the new senior editor and to Alexander Hillel for assuming the role of editor for the laryngology section. It has been the highlight of my career to have led a spectacular group of senior editors and our new associate editors in continuing the legacy of the Cummings text as the definitive resource for up-to-date knowledge and practice for Otolaryngology–Head and Neck Surgery. As an editorial team, we are ultimately indebted to the authors who have not only committed tremendous time and thought into preparing chapters that represent the current state of knowledge and practice, but who have also done so in a manner that can be effectively accessed by learners and practitioners alike. I save the penultimate acknowledgment for my teacher, mentor, and friend, Charles Cummings. He has leveraged his unparalleled credibility as a leader in the specialty and empowered us with the vision to continuously advance the field and perpetuate a culture of innovation and excellence in our care of patients and development of subsequent generations of otolaryngologists.

**Paul W. Flint**

I would like to thank Paul Flint for leading our editorial team through the planning process in preparation for the eighth edition of *Cummings Otolaryngology: Head and Neck Surgery*. I am personally grateful that he gave me the opportunity to participate in the continuing legacy of the Cummings text, starting with the seventh edition. It has been particularly heartwarming to again work with a respected teacher, mentor, and colleague.

My role as editor of the Otolaryngology, Neurotology, and Skull Base section, and now lead editor, brings me full circle in a professional journey in which this text has been a reliable and ever-present resource. I devote my efforts in honor of all the teachers, mentors, and sponsors that I have had along this journey from Montego Bay, Jamaica, to Los Angeles, Boston, Baltimore, and most recently Durham, North Carolina. In particular, Charles Cummings and John Niparko loom large in the development of my professional identity as an academic otolaryngologist and neurotologist, and it is an honor to continue their work.

I give special thanks to Charles Limb for serving as Associate Editor for the Otolaryngology, Neurotology and Skull Base section. His wise counsel and consistent contribution to the work of supporting 54 authorship teams was critical to implementing improvements to this section. I am very grateful to our authors for the skill and time that they invested in organizing and presenting state-of-the-art knowledge and practice. Thanks to Jessica McCool and all members of the Elsevier publishing team who have supported our editors and authors to produce a high-quality product that has stood the test of time. Finally, and most importantly, I would like to acknowledge the shared sacrifice of my family in making it possible for me to serve in this profession at the full extent of my abilities, including my parents, Millicent and Howard, my wife, Sarah, and my children, Natalie and Ben.

**Howard W. Francis**

It continues to be a distinct honor and pleasure to be part of the editorial team assembled for this eighth edition of *Cummings Otolaryngology: Head and Neck Surgery*. The publishers

and authors have worked tirelessly to produce chapters that are comprehensive in scope and depth. My sincere thanks go to all the authors and their families, who inevitably have put up with liberal amounts of burning the midnight oil. In its turn, my family has unwaveringly endorsed the time away required for this project. So heartfelt love and thanks go to my wife Helen, as well as to each of my children and grandchildren. The fellows and my colleagues at Advent Health Celebration Otolaryngology–Head & Neck Surgery have also been highly supportive.

The ability to purvey knowledge starts with one's education. Thanks must go to my late parents Thomas and Marjorie Haughey, my teachers, medical school professors, and otolaryngology residency and fellowship mentors both in Auckland, New Zealand, and at the University of Iowa.

The advice and support of Associate Editor Carole Fakhry, MD, for the Head and Neck chapters are much appreciated, and readers can look forward to her expert input as an editor in future editions.

As with many sustained academic endeavors, subject matter and its implications change over time. The material in this text has understandably become broader with each edition. My sincere hope is that readers will benefit greatly in knowledge and practice from this textbook's outstanding content and technical excellence, better accomplishing our common goal of top-quality patient care. As we enjoy this publication, I remind myself that the ultimate source of all knowledge and truth is found in the words of Proverbs 2:6: "The Lord gives wisdom and from his mouth come knowledge and understanding."

**Bruce. H. Haughey**

I would like to thank Paul Flint and Howard Francis for the opportunity to serve as an editor for the eighth edition of *Cummings Otolaryngology: Head and Neck Surgery*. As they have been successive editors in chief of this text, they were also successive program directors for me and a generation of Hopkins residents. Paul and Howard promoted an environment where the surgical training was rigorous and, as importantly, they encouraged us to deeply explore and develop an academic niche. That translated to an atmosphere full of promise and opened our eyes to the ways we could make a difference for our patients and impact the field more broadly.

I am grateful to Charlie Cummings for his mentorship over the years. I feel lucky for our regular conversations and continue to learn from his wisdom.

Finally, I thank my wife, Janis Taube, for support through our journey from New Orleans to Baltimore, with short stops in Palo Alto and Atlanta. Maryland has become home to our family, and it has been a delight watching our children sail on Chesapeake Bay.

**Alexander T. Hillel**

It is an honor to serve as editor of the pediatric otolaryngology chapters for the premier textbook in otolaryngology–head and neck surgery. Five years is a long time in the world of medicine, especially in pediatric otolaryngology, which often involves complex multidisciplinary care for children with congenital disorders. Technical advances have allowed for more procedures to be done endoscopically, avoiding the morbidity of open repair.

I am grateful to my colleagues who agreed to serve as authors and share their knowledge and experience to benefit future generations of otolaryngologists. The chapter images have been collected over years of practice, and I recognize the time spent during evenings and weekends after clinical and other obligations are met. I thank my husband, Edward Karls, and my children, Matthew, Michelle, Maria, and Melanie, for their love, patience and support.

**Marci M. Lesperance**

It has been a tremendous honor and privilege to have been involved with “Cummings” for this and the previous three editions and to have, hopefully, contributed to its ever-expanding international influence and readership. I would like to sincerely thank Paul Flint and his colleagues for my continued involvement in this prestigious project, the publishers for their exemplary efficiency in its management, and Devyani Lal, who has been a huge help as my associate editor. I must also pay tribute to two heroes: Charlie Cummings for his friendship, wit, and wisdom, and to my long-suffering husband, David Howard, for his unfailing support, encouragement, and endless good humor.

**Valerie J. Lund**

It is a great honor and pleasure to be organizing the Facial Plastic Surgery section of this esteemed textbook. A huge and sincere

note of gratitude goes to my associate editor, Sam Oyer, MD, who has led the charge of this eighth edition. The final product only comes together with the dedicated efforts of the many authors from around the country who have volunteered their time and expertise toward this effort.

**Stephen S. Park**

This being my final term serving as an editor, I wish to express sincere gratitude to my editorial colleagues and the Elsevier team for the privilege of serving in this role for nearly three decades. While the journey has been academically fulfilling and rewarding, the time does come to pass the baton to the next generation of talented individuals. The saying “all good things must come to an end” reflects a sentiment that often rings true, as it does for me at this time. To all the authors who selflessly shared their expertise and valuable time in composing chapters, I express my deepest appreciation. Also, a special recognition goes to Cherie-Ann Nathan, who has kindly accepted the responsibility of carrying on with my duties. Finally, thank you to Charlie Cummings and Paul Flint for your leadership, and to Bruce Haughey for serving with me on the head and neck section. I wish the team of editors continued success in maintaining this comprehensive textbook as a renown resource for otolaryngologists—head and neck surgeons worldwide.

**K. Thomas Robbins**



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#### **Appendix: Temporal bone anatomy in serial sections**

Vertically sectioned normal temporal bone arranged in sequence at variable intervals; 29 slides show relevant structures, and anatomic relations are noted and labeled.

## SECTION 1 General Considerations

## 73 Tumor Immunology and Immunotherapy

*Nicole C. Schmitt, Robert L. Ferris*

## KEY POINTS

- Head and neck squamous cell carcinomas (HNSCCs) have a relatively high number of mutations (high tumor mutational burden) but have developed ways to evade the antitumor immune response.
- Targeted monoclonal antibodies to tumor antigens, such as cetuximab, may work in part by stimulating immune responses.
- Immune checkpoint inhibitors have shown activity in recurrent/metastatic HNSCC, and studies are underway for previously untreated, locally advanced disease.
- Although vaccines for prevention of infection with human papillomavirus (HPV) infection are not useful for treating HPV-driven oropharyngeal carcinoma, therapeutic vaccines for HPV-related HNSCCs are an active area of research.
- Adoptive transfer of T cells and other immune cells is another immunotherapeutic strategy under study for HNSCCs.
- Immune checkpoint inhibitors have been combined with surgery, chemotherapy, radiation, targeted therapies, and other forms of immunotherapy, with some encouraging results.
- Immunotherapeutic strategies are likely to be incorporated more widely into standard treatment paradigms for HNSCCs in the future.

Immunotherapies, which are agents that enhance the natural immune response to cancer, have been incorporated into standard treatment paradigms for head and neck squamous cell carcinoma (HNSCC) and other cancers. Understanding how such therapies work requires understanding some basic principles of tumor immunology. In this chapter, we outline the fundamental components of the antitumor immune response, followed by a description of immunotherapeutic strategies that are currently in use or under investigation for HNSCC.

## BASICS OF TUMOR IMMUNOLOGY

Cancer has been described as a genetic disorder leading to unchecked cell growth. Chronic inflammation and cellular stress induced by tobacco, other carcinogens, and other forms of chronic irritation lead to increasing genomic instability. The immune system provides a safety net by responding to cells that have mutations or other abnormalities. This response consists of an innate immune response, which is rapid and nonspecific, and an adaptive immune response, which involves specific tumor antigens. The adaptive response is slower but more durable.

The first line of defense is the innate immune system, which recognizes patterns of cellular stress. Cells that are stressed, inflamed, or infected will release damage-associated molecular pattern molecules (DAMPs), which promote wound healing and attract immune cells to the site of damage.<sup>1</sup> The release of DAMPs and chemokines attracts natural killer (NK) cells, macrophages, and other immune cells to the tumor microenvironment (TME). The NK cells recognize and kill cells that show aberrant signals, such as low expression of major histocompatibility complex (MHC) molecules, which are needed for cells to present antigens to lymphocytes (as described later). These “first responder” NK cells also kill cells that are bound by antibodies in a process known as antibody-dependent cell-mediated cytotoxicity.

The adaptive immune response is more powerful and durable. Adaptive immunity arises only if tumors possess antigens, which are proteins perceived as foreign that can be recognized by lymphocytes. In head and neck cancer, these antigens belong to one of three categories:

1. Tumor-associated antigens: normal proteins expressed at very high levels, such as epidermal growth factor receptor (EGFR)
2. Neoantigens: mutated proteins, such as mutated p53
3. Viral antigens: foreign viral material, such as E6, E7, and other human papillomavirus (HPV) oncoproteins

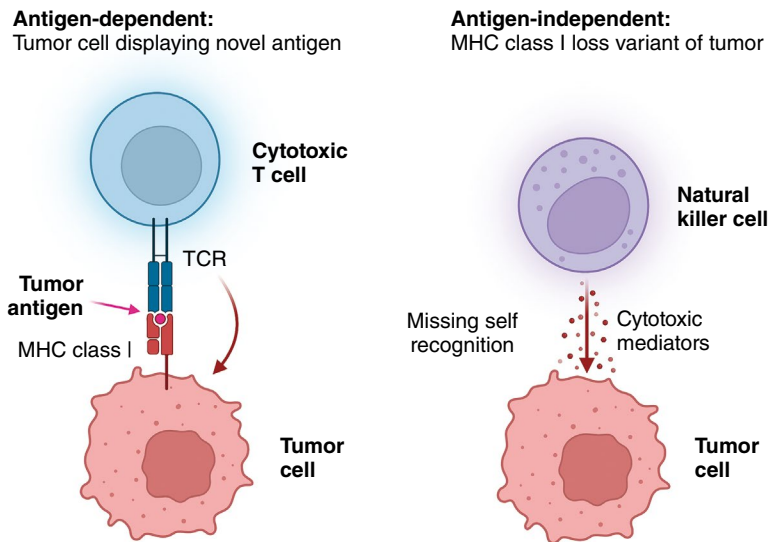
The antitumor immune response is stronger in the presence of viral material or large numbers of neoantigens. HNSCC has a relatively high tumor mutational burden compared with other tumor types,<sup>2</sup> which is one of the reasons why some HNSCC patients respond well to immunotherapy.

To elicit an adaptive immune response, these tumor antigens must be processed inside the tumor cell, loaded onto an MHC molecule, then travel to the surface of the cell, where the antigen-MHC complex can then be recognized by T-cell receptors (TCRs). After recognition of a peptide-MHC complex on the surface of the tumor cell, the T cell can directly kill the tumor cell. An overview of tumor-cell killing by T cells versus NK cells is shown in [Fig. 73.1](#).

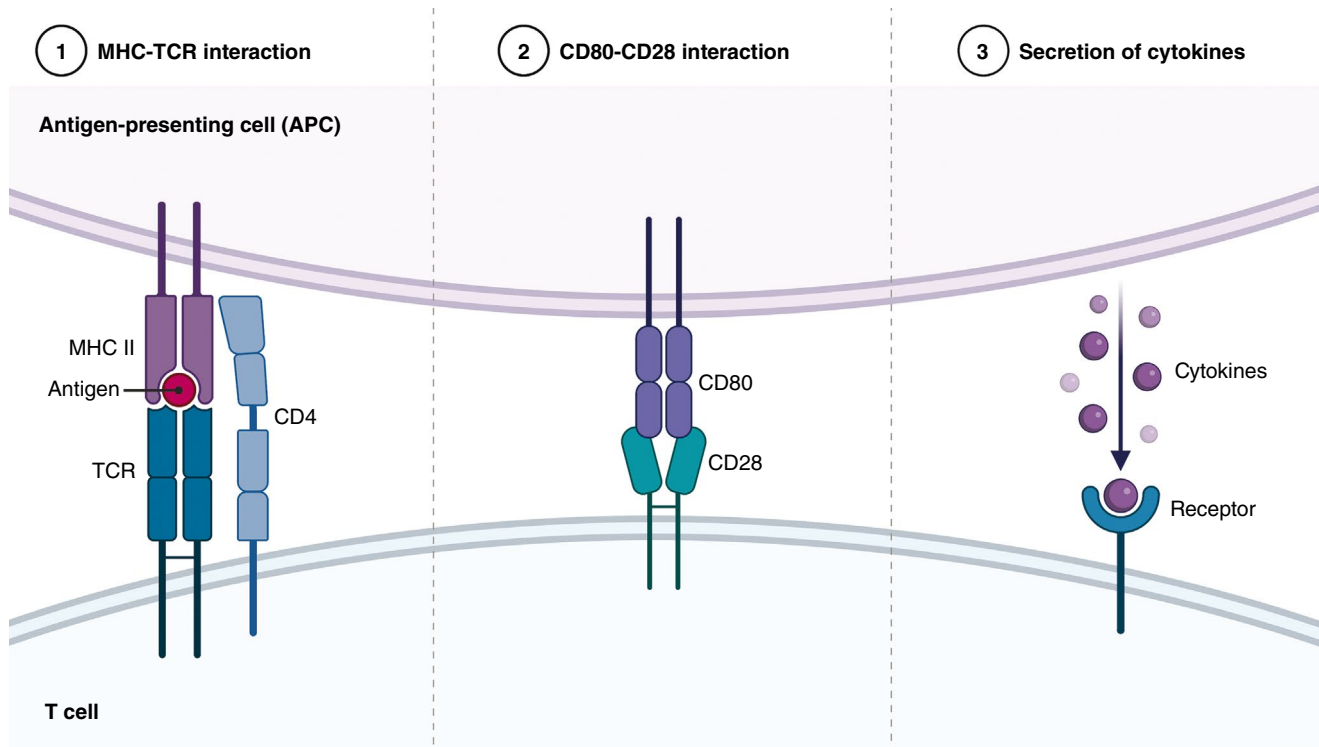
The process of antigen processing and presentation occurs in all cells, but especially in antigen-presenting cells (APCs). These APCs engulf and process proteins found in the TME and present potential antigens to T cells. Toll-like receptors (TLRs) present on APCs are activated by the DAMPs secreted by stressed and dying cells, leading to APC maturation/activation. There are three main signals for activation of the adaptive immune response by APCs and T cells ([Fig. 73.2](#)):

1. Binding of an antigen-specific TCR to the antigen-MHC complex on the APC.
2. Activation of costimulatory receptors (CD27/CD28), which serve to activate and promote survival of the T cell.
3. Production of cytokines, resulting in activation and differentiation of T cells and other immune cells.

This cascade of events results in immune-mediated tissue-specific destruction, inducing rejection and killing of transformed cancer cells.<sup>1</sup> To survive this process of immune surveillance, cancer



**Fig. 73.1** Antigen-dependent and antigen-independent killing of tumor cells by immune cells. Antigen-dependent killing involves cytotoxic  $CD8^+$  T cells. The T-cell receptor (*TCR*) binds to a specific tumor antigen loaded on a major histocompatibility complex (*MHC*), followed by activation of the T cell and killing of the tumor cell. In antigen-independent killing, natural killer cells recognize nonspecific patterns, such as low expression of *MHC* class I, then release cytotoxic mediators to kill the offending cell. (Created with BioRender.com.)



**Fig. 73.2** Three signals are required for activation of a T cell after contact with an antigen-presenting cell. In the first signal, the T-cell receptor (*TCR*) binds to an antigen loaded on a major histocompatibility complex (*MHC*). The second signal involves interaction between costimulatory receptors on the T cell (*CD28*) and dendritic cell (*CD80*). Secretion of cytokines comprises the third signal, which induces T-cell survival and proliferation. (Created with BioRender.com.)

## Advanced Laryngeal Cancer

Locally advanced laryngeal cancers are glottic, supraglottic, transglottic, aryepiglottic, or even medial piriform cancers distinguished by two fundamental features: (1) permeation of the paraglottic space (therefore advanced cancers impair the motion on one side) and (2) a clearly lateralized disposition (advanced cancers seem to permeate the “hemilarynx”).

The block to encompass such a cancer corresponds to an NTL.<sup>102</sup> NTL is a complete supraglottic laryngectomy plus an extended hemilaryngectomy, combined to include all of one paraglottic space and all of its contiguous neighbors (i.e., thyroid lobe and isthmus, hemiricoid, arytenoids, piriform, anterior commissure, and subglottis). However, a great deal of the contralateral anterior glottis is necessary to encompass the cancer. Patients undergoing NTL retain a lung-powered voice—a prosthesis-free tracheopharyngeal fistula voice—but their stoma is permanent.

What saves these patients from being classified as “very advanced” are the following characteristics:

1. Most of the subglottic mucosa within the cricoid, certainly all of it on the “good” side, is free of cancer.
2. The contralateral ventricle is clear of cancer.
3. The contralateral vocal cord is only involved in the superficial mucosa and the most anterior glottic musculature.
4. The posterior commissure and postcricoid regions are completely clear.

To recognize patients with locally advanced laryngeal cancer, we have to be able to identify and exclude the very advanced cancers, for which NTL would not be safe. “Very advanced” means the only dependable ablative option is TL and the preferred voice strategy is TEP. Typical very advanced laryngeal cancers are midline and bilateral, not lateralized. For example:

1. Massive “horseshoe” glottic/subglottic cancers (both ventricles and both muscular vocal cords are cancerous).
2. Significant subglottic cancers (generally involve the cricoid bilaterally and often present with airway obstruction).
3. Posterior commissure/postcricoid cancers (both arytenoid complexes are involved).

NTL is the most logical open “block” for locally advanced cancers. But NTL requires a specialized lateral laryngotomy. The challenge is to enter the lumen without encountering cancer and without compromising the future speaking shunt. In many candidates, it would be easier to outline the block from within the lumen of the larynx. And the laser would be the ideal tool. More subglottic mucosa could be saved (which improves the tapered capacity of the inferior shunt—the tracheocricoid entry into the speaking shunt). More interarytenoid soft tissue could be saved (which contributes to the shunt’s voicing and valving capacities). Occasionally, it might be recognized that both arytenoids were actually clear. That is, the cancer was intermediate, not advanced, and a logical laser supracricoid operation could be performed. This would confer an important advantage for the patient—no permanent tracheotomy.

Generally, we find locally advanced cases cannot be treated by TLM because reconstruction is required. The value of TLM lies not in complete excision, but in prereleasing the crucial tissue that really needs to be excised—this can define whether the cancer actually rises to the level of an NTL. Prerelease occurs with visible direction from familiar endolaryngeal landmarks, and it avoids the cancer itself. Then the surgeon can perform open delivery through the neck. No concerns exist about the site of entry, where the true margins lie or where unseen submucosal cancer might extend. Perhaps the pharyngeal augmentation flap (to be turned down from the ipsilateral side to participate in the shunt<sup>101</sup>) can be precut with the laser as well. Voice shunt reconstruction would

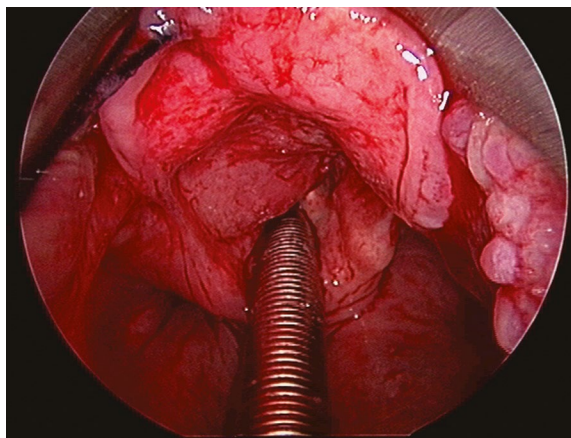
then be a simplified assembly with precut margins, no mucosal bleeding, and the least chance of cautery damage to the nerve supply or the muscular components of the shunt. The exception is when both arytenoids and cricoarytenoid joints—or at least the posterior half of the arytenoids—can be preserved. In this situation, complete tumor excision is possible via TLM, generally with acceptable functional consequences (Figs. 105.4 to 105.6).

## Very Advanced Laryngeal Cancer

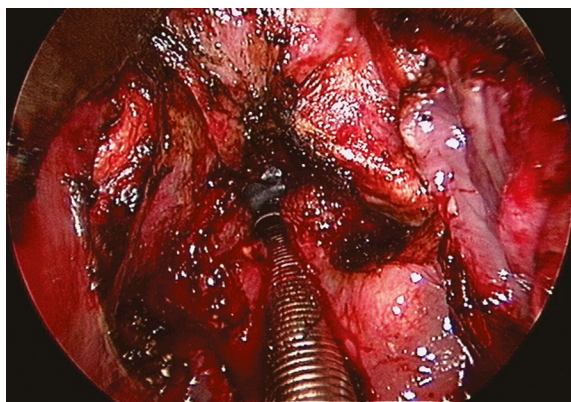
TLM has no apparent application in the locally very advanced category of laryngeal cancer. The exception might be the emergency treatment of neglected cancer with airway obstruction.<sup>105</sup>

## TRANSORAL LASER MICROSURGERY AND NECK DISSECTION

The neck nodes are treated by open surgery or postoperative radiotherapy. We can carry out a neck dissection at the same sitting as TLM on the primary, but laser endoscopic surgery cancels the argument to perform a node dissection now because “the neck is already violated” (to access the primary). A better time might be weeks later. One unproven hypothesis suggests later is better because the micrometastases “in transit” at the time of the TLM will have had time to lodge in the nodes. A more practical reason

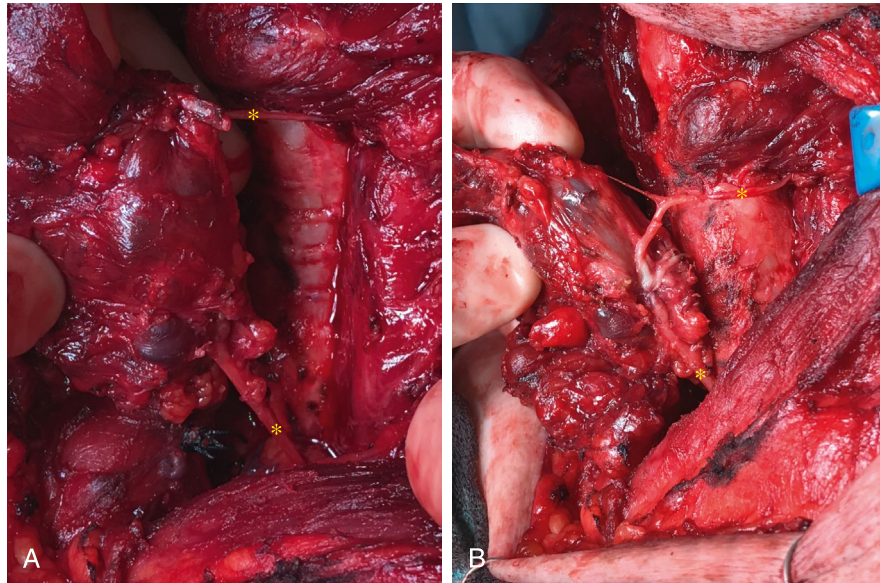


**Fig. 105.4** Preoperative T4 transglottic squamous cell carcinoma (cartilage penetration).

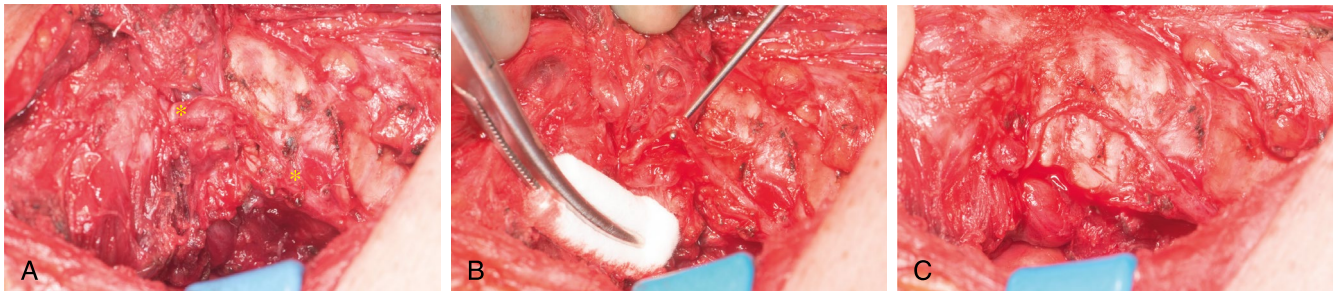


**Fig. 105.5** Extensive transoral laser microsurgery resection removing left and anterior thyroid cartilage, both true vocal cords, supraglottic structures and preepiglottic space, and some strap muscle, but preserving cricoid ring and both posterior arytenoids.

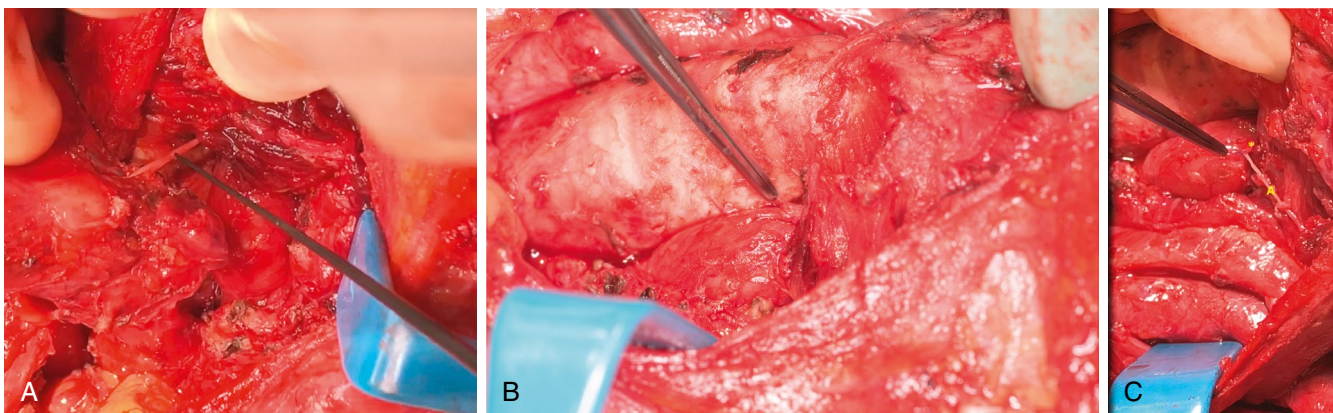




**Fig. 120.9** (A) Intraoperative photograph demonstrating encasement of the recurrent laryngeal nerve (asterisk) with tumor. If the vocal cord has some mobility preoperatively, attempt can be made to dissect the nerve through tumor. (B) In this particular case, the nerve can be visualized grossly invaded with tumor (enlarged and discolored nerve), requiring nerve sacrifice. Attempt should be made to re-anastomose the proximal and distal segments of the nerve, and if this not possible, the ansa cervicalis nerve can be anastomosed to the distal end of the recurrent laryngeal nerve as it enters the cricothyroid joint.



**Fig. 120.10** (A) Residual/recurrent thyroid disease at the cricothyroid joint is often intimately associated with the recurrent laryngeal nerve. In this revision central compartment dissection, the left recurrent laryngeal nerve (asterisk) can be seen partially encased with tumor at the cricothyroid joint. (B–C) demonstrate stepwise microdissection and mobilization of the recurrent laryngeal nerve from tumor, with preservation of nerve integrity.



**Fig. 120.11** (A) Large thyroid tumor with encasement and gross involvement of the left recurrent laryngeal nerve, nerve stimulator. (B) After tumor resection, the distal stump (forceps) of the recurrent laryngeal nerve has been preserved for ansa cervicalis to recurrent laryngeal nerve anastomosis. (C) Ansa cervicalis (A) to recurrent laryngeal nerve (asterisk) anastomosis.