Diseases of

EAR, NOSE & THROAT

with Head & Neck Surgery

HIGHLIGHTS

• Anatomy of skull and its bones, branchial apparatus and CT anatomy of head and neck
• Microbiology and antimicrobial therapy
• Clinical examination includes swelling, ulcer, sinus, fistula, cranial nerves, headache, facial pain and temporomandibular disorders
• Recent advances include tumor biology, radiofrequency surgery, coblation and robotic surgery
• Surgeries include rhinoplasty, pituitary, endoscopic skull base, thyroid and parathyroid

Mohan Bansal
Diseases of
EAR, NOSE AND THROAT
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Head and Neck Surgery
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Head and Neck Surgery

SECOND EDITION

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Dedicated to

Almighty Lord, my parents, teachers, family, patients, and students.

Shri Ramakrishna Paramahansa

He indeed is blessed, in whom all the qualities of head and heart are fully developed and evenly balanced. He acquits himself admirably well in whatever position he may be placed. He is full of guileless faith and love for God, and yet his dealings with others leave nothing to be desired. When he is engaged in worldly affairs, he is a thorough man of business. In the assembly of the learned, he establishes his claims as a man of superior learning, and in debates he shows wonderful powers of reasoning. To his parents, he is obedient and affectionate; to his relations and friends, he is loving and sweet; to his neighbors, he is kind and sympathetic and always ready to do goods; to his wife, he is the God of love. Such a man is indeed perfect.

Holy Mother Sri Sarada Devi

If you want peace, do not find fault with others. Rather see your own faults. Learn to make the world your own. No one is a stranger, my child; the whole world is your own.

Swami Vivekananda

We are responsible for what we are, and whatever we wish ourselves to be, we have the power to make ourselves. If what we are now has been the result of our own past actions, it certainly follows that whatever we wish to be in future can be produced by our present actions. Man is man, so long as he is struggling to rise above nature, and this nature is both internal and external.
Preface to the Second Edition

As long as I live, so long do I learn

• Bhagwan Sri Ramakrishna Dev •

The first edition of Diseases of Ear, Nose and Throat with Head and Neck Surgery presented the essential knowledge of otorhinolaryngology, head and neck surgery in a concise and highly accessible format. The scope and didactic presentation made the book attractive to medical students, residents and practitioners, both as a textbook and a reference source. Owing to its continuing success, second edition was very much in demand, and I am grateful to the readers and teachers for their support and feedback. Many expressed their feelings about the first edition as, “It was the book that got us through the examinations”.

When I started working for the second edition, I did not quite grasp the magnitude of the task. I have been sensitive to the fact that now readers would have higher expectations and thus have strived to maintain the international standards. ‘Otolaryngology, head and neck surgery’ has shown fast-paced, progressive development and better understanding of the pathophysiology. The challenge for the 21st century ENT, head and neck surgeon is to remain abreast with ever-expanding knowledge and technologies, while being occupied in their clinical practice. It was, therefore, necessary to revise and update all the chapters to bring the second edition up to the current standards of knowledge and technology. Some of the chapters are restructured. The latest insight will facilitate a better understanding of the diagnostic and therapeutic issues and challenges of our specialty. It is intended to make it easy for the clinicians.

The general format of the book has remained unchanged. As in the first edition, it offers a balanced presentation of contents and emphasizes the practical aspects of clinical diagnosis and patient management. The figures supplementing the text have received particular attention. Numerous full-colored figures and additional contents have been added wherever necessary. I hope that this edition will continue to be an important guide to ENT, head and neck surgery for the students, trainees, and the specialists.

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Preface to the First Edition

Diseases of Ear, Nose and Throat with Head and Neck Surgery that represents otorhinolaryngology, head and neck surgery in all of its diversity, is created to fill the need of contemporary definitive book. The reader will find boxes, tables, flow charts, line diagrams and photographs, which serve to enhance learning. The book is comprehensive and of broader scope and is designed for students, residents and practitioners alike. It offers a balanced presentation of contents and emphasizes the practical features of clinical diagnosis and patient management. The students will like its simplicity, directness and clarity. Each chapter includes clear, compelling, and up-to-date discussions and expertly executed and generously sized art. The brevity, conciseness, readable format and easy accessibility of key information will facilitate efficient use in any practice setting. Each page is carefully laid out to place related text, figures, and tables near one another to minimize the need for page turning. To provide an overview, each chapter begins with the list of its contents (Points of Focus) and ends with a Further Reading section. Each chapter has a Clinical Highlights section for the quick revision of the students. This section has been especially prepared for answering frequently asked MCQs, short-answer questions and oral/viva questions. The Appendix contains Top 101 Clinical Secrets and Problem-oriented Cases which will be of immense use and interest to the readers.

I would like to acknowledge my parents, Late Shri Ramchandra and Smt Kalawati Devi Bansal, for enabling me to survive comfortably during my seemingly endless years of education. My family has unswervingly endorsed the time required for this mission, so heartfelt love and thanks go to my wife Sushma, as well as my children Tejal and Mohit and his wife Astha. My loyal assistant for the last 10 years, Tejal Patel, has provided amounts of all-round care to cover for my time. I wish to thank my professor friends who spared their valuable time in reviewing the chapters.

The process of learning is truly lifelong. Creating this text allows me to continue to become invigorated and inspired by otolaryngology. I hope that my quest to document significant and up-to-date information has been successful. My sincere hope is that readers, everywhere, will benefit from this book. I invite readers and educators to send their suggestions so that I can include their names in the next edition. The structure, content, and production values of this book will be shaped by its relationship with educators and readers.

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For *Diseases of Ear, Nose and Throat with Head and Neck Surgery*, I have enjoyed the opportunity of collaborating with a group of dedicated and talented professionals. I would like to recognize and thank the people who indeed worked hard to bring this book to you. Shri Jitendar P Vij (Group Chairman) of M/s Jaypee Brothers Medical Publishers (P) Ltd, New Delhi, India, illuminated the path for this book with his creative ideas and dedication. Mr Ankit Vij (Group President), the young and dynamic leader, took personal interest to achieve the best. The suggestions from Ritu Sharma (Director–Content Strategy) and Chetna Malhotra Vohra (Associate Director–Content Strategy) were very practical and meaningful. I would also like to extend my appreciation for the entire production team: Dr Nidhi Sinha (Development Editor), Mr Mohd Iqbal (Typesetter), and Mr Ram Singh Pundir (Graphic Designer), whose thorough and sincere editorial work was extremely valuable to the second edition of this book. Dr Alaap Shah (our PG student) shepherded the manuscript and electronic files. Dr Mayur Dodia, Dr Rakhi Thakker and Dr Bhavik Gosai (our PG students) have collaborated on the clinical photos and videos for the book. Their artistic ability, organizational skills, attention to detail and understanding of requirement greatly enhance the visual appeal.

I would like to express my feelings of gratitude to the Trustees of CU Shah Medical College (CUSMC), Surendranagar, Gujarat, India—Dr Jitendra Sanghavi, Mr Nilesh Doshi and Mr Hemant Shah and Directors—Dr NP Gopinath and Dr Suhasini Nagda. I am thankful to Professor Pankaj Shah (HOD), Dr Vinod Khandhar and Dr Bhargav Jadav of our ENT Department, for their valuable and meaningful discussions. I feel immense pleasure to express my heartfelt emotions to our other CUSMC family members Professor Dimple Mehta (Dean), Professor Roopam Gupta (Medical Superintendent), Professor Manohar Mehta (HOD Surgery), Professor Sanjay Mehta (HOD Microbiology), Professor Rina Gadhi (HOD Anesthesia), Professor Payal Panda (HOD Radiology), Dr Rajesh Naval, Dr Nanadan Upadhyay, Dr Navin Mehta and Dr Shyamji Parmar (Chief Librarian), for their kind cooperation and friendly help.

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**REVIEWERS**

The response I received from the reviewers, all leaders in their fields, was overwhelming. I am grateful to all of them. They generously provided their time and expertise in reviewing the chapters. Their insightful suggestions for improvement helped me maintain the accuracy and clarity of the book. The chapters were sent for review by email to the following faculties of ENT:

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Each work has to pass through these stages—ridicule, opposition and then acceptance. Each man, who thinks ahead of his time is sure to be misunderstood.

—Swami Vivekananda

Points of Focus

**LASER**

**RELATED PHYSICS**
- Properties of Radiant Laser Energy

**CONTROL OF LASER**
- Transverse Electromagnetic Mode

**TISSUE EFFECT**

**LASER IN OTOLARYNGOLOGY**
- Properties of Commonly Used Lasers
  - Argon Laser
  - Potassium-Titanyl-Phosphate-532 Laser

**PHOTODYNAMIC THERAPY**

**RADIOFREQUENCY SURGERY**

**CRYOSURGERY**

**HYPERBARIC OXYGEN THERAPY**

**ROBOTIC SURGERY IN OTORHINOLARYNGOLOGY**

**CLINICAL HIGHLIGHTS**

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**INTRODUCTION**

LASER is an acronym for **Light Amplification by Stimulated Emission of Radiation**. Laser light is the brightest monochromatic (one wavelength) light. In addition to diagnostic medicine and surgery, the laser is used in research laboratories, communications, surveying, manufacturing, lecture pointers, printers, CD players and engraving. Bar code scanners are used in supermarkets and shops.

**RELATED PHYSICS**

- **Spontaneous emission of radiation**: In a stable atom, there are equal number of protons and electrons. Electrons revolve around the nucleus in one or several discrete orbits. The orbits close to nucleus, have lower energy levels than the larger shells, which are away from nucleus. The interaction of electron with photon (called absorption), which is a quantum of light, makes the atom excited. During excitation, an electron of low-energy level can go into higher energy orbit. But within a very short time (8–10 seconds) the electron spontaneously drops back to its lower level and gives up energy difference. During this process, atom emits extra energy as photon of light, which is called as spontaneous emission of radiation.

- **Stimulated emission of radiation**: If a photon of correct energy hits an excited atom, it results in emission of two identical photons, which have same frequency and energy and travel in same direction. This stimulated emission of radiation, which was described by Einstein, is the basic fundamental principle of laser science.

- **Radiant laser energy**: The stimulated radiation is amplified with the help of two mirrors in an optical resonating chamber, which is filled with an active medium, such as Argon (Ar), neodymium:yttrium-aluminum-garnet (Nd:YAG) or carbon dioxide (CO₂). An electric current excites this active medium, which can consist of molecules, atoms, ions semiconductors or even free electrons in an accelerator. Mirrors reflect the photons back and forth. One of the two mirrors is partially transmissive, which emits some of the radiant energy as laser.
Properties of Radiant Laser Energy
The radiant laser energy is a type of electromagnetic radiations. It has following qualities that distinguish it from disorganized light of a bulb (Fig. 1):
- Monochromatic, i.e. same wavelength (single color)
- Collimated (unidirectional)
- Coherent: Both temporally (waves of light oscillating in a phase) and spatially (photons are equal and parallel)
- Extremely intense.

CONTROL OF LASER
The variables of lasers, which can be controlled, are power (watts), spot size (millimeters) and exposure time (seconds).
- Irradiance (W/cm²): It considers surface area of focal spot. It is more useful measure than power, which may be kept constant. Irradiance varies directly with power and inversely with spot size. The laser lens setting (focal length) and working distance combinations decide the size of focal spot. Larger the focal spot (unfocussed and away from focal plane), lower the irradiance. Smaller the focal spot (focused in focal plane), higher the irradiance, which results in precise cutting and vaporization.
- Depth of focus: The beam waist presents over a range of distances called depth of focus.
- Fluence (J/cm²): It is a measure of the total amount of laser energy per unit area. It varies directly with exposure time (seconds) of laser beam to a unit area. Working in pulsed mode or in continuous mode can change fluence.

Transverse Electromagnetic Mode (TEM)
Transverse electromagnetic mode (TEM) determines the shape of laser spot. It refers to the distribution of radiant energy of laser beam across the focal spot. The different modes of TEM are:
- TEM₀₀: Laser spot is circular on cross-section. The power density is greatest at the center and progressively diminishes peripherally (Gaussian distribution).
- TEM₀₁ and TEM₁₀: Beams cannot be focused to a small spot and have complex distribution of energy. It results in predictable tissue vaporization.

TISSUE EFFECT
The tissue deals with incident laser energy in four ways (Fig. 2):
1. Reflects: No effect on the tissue
2. Absorbs: Results in surgical interaction with tissue and varies with laser’s wavelength
3. Transmits: No effect on the tissue
4. Scatters: Spreads the energy and limits the penetration depth.
- The energy, which is reflected from or transmitted through the tissue, will not have any effect on the tissue. Energy that is absorbed results in surgical interaction with tissue and varies with laser’s wavelength.
- Wavelength: Shorter the wavelength, more is the scattering, which spreads the energy and limits the penetration depth.
- Levels of heating and tissue changes: The primary form of interaction of absorbed laser with tissue is heating, the level of which decides the following changes in the tissue:
  - 60–65°C: Protein denaturation and blanching of tissue
  - 100°C: Vaporization of intracellular water, vacuole formation, craters and tissue shrinkage
  - Several 100°C: Carbonization, disintegration, smoke, destruction and gas generation.

Zones of Tissue Damage (Fig. 3)
- Central area of tissue vaporization: In the center of the wound is an area of tissue vaporization that makes a crater and carbon flakes.
- Middle area of thermal necrosis: Central crater is surrounded by an area of necrosis and small vessels, nerves and lymphatics are sealed.
- Outer area of thermal conductivity and repair: This is the outermost area that heals with passage of time.
- The short laser pulse minimizes the lateral thermal damage.

Uses of LASER Energies
- Photothermal: To cut, coagulate and vaporize
- Photoacoustic: To break stones (lithotripsy)
- Photochemical: Photodynamic therapy for destroying cancer tissue
- Photodissociation (LASIK Lasers): To reshape cornea in cases of refractive errors.

LASER IN OTOLARYNGOLOGY
The lasers beams are used to vaporize, cut and coagulate the tissue. The clinical applications depend on their wavelength
and special absorptive powers of the target tissues. The laser can be ultraviolet, which results in heating and photodissociation of chemical bonds. The most commonly used lasers emit either visible (Ar and KTP-532 lasers) or infrared light CO₂ laser.

- **Properties of commonly used lasers and ear, nose and throat (ENT) applications:** They are given in Table 1.
- **Most commonly used:** They are CO₂, Nd:YAG, KTP-532 and Ar
- **Other:** Other lasers used in otolaryngology are Ar-tunable dye laser and flash lamp pumped dye laser.
- **Under investigations:** The lasers under investigations include erbium:YAG (Er:YAG) and holmium:YAG (Ho:YAG) lasers.

- **Visible lasers:** Ar and KTP-532
- **Invisible lasers:** CO₂, Nd:YAG, excimer, Ho:YAG and Er:YAG
- **Lasers need optical fibers:** Ar, KTP-532, diode, Nd:YAG, Ho:YAG and Er:YAG
- **Lasers for ear surgery:** CO₂, Ar, KTP-532 and Er:YAG

### Argon Laser

Argon laser passes through clear fluid and is absorbed by hemoglobin and pigmented tissues.

- **Indications:**
  - **Vascular lesions:** Photocoagulation of port-wine stain, hemangioma and telangiectasia.
  - **Retinal lesions:** It passes through the clear aqueous tissues (cornea, lens and vitreous).
  - **Ear microsurgery:** Its uses in ear microsurgery are lysis of middle ear adhesions, spot welding or tympanoplasty grafts.
    - **Stapedotomy:** A drop of blood is kept on stapes footplate before its use in stapedotomy.

### Potassium-Titanyl-Phosphate-532 Laser (KTP-532)

Potassium-titanyl-phosphate (KTP) laser has wavelength of 532 nm (blue-green) and comparable with Ar-laser. It falls in visible spectrum and is selectively absorbed by pigment and more strongly by hemoglobin. Hand-held probe facilitates its use in endoscopic sinus surgery and microlaryngeal surgery. The optical fiber delivery can be manipulated through rigid bronchoscope.

- **Indications:** It is first choice in the following conditions:
  - **Ear:** Stapedotomy
  - **Nose:** Polyps, concha bullosa, epistaxis, turbinate hypertrophy and telangiectasia
  - **Oral cavity:** Verrucous and T1 carcinoma, leukoplakia, erythroplakia, early tongue cancer T1, laryngoma
  - **Oropharynx:** Recurrent tonsillitis and hypertrophy, uvulopalatopharyngoplasty in obstructive sleep apnea, T1 and T2 carcinoma
  - **Larynx:** Laryngocoele, cyst, granulomas, stenosis (glottic and subglottic), bilateral vocal cord paralysis, recurrent respiratory papillomas, suprahypopharyngeal T1 carcinoma and obstructing carcinoma
  - **Skin:** Pigmented dermal lesions.

### Neodymium:Yttrium-Aluminum-Garnet Laser (Nd:YAG)

Neodymium:yttrium-aluminum-garnet (Nd:YAG) laser can be transmitted by flexible endoscopes and has effective

### Table 1: Properties of commonly used lasers and their ENT applications

<table>
<thead>
<tr>
<th>Properties</th>
<th>Ar laser</th>
<th>Nd:YAG laser</th>
<th>CO₂ laser</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electromagnetic range</td>
<td>Visible</td>
<td>Invisible</td>
<td>Invisible</td>
</tr>
<tr>
<td>Color</td>
<td>Blue-green</td>
<td>Colorless</td>
<td>Red light of helium-neon</td>
</tr>
<tr>
<td>Wavelength</td>
<td>0.488 and 0.514 μm</td>
<td>1.064 μm</td>
<td>10.6 μm</td>
</tr>
<tr>
<td>Extinction length*</td>
<td>80 m</td>
<td>40 m</td>
<td>0.03 mm</td>
</tr>
<tr>
<td>Transmitted through</td>
<td>Clear aqueous tissue</td>
<td>Clear liquids</td>
<td>Water, tissue with high-water content</td>
</tr>
<tr>
<td>Absorption by</td>
<td>Hemoglobin, pigmented tissue</td>
<td>Darkly pigmented tissue, charred debris</td>
<td>Water, tissue with high-water content</td>
</tr>
<tr>
<td>Scattering</td>
<td>Less</td>
<td>More</td>
<td>Negligible</td>
</tr>
<tr>
<td>Clinical applications</td>
<td>Port-wine stains, hemangiomas, telangiectasia, stapedotomy</td>
<td>Obstructive lesions of trachea, bronchus, esophagus; vascular, lymphatic lesions</td>
<td>Extremely versatile use in ear, nose and throat lesions</td>
</tr>
<tr>
<td>Precision</td>
<td>Good</td>
<td>Less</td>
<td>Good</td>
</tr>
</tbody>
</table>

Abbreviations: Ar, Argon; Nd:YAG, neodymium:yttrium-aluminum-garnet; CO₂, carbon dioxide

*Extinction length: The thickness of water necessary to absorb 90% of the incident laser energy
coagulative properties. It controls the bleeding well. The flexible fiberoptic delivery system allows its use with flexible endoscope.

It is excellent for tissue coagulation, but the precision is poor as the tissue damage is widespread and depth of tissue penetration is less predictable. It can be used in combination with CO₂ laser.

- **Indications:** It is advantageously used for following lesions as control of bleeding (dangerous in bronchoscopy) is more secure.
  - Obstructive malignant tumor of trachea, bronchus and esophagus
  - Vascular lesions: Hereditary hemorrhagic telangiectasia of nose
  - Lymphatic disorders: Lymphangioma.

**Carbon Dioxide (CO₂) Laser**

Carbon dioxide laser requires aiming beam of helium-neon laser. It is the most commonly used laser in ENT surgery. It is transmitted through an articulating arm and can be used freehand for microscopic surgery, attached to microscope and adapted to rigid bronchoscope. Its main limitation is that it cannot pass through the flexible endoscopes.

It is effective not only in vaporizing tissues, but it also provides bloodless field. Surgery can be performed in cases of hypertension, bleeding dyscrasias and coagulopathies. The other advantages are precision surgery and less postoperative edema and pain.

- **Advantages:**
  - Negligible scattering and reflection
  - Absorption independent of color
  - Minimal thermal effect on adjacent tissue.
- **Indications:**
  - **Nose:** Papillomas, rhinophyma, telangiectasia, nasal polyps, choanal atresia and turbinate hypertrophy
  - **Oral cavity:** Leukoplakia, erythroplakia, small superficial cancers and debulking of large, recurrent or inoperable tumors
  - **Oropharynx:** Recurrent tonsillitis and hypertrophy, tonsillar and pharyngeal tumors, tongue T₁ and limited T₂ cancer
  - **Larynx:** Papilloma, web, stenosis (glottic and subglottic), capillary hemangiomas, vocal nodule, Reinke’s edema, leukoplakia of cord, polypoid degeneration of cord, synechioidal edema, T₁, micdoidal carcinoma without anterior commissure involvement, supraglottic supraglottic T₁ cancer, laryngoecele, cysts and granulomas
  - **Trachea and bronchi:** Recurrent papillomatosis, tracheal stenosis, granulation tissue and bronchial adenoma, debulking of obstructive malignant lesions of trachea or bronchi
  - **Plastic surgery:** Benign and malignant tumors of skin, vaporization of nevi and tattoos
  - **Ear:** Stapedotomy and acoustic neuroma.

**Laser Resurfacing and Photorejuvenation**

- **Ablative lasers:** With target tissue (chromophore) being water, they involve principle of selective photothermolysis.
  - CO₂ laser
  - Er:YAG laser: Ten-fold greater absorption than CO₂ laser, so more precise tissue ablation, less erythema and risk of abnormal pigmentation and shorter recovery time.
  - **Nonablative lasers:** Produce thermal injury to dermis while preserving epidermis and thus improve rhytids. Laser photorejuvenation involves proliferation of fibroblasts with new types I and III collagen and elastin deposition in the papillary dermis.
  - **Vascular lasers:** Pulsed KTP and pulsed dye target hemoglobin
  - **Intense pulsed light (IPL) laser** targets melanin and hemoglobin
  - **Infrared laser (Nd:YAG laser):** To protect epidermis, some cooling mechanisms are required
  - **Fractionated CO₂ laser:** Fractional laser resurfacing ablates microscopic columns of epidermis and dermis over a fraction of skin area.
  - **Preoperative treatment:** Role of hydroquinone, glycolic acid, isotretinoin and antibiotics is debatable.
  - Prophylactic antiviral therapy
  - Avoid sun exposure.
  - **Most common complications:** Milia, hypopigmentation, hyperpigmentation, scar, infection (viral, fungal, bacterial) and contact dermatitis.

**Advantages of LASER:**
- High precision
- Easy and rapid tissue ablation
- Less postoperative pain and edema

**Disadvantages of LASER:**
- High cost of machine and maintenance
- Special training of healthcare personnel
- Special precautions and safety measures to prevent hazards of laser

**Complications and Safety**

The laser is a potentially dangerous instrument. The utmost caution is required to prevent accidents, which can injure not only patient but also healthcare personnel presents in operation room.

- **Education of staff:** The operating surgeon and anesthesiologist must have proper experience and training. Nursing and operation theater (OT) personnel should be conversant with safety measures before operating laser.
- **Protection of eye:** Protective eyeglasses with side protectors are specific for the wavelength of each laser (blue-green glasses with optical density of 6 for Nd:YAG laser; orange-yellow glasses for Ar, KTP or dye lasers). They must be worn by the patient, surgeon, anesthetist, assistants, nurses and all other personnel present in operating room. They prevent accidental burns to cornea, retina and lens (lenticular opacities). Patient’s eyes are protected by a double layer of saline moistened eye pads.
- **Protection of skin:** All exposed parts of the patient not in surgical field (skin, mucous membranes and teeth) are protected by saline-soaked towels, pads or sponges that are moistened periodically.
- **Evacuation of smoke:** Two separate suction, one for the blood and mucous and the other for smoke and steam (produced by laser vaporization of tissues), are used.
• Anesthetic gases and equipment: The endotracheal tube fire is the dreaded complication. Only nonflammable gases (such as halothane or enflurane) are used. During the CO₂ laser, red rubber or silicone tube is wrapped by reflective metallic foil. Cuff of endotracheal tube is inflated with saline water, which may be colored by methylene blue that helps in warning about the leak of cuff. Tubes are further protected with saline-soaked cotton. The colorless or white polyvinyl or silicone tube that does not have any black or dark marking or a lead-lined marking along the side is safest with the use of Nd:YAG laser.

Management of laser-induced endotracheal tube (ETT) fire: Best is prevention.
- Stop ventilation, i.e. flow of oxygen to ETT
- Immediately withdraw the burnt tube
- Flood the area with saline irrigation
- Mask ventilate with 100% oxygen
- Introduce new ETT at the earliest
- High dose of intravenous steroids
- Consider positive end-expiratory pressure (PEEP) and continued ventilatory support
- Bronchoscopy: To assess the damage to tracheobronchial tree. Patient may need repeated bronchoscopies after operation.

## PHOTODYNAMIC THERAPY

### PRINCIPLE

Photodynamic therapy (PDT) is an upcoming modality. It is based on the principle that photosensitizing agent is taken up preferentially by the malignant cells, which are then exposed to specific wavelength of laser (such as Ar-tunable dye laser with a wavelength of 630 nm). Laser activates the photosensitizing agent, and thus destroys the cancer cells. There is preferential uptake of photosensitizer photofrin (dihematoporphyrin ether or DHE) (given intravenously) by the malignant cells.

Light activation of photoconcentrated DHE results in mitochondrial damage and apoptosis in malignant cells. Erythrocyte leakage and endothelial damage of vessels cause ischemic necrosis of tumor tissue.

### INDICATIONS

- Photodynamic therapy is helpful in treating cancer of skin, larynx, nasopharynx, aerodigestive tract and endobronchial region (See also Chapter 50 “Malignant Tumors of Larynx”).
- It has also been used in cases of recurrences after radiation or surgery.
- Superficial cancers of larynx have been treated with PDT. It has got US-FDA approval for treating obstructing esophageal and endobronchial tumors and minimally invasive endobronchial nonsmall cell carcinoma.

### SIDE EFFECTS

The main side effect of PDT is generalized skin photosensitization. Patient should use sun-protective clothing to avoid exposure to sunlight.

## RADIOFREQUENCY SURGERY

- Radiofrequency cuts and coagulates tissues with minimal lateral tissue damage.
- Heating of the tissue causes protein coagulation and tissue necrosis.
- There is no charring.
- The scar formation occurs in 3 weeks.
- It reduces the size of tissue.

### INDICATIONS

Radiofrequency (RF) surgery reduces the volume of tissues. This minimally invasive surgery can be done as an outpatient department (OPD) procedure. It can be used in the following disorders:
- **Nasal obstruction:**
  - Reduction of hypertrophied inferior turbinates.
- **Snoring and obstructive sleep apnea (OSA):** See Chapter 40 “Snoring and Obstructive Sleep Apnea”.
  - Reduction of redundant soft palate and uvulopalatoplasty
  - Reduction of fullness in base of tongue.
- **Linguual thyroid**
- **Tonsillectomy**
- **Microaryngeal surgery**
  - to remove granuloma, papilloma and cyst
- **Myringotomy**
- **Rhinophyma**
- **Cosmetic:**
  - Removal of skin lesions.

### MATERIAL AND METHOD

The machine generates electromagnetic waves of very high frequency (350 kHz to 4 MHz). Usually, 460 kHz RF is delivered through the probe, which is inserted into the tissue and causes ionic agitation. The parameters, which can be controlled by the device, include:
- Power in watts
- Temperature in degrees of Celsius
- Resistance in Ohms
- Treatment time in seconds
- Energy in Joules (watts x seconds).

### Harmonic scalpel and Coblotion (Cold ablation): See chapter 57 “Adenotonsillectomy”.

## CRYOSURGERY

### PRINCIPLE

At −30°C and below, rapid freezing of tissues and slow thawing result in the destruction of tissue. This principle of cryosurgery has been used to treat benign, premalignant and malignant lesions.

The freezing agents are used either by an open method (liquid nitrogen spray or CO₂ snow) or through a closed system cryoprobe, which is based on Joule-Thomson effect (rapid expansion of compressed gas through a small hole produces cooling). The freezing agents employed in closed systems probes are: liquid nitrogen, nitrous oxide or CO₂. The probes are available in different sizes and designs and produce a tip temperature of −70°C. The thermocouples of probes can be inserted into the tissue to monitor the temperature.

### TISSUE EFFECT

The cell death due to freezing occurs through following mechanisms:
- **Dehydration** occurs due to crystallization of intracellular and extracellular water and that increases electrolytes concentration. The pH changes occur. Urea and dissolved gases develop toxic concentrations and result in cell death.
- **Denaturation** of cell membrane lipoproteins makes cell membrane permeable to cations. Thawing of cells, which become full of cations, results in lysis of cells.
- **Thermal shock** arrests the cellular respiration.
- **Vascular stasis** of both arterial and venous blood results in ischemic infarction. Cryosurgery is useful in the treatment of vascular lesions (hemangioma, angiofibroma and glomus tumors) because thrombosis of capillaries results in less bleeding.
- **Autoantibodies** specific to the frozen tumor tissues may provide tissue-specific immunity to subsequent recurrence.

### Technique

- **Anesthesia**: Cryosurgery can be done under either local anesthesia or mild sedation or even without anesthesia because tissue freezing itself causes numbness.
- **Freezing**: The cryoprobe is applied into or upon the tissues (which are insulated and include a margin of normal tissue) for 3–8 minutes. It results in rapid freezing.
- **Thawing**: Then the frozen tissue is allowed to thaw slowly.
- **Repetitions**: The procedure may be repeated as required once or twice to achieve the best result.
- **Thermocouple**: If available, a thermocouple will ensure freezing at an adequate depth.
- **Healing**: The wound heals by secondary intention. The slough usually falls in 3–6 weeks and, if needed, the procedure can be repeated.

### Indications

The increasing availability and popularity of laser is fast declining the indications of cryosurgery. Its lower cost still makes it an option in developing countries.

- **Benign vascular tumors**: Hemangiomas of skin, oral cavity and oropharynx, angiofibroma and glomus tumor
- **Premalignant lesions**: Leukoplakia of cheek, tongue, floor of mouth and solar keratosis (precancerous condition of skin). The scarring is less and quality of regenerated epithelium is better in comparison to diathermy.
- **Malignant lesions**: Intraepithelial carcinoma (Bowen’s disease) and basal cell carcinoma of skin. Palliation of advanced cancers, recurrent and residual tumors. Debubling of tumor facilitates deglutition and respiration. It reduces bleeding and relieves pain. Cryotheraphy does not cause necrosis of bone and cartilage, which may underlie the lesion. Recurrent tumors and ill-defined lesions are not good cases for cryotherapy.
- **Nose**: Reduction of turbinates improves the airway. In allergic rhinitis, it controls sneezing and rhinorrhea.
- **Tonsils**: Cryodestruction of tonsils is considered in high-risk patients.

### Advantages

- **Anesthesia**: No need of general anesthesia. So good for high-risk patients
- **Bleeding**: The patients with bleeding disorders or coagulopathies can be managed.
- **Palliation**: In multiple and recurrent cancers where second course of radiotherapy cannot be used.
- **Minimal aftereffects**, such as discomfort and pain.
- **Minimal scarring**: Good for sites known for keloid development.
- **Outpatient department**: Cryosurgery can be done as an OPD procedure.
- **Lower cost in comparison to laser.**

### Disadvantages

- Excisional biopsy and histopathological assessment of tumor margins are not possible.
- **Depth of freezing is unpredictable.**
- **Side effects**: Causes skin depigmentation and loss of hair (destruction of hair follicles).

### Hyperbaric Oxygen Therapy (HBOT)

Hyperbaric oxygen therapy (HBOT) is breathing pure oxygen in a pressurized room or tube. It is a treatment for decompression sickness, serious infections, arterial gas embolism and wounds that will not heal due to diabetes and radiation injury.

In a hyperbaric oxygen therapy chamber, the air pressure is increased to three times higher than normal air pressure. Lungs can gather more oxygen. Blood carries this oxygen throughout the body. This helps to fight bacteria and stimulates the release of growth factors and stem cells, which promote healing.

### Mode of Action

- Increased partial pressure of oxygen (pO\textsubscript{2}) (up to 460% increase in pO\textsubscript{2}) in perilymph and endolymph supplies oxygen to the inner hair cells. The pO\textsubscript{2} level remains 60% above the normal after 1 hour of termination of hyperbaric oxygen (HBO\textsubscript{2}) therapy.
- Reduction of hematocrit and decrease in blood viscosity improve diffusion of oxygen to ischemic cells.

### Material and Method

Patient inhales 100% oxygen for 1 hour at atmospheric pressure of 2.4 atm in a HBO\textsubscript{2} chamber. In addition to 1 hour oxygen inhalation under pressure, the compression and decompression time of the chamber is 10–15 minutes, respectively. Usually, a total of 10–20 such sittings (six per week) are given.

### Indications

Hyperbaric oxygen has been used with success in following disorders:

- **Sudden idiopathic sensorineural hearing loss and tinnitus**: The results are better, if therapy is started earlier.
In various studies, improvements have been reported in 30–80% of the patients.

- Acoustic trauma
- Noise-induced hearing loss
- Malignant otitis externa
- Mucormycosis of paranasal sinuses
- Skin flaps with compromised blood supply
- Radiation tissue damage
- Healing problems in diabetes
- Crush injuries
- Osteomyelitis
- Bell’s palsy.

**Related Disciplines**

- Noise
- Acoustic trauma
- Noise-induced hearing loss
- Malignant otitis externa
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**Complications**

It is generally a safe procedure but treatment does carry following potential risks: temporary myopia, tympanic membrane rupture, lung collapse, seizures and fire of the treatment chamber.

**Robotic Surgery in Otorhinolaryngology**

Robotic surgery in ENT is getting established. Transoral robotic surgery (TORS) got US-FDA approval in December 2009. The term robot is derived from the Czech word robota, which means servitude or compulsory laborer. First robot-assisted surgery “stereotactic brain biopsy” was done in 1985, while first ENT surgery “vallecular cyst marsupialization” was performed in 2005.

**Advantages**

- Higher level of precision with multiplanar tissue transection
- Three-dimensional visualization
- Bypass traditional line-of-sight limitations
- Superior instrument control and manipulation
- Motion scaling and wristed instrumentation abolish the effect of hand tremors of surgeon and provide improved dexterity and precision.
- Less blood loss
- Shorter length of hospital stay
- Better functional outcomes
- Less morbidity
- Fewer perioperative complications
- Less steep learning curve.

**Disadvantages**

- **Too expensive:** Higher cost of buying and maintaining
- Larger instruments in comparison to smaller areas of oral cavity and neck
- Bulky
- Additional space requirement in OT
- Lack of tactile and haptic feedback

- Longer initial operating time
- **Longer initial docking time:** Moving and keeping the robot in position. Robot arms connection to trocars. Positioning robotic instruments and camera.

**Current Applications**

- Transoral robotic surgery:
  - Oropharyngeal cancer T1 or T2
  - Supraglottic cancer T1 or T2 (supraglottic laryngectomy)
  - Radical tonsillectomy
  - Tongue base resection in obstructive sleep apnea and unknown primary neck nodes
  - Lingual tonsillectomy for obstructive sleep apnea
  - Partial glossectomy
  - Cordectomy in T1 glottic cancer
  - Total laryngectomy.

- Transcervical surgery:
  - Transaxillary thyroidectomy.

- Single axillary incision robotic surgery:
  - Lobectomy
  - Thyroidectomy
  - Parathyroidectomy
  - Neck dissections.

- Face-lift or retroauricular approach robotic-assisted surgery:
  - Thyroidectomy
  - Parotidectomy
  - Submandibular gland excision
  - Neck dissections.

- Robotic skull-base surgery
- Robotic surgery in pediatric airway.

**Da Vinci Surgical Robotics System (Intuitive Surgical Inc., Sunnyvale, CA)**

This telemanipulator consists of surgeon console and patient side cart.

- **Surgeon console:** It has two control handles and a virtual three-dimensional vision projection system. Here, primary surgeon controls the robotic instruments and camera. Hand movements of the surgeon are tracked 1,300 times a second and relayed to the tips of instruments for surgical maneuvers.

- **Patient side cart:** It has robotic arms. Three arms manipulate operative instruments such as retractor for retracting tissue, scissors for cutting, clip appliers for clamping, forceps for tissue manipulation and suturing and electrocautery. Fourth arm controls video endoscope. Here, an assistant changes and adjusts the instruments.

- **Video system:** It has twin-mounted endoscopes. Each endoscope projects separate image to each eye of the console to produce true three-dimensional images.

- **EndoWrist technology:** It provides 7 degrees of freedom to the instruments and closely mimics the wrist movements of the surgeon.

**Clinical Highlights**

1. **Argon laser:** It is useful for middle ear surgery.
2. **Cryosurgery:** To cause cell death, temperature should at least reach −30°C. In cryosurgery, liquid nitrogen is applied at −30°C. The cryoprobe is kept for 3–8 minutes, so that area is frozen rapidly reaching a temperature of about −70°C.