Pediatric Otolaryngology

Pediatric Otolaryngology:

A Concise Guide to Pediatric Ear, Nose and Throat

Edited by

Jerome W. Thompson

Cambridge Scholars Publishing

Pediatric Otolaryngology:
A Concise Guide to Pediatric Ear, Nose and Throat

Edited by Jerome W. Thompson

This book first published 2020

Cambridge Scholars Publishing

Lady Stephenson Library, Newcastle upon Tyne, NE6 2PA, UK

British Library Cataloguing in Publication Data
A catalogue record for this book is available from the British Library

ISBN (10): 1-5275-4359-5
ISBN (13): 978-1-5275-4359-1

This book is dedicated to the memory of one of our authors, a great colleague and close friend. He saved many lives and served the under privileged.

Francisco Vieira M.D.
1957-2019

TABLE OF CONTENTS

FOREWORD

There is a need for a concise reference in Pediatric Otolaryngology. Throughout the world physicians and other health care professionals are now required to periodically update their license by taking an all-inclusive exam covering every aspect of their field. Most review books are question based and can miss important areas. The goal of this book was to provide a brief, but thorough review of the important areas in Pediatric ENT, so review can be quick and effective. From our other book *Managing the Difficult Airway* we found a very large audience in the non-ENT physician community. Nurse practitioners, critical care providers, anesthesiologists, CRNAs, emergency room personnel, and primary care providers all consulted our book regularly to assist in the care of children with airway problems. It became apparent that there was an unmet need for this type of information. The challenge is with the Internet, that information is at your fingertips. It is worrisome that we found about 1/3 of the information in the initial search results was in error or seriously outdated. Our hope is to update this reference regularly so that it remains relevant. Pharmaceutical, and medical device sales forces should avail themselves of this reference, so that they have a more in-depth knowledge of the uses of their products and why they are needed in the market place. Medical students are continuously searching for a concise reference in their harried efforts to learn medicine. I hope that our patients benefit the most from this effort.

Dr. Jerome W Thompson MD,
Past Chair of Otolaryngology, The University of Tennessee, Memphis.
Founding Member of Amer. Society of Pediatric Otolaryngology (ASPO)
Past President of ASPO

ACKNOWLEDGEMENTS

I would like to thank our Publisher Cambridge Scholars Publishing for the opportunity to publish this book.

I greatly appreciate all the contributions by our authors.

Special thanks to:

My wife Mary and our children who have made so many sacrifices of their time with me to get this book done.

Natasha Ball, RN Supervisor, Department of Otolaryngology at ULPS

Erica Jones, Office Coordinator, Department of Otolaryngology at ULPS

Richard Anderson III,

Susan Morecroft the proofreader who tolerated our American grammar and corrected it.

JP Publishers for the use of their images.

William Clinkscale, one of our residents is a professional artist, as well as a surgeon. He did our cover painting with the understanding of an otolaryngologist.

My greatest gratitude goes to Travis Washington. He is a professional graphic artist who did most of our artwork. Some of the originals now hang in my office.

travisw901@gmail.com

CHAPTER 1

ANATOMY AND PHYSIOLOGY OF THE PEDIATRIC HEAD AND NECK

JEROME W. THOMPSON MD. MBA.

Head

A child's head has different proportions than those of adolescents and adults. The face to cranium ratio is about 1:8 at birth, 1:5 at seven, and 1:2 as an adult (**Figure 1-1**). The upper cranium occupies a large proportion of a child's head; therefore, trauma is more likely to be to the cranium than the midface (Figaji 2017). Some areas of a child's skull have not ossified and are soft and pliable for a year. These fibrous junctions are called fontanels (**Figure 1-2**). The tenseness of these membranes can frequently be used to judge if there is increased intra-cranial pressure, either from congenital anomalies, tumors or traumatic injury. They can be so prominent that inadvertent compression during intubation or other manipulation of the infant's head can cause brain injury (Figaji 2017).

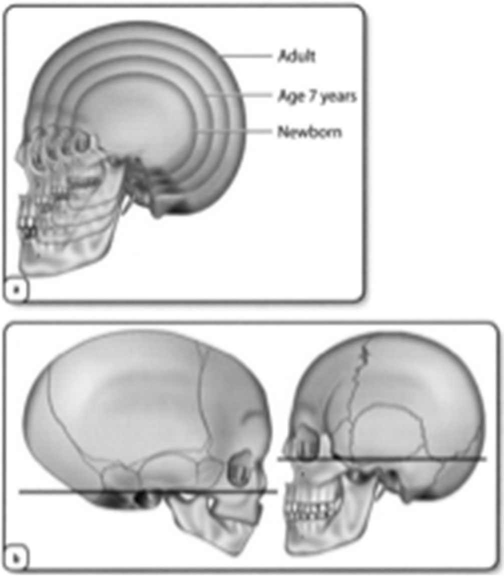

Fig. 1-1 An infant's head in comparison to the adult head shape and size. This helps to explain the lesser number of facial injuries to young children as compared to adults. By permission from Thompson J, Vieira F, Rutter M; Management of the Difficult Airway: A Handbook for Surgeons; JP Medical Ltd 2016

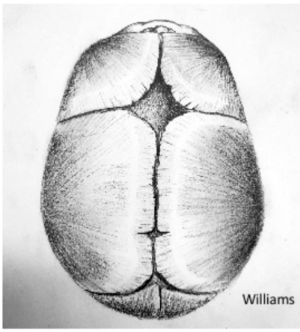

Fig. 1-2 The anterior fontanels can be seen in this image as susceptible to injury by a finger or hand during exam.

THE NOSE

External Nose

The external nose consists of soft tissue, cartilage, and bone. The distal half of the nasal dorsum is flexible due to the skin covered cartilage infrastructure. This cartilage connects the pliable anterior nasal dorsum to the bony palatal floor of the nose, and nasal bony process of the frontal bones. The posterior part of the external nose is composed of this same cartilage and bone. The blade-like nasal bones protrude from the maxilla between the orbits like small hoods. The region of the lower anterior nose is the vestibule, a soft tissue entry to the nasal cavity. This region contains the internal nasal valves that control airflow into the nose. The distal two-thirds of the nasal dorsum are composed of the vertical quadrangular cartilage, and the posterior one-third by the bone of the vomer bone strut (**Figure 1-3**).

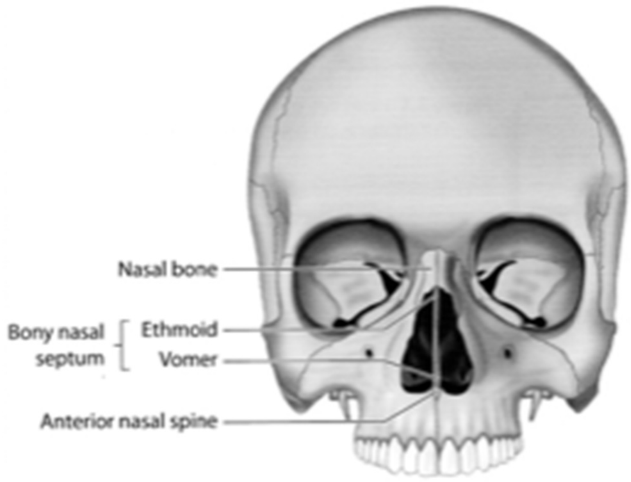

Fig. 1-3 Diagram of the front of the bony skull and pyramidal aperture. By permission from Thompson J, Vieira F, Rutter M; Management of the Difficult Airway: A Handbook for Surgeons; JP Medical Ltd 2016

Internal Nose

The first bony structure of the internal aspect of the nose is the pyramidal aperture. Shaped like a pyramid it is usually a wide opening and a prominent aspect of the anterior skull. This opening can be narrow and a cause of respiratory distress in infants.

The nasal septum is a mucus membrane-covered, avascular and vertical quadrangular cartilaginous plate that separates the two anterior nasal cavities. This allows natural and synthetic vasoactive natural substances to increase the porosity of vessels in the mucosa, making the mucosa swollen, edematous and obstructive with extracellular fluid. By constricting the vascularity, the tissues thin and are more conducive to air flow. This blood supply is separated by the midline cartilage, and allows the nose to alternatively shut down one side of the nasal cavity. This allows it to recover from being exposed to the atmosphere, while on the other side the nasal cavity opens up and starts to warm, cool, or humidify the inhaled air. This cycles as a 12-hour circadian rhythm. Pharmacologic alteration of this cycle in preparation for surgery has led to deaths (Koehntop DE et al. 1977). This cartilage is also the anterior strut that supports the soft nasal tip and the anterior two-thirds of the nasal bridge.

The turbinates are bony supports for the mucosa which act as the cooling, warming, or humidifying fins for the nose. There are three on each side. They protrude into the nasal cavity from the sides, stacked from top to bottom (**Figure 1-4**).

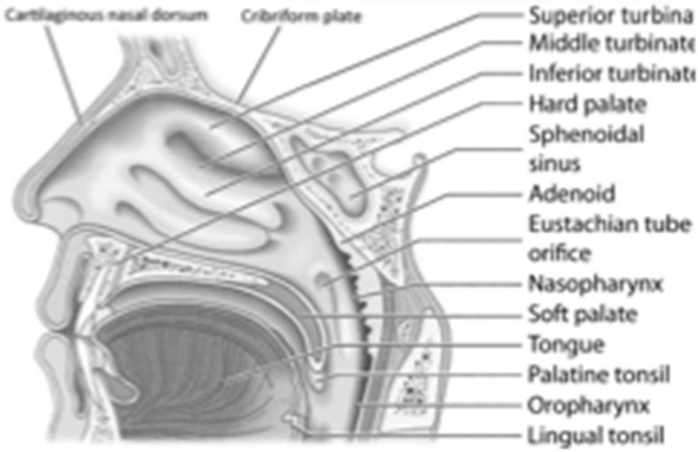

Fig. 1-4 This is a lateral view of the nasal structures. The three levels of the turbinates can be seen. Also, the sphenoid sinus and adenoid pad in the nasopharynx can be identified. By permission from Thompson J, Vieira F, Rutter M; Management of the Difficult Airway: A Handbook for Surgeons; JP Medical Ltd 2016

The structure of the turbinates is very important to understand for nasal intubation. The avenue of least resistance is between the middle and lower turbinates, and not along the floor of the nose (**Figure 1-5**).

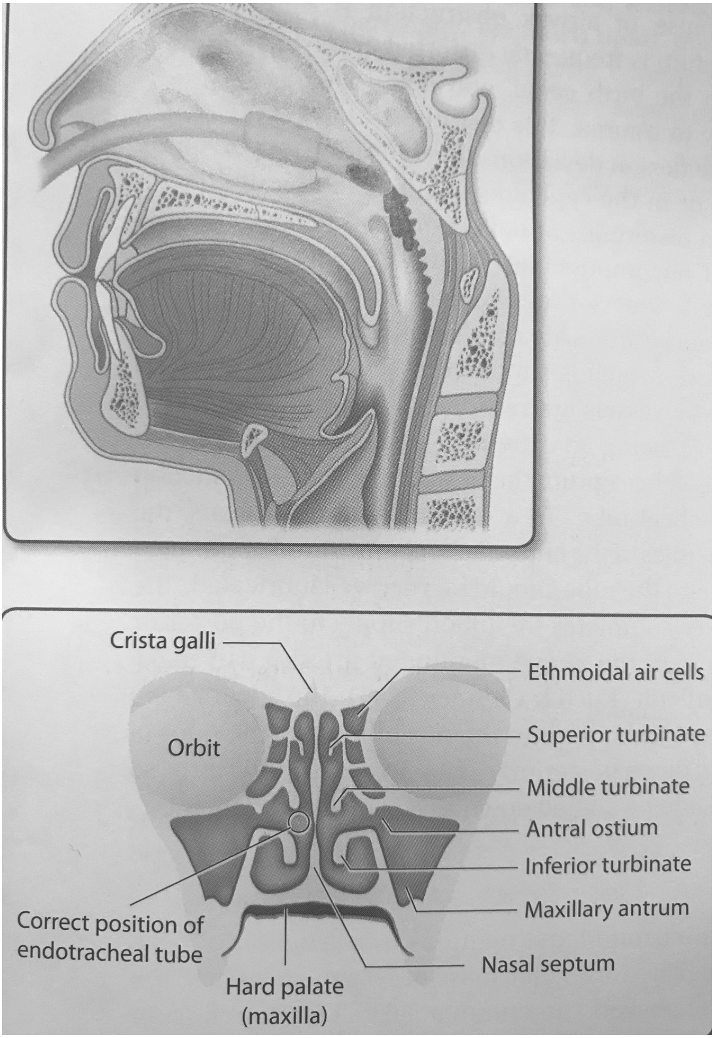

Fig. 1-5 The pathway of least resistance and the safest is between the second and third turbinates for nasal intubation. By permission from Thompson J, Vieira F, Rutter M; Management of the Difficult Airway: A Handbook for Surgeons; JP Medical Ltd 2016

It is important to understand that the skull base tapers downward posteriorly and that a soft and well-vascularized adenoid pad is present on the upper back wall. Injury to the adenoid can lead to significant bleeding during intubation.

The cribriform plate forms the roof of the nasal cavity. It is perforated, fragile and susceptible to injury from skull or facial fractures, nasal and sinus surgery (Cameron 1993).

The sense of smell arises from the many nerve fibers of the sensory respiratory epithelium in the upper one-third of the nose. These fibers transmit electrical signals via a bipolar nerve through the cribriform plate to the olfactory bulb, the first cranial nerve (CN I). The signals then pass through several synapses to the olfactory cortex where they are recognized as an odor.

Endotracheal tubes (ET tubes) or nasogastric tubes (NG tubes) should not be passed through the nose if these injuries are suspected, without the assistance of neurosurgery or ENT surgeons. ET and NG tubes have been passed into the brain during nasal intubation in patients with head trauma and in normal infants through this weak area. This trauma can frequently cause significant bleeding from injury to the adenoid (**Figure 1-5**).

The rest of the nasal mucus membranes is covered by a pseudo-stratified respiratory epithelium. Important structures drain beneath each of the turbinates. Anteriorly, under the inferior turbinate, is found the opening of the lacrimal duct. This should be preserved during trauma repair, or intra nasal and sinus surgery. The otolaryngologist is frequently asked by ophthalmologists to move the inferior turbinate medially so that a lacrimal probe can be seen in the nose or so a lacrimal catheter can be retrieved. The maxillary, ethmoid and frontal sinuses drain under the middle turbinates through the hiatus semilunaris. The middle turbinate bone is the major landmark for endoscopic surgery and should be preserved. It can be flat or bulging, containing an obstructing air-filled bony sack called a concha bullosa. These bullae can cause obstruction, but can be easily fractured and compressed medially to facilitate drainage of the sinuses or for intubation (Tanyeri H. 2012). The sphenoid sinus enters high on the posterior wall of the nose adjacent to the superior turbinate (**Figure 1.6**).

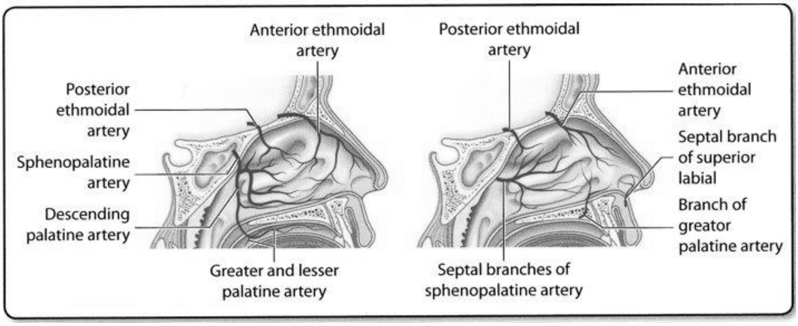

Fig. 1-6: The nasal vasculature is complex and can easily be injured. By permission from Thomson J, Viera F, Rutter M; Management of the Difficult Airway: A Handbook for Surgeons; JP Medical Ltd, 2016.

The blood supply of the nose arises from the sphenopalatine (SPA), palatal, anterior ethmoidal, posterior ethmoidal, and labial arteries. Little's area or Kiesselbach's plexus, is a rich vascular network in the anterior inferior aspect of the septum. Most cases of epistaxis in children occur in this important vascular structure which can be easily injured with a suction catheter, an endotracheal tube, or a little fingernail. To avoid injury to the plexus, the leading tip and the side holes of the endotracheal tube should be angled away from the septum and the tube should be very well lubricated. The sphenopalatine artery supplies the posterior one-third. It is more common in older adults who usually have more posterior hypertensive bleeds from the SPA (Kost SI) (**Figure 1-7**).

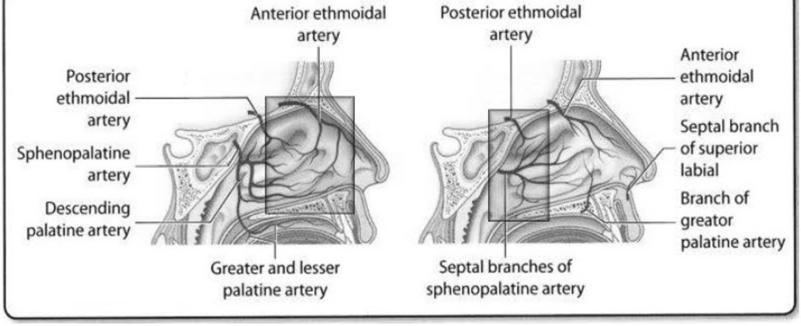

Fig. 1-7 Nasal Vasculature (JP 2.5). By permission from Thompson J, Vieira F, Rutter M; Management of the Difficult Airway: A Handbook for Surgeons; JP Medical Ltd 2016

The anterior ethmoidal and labial arteries also supply the anterior nose. Therefore, different strategies are required to control epistaxis in children vs. the adult. Bleeding from these arteries can make airway management difficult (Reyes et al. 1992). The choanae are the posterior openings of the nose into the nasopharynx. The roof of the nose is slightly tilted down in the back as compared to the front so the intubation tube should be angled down as it is inserted.

Nasopharynx

The adenoid is a deeply-pocked irregular mass of lymphoid tissue in the upper aspect of the nasopharynx. It has a major immune function in children, trapping respiratory viruses and making antibodies and T-cells. The pockets can entrap a flexible fiberoptic scope and break the guide-wires that steer it in a novice’s hands. The adenoid is soft and can be impaled by an endotracheal tube and impede the passage of the tube leading to profuse bleeding. They can hypertrophy, encroach upon, or engulf the choanae and enter into the posterior nasal cavity, completely obstructing it. This prevents fiberoptic scopes or endotracheal tubes from passing.

Oral Cavity

Maxilla

The upper teeth arise in the paired maxillary bones. They represent the majority of the mid-facial mass. These bones are stable and only mobile when there is a Le Forte I, II, or III fracture of the face. When fractured and mobile, entubation can be compromised and dangerous (Cummings) (**Figure 1-8**).

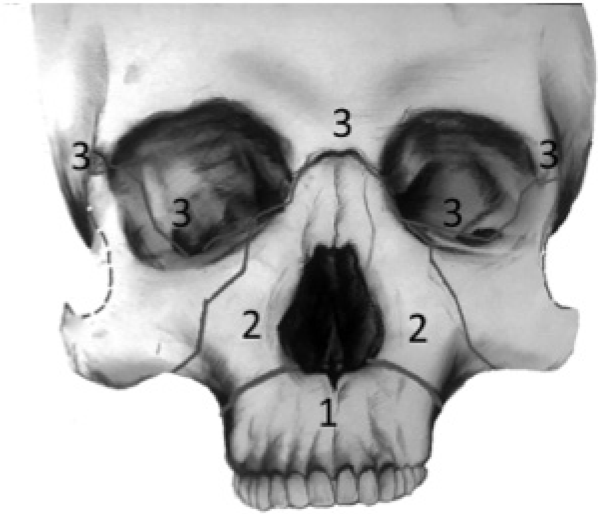

Fig. 1-8 Images of Le Fort type I, II, and III mid-face fractures.

The maxilla contains the large, paired maxillary sinuses. The ethmoids start as buds from the maxillary sinus and continue up the inside of the wall of the nasal bone to then bud off the frontal sinuses by the pre-teens. The ethmoids are identifiable on CT after the age of 2 years. Anatomically, they are arbitrarily divided into three subdivisions on both sides: the anterior, middle and posterior. The frontal sinuses are in the forehead in a batwing configuration just above the orbits. The sphenoid sinus resides in the base of the skull behind the ethmoids and below the brain.

Mandible

The mandible is derived from neural crest cells that form the first pharyngeal arch; it cartilaginizes and then ossifies. It subsequently has its own cartilage, then bone, nerve and artery. The location of the lower jaw or mandible or occlusion is classified into one of three positions using Angle's classification of the permanent mandibular teeth in relation to the maxillary teeth (Brin et al. 2000) (**Figure 1-9**).

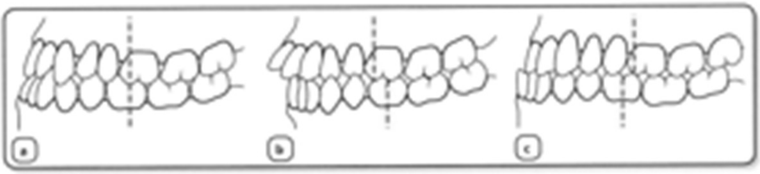

Fig. 1-9 These diagrams demonstrate the three classical occlusion configurations that assist in describing and correcting occlusion, either congenital or traumatically acquired. Nomenclature (JP 2.8). By permission from Thompson J, Vieira F, Rutter M; Management of the Difficult Airway: A Handbook for Surgeons; JP Medical Ltd 2016

Class I occlusion is where the first maxillary molar is slightly posterior to the first mandibular molar and the mesiobuccal or forward cusp rests in the valley or buccal groove of the first mandibular molar, and it is considered normal occlusion. Buckteeth, or Class II occlusion is where the first maxillary molar is just forward of the mandibular molar, and the mesiobuccal or forward cusp rests anterior to the valley or buccal groove of the first mandibular molar. The Pierre Robin sequence is severe retrognathic or class II occlusion associated with a small jaw that can obstruct the ability to intubate orally. Prognathic, class III occlusion is where the lower jaw juts out over the maxillary teeth and the mesiobuccal cusp of the first maxillary molar rests posterior to the mandibular buccal groove. The extensive mobility of the mandible is due to the complex temporal mandibular joint with four articular surfaces, which give it multidirectional capabilities.

Tongue

The tongue embryologically arises from two separate anlages: an anterior and a posterior, each with a different function. The front one-third propels food and liquids into the oropharynx. If the front part fails to form adequately and shape the jaw, it will be excessively narrow and present difficulties with eating and intubation. The hypoglossal nerve or cranial nerve XII provides the motor nerve supply to the tongue. The sensory function is provided by the lingual nerve, a branch of the mandibular nerve, which wraps around the submandibular salivary duct. This innervates the anterior two-thirds of the tongue with taste. The glossopharyngeal nerve or cranial nerve IX innervates the posterior one-third of the tongue including the circumvallate papillae. Taste fibers in the lingual nerve originate from the geniculate ganglion of the facial nerve and join the lingual nerve via the chorda tympani from the ear. The vallecula was called the diamond smuggler's pouch because diamonds could be held undetected there for long periods of time. Food, foreign bodies and pills can also catch there. It is in this pouch that the distal tip of the Macintosh laryngoscope blade is placed at the junction of the epiglottis, the hyoepiglottic ligament and the posterior base of the tongue. Pressure there flips the epiglottis up and facilitates visualization of the vocal cords for intubation.

The Mallampati scale evaluates the degree of epiglottic visibility over the tongue and, therefore predicts the ease or difficulty of intubation (Mallampati 1985) (**Figure 1-10**).

The base of the tongue is adjacent to the oropharynx and provides the last thrust of the oropharynx toward the hypopharynx and then into the esophagus.

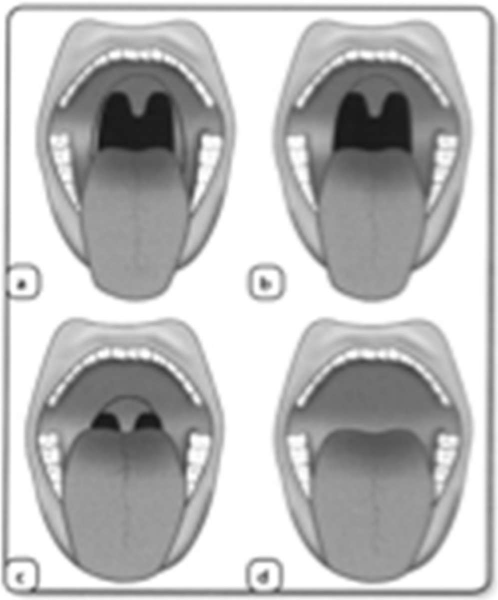

Fig. 1-10 The Mallampati scale evaluates the amount of oropharynx that is accessible for intubation. The size of the tongue, length of the palate and lateral encroachment of the tonsil and tonsillar pillars all contribute to the score. **(JP Figure 2.9)** By permission from Thompson J, Vieira F, Rutter M; Management of the Difficult Airway: A Handbook for Surgeons; JP Medical Ltd 2016

Hypopharynx

In the second year of life, the larynx descends in the neck. This accompanies the pharyngeal elongation. As a result, the soft palate and the larynx are no longer in contact with each other but are separated by a significant gap. The gap is evolutionarily essential to allow greater vocal power and complexity in sound generation and thus, the human voice. This growth and separation also increase the intricacy of the swallowing process. It tapers narrowly at the upper end of the esophagus and forms a funnel. The posterior border is the inferior constrictor and anteriorly, the larynx, the epiglottis and the arytenoids. The pyriform fossae are funnel-shaped regions of the distal throat on either side of the larynx that can direct errant endotracheal tubes easily into the upper esophagus (**Figure 1-11**)

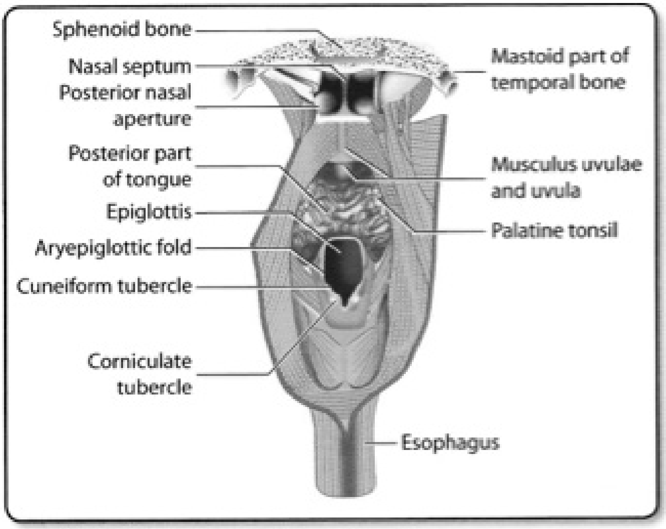

Fig. 1-11 This posterior view of the hypopharynx shows the base of the tongue and the posterior aspect of the soft palate. (Figure JP 2.12) By permission from Thompson J, Vieira F, Rutter M; Management of the Difficult Airway: A Handbook for Surgeons; JP Medical Ltd 2016

The hyoid bone is the bony structure derived from the second and third branchial arches, and the foundation for the tongue muscles. It is U-shaped, supports the larynx, and stabilizes the hypopharynx. The broad thyrohyoid membrane is connected to the thyroid cartilage. It is also the most effective anterior internal pressure point to see the larynx during intubation with a

Macintosh and Miller blade. It can be mistaken for the cricoid cartilage since it is easily palpated and thus a cricothyrotomy can be placed too high above the larynx with disastrous results. The superior cornu of the thyroid cartilage attaches to the thyrohyoid ligament, whereas the inferior articulates with the cricoid cartilage.

Laryngeal Complex

The laryngeal skeleton is made of one bone and six cartilages (3 paired and 3 unpaired) strung together in a series and suspended from the skull base and mandible by muscles and ligaments (**Figure 1-12**).

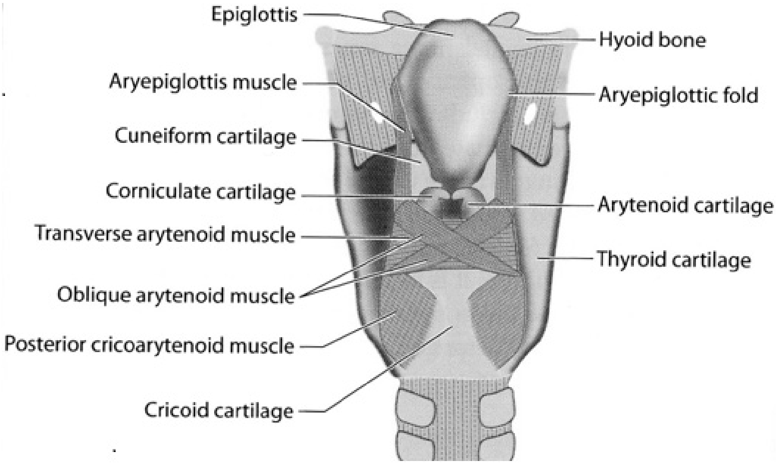

Fig. 1-12 The muscles of the posterior larynx are displayed in this drawing in relation to the tongue and palate viewed from the rear. (JP **2.11)** By permission from Thompson J, Vieira F, Rutter M; Management of the Difficult Airway: A Handbook for Surgeons; JP Medical Ltd 2016

The thyroid cartilage is composed of two halves fused anteriorly at a 60^0 angle. The superior cornu of the thyroid cartilage attaches to the thyrohyoid ligament, whereas the inferior cornu articulates with the cricoid cartilage. Anatomically this joint is an important site to locate the recurrent laryngeal nerve. The epiglottis is a fibroelastic cartilage, attached anteriorly at the midline to the inner surface of the thyroid cartilage and supported by the hyoepiglottic ligament (**Figure 1-13**). The cricoid cartilage supplies support for the subglottis. The subglottis is the only portion of the airway with a completely rigid, circular external structure. The cricothyroid membrane is clinically important. This spans the space between the thyroid cartilage and the cricoid. It suspends the cricoid and the trachea to the thyroid cartilage. It is tough but thin and is an excellent site for an emergency airway, because of the clear anatomy of the thyroid cartilage and the solid bar of the anterior cricoid.

The cricoid is the only complete ring of the laryngeal complex or of the trachea. It has a smaller cross-sectional area than the trachea and is the site of most intubation injury. Anteriorly, the cricoid is 0.3-0.5 cm high, with a smooth curved surface. Posteriorly, it is 1-2 cm high and the superior surface is flattened centrally to provide an area of articulation for the arytenoid cartilages. On each side, the cricoid articulates with the inferior cornu of the thyroid cartilage allowing rotation in a sagittal plane, opening and closing the anterior cricothyroid space to change pitch. This is the easiest site to locate the recurrent laryngeal nerve. Each arytenoid cartilage is finger-shaped with a broad base which articulates with the cricoid with a synovial joint allowing movement in multiple axes, assisting in complex vocalization. Two other small sesamoid cartilages, the corniculate and the cuneiform, are located superior to the arytenoid and support the aryepiglottic fold. The vocal process, the anterior projection of the arytenoid, attaches to the posterior membranous portion of the vocal fold (**Figure 1-14**). The conus elasticus is a fibroelastic membrane that provides inferior support to the vocal fold and connects it to the trachea proper. The quadrangular membrane supports the supraglottis, connecting the epiglottis to the arytenoids. The superior edge forms the aryepiglottic fold (**Figure 1-15**).

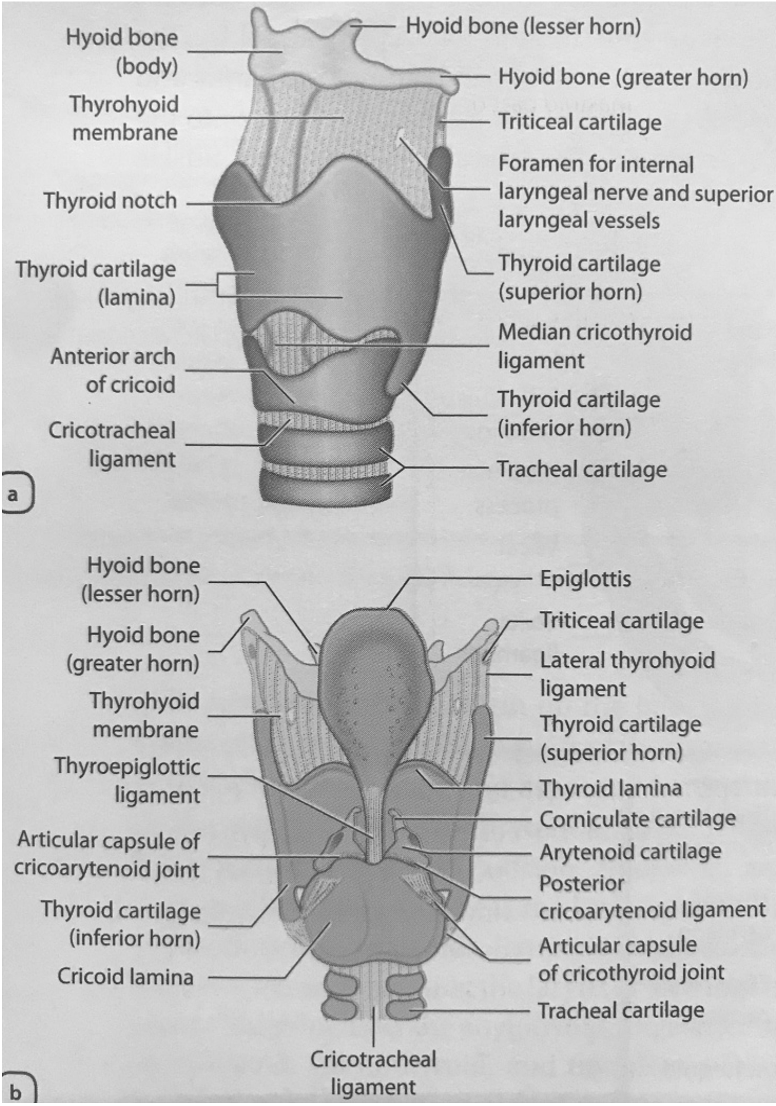

Fig. 1-13 This drawing displays the full cartilaginous skeleton of the larynx. The shield of the thyroid, the spoon shape of the epiglottis, and the signet ring configuration of the cricoid. Of special note is the interlocking of the three cartilages for strength. **(JP 2.13)** By permission from Thompson J, Vieira F, Rutter M; Management of the Difficult Airway: A Handbook for Surgeons; JP Medical Ltd 2016

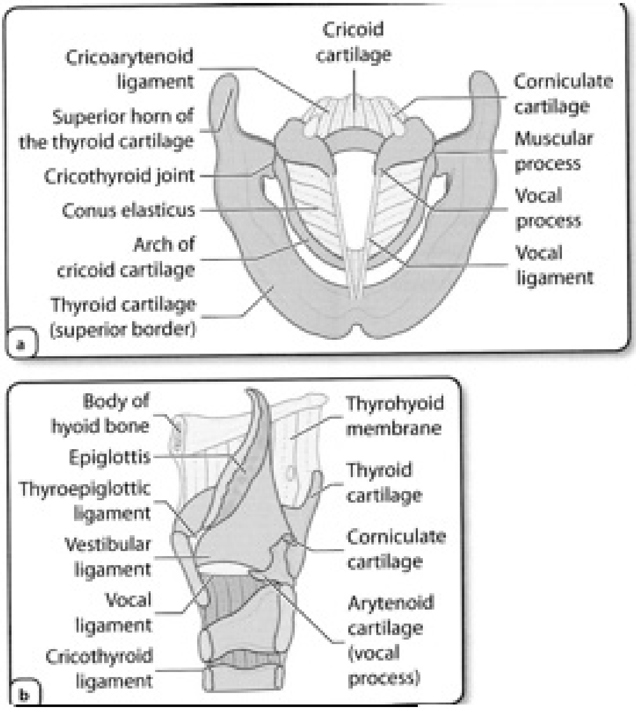

Fig. 1-14 This image demonstrates the relationship of the cartilages to the vocal cords. (JP 2.14) By permission from Thompson J, Vieira F, Rutter M; Management of the Difficult Airway: A Handbook for Surgeons; JP Medical Ltd 201

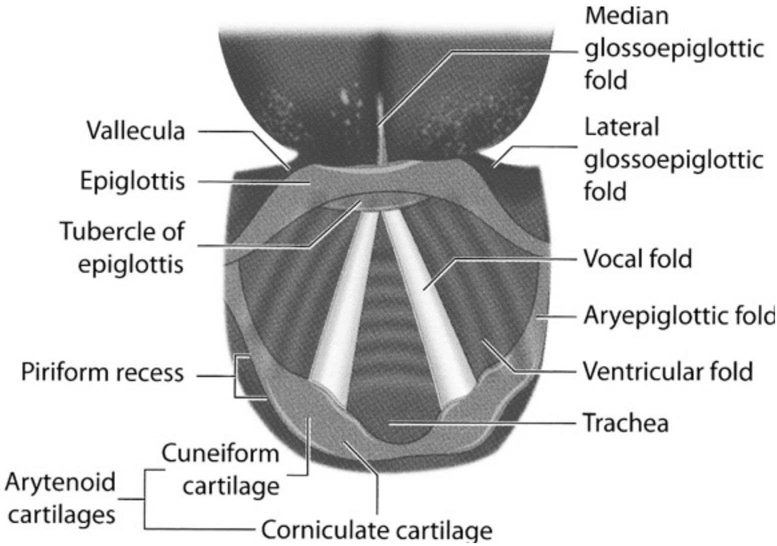

Fig. 1-15 The vocal cords are seen in their open position and in relation to the soft structures of the larynx. (JP 2.15) By permission from Thompson J, Vieira F, Rutter M; Management of the Difficult Airway: A Handbook for Surgeons; JP Medical Ltd 2016

Vocal cord motion is the result of a complex dynamic between combined intrinsic and extrinsic muscle action. The posterior cricoarytenoid muscle is the major adductor of the glottis and originates from the posterior surface of the cricoid, inserting onto the muscular process of the arytenoid. It adducts and externally rotates the arytenoid cartilage. The lateral cricoarytenoid muscle adducts with its origin on the lateral aspect of the cricoid and insertion on the muscular process of the arytenoid. It adducts by internally rotating the arytenoid on the cricoarytenoid joint.

The posterior arytenoid and inter-arytenoid are also minor adductors but suspected just to modulate vocalization. The only unpaired laryngeal muscle is the inter-arytenoid. It functions to adduct the vocal folds.

The thyroarytenoid muscle arises from the inner aspect of the thyroid cartilage and inserts on the vocal process of the arytenoid. Contraction of this muscle results in increasing vocal fold tension, thickness and stiffness. Extrinsic laryngeal muscles are responsible for elevating or depressing the larynx or moving it in the anterior-posterior plane. They include the cricothyroid, mylohyoid, digastric, stylohyoid, omohyoid, sternohyoid, sternothyroid and thyrohyoid muscles (**Figure 1-16**). Also included are the six nerves, four motor and two sensory, that supply the larynx: the paired sets of motor nerves, the right and left recurrent motor nerves for the intrinsic laryngeal muscles, and the paired right and left superior laryngeal nerves, which are both sensory and motor (**Figure 1-17**). Each of the paired internal superior laryngeal nerves carries a separate sensory and motor branch. The sensory branch provides sensation to the internal larynx, while the superior external laryngeal motor branch supplies the cricothyroid muscle.

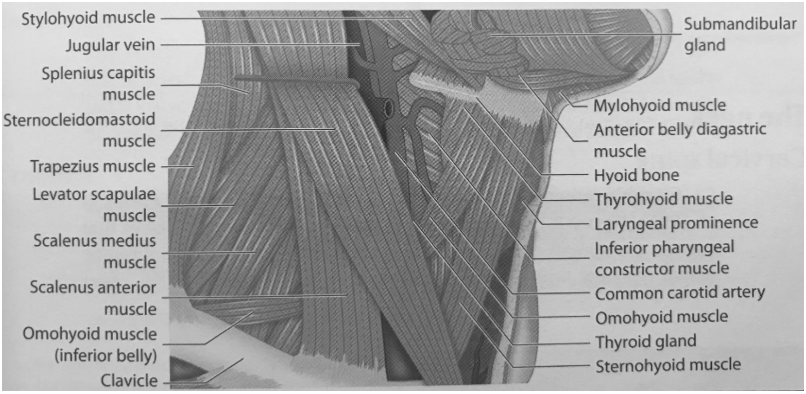

Fig. 1-16 Demonstrates the muscle of the neck. **(Figure 2.16)**. By permission from Thompson J, Vieira F, Rutter M; Management of the Difficult Airway: A Handbook for Surgeons; JP Medical Ltd 2016