FIBEROPTIC INTUBATION IN PEDIATRICS

An Essay study
Submitted for fulfillment of the master degree in Anesthesiology

Presented by

Victor Farouk Jaccoub
M.B.B.Ch
Faculty of Medicine, Cairo University

Supervised by

Prof. Dr. Amal Hanafy Abu El Ela
Professor of anesthesia
Faculty of Medicine, Cairo University

Prof. Dr. Inas Mohamed El Ghareeb El Shazly
Professor of anesthesia
Faculty of Medicine, Cairo University

Ass. Prof. Dr. Maha Gamil Hanna
Assistant Professor of anesthesia
Faculty of Medicine, Cairo University

Faculty of Medicine
Cairo University

(2007)

Acknowledgement

First of all, *I would like to thank **God** (our shepherd) for his care throughout my life and for helping me to do this study.*

Secondly, *I would like to thank **my professors** in the Anesthesiology department for their great help respectively;*

Dr. Amal Hanafy Abu El Ela
Professor of Anesthesiology, Faculty of Medicine; Cairo University.
For her grateful supervision, instructions and encouragement that helped me to present such a great work.

Dr. Inas Mohamed El Ghareeb El Shazly
Professor of Anesthesiology, Faculty of Medicine; Cairo University.
For her careful attention for the details involved in producing such a study.

Dr. Maha Gamil Hanna
Assistant Professor of Anesthesiology, Faculty of Medicine; Cairo University.
For her appreciated help in finding materials essential for that study.

Last and not least, *I would like to thank **my great family** for their support, love and patience that enabled me to complete this study.*

Abstract

Flexible fiberoptic intubation of the trachea is a standard technique to establish an airway in pediatric patients who are known or suspected to be difficult to manage by mask ventilation or by standard methods for placement of an endotracheal tube. However, flexible fiberoptic intubation in pediatrics is not the same as in adults because the airway anatomy of children differs with age. In addition, the characteristics of the commonly used pediatric fiberscopes differ from those used in adults, i.e., they are smaller, have reduced fields of vision, have different ranges of tip angulation, and have an insertion cord that is thinner and more flexible.

(Key Words: Fiberscope – Pediatrics – Pediatric Intubation – Difficult Airway)

Contents

- Chapter I: Pediatric Airway Anatomy ……. 8
- Chapter II: Clinical Significance of Fiberscopic Airway Management …… 28
- Chapter III: Physics of Light Transmission and Its Application In Fiberscopes …… 36
- Chapter IV: Technical Principles of Flexible Fiberscopes ……..... 52
- Chapter V: The Role Of Fiberscopes in Pediatric Intubation …… 77
- Chapter VI: Problems During Fiberoptic Intubation In Pediatrics …… 101
- Chapter VII: Alternative Airway Devices for Difficult Airway Management …… 109
- Summary ……..... 113
- References ……..... 116

List of figures

Anatomy:

– Figure 1.1 (tongue and epiglottis development)…….8
– Figure 1.2 (laryngeal development)……9
– Figure 1.3 (hard palate)……..12
– Figure 1.4 (muscles of the soft palate)……...13
– Figure 1.5 (nerve supply and blood supply of the palate)……..13
– Figure 1.6 (dorsum of the tongue)……..14
– Figure 1.7 (extrinsic muscles of the tongue)……..15
– Figure 1.8 (lymphatic drainage and nerve supply of the tongue)……...16
– Figure 1.9 (the tonsils)……18
– Figure 1.10 (the cartilages of the larynx)……20
– Figure 1.11 (the structure of the larynx)…….21
– Figure 1.12 (the trachea)…….26

Physics of light transmission:

– Figure 3.1 (reflection of light)……36
– Figure 3.2 (refraction of light)……38
– Figure 3.3 (acceptance angle)……38
– Figure 3.4 (step index and gradient index fibers)……...40
– Figure 3.5 (refraction and reflection at the interface between two media)..…..41
– Figure 3.6 (pathway of light in a step index fiber)…….43
– Figure 3.7 (pathway of light in a GRIN fiber)……44
– Figure 3.8 (The refractive index of GRIN fiber with different g-values)……..45
– Figure 3.9 (low and high resolution images)……..46
– Figure 3.10 (structure of step index and GRIN fibers)……...47
– Figure 3.11 (light rays in the SI and GRIN fibers)…….48
– Figure 3.12 (the structure of the fiberscope)……..50

Technical principles of fiberscopes:

– Figure 4.1 (transmission of light and images in an endoscope)…….56
– Figure 4.2 (broken fibers and blind spots)……..58
– Figure 4.3 (Xenon and Halogen light sources)……...61
– Figure 4.4 (Video-Endoscopy system)……...63
– Figure 4.5 (components of Video-Endoscopy system)……...65
– Figure 4.6 (clean and debris covered fibers)……...67
– Figure 4.7 (Automatic fiberscope cleaner)……..69
– Figure 4.8 (Manual cleaning)……..70
– Figure 4.9 (leakage testing)……71

Role of the fiberscope in pediatric intubation:

– Figure 5.1 (the Epiglottis)……...87
– Figure 5.2 (the Trachea)…….88
– Figure 5.3 (the bifurcation of the trachea)……..88
– Figure 5.4 (Freeman-Sheldon Syndrome)……..97
– Figure 5.5 (Pierre-Robin Syndrome)……..98

– Figure 5.6 (Klippel-Fiel Syndrome)……98
– Figure 5.7 (Kniest Syndrome)…….100

Alternative Airway devices:
– Figure 7.1 (the Wu-scope)…….110
– Figure 7.2 (the VETT system)……...111
– Figure 7.3 (the Trach view)……112
– Figure 7.4 (Optical stylets)…….112

List of Tables

– Table 1: Incidence of difficult intubations …… 30
– Table 2: technical specifications of fiberscopes and bronchoscopes ……. 55
– Table 3: causes of loss of light intensity …… 59
– Table 4: Technical specifications of intubation fiberscopes……... 62
– Table 5: Nebulized lidocaine volumes and concentrations …… 94

Introduction

The flexible fiberoptic endoscope (FFE) is the most valuable single tool available to the anesthesiologist faced with a difficult airway. When faced with potentially difficult tracheal intubation, the FFE should be the first, not the last, tool.

The name endoscope is derived from two Greek words which are ***endom*** (within) and ***skopein*** (view). The endoscope is an optical instrument used for viewing internal organs through natural openings. Generally, a flexible endoscope is referred to as a fiberscope.

Flexible fiberoptic intubation of the trachea is a standard technique to establish an airway in pediatric patients who are known or suspected to be difficult to manage by mask ventilation or by standard methods for placement of an endotracheal tube.

However, flexible fiberoptic intubation in pediatrics is not the same as in adults because the airway anatomy of children differs with age. In addition, the characteristics of the commonly used pediatric fiberscopes differ from those used in adults.

I. PEDIATRIC AIRWAY ANATOMY

A. DEVELOPMENT:

1. The Oral Cavity:

The oral cavity consists of several structures namely, the palate, the tongue, the mandible, the alveolar margin, the teeth, the floor of the mouth. [1]

1.1. The Palate:

It develops from fusion of the **primitive palate** that arises from the **fronto-nasal process**, [2] with the palatal processes of the maxillary mesoderm, bilaterally. [3]

Anomalous fusion of the maxillary palatal processes with each other or with the posterior margin of the primitive palate results in cleft palate. [4]

1.2. The Tongue:

The tongue is initially represented by:

i. The **anterior 2/3 of the tongue** arises from the **tuberculum impar** and the adjacent regions of both mandibular **(1st pharyngeal) arches.** [3]

ii. The **posterior 1/3** is formed from fusion of the **2nd and 3rd pharyngeal arches, the copula, and a small portion of the 4th pharyngeal arch.** [5]

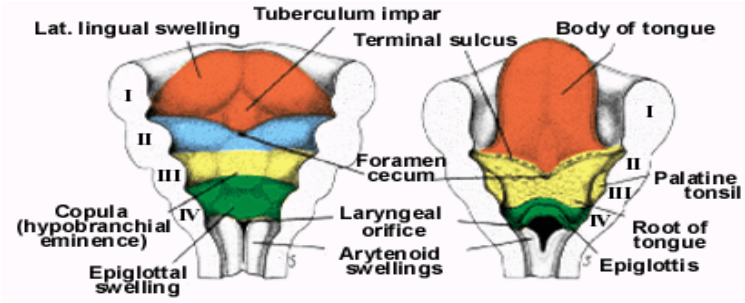

Fig. 1.1 Tongue and epilottis development [5]

2. The Larynx:

The larynx, trachea, bronchi and lungs arise from a midline ventral respiratory diverticulum of the foregut known as the **larygeotracheal groove**. [6]

The **epiglottis** develops from the **posterior part of the hypobranchial eminence**. [5]

Development of the larynx [7]

- Epithelium develops from endoderm of laryngotracheal tube.
- Mesoderm develops from splanchnic mesoderm.
- Cartilages develop from neural crest cells

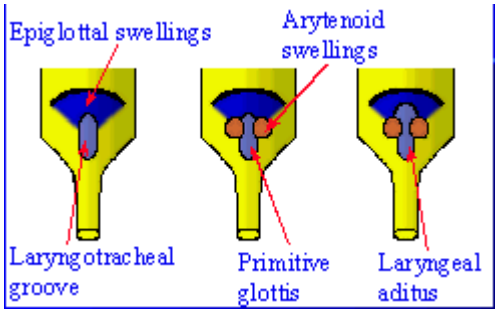

Fig. 1.2 Laryngeal development [7]

3. Trachea, bronchi and lungs:

The respiratory system develops from a midline diverticulum in the foregut called the laryngeotracheal groove (25 days of gestation), immediately caudal to the hypobranchial eminence. [8]

THE ANATOMY PROPER:

1. The Oral Cavity:

The oral cavity is divided into a vestibule, between the lips, cheeks, gums and teeth, and a posterior buccal cavity, bounded by the dental arches. [9]

The submucosa contains small mucus-secreting labial glands. The tortuous labial arteries are embedded in each lip with anastomosis across the midline. The sensory nerve supply of the lips is derived from the labial branches of the maxillary and mandibular branches of the trigeminal nerve. The lymphatic vessels pass into the anterior auricular, submandibular and submetal nodes and then into the deep cervical lymph nodes. [9]

1.1. The Vestibule:

This is a narrow cleft between the lips and the alveolar margin. The main boundary wall of the vestibule is partly muscular and partly osseous. The ***buccinator*** muscle forms the main muscular component. This muscle is strengthened externally by a strong fascial layer, **the *buccopharyngeal*** fascia. [9]

The duct of the parotid gland opens into the vestibule opposite the crown of the second upper molar tooth. [9]

In young infants a considerable amount of ***fat, giving the cheek a rounded appearance***. [9]

1.2. The Buccal Cavity:

This cavity lies within the dental arches and communicates posteriorly with the oropharynx through the oropharyngeal isthmus at the level of the palatoglossal arches. [9]

The roof of the buccal cavity is formed by the hard palate and the anterior part of the soft palate. The floor is formed by the dorsal surface of the anterior two-thirds of the tongue. [9]

Blood supply:

The mouth is supplied mainly by:

1. The ***inferior labial artery***, a branch of the facial artery, supplies the glands, mucous membranes and the muscles of the lower lip. [6]

2. The ***lingual branch*** of the inferior labial artery supplies the mucous membrane of the mouth. [6]

3. The ***superior labial artery***, another branch of the facial artery, supplies the upper lip. [6]

4. Branches of the ***greater palatine artery***, supply the palate, mucous membrane of the roof of the mouth, and gums. [6]

5. The branches of the ***infra-orbital*** and of the ***posterior superior alveolar arteries*** supply the upper lip and the gum respectively. [6]

Nerve supply:

1. The ***Maxillary nerve*** supplies the upper gum through its anterior palatine, naso-palatine and anterior, middle and posterior superior alveolar branches.[6]

2. The ***Mandibular nerve*** supplies the lower gum through its inferior alveolar, lingual and buccal branches [6]

Lymphatic drainage:

The lymph vessels of the outer (buccal) aspects of both the upper and lower gums drain, with the deeper tissues of the cheek, into the ***submandibular nodes.*** [10]

The inner (lingual) aspect of the gum also drains into the ***submandibular group***, ***upper deep cervical nodes*** and ***retro-phryngeal nodes.*** The gum round the lower incisor teeth sometimes drains into the ***submental nodes.*** [10]

1.3. Dental Arches:

In the human ***Temporary dentition***, completed during the first two years of life, there are ten teeth in each jaw. [11]

1.4. The Palate:

The palate forms the roof of the mouth and the floor of the nasal fossa. The ***anterior two thirds*** are rigid and are distinguished as the ***hard palate***. [12]

The ***posterior one-third*** constitutes the ***soft palate***, a movable fibro-muscular partition which is attached to the posterior margin of the hard palate and to the side wall of the pharynx. [12]

1.4.1. The Hard Palate:

The mucous membrane of the hard palate is firmly united to the periosteum to form a muco-periosteum. [12]

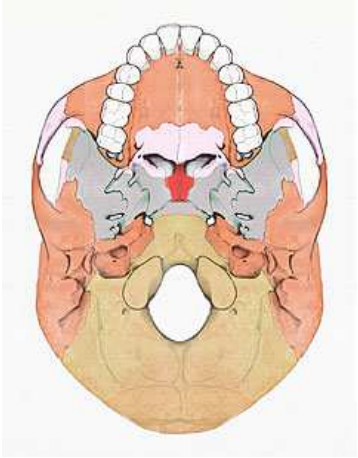

Fig. 1.3 The hard palate [12]

1.4.2. The Soft Palate:

The soft palate consists of a dense fibrous framework called the palatine aponeurosis, formed by the expanded tendons of the tensor palate muscles. To this aponeurosis the other palatine muscles are attached. [13]

The ***palato-glossal fold*** formed by the palatoglossus muscle, and a posterior one to the pharyngeal wall, the ***palatopharyngeal fold***, formed by the palatopharyngeus muscle. [14]

Muscles of the soft palate: [14]

1) ***Tensor veli palatini***
2) ***Levator veli palatini***
3) ***Palatoglossus***
4) ***Palatopharyngeus***
5) ***Musculus uvulae***

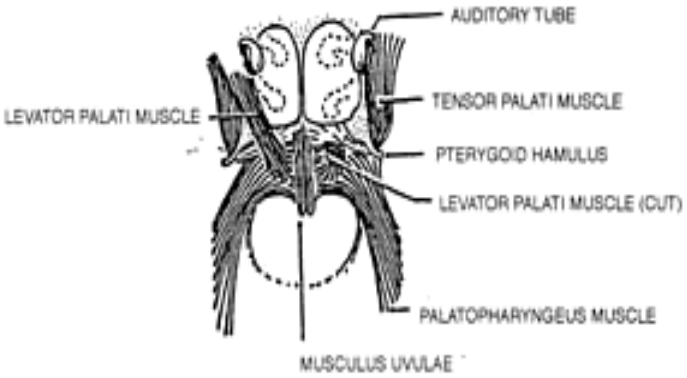

Fig. 1.4 muscles of the soft palate [14]

Nerve supply: [13]

The pharyngeal plexus, supplies all muscles of the soft palate except the tensor palati. The ***tensor palati*** muscle is supplied by the ***mandibular division of the trigeminal nerve***.

The spheno-palatine ganglion and the glossopharyngeal nerve: Gives the sensory innervation of the soft palate. [13]

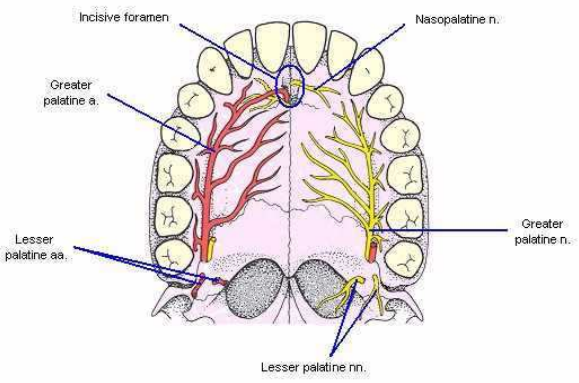

Fig. 1.5 nerve and blood supply of the palate [13]

Blood supply: [13]

- ***Ascending palatine*** branch of the facial artery.
- ***Lesser palatine*** branches of ***the greater palatine*** branch of the maxillary artery.
- ***Palatine*** branch of the ascending pharyngeal artery.

The venous drainage runs mainly into the ***tonsillar*** and ***pterygoid plexuses***, to the anterior facial vein through the deep facial vein.

Lymphatic drainage: [10]

The lymphatic drainage of the soft palate is partly to the ***retropharyngeal*** nodes and partly direct to the ***upper deep cervical nodes***.

1.5. Tongue:

The tongue is a muscular organ situated in the floor of the mouth and the anterior wall of the pharynx.

The dorsum of the tongue is subdivided by a "V-shaped" groove, the ***sulcus terminalis***, into an anterior palatine part and a posterior pharyngeal part. Anterior to the groove are the ***vallate papillae***. [15]

The structure of the tongue includes: [15]

1) ***Mucous membrane.***
2) ***Mucous glands.***
3) ***Lymphoid tissue and fat.***
4) ***Interlacing bundles of striated muscle fibers.***
5) ***Fibrous tissue.***

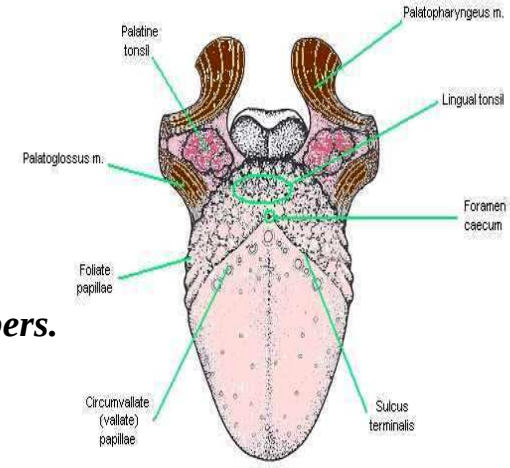

Fig. 1.6 Dorsum of tongue [15]

A median connective tissue septum divides the tongue into right and left halves. The septum prevents spread of any abscess from one side to the other. [15]

1.5.1. Mucous Membrane:

The mucosa of the tongue is firmly adherent to the underlying muscle tissue. ***The oral part*** of the mucous membrane is pink and studded with numerous small projections, the papillae. ***The pharyngeal part*** is smoother and shows nodular elevations due to the underlying lymphoid nodules and mucous glands. [15]

A median fold, the ***glosso-epiglottic fold***, passes backwards from the root of the tongue to the epiglottis, on each side of which there is a depression, ***the vallecula***. [15]

On the inferior surface of the tongue the mucous membrane is thin and smooth and more ***loosely connected to the underlying muscle. In the median line*** below the tip of the tongue the mucous membrane is raised into a sagittal fold, ***the frenulum lingue***. [15]

1.5.2. Muscles: [16]

Include;

The extrinsic muscles:

- Genioglossus.
- Chondroglossus.
- Glossopalatinus.
- Hyoglossus.
- Styloglossus.

The intrinsic muscles:

- Longitudinalis superior.
- Longitudinalis inferior.
- Transverses.
- Verticalis.

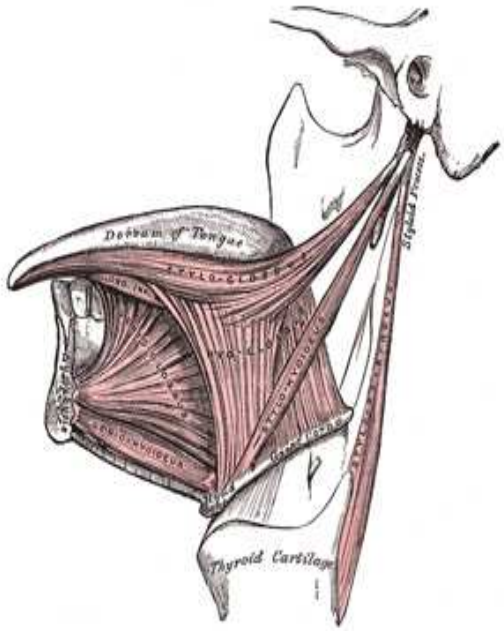

Fig. 1.7 Extrinsic muscles of tongue. [16]