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The Effect of Intra-Cuff Lidocaine during General Anesthesia on the Incidence of Postintubation-Related Sore Throat and Emergence phenomenon

Submitted for Partial Fulfilment of Master Degree in Anesthesiology

BY

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LIST OF ABBREVIATIONS

ETT	Endotracheal Tube
POST	Post-operative Sore Throat
GA	General Anesthesia
CTM	Cricothyroid Membrane
PVC	Polyvinyl Chloride
LMA	Laryngeal Mask Airway
HPLV	High Pressure, Low Volume
ILMA	Intubating Laryngeal Mask Airway
HVLP	High Volume, Low Pressure
VAP	Ventilator-Associated Pneumonia
PU	Polyurethane
WOB	Work Of Breathing
PEEP	Positive End-Expiratory Pressure
LA	Local Anesthetic
H2-receptor	Histamine type "2" receptor

EtCO2	End-tidal Carbon Dioxide
PACU	Post-Anesthesia Care Unit
MAC	Minimal Alveolar Concentration
NIBP	Non-Invasive Blood Pressure
CPR	Cardiopulmonary Resuscitation
CO	Cardiac Output
ASA	American Society of Anesthesia
GI	Gastrointestinal
SD	Standard Deviation
LSD	Least Significant Difference
ANOVA	Analysis Of Variance
UL	Upper Limb
LL	Lower Limb

LIST OF SYMBOLS

α	Alpha
β	Beta
Γ	Gamma
∑	Sum
n	Number of observations
x^2	Chi-square
%	Percentage

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INTRODUCTION

Postoperative sore throat and other airway morbidities are common troublesome after general anesthesia using the endotracheal tube (ETT). The postintubation-related emergence phenomenon is a cluster of airway complications associated with tracheal intubation or extubation after general anesthesia. Various symptoms result from mucosal injury or inflammation caused by airway instrumentation (i.e. laryngoscope and suctioning) or the irritating effects of a foreign object (i.e. endotracheal tube). Postoperative sore throat (POST) is one of the most undesirable morbidities that occur in approximately 50% or more surgical patients ***(Biro et al., 2005)***.

During emergence from general anesthesia, patients may experience vigorous coughing, agitation or restlessness which might increase intracranial, intra-thoracic or intra-abdominal pressure, resulting in bronchospasm, wound dehiscence, and bleeding. Other laryngeal complication such as hoarseness, dysphonia, or dysphagia was also noted during the postoperative care ***(Stoelting, 1977)***.

Prevention strategies for POST and other airway complications during emergence have recently shifted from non-pharmacological (e.g., ETT size, cuff pressure or volume control) to pharmacological strategies. Various prophylactic interventions such as anti-inflammatory drugs, opioids, steroids, or local anesthetics have been employed extensively. Lidocaine is one of the most commonly used drugs for preventing POST, and its efficacy was evaluated in a Cochrane review in 2009 ***(Tanaka et al., 2009).***

Nevertheless, the clinical application of the results of this study may still be equivocal, because the route of lidocaine administration was not adequately confined, and its effectiveness on other relevant morbidities was not fully considered. Lidocaine, when administered as a cuff inflation medium, may protect the tracheal mucosa through its continuous topical anesthetic effect, and prevent the diffusion of nitrous oxide into the cuff. Thus, we conducted this study aiming to improve the outcomes where lidocaine was administered as a cuff medium of an ETT for patients undergoing general anesthesia ***(D'Aragon et al., 2013).***

AIM OF WORK

The aim of this study is to improve the outcome of the patients undergoing surgical operations under general anesthesia (GA) who suffer from postintubation-related sore throat and emergence phenomenon.

ANATOMY OF AIRWAY

The upper airway consists of the pharynx, nose, mouth, larynx, trachea, and main-stem bronchi. The mouth and pharynx are also a part of the upper gastrointestinal tract. The laryngeal structures in part serve to prevent aspiration into the trachea ***(Butterworth et al., 2013)***.

There are two openings to the human airway: the nose, which leads to the nasopharynx, and the mouth, which leads to the oropharynx. These passages are separated anteriorly by the palate, but they join posteriorly in the pharynx **(Figure 1–1)**. The pharynx is a U-shaped fibromuscular structure that extends from the base of the skull to the cricoid cartilage at the entrance to the esophagus. It opens anteriorly into the nasal cavity, the mouth, the larynx, and the nasopharynx, oropharynx, and laryngopharynx, respectively. The nasopharynx is separated from the oropharynx by an imaginary plane that extends posteriorly. At the base of the tongue, the epiglottis functionally separates the oropharynx from the laryngopharynx (or hypopharynx) ***(Mackey et al., 2006)***.

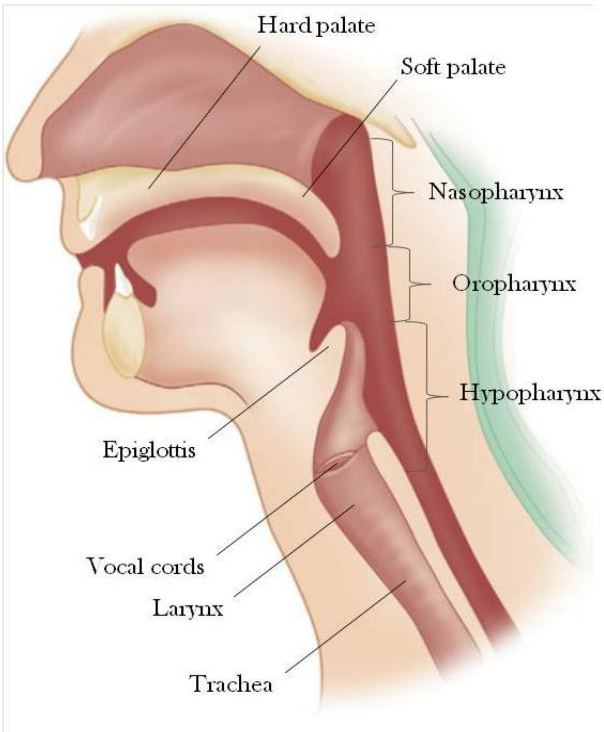

Figure 1-1: Anatomy of the airway ***(Morgan & Mikhail, 2013)***

The epiglottis prevents aspiration by covering the glottis—the opening of the larynx during swallowing. The larynx is a cartilaginous skeleton held together by ligaments and muscle. The larynx is composed of nine cartilages (**Figure 1–2**): thyroid, cricoid, epiglottic, and (in pairs) arytenoid, corniculate, and cuneiform. The thyroid cartilage shields the conus elasticus, which forms the vocal cords ***(Butterworth et al., 2013).***

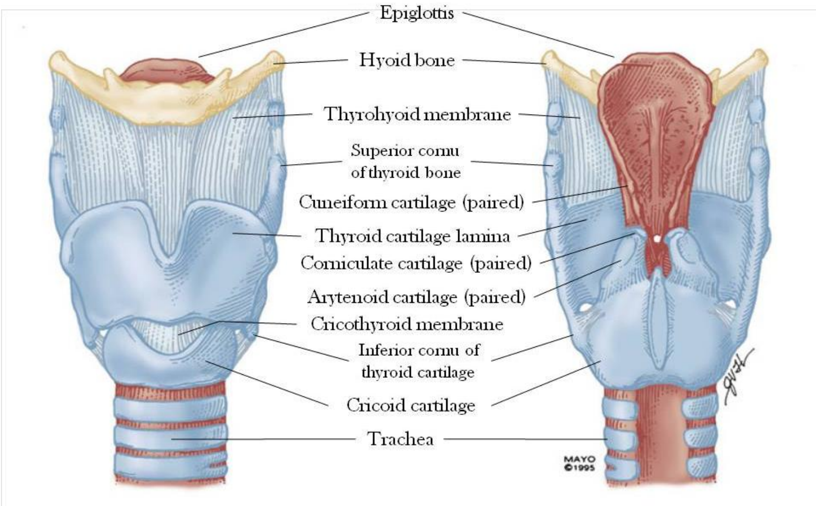

Figure 1-2: Cartilaginous structures comprising the larynx ***(Morgan & Mikhail, 2013)***

The sensory supply to the upper airway is derived from the cranial nerves (**Figure 1–3**). The mucous membranes of the nose are innervated by the ophthalmic division (V 1) of the trigeminal nerve anteriorly (anterior ethmoidal nerve) and by the maxillary division (V 2) posteriorly (sphenopalatine nerves). The palatine nerves provide sensory fibers from the trigeminal nerve (V) to the superior and inferior surfaces of the hard and soft palate ***(Mackey et al., 2006).***

The **olfactory nerve** (cranial nerve I) innervates the nasal mucosa to provide the sense of smell. The lingual nerve (a branch of the mandibular division [V 3] of the trigeminal nerve) and the glossopharyngeal nerve (the ninth cranial nerve) provide general sensation to the anterior two-thirds and posterior one-third of the tongue, respectively. Branches of the facial nerve (VII) and glossopharyngeal nerve provide the sensation of taste to those areas, respectively. The **glossopharyngeal nerve** also innervates the roof of the pharynx, the tonsils, and the undersurface of the soft palate. The **vagus nerve** (the tenth cranial nerve) provides sensation to the airway below the epiglottis. The superior laryngeal branch of the vagus divides into an external (motor) nerve and an internal (sensory) laryngeal nerve that provide sensory supply to the larynx between the epiglottis and the vocal cords. Another branch of the vagus, the **recurrent laryngeal nerve**, innervates the larynx below the vocal cords and the trachea. The muscles of the larynx are innervated by the recurrent laryngeal nerve, with the exception of the cricothyroid muscle, which is innervated by the external (motor) laryngeal nerve, a branch of the superior laryngeal nerve. The posterior cricoarytenoid muscles abduct the vocal cords, whereas the lateral cricoarytenoid muscles are the principal adductors ***(Butterworth et al., 2013).***

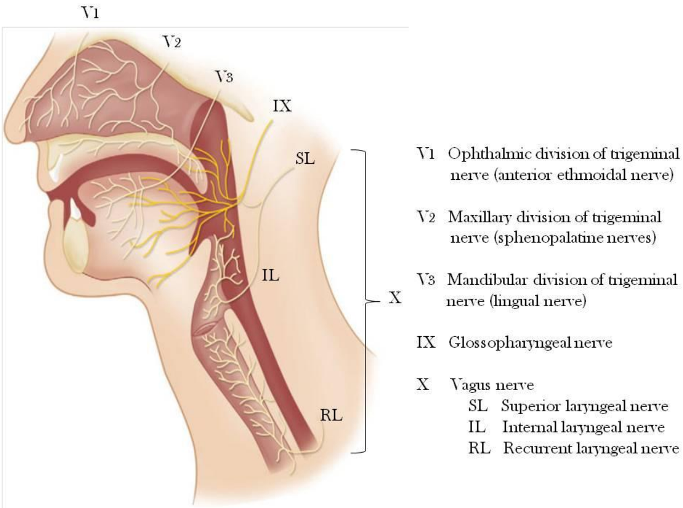

Figure 1-3: Sensory nerve supply of the airway ***(Morgan & Mikhail, 2013)***

Phonation involves complex simultaneous actions by several laryngeal muscles. Damage to the motor nerves innervating the larynx leads to a spectrum of speech disorders. Unilateral denervation of a cricothyroid muscle causes very subtle clinical findings. Bilateral palsy of the superior laryngeal nerve may result in hoarseness or easy tiring of the voice, but airway control is not jeopardized. Unilateral paralysis of a recurrent laryngeal nerve results in paralysis of the ipsilateral vocal cord, causing deterioration in voice quality. Assuming intact superior laryngeal nerves, *acute* bilateral recurrent laryngeal nerve palsy can result in stridor and respiratory distress because of the remaining unopposed tension of the cricothyroid muscles. Airway problems are less frequent in *chronic* bilateral recurrent laryngeal nerve loss because of the development of various compensatory mechanisms (eg, atrophy of the laryngeal musculature). Bilateral injury to the vagus nerve affects both the superior and the recurrent laryngeal nerves. Thus, bilateral vagal denervation produces flaccid, mid-positioned vocal cords similar to those seen after administration of succinylcholine **(Table 1-1)**. Although phonation is severely impaired in these patients, airway control is rarely a problem ***(Wasnick et al., 2002)***.

Table 1-1: The effect of laryngeal nerves injury on the voice ***(Wasnick et al., 2002)***

Nerve	Effect of nerve injury
Superior laryngeal nerve	
Unilateral	Minimal effects
Bilateral	Hoarsness, tiring of voice
Recurrent laryngeal nerve	
Unilateral	Hoarsness
Bilateral	
Acute	Stridor, respiratory distress
Chronic	Aphonia
Vagus nerve	
Unilateral	Hoarsness
Bilateral	Aphonia

The blood supply of the larynx is derived from branches of the thyroid arteries. The cricothyroid artery arises from the superior thyroid artery itself, the first branch given off from the external carotid artery, and crosses the upper cricothyroid membrane (CTM), which extends from the cricoid cartilage to the thyroid cartilage. The superior thyroid artery is found along the lateral edge of the CTM ***(Mackey et al., 2006)***.

The trachea begins beneath the cricoid cartilage and extends to the carina, the point at which the right and left main-stem bronchi divide. Anteriorly, the trachea consists of cartilaginous rings; posteriorly, the trachea is membranous. Trachea is a tube of 12 cm length connecting the larynx to the principal bronchi that lead to the lungs. The main functions of the trachea comprise air flow into the lungs, mucociliary clearance, and humidification and warming of air. Mucociliary clearance is achieved by kinocilia and goblet cells in the mucosa, and by tracheal glands. The trachea develops from the endodermal lining of the foregut in interaction with the visceral mesoderm. ***(Schafer T., 2014).***

Tracheal mucosal capillary perfusion pressure in man ranges from 16 to 25 cmH_2O. The capillary blood flow has been shown to be compromised at lateral wall pressures above 25 cmH_2O (18 mmHg), with cessation of flow to the mucosa over the tracheal rings and posterior tracheal wall at a lateral wall pressure (critical perfusion pressure) of 50 cmH2O (37 mmHg) ***(Smith and McArdle, 2002).***

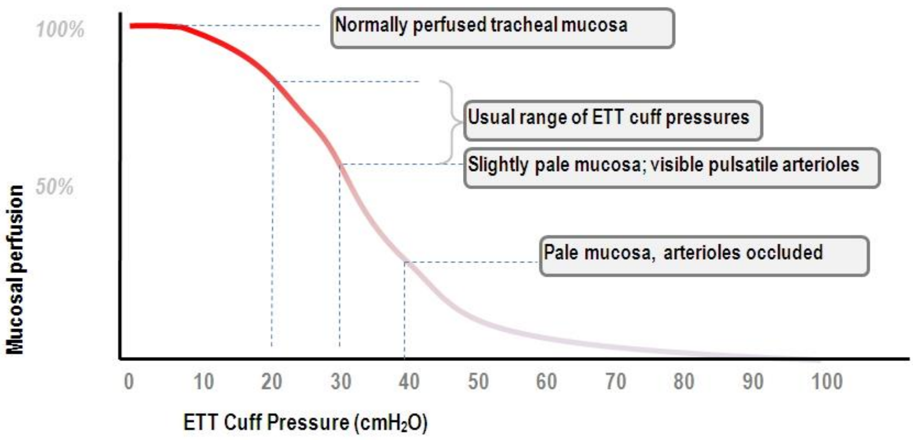

Figure 1-4: The effect of the ETT cuff pressure on the tracheal mucosal perfusion *(Seegobin et al., 1984)*

From the graph, we can see that:
Cuff pressure greater than 27 cm H20 is associated with a 75% reduction in blood flow to the trachea at the cuff.
Cuff pressure greater than 48 cm H20 can completely stop capillary blood flow.
Cuff pressure greater than 50 cm H20 can cause total obstruction of tracheal blood flow.

CHARACTERISTICS OF ENDOTRACHEAL TUBES

The earliest recorded use of airway manipulation with an artificial device dates back to early Roman civilization when Asclepiades performed a tracheostomy for laryngeal edema. Today it is clear that the role of the endotracheal tube (ETT) in medicine is as invaluable as that of any other medical device created to date. The establishment of a definitive airway via the ETT in both elective and emergency situations has allowed for the delivery of immediate life-sustaining therapies during resuscitation, the maintenance of oxygenation and ventilation in prolonged illness, and the (temporary) delivery of inhaled anesthesia. This chapter begins with a brief history of the development of the ETT. It reviews basic airway anatomy with regard to ETT placement, physiologic effect due to ETT placement, and choice of proper tracheal tube size ***(Mort et al., 2015)***.

❖ **Structure of tracheal tubes:**

Between the time of Asclepiades and the present, ETTs have been constructed of a variety of materials, including reed, brass, and steel. Eventually, in 1917, Magill and Rowbotham manufactured them from rubber for the purpose of administering anesthesia. In 1928, when Guedel and Waters added a protective cuff to prevent aspiration, the modern ETT was born. Rubber, however, had limitations in this application, such as increased stiffness with rising temperature and limited adhesive properties with different polymers, which required the cuffs to be manufactured from the same polymer as the tube. These shortcomings led to the search for alternative materials. In 1967, polyvinyl chloride (PVC) was popularized by Dr. S. A. Leader, and it has since been the material most commonly used (Figure 2-1). One property that makes PVC attractive is that it provides stiffness to an ETT at room temperature to assist with intubation yet becomes more malleable with the increased temperature in situ. Other properties include the ability to embed radiopaque lines in the material to assist with positioning and recognition on a radiograph. Because it accepts many materials, the addition of an exteriorized inflation line to connect the pilot balloon to the cuff can allow for varied cuff materials. Finally, it simply is much lower in cost than other available materials ***(Keck et al., 2015)***.

The 15-mm adapter allows for universality between ventilating devices such as a bag-mask ventilation system, anesthesia circuit, or ventilator circuit. The adapter fits ETTs as large as 12 mm internal diameter and as small as 3 mm, thereby providing further commonality among multiple ETTs and ventilating devices. Having one standard size also allows for interchange between devices made for tracheostomies or