ISSN (O):2395-2822; ISSN (P):2395-2814

An Introduction to Airway Assessment and Management (Concise Airway Anatomy and Pathophysiology).

Gamal Ejaimi[1], Sittelnissa Saeed[1]

[1]Assistant Professor of Anaesthesia and intensive care, Department of surgery, Faculty of Medicine, King Khalid University, Abha, Kingdom of Saudi Arabia, Aseer Central Hospital, Department of Anaesthesia & Critical Care Unit.

Received: November 2016
Accepted: December 2016

ABSTRACT

Airway management is a fundamental aspect of anaesthetic practice and of emergency and critical care medicine . Airway problems and obstruction is a preventable cause of deaths worldwide. Without an adequate airway management, all other maneuvers and resuscitation efforts will end with failure. Both elective and emergency airway need a plan and deep knowledge which obtained by good orientation, systemic approach, and close adherence with update protocols and guide lines.

Keywords: Airway, Oxygen, Hypoxia, anesthesia, Intensive care.

INTRODUCTION

Airway management is a fundamental aspect of anaesthetic practice and of emergency and critical care medicine. However, no doubt medical practice personal in other medical specialties needs to know it well.

Airway problems and obstruction is a preventable cause of deaths worldwide. Without an adequate airway management, all other maneuvers and resuscitation efforts will end with failure. Both elective and emergency airway need a plan and deep knowledge which obtained by good orientation, systemic approach, and close adherence with update protocols and guide lines. Therefore, airway assessment and management is the most vital medical conditions.

Goals

1) To obtain an introduction to airway assessment and management by easy understanding of human airway anatomy and pathophysiology.

Name & Address of Corresponding Author
Dr. Gamal Ejaimi
Assistant Professor of Anaesthesia and intensive care,
Department of surgery, Faculty of Medicine,
King Khalid University, Abha,
Kingdom of Saudi Arabia,
Aseer Central Hospital,
Department of Anaesthesia & Critical Care Unit.

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1) Concise Airway Anatomy
2) Component of inhaled and exhaled gas
3) Oxygen cascade
4) Oxygen carrying, content, delivery, and consumption
5) Hypoxia.
6) Cyanosis.

UPPER AIRWAY ANATOMY

Airway anatomy is divided into upper and lower airway. The upper airway consists of:

- Nose,
- Pharynx,
- Larynx and,
- Trachea.

Nose anatomy

- Pyramidal in shape.
- Consist of cartilage and bone.
- Divided by a midline septum into two nasal cavities.
- Lateral wall has three concha-shaped bone called turbinates lying as superior, middle, and inferior.
- Maintain airway passage, heat and humidity inspired gas. [1]

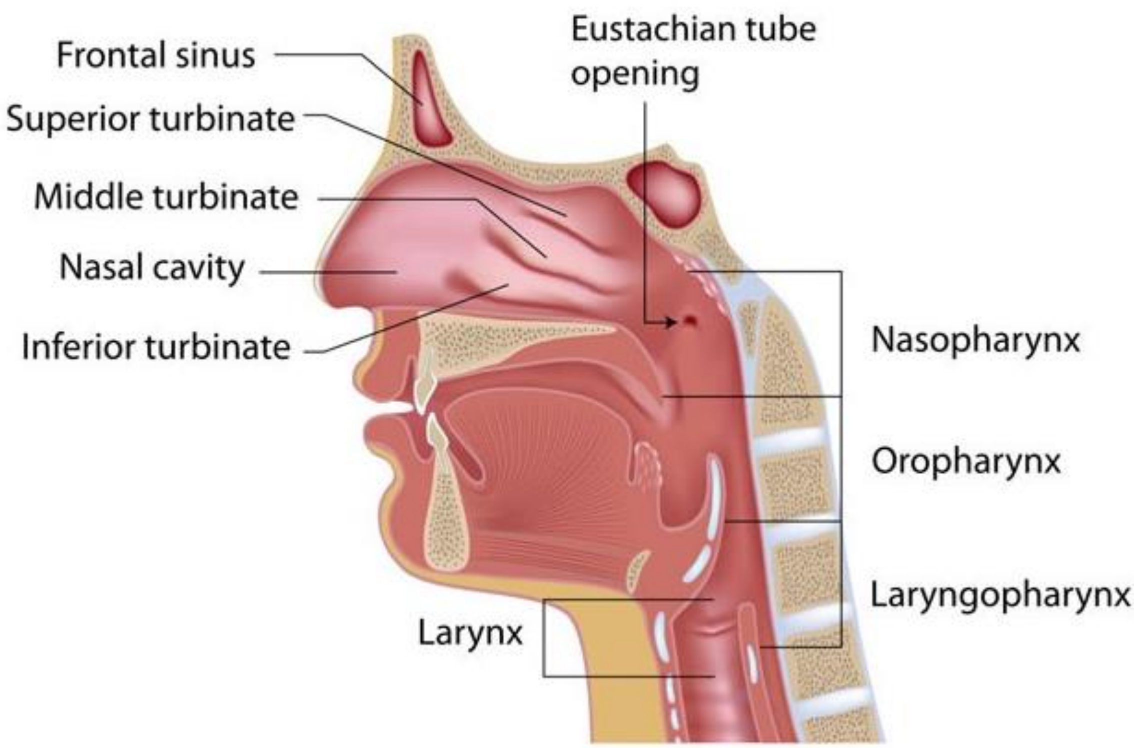

Figure 1: Illustration of sagittal section of nose showing lateral wall with turbinate. http://www.amulyabharat.com/nose-anatomy-external-diagram/

Pharynx anatomy

Pharynx compose of exterior and interior parts. The interior part is divided to Nasopharynx, Oropharynx, and Laryngopharynx. [1]

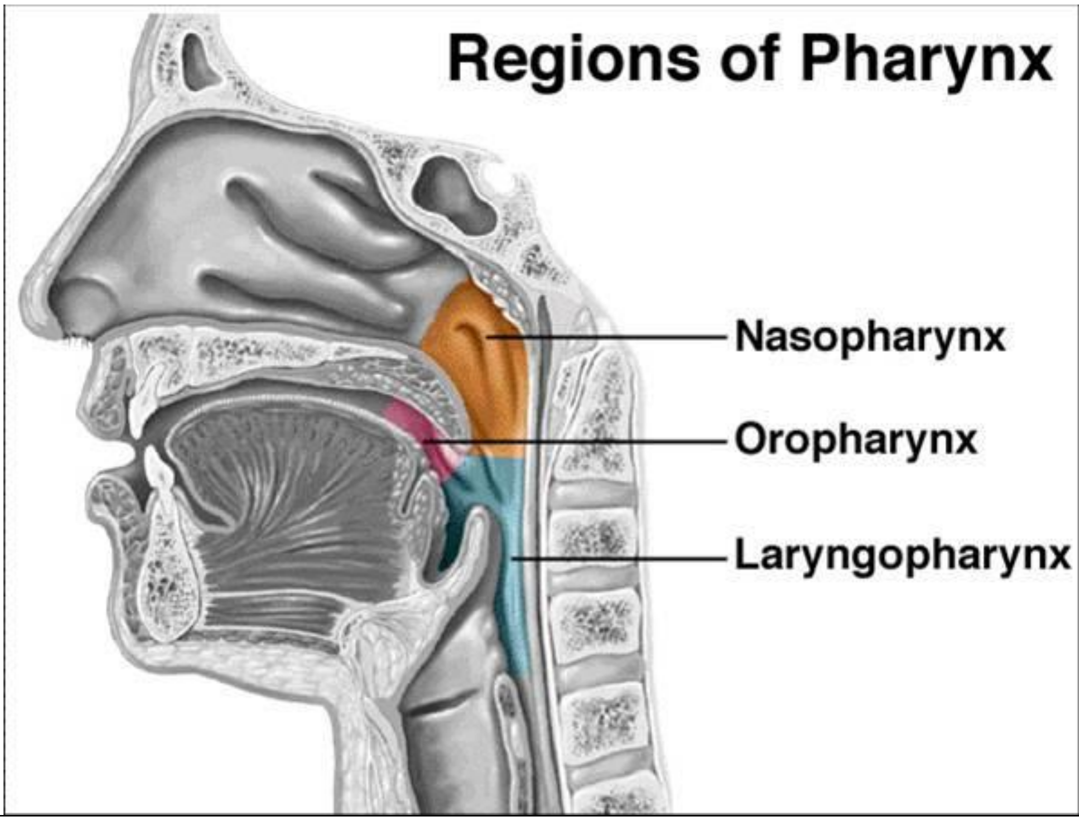

Figure 2: Pharynx. http://msk-anatomy.blogspot.com/2012/06/pharynx-anatomy.html

Larynx

- It makes a conduit between base of the tongue and trachea.
- The length of larynx is about 44 mm in adult male and 36 mm in female.
- It composed of; Three unpaired large cartilages (cricoid, thyroid, epiglottis) and Three pairs of smaller cartilages (arytenoids, corniculate, and cuneiform).
- Cricoid cartilage is the only complete cartilage in the larynx and lie opposite to C6 Body.
- Have Intrinsic and extrinsic muscles.
- Intrinsic muscles; cricothyroid, posterior cricoarytenoid, lateral cricoarytenoid, transverse arytenoid, and thyroarytenoid muscles.
- *All intrinsic muscles of the larynx are abductor except lateral cricoarytenoid which is adductor.* [1]

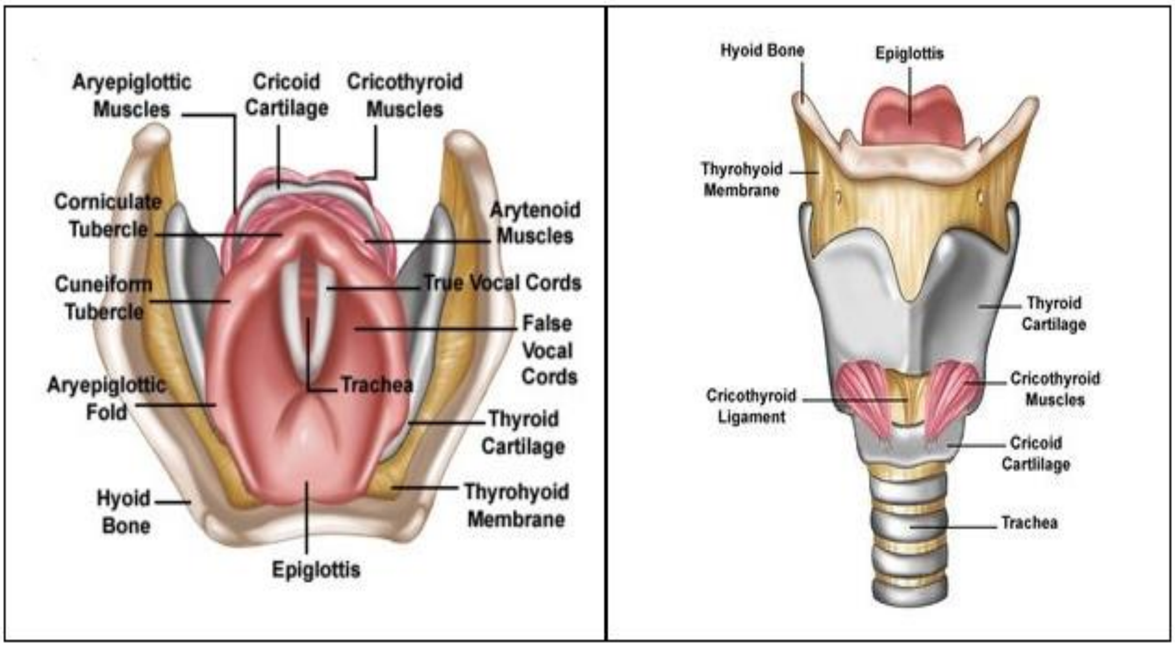

Figure 3: Larynx. http://www.gbmc.org/anatomyandphysiology

Upper airway innervation

- Three major neural pathways supply sensation to airway structures.
- Terminal branches of the ophthalmic and maxillary divisions of the trigeminal nerve supply the nasal cavity and turbinates.
- The oropharynx and posterior third of the tongue are supplied by the glossopharyngeal nerve.
- Branches of the vagus nerve innervate the epiglottis and more distal airway structures.
- All intrinsic muscles are supplied by recurrent laryngeal nerve except cricothyroidotomy (CT) which innervated by external laryngeal nerve-branch of superior laryngeal nerve.
- Injury of external laryngeal nerve during thyroidectomy or cricothyrotomy result in hoarseness of the voice and an inability to produce high-pitched sounds.
- Types of Injuries of recurrent laryngeal nerve:
- Unilateral = voice changes-hoarseness of voice.
- Bilateral = aphonia and breathing difficulty.
- Internal laryngeal nerve supply a sensory innervation to the laryngeal cavity down to the level of the vocal folds, including posterior surface of the epiglottis.
- Recurrent laryngeal nerve gives a sensory innervation to the laryngeal cavity below the level of the vocal folds. [1]

Trachea:

- Trachea is about 15 cm (6 inches) long and 2 to 3 cm in diameter in adult male.
- Begin from the inferior end of the larynx (C6 vertebra) to its point of bifurcation (between T5 and 7 vertebral level).
- Contain a series of 16 to 20 horseshoe-shaped Cartilaginous rings-having a posterior part of fibrous tissue.
- Sensory innervation by branches of vagus nerve including recurrent laryngeal nerve. [2]

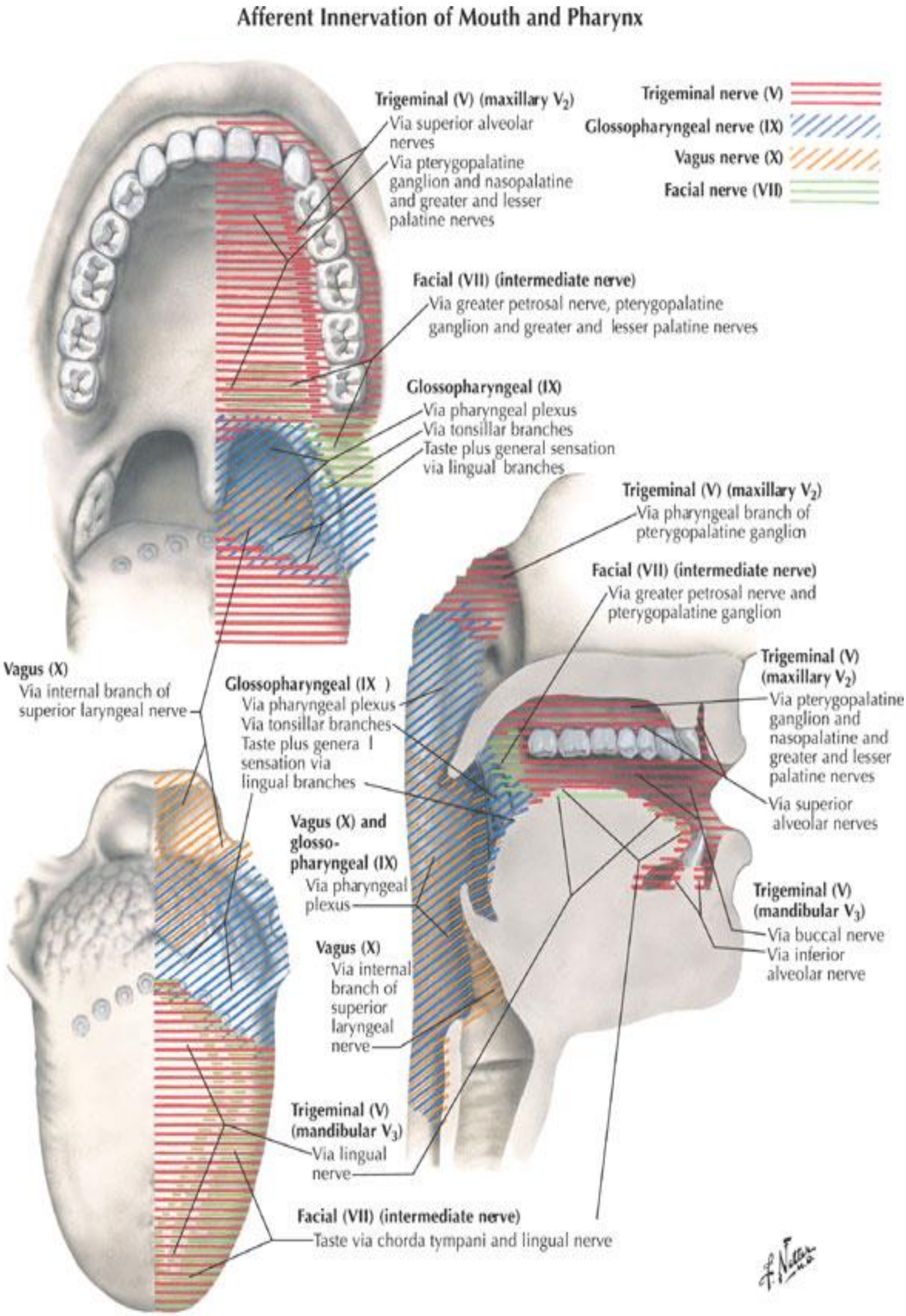

Figure 4: http://www.nature.com/gimo/contents/pt1/images/gimo2-f5.jpg

COMPOSITION OF INHALED AND EXHALED AIR

Composition Of Inhaled And Exhaled Air[3]

Gas	Amount in inhaled air	Amount in exhaled air
Oxygen	20.84%	13.6% - 16%
Carbon Dioxide	Very small amount (0.04%)	4% - 5.3%
Nitrogen	78.62%	78.04%
Water vapour	Small amount (0.5%)	Large amount
Argon	0.96%	1%

OXYGEN CASCADE AND OXYGEN CARRYING CAPACITY, DELIVERY AND CONSUMPTION

Oxygen cascade:

Oxygen is extracted or transported from atmosphere to tissue cells mitochondria by cardiorespiratory system. This process is known as oxygen cascade.

At sea level, the atmospheric pressure is 760mmHg, and oxygen makes up 21% (20.094% to be exact) of inspired air: so oxygen exerts a partial pressure of 760 x 0.21 = 159mmHg.This is the starting point of the oxygen cascade, as one moves down through the body to the cell, oxygen is diluted down, extracted or otherwise lost, so that at cellular level the PO2 may only be 3 or 4 mmHg. [4]

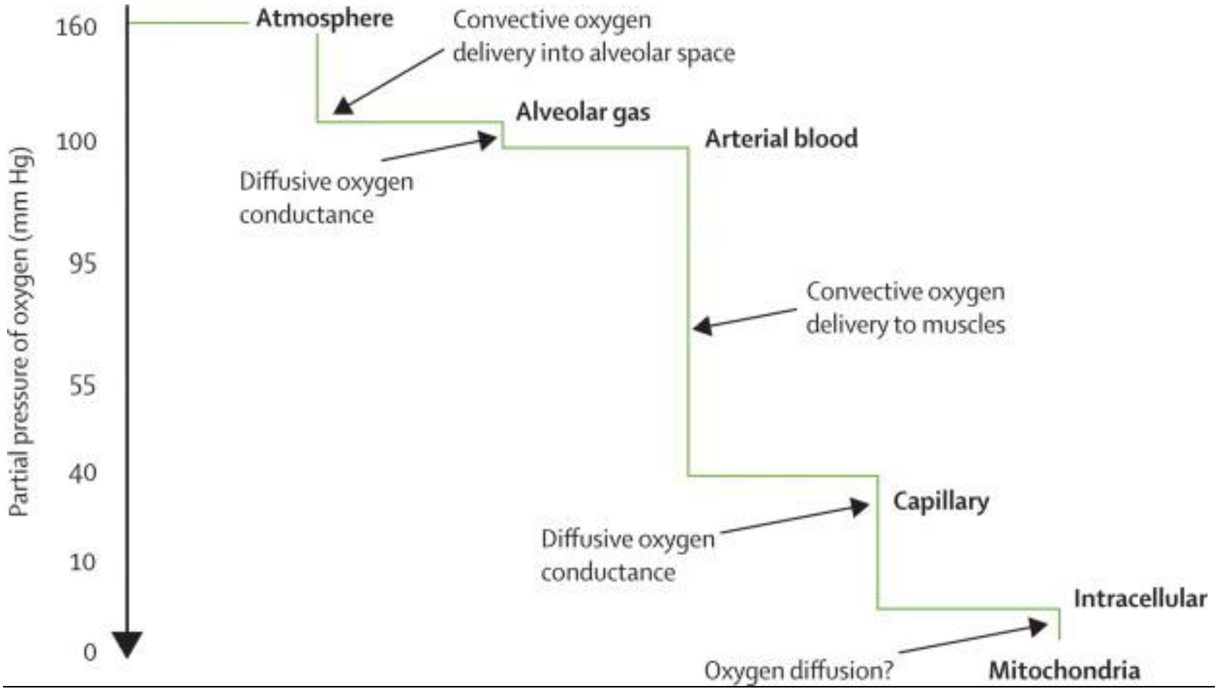

Figure 5: The sequential reduction in the partial pressure of oxygen throughout the oxygen cascade, from the air to mitochondria in muscle cells The Lancet Oncology. Volume 10, No. 6, p598–605, June 2009.

Oxygen carrying capacity:

1) Arterial oxygen content:
   - CaO_2 is the amount of oxygen bound to hemoglobin plus the amount of oxygen dissolved in arterial blood:
   - CaO_2 (mL O_2/dL) = (1.34 x Hb x SaO_2) + (0.0031 x PaO_2)
   - Normal CaO_2 is approximately 20 mL O_2/dL. [5,6]

2) Venous oxygen content:
   - CvO_2 is the amount of oxygen bound to hemoglobin plus the amount of oxygen dissolved in mixed venous blood:
   - CvO_2 (mL O_2/dL) = (1.34 x Hb x SvO_2) + (0.0031 x PvO_2)
   - Normal CvO_2 is approximately 15 mL O_2/dL. [6]

Oxygen delivery:

- Oxygen delivery (DO_2) is the rate at which oxygen is transported from the lungs to the microcirculation.
- DO_2 (mL/min) = Q x CaO_2
- Normal DO_2 is approximately 1000 mL/min.
- Or approximately 500 mL/min/m^2 if cardiac index is substituted for cardiac output. [6]

Oxygen consumption:

- Oxygen consumption (VO_2) is the rate at which oxygen is removed from the blood for use by the tissues.
- VO_2 (mL O_2/min) = Q x (CaO_2 - CvO_2) by Fick equation

- Normal VO_2 in a normal person at rest is approximately 250 mL O_2/min. [6]

Oxygen extraction:

- Oxygen extraction is the slope of the relationship between oxygen delivery (DO_2) and oxygen consumption (VO_2).
- O_2 Extraction Ratio = (CaO_2 - CvO_2)/CaO_2
- Normal O_2 extraction ratios range from 0.25 to 0.3. [6]

HYPOXEMIA AND HYPOXIA

- Hypoxemia is low oxygen tension in the blood-NR=80-100 mmHg.
- Hypoxia is low oxygenation at tissue level.

Type of hypoxia

- Hypoxemic hypoxia.
- Stagnant hypoxia or circulatory hypoxia.
- Anemic hypoxia.
- Histotoxic hypoxia.
- Oxygen affinity hypoxia. [7]

Hypoxemic hypoxia:

- $PAO_2 = Fio_2 \times (BP - PH_2O) - PCO_2 / R$.
- $PAO_2 = 0.21 \times (760 - 47) - 40 / 0.8 = 100$ mmHg.

Where:

- PAO_2 is the alveolar oxygen tension,
- Fio_2 is the fraction of inspired oxygen.
- BP is the barometric pressure (760 mmHg at sea level).
- PH_2O is the pressure of water vapor in the inspired air (47 mmHg),
- PCO_2 is the arterial carbon dioxide tension, and
- R is the respiratory quotient (assumed to be 0.8 in most patients).
- (the A-a gradient), the difference between alveolar and arterial oxygen tension (normal < 20).

Hypoxemic hypoxia Causes:

- **Low PaO_2;** (decreased Fio2, low barometric pressure, or causes of elevated Pco2). Any cause of hypoventilation will cause hypoxemia if Pco2 rises high enough.
- **V/Q mismatch;** in the lungs causing a widened A-a gradient. V/Q mismatch responds to oxygen therapy. Pneumonia, heart failure, and atelectasis are common causes of V/Q mismatch.
- **Increased pulmonary shunt:** Increased pulmonary shunt (Qs/Qt), resulting in perfusion without gas exchange which does not respond to oxygen therapy. Adult respiratory distress syndrome (ARDS) is an example of severe Qs/Qt. [7]

Stagnant hypoxia:

- Stagnant hypoxia also known as circulatory hypoxia. [7]

Causes:

- Decrease in cardiac output., Extremely low cardiac out-put (e.g., cardiogenic shock).
- Non-pulmonary shunt, like liver cirrhosis when large amounts of blood flow bypass the lungs entirely preventing gas exchange.

Anemic hypoxia:

- In anemic hypoxia, the reduction of tissue oxygenation is a consequence of low hemoglobin or hemoglobin with abnormal oxygen carrying capacity. [7]

Histotoxic hypoxia:

- In histotoxic hypoxia, oxygen is available but tissues will not able to utilize it due to binding with another agent like cyanide poisoning, where cyanide interferes with aerobic cellular metabolism and bind to tissue instead of oxygen. [7]

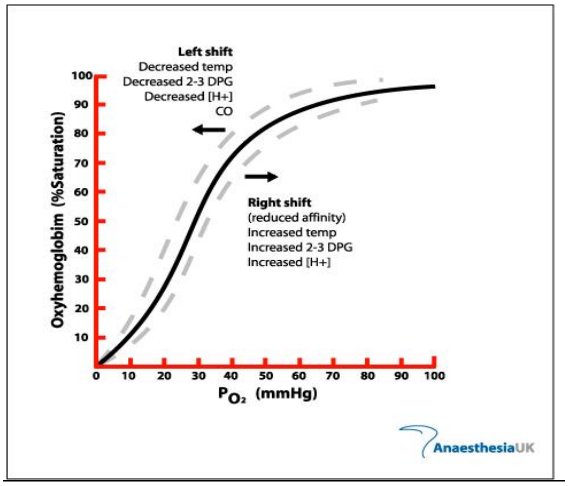

Figure 6: The oxygen dissociation curve from Anaesthesia UK. http://www.frca.co.uk/article.aspx?articleid=100345

CYANOSIS

Cyanosis is a physical sign causing bluish discoloration of the skin and mucous membranes. Cyanosis is caused by a lack of oxygen in the blood which may be due to many different causes. During airway management, it is mainly due to lack of oxygen because of airway obstruction or failure to secure patent airway. It is one of alerting signs, beside paradoxical breathing movements, cyanosis and intercostal retractions, which indicate respiratory insufficiency and impending arrest. Again, Cyanosis is alerting signs during airway management which occur during difficult or failure intubation or inadequate mask ventilation. [8]

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How to cite this article: Ejaimi G, Sittelnissa A. Saeed. An Introduction to Airway Assessment and Management (Concise Airway Anatomy and Pathophysiology). Ann. Int. Med. Den. Res. 2017; 3(1):AN01-AN07.

Source of Support: Nil, **Conflict of Interest:** None declared