Anesthesia effects on the respiratory system

The primary functions of the respiratory system are:
1. Ventilation; the movement of air into and out of the lungs.
2. Gas exchange; is the transfer of oxygen into the blood and carbon dioxide removal.

General anesthesia has several effects on both of these key functions. The passage of gas into the lungs may be impaired by obstruction of the airway; the distribution of gas within the lungs may change and the transfer of oxygen (and anesthetic gases) into the blood may be impaired.
Most of these adverse effects can be seen during anesthesia and in many patients, these extend into the postoperative period.

HOW ANAESTHESIA AFFECTS VENTILATION??

1. Airway obstruction

General anesthesia, with or without the use of neuromuscular blocking drugs, results in the loss of airway patency due to the relaxation of the pharyngeal muscles and posterior displacement of the tongue.
The ability to manage secretions is lost, and saliva and mucous can obstruct the oropharynx. The loss of the cough reflex allows secretions (or refluxed gastric contents) onto the vocal cords, causing laryngospasm, or to enter the trachea and lungs causing bronchospasm.
These effects result in airway obstruction and prevent the passage of gases into and out of the lungs resulting in hypoxia and hypercapnia.

2. Reduced ventilation

All anesthetic drugs (except ketamine, ether, and nitrous oxide) cause a dose-dependent reduction in minute ventilation. This can be due to either a reduction in the respiratory rate (e.g., opioids), a reduction in the tidal volume (e.g., volatile anesthetics), or both (e.g., propofol).

The ventilatory response to carbon dioxide is reduced by all anesthetic drugs, as a result, anesthetized patients become hypercapnic.

HOW ANAESTHESIA AFFECTS GAS EXCHANGE??

Anesthesia affects gas exchange by:

1. Changes in functional residual capacity (FRC)
2. Changes in ventilation and perfusion.
3. Hypoxic pulmonary vasoconstriction (HPV).

Oxygen is the gas of primary importance.

Oxygenation is dependent upon:

1. The inspired oxygen content.
2. The presence of a patent airway.
3. Adequate alveolar ventilation.
4. Appropriate matching between ventilation and perfusion in the lung.
5. The transfer of oxygen across the alveolar and endothelial membranes.

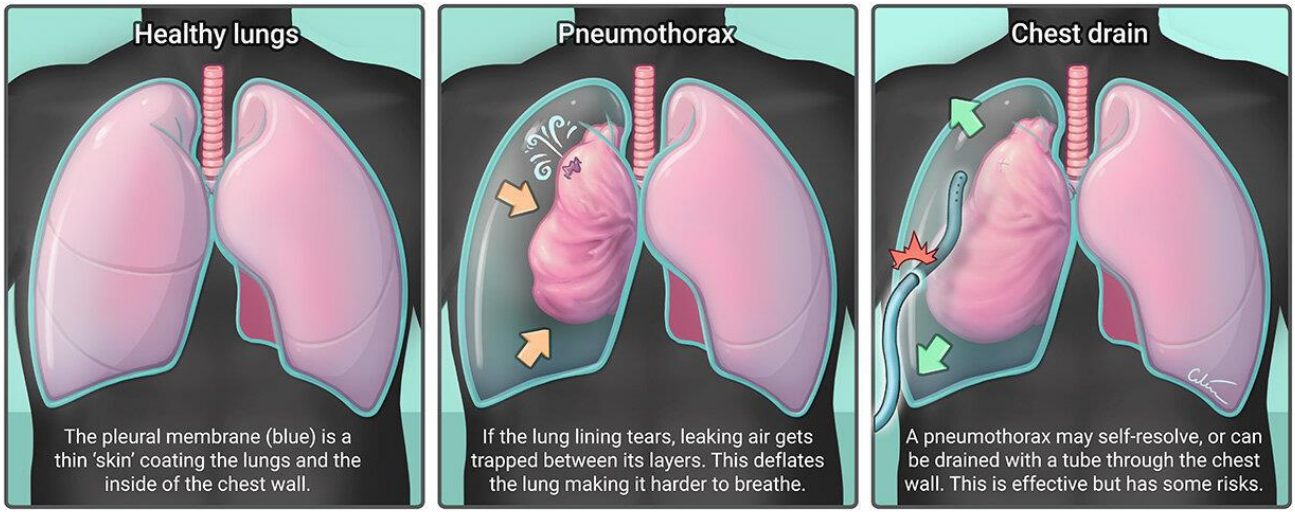
HOW MECHANICAL VENTILATION CAN DAMAGE LUNG TISSUE??

1.Acute Respiratory Distress Syndrome ARDS

Mechanical ventilation can directly damage lung parenchyma. Large tidal volumes (>12ml/kg) cause alveoli shearing stress, releasing inflammatory **substances**. These inflammatory mediators result in edema in the interstitial wall of the alveoli, which reduces lung compliance and gas transfer causing hypoxia. This is termed acute respiratory distress syndrome (ARDS) and results in prolonged stays in the intensive care unit (ICU) with a mortality of up to 40%.

2. Pneumothorax (Barotrauma)

Pneumothorax occurs when air is trapped between the two pleural layers of the lungs with a loss of negative pressure that causes the lung to collapse. High inspiratory pressures or large tidal volumes can cause pneumothorax,



THE PHARMACOLOGICAL EFFECTS OF ANAESTHESIA

Table 1. Summary of the effects of the main anesthetic drugs on the respiratory system.

Inhalational agents	*Positive effects*	*Negative effects*
Isoflurane	Bronchodilation	Reduced MV. Reduced response to hypoxia & hypercarbia. **Pungent** – causes coughing. Increased secretions.
Sevoflurane	MV stable Bronchodilation Non-irritant	Hypercarbia. Depressed response to CO2.
Halothane	Bronchodilation Non- irritant Reduced bronchial secretions	Reduced MV, Blunted response to hypoxia and hypercarbia.

Iv Induction agents	Positive effects	Negative effects
Thiopentone	……..	Dose dependent respiratory depression. Increased bronchial smooth muscle tone with increased bronchospasm & Laryngospasm.
Propofol	Laryngeal relaxation – ease of LMA insertion. Bronchodilation.	Respiratory depression. Reduced response to hypoxia & hypercarbia.
Ketamine	Preserved laryngeal reflexes. Maintain patent airway. Less respiratory depression. Reduction in bronchial smooth muscle tone.	Increased saliva and mucous production.
Opiates	Anti-tussive	Respiratory depression. Chest wall rigidity. Bronchospasm.

MV = Minute Ventilation
TV = Tidal Volume
RR = Respiratory Rate
HPV = Hypoxic Pulmonary Vasoconstriction
LMA = Laryngeal Mask Airway.

MANAGING THE EFFECTS OF ANAESTHESIA ON THE RESPIRATORY SYSTEM

I. pre-operatively

a. Positioning patients at a 45° angle before induction helps to reduce the fall in the FRC.
b. Pre-oxygenation to maximize the oxygen content of the FRC can significantly increase the time from apnea to hypoxia.
c. Antimuscarinic drugs (atropine, glycopyrrolate) given before induction reduce the quantity of saliva in the airway.

II. Intra-operatively

a. Mechanical ventilation, in particular for obese patients, reduces airway collapse and atelectasis. Positive end-expiratory pressure (PEEP) helps to maintain alveolar patency and prevent hypoxia. If the patient is breathing spontaneously, continuous positive airway pressure (CPAP) will have the same effect.
b. PEEP and recruitment maneuvers can be used to open collapsed portions of the lung. Recruitment is achieved by prolonged periods of high PEEP, Lung protective strategies that are used to treat ARDS can also be used safely for obese patients, bariatric and laparoscopic surgery, and the elderly during anesthesia to reduce atelectasis and increase oxygenation.

III. post-operatively

Oxygen can be continued into the postoperative period in patients at risk of hypoxia. Head-up tilt increases the FRC and helps prevent atelectasis. In obese patients, extubating on to a CPAP mask may help prevent airway collapse and atelectasis and maintain arterial oxygenation. Similarly, extubating ICU patients on to bi-level noninvasive ventilation has been shown to reduce the rate of re-intubation. Make sure the patient has good postoperative analgesia. Patients should be able to take deep breaths and cough.

Selects the best single choice

1- All the following are positive effects of ketamine on respiratory system except one
a) Reduction in bronchial smooth muscle tone
b) Maintain patent airway.
c) Less respiratory depression
d) Anti-tussive.
e) Preserved laryngeal reflexes.

2- All the following methods used to decrease the effect of anesthesia on respiratory system except one:
a) Oxygen can be continued into the postoperative period in patients at risk of hypoxia.
b) atropine, glycopyrrolate) given before induction reduce the quantity of saliva in the airway.
c) Head down position before induction helps to reduce the fall in the FRC.
d) Positive end-expiratory pressure (PEEP) helps to maintain alveolar patency and prevent hypoxia.
e) In obese patients, extubation onto a CPAP mask may help prevent airway collapse and atelectasis.

3- Negative effects of Isoflurane on respiratory system (all true except one
a) Increased secretions
b) Reduced minute ventilation.
c) Sweet odor.
d) Reduced response to hypoxia.
e) Reduced response to hypercarbia.

4- All the following anesthetic drugs cause a dose-dependent reduction in minute ventilation except one
a) Ketamine.
b) Propofol
c) Thiopental
d) etomidate.
e) Isoflurane.

5- Anesthesia affects gas exchange by (all true except one)
a) decrase FRC,
b) Increases shunt.
c) Increases VQ mismatch.
d) Suppress Hypoxic pulmonary vasoconstriction.
e) Increases in tidal volume.