Different strategies for lung recruitment in intensive care unit

Essay

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List of Abbreviations

Abbreviation	Meaning
A-a gradient	Alveolar to arterial gradient
AECC	American-European consensus conference
ALI	Acute lung injury
APRV	Airway pressure release ventilation
AR	Alveolar recruitment
ARDS	Acute respiratory distress syndrome
BAL	Broncho alveolar lavage
BiPAP	Bilevel positive airway pressure
BNP	Brain natriuretic peptide
CAT	Computed axial tomography
CMV	Conventional mechanical ventilation
COP	Critical opening pressure
CPAP	Continuous positive airway pressure
CSF	Cerebrospinal fluid
CT	Computed tomography
CXR	Chest X ray
DPG	Diphosphoglycerate
ECMO	Extra-corporeal membrane oxygenation
ERV	Expiratory reserve volume
e-sigh	Extended sigh
FEV_1	Forced expiratory volume in one second

Abbreviation	Meaning
Fio_2	Fraction of inspired oxygen in blood
FRC	Functional residual capacity
Hb	Hemoglobin
HFOV	High frequency oscillatory ventilation
IC	Inspiratory capacity
ICAM	Intercellular adhesion molecule 1
ICNARC	Intensive care national audit and research center
ICU	Intensive care unit
IL1,6,8	Inerleukin 1,6,8
IRF	Inspiratory reserve volume
mP_{aw}	Mean airway pressure
P_{atm}	Atmospheric pressure
$P_{critical}$	Critical opening pressure
$P\ H_2O$	Water vapor pressure
P_{plat}	Plateau pressure
PAI-1	Plasminogen activator inhibitor 1
P_Ao_2	Partial pressure of alveolar oxygen
P_ao_2	Partial pressure of arterial oxygen
Pco_2	Partial pressure of carbon dioxide
PCV	Pressure controlled ventilation
PEEP	Positive end-expiratory pressure
PFC's	Perfludrocarbons

Abbreviation	Meaning
PFT	Pulmonary function testing
P_L	Transpulmonary pressure
PS	Pressure support
PSV	Pressure support ventilation
PVR	Pulmonary vascular resistance
R	Respiratory quotient
RM	Recruitment maneuver
RV	Residual volume
SI	Sustained inflation
SO_2	Oxygen saturation
SP-D	Surfactant protein-D
SRM	Staircase recruitment maneuver
TLC	Total lung capacity
TNF	Tumour necrosis factor
TNFR-1	Tumour necrosis factor receptor 1
V/Q	Ventilation/perfusion relationship
VC	Vital capacity
VILI	Ventilator induced lung injury
V_t	Tidal volume
VWF	Von willebrand

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Introduction

Recruitment maneuver (RM) denotes the dynamic process of an intentional transient increase in transpulmonary pressure (P_L) aimed at opening unstable airless alveoli, which has also been termed alveolar recruitment maneuver ***(Tremblay and Slutsky, 2006).***

Recruiting the lung is a ventilatory strategy that can prevent ventilator-induced lung injury (VILI). This benefit may result from two mechanisms. The first is the increase in the aerated lung mass, which contributes to minimize the lung heterogeneity and to increase the size of the "baby lung". The second is the prevention of the repeated opening and closure of the terminal respiratory units ***(Halbertsma et al., 2010).***

RMs have probably long been used mostly to improve oxygenation, which is a good thing if this improvement results from or is associated with lung recruitment. However, the global effect of RM is actually a balance between positive effects (reduction in VILI, improvement in oxygenation) and negative effects (increase in VILI, hemodynamics impairment). From this balance, one can expect favorable or poor outcome of the patient ***(Guerin et al., 2011)***.

Alveolar recruitment can be achieved using a variety of techniques, and lack of standardization in this regard acts as a barrier to widespread use in critical care. The ideal technique would provide sustainable alveolar recruitment to correct and prevent hypoxemia, and improve lung mechanics (improving ventilation) while having a low incidence of complications/adverse effects. Additionally, to increase the potential for widespread implementation, an ideal RM would not be complicated and time consuming to perform. The techniques used to perform RM and the results obtained vary greatly among the different studies, in terms of both the timing and the duration of application. Both conventional and alternative mechanical ventilation modes can be used ***(Lapinsky and Mehta, 2005).***

Aim of the Work

The aim of essay is to discuss the role of different strategies of lung recruitment in mechanically ventilated patients in intensive care unit.

Anatomy

- **Trachea**

The trachea can be divided into two parts: upper (or cervical) and lower (or thoracic), including the tracheal bifurcation. The length of the trachea in the supine position is 10-13 centimeters from the laryngotracheal junction at C_6 (cricoid cartilage) to T_4 where the bifurcation is located. In upright posture, the trachea is located between C_6 and T_6 (Fig.1). The tracheal length may increase by approximately 1.5-2.5 cm during the processes of swallowing ***(Skandalakis et al., 2004)***.

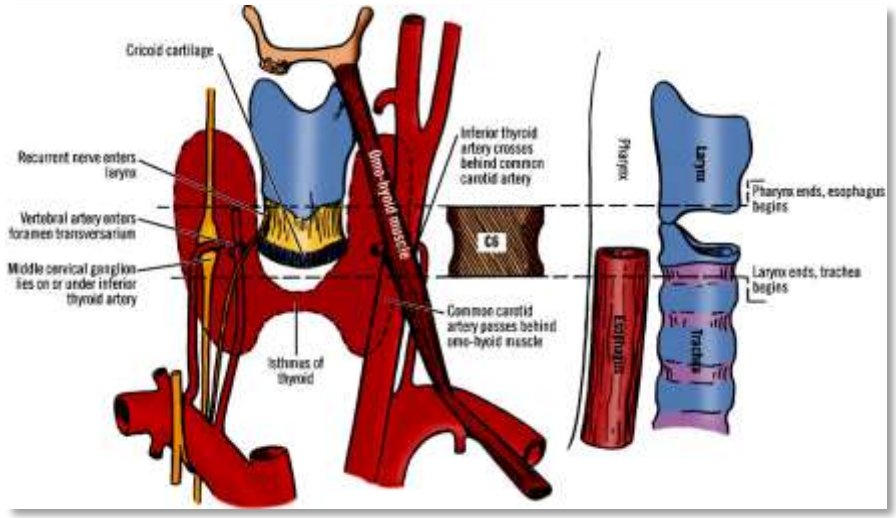

Fig. (1): Origin of the trachea at the level of the sixth cervical vertebra ***(Skandalakis et al., 2004)*.**

The trachea can be located totally within the mediastinum when the neck is flexed, because the cricoid cartilage drops to the level of the thoracic inlet ***(Ellis, 2006)***.

The position of the trachea is not fixed; it can deviate to the right or left because it is ensheathed within a stroma of loose connective tissue that also is related to the esophagus. The trachea has 15-20 U-shaped rings of hyaline cartilage that are responsible for the lateral rigidity of the organ. The rings are united by a thin elastic membrane. Posteriorly, the cartilages are united by the thin tracheal smooth muscle (the trachealis) ***(Endo et al., 2000)***.

- **Bronchi**

Each primary bronchus extends from the tracheal bifurcation to the hilum of the related lung. The shorter and larger (2.5 cm) right bronchus turns only slightly from the vertical orientation of the trachea through the mediastinum. The length of the left primary bronchus is almost double that of the right primary bronchus and passes more obliquely laterally to the left. The left bronchus crosses anterior to the esophagus to reach the left hilum behind the left third costal cartilage. Both bronchi have mobility and elasticity comparable to that of the trachea, although the

irregularity of the cartilaginous plates increases distally. The plates of cartilage decrease in prominence within the lungs, disappearing at the level of the bronchioles ***(Schuster et al., 2000)***.

The left lung is more vulnerable to bronchiectasis than the right, a clinical observation that could be explained on the basis of the anatomic peculiarities of the left main bronchus. The latter, when compared to the right bronchus, has a longer mediastinal course, a narrower diameter, and limited peribronchial space as it passes through the subaortic tunnel. The left lung, when compared to the right, is more vulnerable to the bronchiectatic process both in frequency and severity. Anatomic features of the left main bronchus make it more prone to obstruction than the right ***(Skandalakis et al., 2004)***.

Innervation

Sympathetic and parasympathetic innervation occurs through the pulmonary and cardiac plexuses. The bronchi are relatively insensitive to pain, and stimulation of their mucosal lining produces coughing ***(Tepas et al., 2000)***.

- **Lungs**

Structure

The lungs are composed of an external serous coat, a subserous areolar tissue and the pulmonary substance or parenchyma. The serous coat is the pulmonary pleura, it is thin, transparent, and invests the entire organ as far as the root. The subserous areolar tissue contains a large proportion of elastic fibers, that invest the entire surface of the lung, and extends inward between the lobules ***(Mary, 2000).***

The parenchyma is composed of secondary lobules which, although closely connected together by an interlobular areolar tissue, are quite distinct from one another. The secondary lobules vary in size; those on the surface are large, of pyramidal form, the base turned toward the surface; those in the interior smaller, and of various forms. Each secondary lobule is composed of several primary lobules, the anatomical units of the lung .The primary lobule consists of an alveolar duct, the air spaces connected with it and their blood vessels, lymphatic and nerves ***(Mary, 2000).***