Effects of Ventilatory Mode on Intraoperative and Postoperative Hypoxemia During One-Lung Ventilation in Thoracic Surgery

Essay

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By

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List of Abbreviations

ALI	:	Acute lung injury
ARDS	:	Acute respiratory distress syndrome
BB	:	Bronchial blocker
CO_2	:	Carbon dioxide
COPD	:	Chronic obstructive pulmonary disease
CPAP	:	Continuous positive airway pressure
CT scan	:	Computed tomography scan
DLT	:	Double lumen tube
$ETCO_2$	:	End tidal CO_2
ETT	:	Endotracheal tube
FBO	:	Fiberoptic bronchoscope
FiO_2	:	Fraction of inspired oxygen
FRC	:	Functional residual capacity
H_2O_2	:	Hydrogen peroxide
HFJV	:	High-frequency jet ventilation
HPV	:	Hypoxic pulmonary vasoconstriction
ICU	:	Intensive care unit
ID	:	Internal diameter
LIP	:	Lower inflection point
mm Hg	:	Millimeter Mercury
N_2O	:	Nitrous oxide
NO	:	Nitric oxide
OD	:	Outer diameter

List of Abbreviations (Cont.)

OLV : One lung ventilation

$PaCO_2$: Arterial Carbon Dioxide tension

PAO_2 : Alveolar partial pressure of O_2

PaO_2 : Arterial Oxygen tension

PCV : Pressure-controlled ventilation

PEEP : Positive end-expiratory pressure

PvO_2 : Mixed venous Oxygen tension

PVR : Pulmonary vascular resistance

Redox : Reduction oxidation

ROS : Reactive Oxygen species

RUL : The right upper lobe

SLT : *Single lumen endobronchial tubes*

TTE : Tracheal tube exchanger

V/Q matching: Ventilation perfusion matching

V_A : Alveolar ventilation

VATS : Video assisted thoracoscopic surgery

VCV : Volume-controlled ventilation

V_D : Dead space

V_T : Tidal volume

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الملخص

لسنوات عديدة ، كان يعتبر نقص التأكسج فى الشرايين أثناء التهوية الرئوية الأحادية المشكلة الأكثر أهمية بالنسبة لطبيب التخدير. في الوقت الحاضر هناك اهتمام متزايد إزاء الآثار المترتبة للوسائط المختلفة لأجهزة التنفس الصناعي فى اختيار طريقة مثلى تنفسية أو متغير التحكم الأمثل للتهوية أثناء التهوية الرئوية الأحادية.

تمثل جراحة الصدر مجموعة فريدة من المشاكل الفسيولوجية لطبيب التخدير التي تتطلب اهتماما خاصا. وتشمل هذه التغيرات الفسيولوجية الناجمة عن وضع المريض فى الوضع الجانبى، وفتح صدره (استرواح الصدر المفتوح) ، والحاجة إلى التهوية الرئوية الاحادية.

إن فهم الاعتبارات الفسيولوجية المتعلقة بهذا الخلل الحادث يقدم فكرة مهمة للتعامل مع التهوية الرئوية الأحادية وبالتالى التوقع والوقاية والعلاج من نقص التأكسج المتعلق بهذا النوع من الجراحات

لقد تم إدخال التهوية الرئوية الاحادية والعزل الرئوى لأول مرة من قبل كارلينز في الخمسينات من القرن الماضي عن طريق تصميمه لأنبوب تجويف مزدوج بخطاف . فى وقت لاحق تم تعديل تصميم الأنبوب ذو التجويف المزدوج وأدخلت تقنيات أخرى أحدث لعزل الرئة وأصبح استخدام منظار الألياف الضوئية حجر الزاوية فى تقنيات العزل الرئوى.

هذا التقدم الكبير فى تقنيات عزل الرئة يعطى طبيب التخدير خيارات متعددة لاختيار أفضل طريقة تناسب المريض ويعتبر الكثيرون أن هذا التقدم هو واحد من التفسيرات لخفض نسبة حدوث نقص التأكسج فى الدم المرتبط بهذا النوع من العمليات فى الآونة الأخيرة.

ان واحدة من الجوانب المهمة التى بحاجة إلى سيطرة جيدة خلال التهوية الرئوية الاحادية هى وضبط اجهزة التنفس الصناعي.لوقت طويل استخدمت تقنية

الحجم الرئوى المعتاد بحجم أكبر (١٠- ١٢ مل/ كج) ولكن استراتيجيات حديثة بدأت فى الظهور.

إن خفض الحجم الرئوى المعتاد الى (٥- ٦ مل/ كج) مع تطبيق الضغط الإيجابى فى آخر الزفير يعطى نتائج أفضل و أيضا " وضع الضغط المتحكم فيه " أفضل من "وضع الحجم المتحكم فيه" فى المرضى الذين يعانون من مرض الانسداد الرئوى المزمن الشديد والأمراض الفقاعية وأمراض الرئة المقيدة عند حدوث تقلبات كبيرة فى الضغط داخل الممر الهوائى وخاصة عند الافاقة والذى يكون غير مرغوب فيه.

وعلى الرغم من إبداء اهتمام كبير للتحكم فى التنفس الصناعى من خلال الرئة المستهوية إلا أن من المهم النظر فى المعاملة الانتقائية فى الرئة الغير المستهوية) لتحسين نسبة التأكسج بالدم بعدة وسائل.

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And at last, thanks to God who gives me all love and care as father to his beloved son

Peter Naiem

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Introduction

Indications and techniques for thoracic surgery have continually evolved since its origins. Common indications are no longer restricted to complications of tuberculosis and suppurative pneumonitis but now include thoracic malignancies (mainly of the lungs and esophagus), chest trauma, esophageal disease, and mediastinal tumours. Anesthetic techniques for separating the ventilation to each lung have allowed the refinement of surgical techniques **(Morgan et al., 2006).**

Thoracic surgery represents a unique set of physiological problems for the anesthesiologist that requires special consideration. These include physiological derangements caused by placing the patient with one side down (lateral decubitus position), opening the chest (open pneumothorax), and the need for one lung ventilation **(Morgan et al., 2006).**

During thoracic surgery, when the anesthetized patient is moved from the supine to the lateral decubitus position, significant alterations in the matching of ventilation and perfusion occur. The changes in ventilation and lung perfusion follow and are essential for the understanding of the perturbations seen with OLV **(Dunn, 2000).**

When switching from two-lung to one-lung ventilation shunt fraction increases, oxygenation is impaired and hypoxemia may occur. Hypoxemia during one-lung ventilation may be prevented by applying a ventilation strategy that avoids alveolar collapse while minimally impairing perfusion of the dependent lung **(Karzai and Schwarzkopf, 2009).**

Physiological Considerations During Anesthesia For Thoracic Surgery

Ventilation – perfusion matching

1. Lung ventilation

Pulmonary ventilation means the inflow and outflow of air between the atmosphere and the lung alveoli **(Guyton et al., 2006).**

Ventilation is measured as the sum of all exhaled gas volume in 1 min (minute ventilation).

The *tidal volume* is the volume of air inspired or expired with each normal breath; it amounts to about 500 milliliters in the adult male **(Guyton et al., 2006).**

Not all the inspired gas mixture reaches alveoli; some of it remains in the airways and is exhaled without being exchanged with alveolar gases. That part of the tidal volume (V_T) not participating in alveolar gas exchange is known as dead space (V_D). Alveolar ventilation (V_A) is the volume of inspired gases actually taking part in gas exchange in 1min.

$$V_A = \text{respiratory rate x } (V_T - V_D)$$

Dead space is actually composed of gases in non-respiratory airways **(anatomic dead space)** as well as in alveoli that are not perfused **(alveolar dead space).** The sum of the two is referred to as **physiological dead space.** In the upright position, dead space is normally about 150 ml for most adults (approximately 2 ml/kg) and is nearly all anatomic **(Morgan et al., 2006).**

Distribution of ventilation:

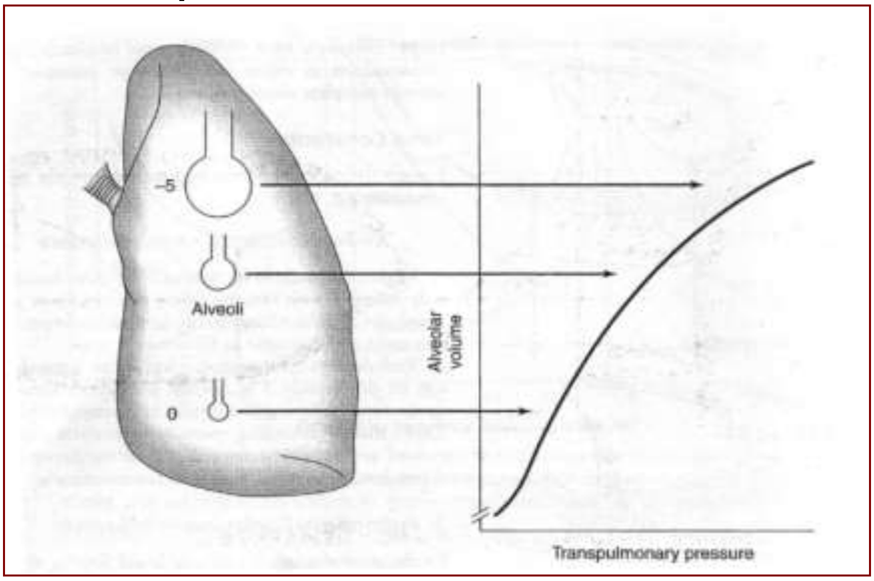

Fig. 1.1 The effect of gravity on alveolar compliance in the upright position **(Morgan et al., 2006).**

Regardless of body position, alveolar ventilation is unevenly distributed in the lungs. The right lung receives more ventilation than the left one (53% versus 47%), and dependent areas of both lungs tend to be better ventilated than do the upper areas because of a gravitationally induced gradient in intrapleural pressure (and necessarily transpulmonary pressure) **(Morgan et al., 2006).**

Pleural pressure decreases about 1 cm H_2O (becomes less negative) per 3 cm decrease in lung height. This difference places alveoli from different areas at different points on the pulmonary compliance curve **(Fig. 1.1).** Because of a higher transpulmonary pressure, alveoli in upper lung areas are near – maximally inflated and relatively noncompliant, and they undergo little more expansion during inspiration. In contrast, the smaller alveoli in dependent areas have a lower transpulmonary pressure, are more compliant, and undergo greater expansion during inspiration **(Morgan et al., 2006).**

2. Lung perfusion

Pulmonary blood flow serves three purposes. First, it delivers oxygen from the alveoli to the body, fueling metabolic oxygen demand. Second, it returns carbon dioxide to the alveoli for removal and exhalation. Third, it provides for left heart preload to support systemic cardiac output **(Lohser, 2008)**.

The pulmonary vascular bed is a low resistance conduit and possesses significant recruitable territory. This allows pulmonary pressures to stay low, even when cardiac output is increased to 30 L/min because of exercise **(Lohser, 2008).**

The major determinants of the distribution of pulmonary blood flow include *hypoxic pulmonary vasoconstriction (HPV), gravity, and non gravitational factors*.