Role of Pulse Oximetry and Capnography in Induced Hypotension

Essay Study

Submitted for the partial fulfillment of master degree in anesthesia

By

Mikhail Samy Fahmy Girgis

M.B.B.Ch

Under supervision of

Prof .Dr. Fikry Fouad Ahmed Elbokl

Professor of Anesthesia, Intensive Care and Pain Management
Faculty of Medicine
Ain Shams University

Prof . Dr. Waleed Abdel Megeed Mohammed

Professor of Anesthesia, Intensive Care and Pain Management
Faculty of Medicine
Ain Shams University

Faculty of Medicine
Ain Shams University
2016

ACKNOWLEDGEMENT

First and foremost thanks to the GOD who always helps me.

I am greatly honored to express my deepest gratitude to *Professor Dr. Fikry Fouad Ahmed Elbokl,* Professor of Anesthesiology, intensive care and pain management Ain Shams University, for his guidance, continuous concern and encouragement, and his sincere support.

My appreciation and thanks should be expressed to *Professor Dr. Waleed Abdelmegeed Mohammed Eltaher,* Professor of Anesthesiology, intensive care and pain management Ain Shams University, whose valuable advice and effort have made this work possible.

Lastly, I would like to thank my wife *Dentist Dr. Sally Samir Shawky* and every member of my family who helped me throughout the steps of this work and throughout all my life.

List of contents

List of abbreviations

AC: Alternating current
AMI: Acute myocardial infarction
ARDS: Acute respiratory distress syndrome
BP: Arterial blood pressure
CBF: Cerebral blood flow
CI: Cardiac index
cm: centimeter
cmH_2O: centimeter water (pressure measurement unit)
CO: Cardiac Output
COAD: Chronic obstructive airway disease
COPA: Cuffed oropharyngeal airway
COPD: Chronic obstructive pulmonary disease
CVP: Central venous pressure
DC: Direct current
DO_2: Oxygen Delivery
DH: Deliberate hypotension
ECG: Electrocardiogram
EEG: Electroencephalogram
EMI: Electromagnetic interference
$EtCO_2$: End-tidal carbon dioxide pressure
FiO_2: Inspiratory fraction of oxygen
$FSpO_2$: Oxygen saturation measured by finger pulse oximetry
GFR: Glomerular filteration rate
Hb A: Hemoglobin A
Hb: Hemoglobin
HbCO: Carboxy-hemoglobin
HbO_2: Oxygenated hemoglobin
HR: Heart rate
HPV: Hypoxic pulmonary vasoconstriction
ICP: Intracranial pressure
ICU: Intensive Care Unit
IR: Infra-red

KHz: Kilohertz
Laser: Light Amplification of Stimulated Emission of Radiation
LED: Light-emitting diode
LMA: Laryngeal mask airway
MAP: Mean arterial blood pressure
MetHb: Methemoglobin
MHz: MegaHertz
min: minutes
mmHg: millimeter mercury (pressure measurement unit)
mmol/L: millimole per liter
MRI: Magnetic Resonance Imaging
nm: nanometer
O_2: Oxygen molecule
Oxy-HB: Oxygenated hemoglobin
P_{50}: Oxygen tension of blood when oxygen saturation is 50%
PA: Pulmonary artery
PAC: Pulmonary artery catheter
PAOP: Pulmonary artery occlusion pressure
PaCO2: Arterial carbon dioxide tension
PaO2: Arterial oxygen tension
PAO2: Alveolar oxygen tension
PCO_2: Carbon dioxide tension of blood
PEEP: Positive end expiratory pressure
PETCO2: End tidal carbon dioxide pressure
PETO2: End tidal oxygen pressure
pH: Negative Logarithm of hydrogen tension of blood
$PHSpO_2$: Oxygen saturation measured by pharyngeal pulse oximetry
PI: Perfusion index
PO_2: Oxygen tension of blood
Ppa: Pulmonary artery pressure
Ppv: Pulmonary venous pressure
PISF: Interstitial fluid pressure
Ppl: Intrapleural pressure

PvO2: Mixed venous oxygen tension
QT: Cardiac out-put
RBCs: Red blood cells
SaO_2: Arterial oxygen saturation measured by blood gas analyzer
$ScvO_2$: Core venous oxygen saturation
SET: Signal Extraction Technology
SpO_2: Oxygen saturation measured by pulse oximetry
SV: Stroke Volume
SVR: Systemic Vascular Resistance
Temp: Temperature degree on Celsius scale
TNF: Tumor necrosis factor
VA/Q: Ventilation to perfusion ratio
VCO2: Carbon dioxide volume
VE: Minute ventilation
Vd: Dead space ventilation
VDALV: Alveolar dead space ventilation
VDANAT: Anatomical dead space ventilation
VDPHYS: Physiological dead space ventilation
VT: Tidal volume
W: Watt

List of figures

List of tables

Introduction
Introduction

It is known that the main task of the anesthesiologists is to ensure safety during anesthesia especially during the operations that require special techniques to facilitate the surgical procedure. for example, the operations that require usage of induced hypotension which is the reduction of the mean arterial blood pressure by 20 % of the base line mean blood pressure of the patient to facilitate exposure of the surgical field **(Donald, 1982).**

The main purpose of induced hypotension is to minimize blood loss to improve operating conditions or to decrease the need of blood transfusion **(Van, Miller, 2000).**

Several techniques are available to induce hypotension, physiological techniques like positioning and mechanical ventilation, pharmacological techniques like usage of volatile anesthetics, direct acting vasodilator drugs, alpha and beta adrenergic blocking drugs, calcium channel blockers and prostaglandin E1. And regional techniques are used like spinal and epidural anesthesia (**Smith, 2001).**

End tidal carbon dioxide is an indispensable monitor for ensuring safety in modern anesthetic practice. Capnography is used clinically as an estimation of carbon dioxide tension **(Gravenstein, 1995).**

Normally the arterial to end co2 difference gradient is less than 5 mm Hg in healthy awake persons. But during induced hypotension, alternation of ventilation to perfusion ratio occurs due to alternation of the ratio between physiological desd space and tidal volume leading to a decrease in end tidal co2 to a greater extent than the arterial co2 tension **(Shanker, Moseley, Kumar, 1991).**

These changes in the gradient may lead to erroneous resetting of the ventilator parameters to maintain the normal value of end tidal co2 tension. This may lead to increase in the value of the arterial co2 tension that could be lethal to the patient (delayed recovery, increased intracranial tension, hypertension, tachycardia). Also it can lead to increased bleeding during surgery which is not the aim of induced hypotension. Therefore, end tidal co2 tension must be correlated to arterial co2 tension during induced hypotension to avoid hypercarbia and its harmful effects **(Serebrovskaya, 1992).**

Despite of the physiological changes that occur during induced hypotension as changes in physiological dead space, cardiac output, and body metabolism, capnography still provides useful information during induced hypotension. For example, a sudden decrease in end tidal co2 can result in a sudden decrease in cardiac output (eg :- pulmonary embolism).Cpnography may help in avoiding hyperventilation because the decrease in arterial co2 tension would further decrease cerebral blood flow. Also capnography has a role in cardiac output monitoring (**Grundy, Nash, Brown, 1982).**

In most clinical settings, pulse oximetry provides continous oxygen saturation data and is used to identify and quantify episodes of hypoxia that could be lethal **(Moller, Pederson, Rasmussen, 1993).**

The pulse oximeter gives no indication about patients ventilation, only the oxygenation status, and thus can give a false sense of security related to ventilation status with administration of supplemental oxygen **(Karen, 2005).**

Older pulse oximeters have demonstrated issues with noise when amplifying weak signals in low perfusion. Conventional pulse oximetry assumes that arterial blood is the only blood moving (pulsating) in the measurement site. During induced hypotension, the venous blood pulsations are difficult to be characterized or eliminated which cause older pulse oximeters to display incorrect values. Current pulse oximetry technologies identify venous blood signal, isolate it, use mathematical methods, cancel the noise and extract the arterial signal. The current technology works accurate when conventional pulse oximeters fail (**Dan Hatlestad, 2002).**

During induced hypotension, the pulse pressure is small, so the noise element of the signal strength is stronger and the signal element is weaker. This noise present in the signal may cause inaccurate values by the usage of older pulse oximeters **(Palve, 1991).**

Aim of the essay

The aim of the essay is to discuss the role of pulse oximetry and capnography in induced hypotension.

History of pulse oximetry

Chronological development of pulse oximetry (Moyle, 2002).

A-1851 Beer–Lambert law.

B-1864 Georg Gabriel Stokes discovers a pigment that is the oxygen carrier in blood.

C-1864 Felix Hoppe-Seyler purifies the pigment and calls it hemoglobin

D-1876 Karl von Veirordt studies the reflection spectra of hemoglobin solutions and the finger.

E-1887–90 Carl Gustav Hufner (1840–94) studies absorption spectra.

F-1919 August Krough (1874–1949) and I Leicht use spectroscopic methods to measure oxygen saturation of blood in fish.

G-1931 Ludwig Nicolai (1904–) investigates the quantitative spectrophotometry of light transmitted through human tissues

H-1934 Kurt Kramer (1906–85) makes precise measurements of the oxygen saturation of blood flowing through cuvettes.

I-1935 David Drabkin (1899–1980) and James Harold Austin (1883–1952) measure the spectrum of undiluted haemolysed and non-haemolysed blood

J-1939–45 Second World War: great military interest in oximetry in pilots at high altitude.

K-1940 JR Squires passes red and infrared light through the finger web for the continuous monitoring of oxygenation; it requires compression of tissues to create a bloodless field for calibration.

L-1940–42 Glen Alan Millikan (1906–47) coins the term oximeter and develops the Millikan oximeter.

M-1948–50 Earl Wood (1912–) develops Wood's ear oximeter.