NEW FEATURES OF ANAESTHESIA MACHINE VENTILATORS

Essay

Submitted for Complete Fulfillment of the
Master Degree (M.Sc.) in
Anaesthesia

By

Shereen Refaat Mahmmoud
(M.B.; B.Ch.)
Resident of Anaesthesiology,
Faculty of Medicine, Cairo University

Supervisors

Prof. Dr. Randa Ismail Elbdawi
Professor of Anaesthesiology,
Faculty of Medicine, Cairo University

Prof. Dr. Hassan Mohammed Ahmed
Professor of Anaesthesiology,
Faculty of Medicine, Cairo University

Dr. Nashwa Nabil Mohammed
Assistant Professor of Anaesthesiology,
Faculty of Medicine, Cairo University

FACULTY OF MEDICINE,
CAIRO UNIVERSITY
2010

بسم ا الرحمن الرحيم

ACKNOWLEDGMENT

I would like to start by thanking ***ALLAH*** *for giving me the ability to complete this work.*

I would like to express my especial cordial thanks, endless gratitude and appreciation to Prof. Dr. ***Randa Ismail Elbdawi****, Professor of Anaesthesiology, Faculty of Medicine, Cairo University, for her supervision, advice and encouragement throughout this work.*

I am also greatly indebted to Prof. Dr. ***Hassan Mohammed Ahmed****, Professor of Anaesthesiology, Faculty of Medicine, Cairo University, who has guided me all through this work with his kind supervision.*

I am also grateful to Dr. ***Nashwa Nabil Mohammed****, Assistant Professor of Anaesthesiology, Faculty of Medicine, Cairo University, for her kind effort and support that made achievement of this work possible.*

Dedicated to

MY FATHER, MY BROTHER & MY SISTER

MY DEAREST HUSBAND

AND A SPECIAL THANKS TO MY

MOTHER WHO ALWAYS SUPPORTS

ME ALL THROUGH MY LIFE

LIST OF ABBREVIATIONS

AC	:	Assisted control ventilation
ADU	:	Anaesthesia delivery unit
APL	:	Adjusting pressure limiting
ARDS	:	Adult respiratory distress syndrome
ARV	:	Airway pressure release ventilation
C	:	Compliance
C dyn	:	Dynamic lung compliance
CC	:	Closing capacity
CL	:	Lung compliance
CMV	:	Controlled mechanical ventilation
CSF	:	Cerebral spinal fluid
CW	:	Chest wall compliance
DISS	:	Diameter index safety system
DLV	:	Differential lung ventilation
FGF	:	Fresh gas flow
FRC	:	Functional residual capacity
FVL	:	Flow volume loop
HFPPV	:	High frequency positive pressure ventilation
HFV	:	High frequency ventilation
IMV	:	Intermittent mandatory ventilation
IRV	:	Inverse ratio ventilation
KPa	:	Kilo Pascal
MAC	:	Minimum alveolar concentration
MEF	:	Mean expiratory flow
MIF	:	Mean inspiratory flow
MMV	:	Mandatory minute ventilation
NEEP	:	Negative end expiratory pressure
NRB	:	Non-rebreathing
OR	:	Operating room
P	:	Pressure gradient
$PaCO_2$	:	CO_2 tension in the arterial blood
PaO_2	:	O_2 tension in the arterial blood
PAO_2	:	O_2 tension in the alveolus
PCV	:	Pressure controlled ventilation
PEEP	:	Positive end expiratory pressure
PISS	:	Pin index safety system

PMGV	:	Piped medical gases and vacuum
Psig	:	Pounds per square inch gauge
PSV	:	Pressure support ventilation
PVL	:	Pressure volume loop
R	:	Airway resistance
SIMV	:	Synchronized intermittent mandatory ventilation
V	:	Rate of air flow
V/Q	:	Ventilation perfusion ratio
Vd	:	Volume of the dead space
VIC	:	Vaporizer inside the circle
VOC	:	Vaporizer outside the circle
Vt	:	Tidal volume
WOB	:	Work of breathing

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ABSTRACT

Anesthesiologists require an extensive knowledge of respiratory physiology to care for patients in the operating room and the intensive care unit. The respiratory system may be regarded as a collapsible elastic sac (the lungs) surrounded by a semirigid cage (the thorax) with a piston at one end (the diaphragm) supplied through a branching set of semirigid tubes (the airway and bronchial tree). The periodic exchange of alveolar gas with the fresh gas from the upper airway reoxygenates desaturated blood and eliminates CO_2. This exchange is brought about by small cyclic pressure gradients established within the airways. Control of breathing during spontaneous ventilation is the result of rhythmic neural activity in respiratory centers within the brain stem originates in the medulla. Two medullary groups of neurons are generally recognized: a dorsal respiratory group, which is primarily active during inspiration; and a ventral respiratory group, which is active during expiration. This activity regulates pulmonary muscles to maintain normal tensions of O_2 and CO_2 in the body. The basic neuronal activity is modified by inputs from other areas in the brain, volutional and autonomic, as well as central receptors The most important of these sensors are chemoreceptors that respond to changes in hydrogen ion concentration and peripheral receptors (sensors) Peripheral Chemoreceptors: the carotid bodies and the aortic bodies and Lung Receptors: stretch receptor are distributed in the smooth muscle of airways. There is different types of current models of anesthesia machine ventilators for example: Dräger Divan ventilator, The Fabius GS; Apolo ventilator, GE ADU ventilator; GE-Aisys, GE-Avance, GE Aespire

Keywords:

Anesthesia Machine Ventilators

Respiratory System

INTRODUCTION

INTRODUCTION

The anesthesia delivery system consists of various components that communicate with each other during the administration of inhalational anesthetics. System components include the anesthesia machine, the vaporizers, the anesthetic breathing circuit, the ventilator, and the scavenging system.

Ventilators generate gas flow by creating a pressure gradient between the proximal airway and the alveoli. Modem ventilators generate positive pressure and gas flow in the upper airway. Ventilator function is best described in' relation to the four phases of the ventilatory cycle: inspiration, the transition from inspiration to expiration, expiration, and the transition from expiration to inspiration. Although several classification schemes exist, the most common is based on inspiratory phase characteristics and the method of cycling from inspiration to expiration. Other classification categories may include power source (e.g. pneumatic-high pressure, pneumatic-Venturi, or electric), design (single-circuit system, double-circuit system, rotary piston, linear piston), and control mechanism (e.g. electronic timer or microprocessor)[1].

Traditionally ventilators on anesthesia machines have a double-circuit system design and are pneumatically powered and electronically controlled. Newer machines also incorporate microprocessor control that relies on sophisticated pressure and flow sensors. This feature allows multiple ventilatory modes, electronic PEEP, tidal volume modulation, and enhanced safety features. Some anesthesia machines (Draeger Fabius GS and 6400) have ventilators that use a single-circuit piston design.

In these traditional ventilators, factors contributing to a discrepancy between set and delivered tidal volumes are hazardous especially in pediatrics and some lung conditions (ARDS), so there is a greatly increased accuracy in tidal volume delivery achieved through compliance and leak testing and compensation, modem ventilators have an unprecedented tidal volume range (usually between 20-1400 ml)[2].

Compliance and leak testing[3]:

The accuracy comes with a price. An electronic leak and compliance test must be repeated every time the circuit is changed, particularly if changing to a circuit with a different configuration (adult circle to pediatric circle, or adult to long circuit). This test is part of the electronic morning check1ist.

The placement of the sensor used to compensate tidal volumes for compliance losses and leaks has some interesting consequences. In traditional ventilators, which are not fresh gas decoupled, the delivered tidal volume is the sum of the volume delivered from the ventilator and the fresh gas volume. Thus, delivered tidal volume may change as FGF is changed. There are two approaches to dealing with the problem:

1. The Drager Julian, Narkomed 6000 and Fabius GS use fresh gas decoupling. The fresh gas is not added to the delivered tidal volume. Thus, fresh gas decoupling helps to ensure that the set and delivered tidal volumes are equal.
2. The second approach is fresh gas compensation, which is utilized in the Aestiva, and S/5 ADU. The volume and flow sensors provide feedback which allows the ventilator to adjust the delivered tidal volume so that it matches the set tidal volume, in spite of the total fresh gas flow, or in case of changes in fresh gas flow.

Besides increased accuracy, the biggest improvement in current ventilators is their flexibility in modes of ventilation through:

- Offering Pressure controlled ventilation (PCV) allows more efficient and safe ventilation of certain types of patients.
- Offering modes that will support spontaneous ventilation which seen in anesthesia with much greater frequency due to the advent of the laryngeal mask airway (LMA). Modes which might be useful include SIMV, PSV, CPAP, and APRV[4].

Because of increased used of low flow anesthesia, high accuracy and efficiency with ensuring safety are required, so the modem ventilators provide factors which enhance the safety and efficiency of low flows which include:

- Compliance and leak testing, automatic leak detection.
- Fresh as compensation or decoupling.
- Warmed absorber heads (Julian, NM 6000).
- Low volume absorber heads allow faster equilibration of dialed and delivered agent concentration.
- Low fresh gas flows allowed by gas machine- most no longer have mandatory minimum oxygen flows of 200-300 mL/min (the exception is Julian with a minimum flow of 500 mL/min).
- Electronic detection of bellows not filling (Julian).
- Low flow wizard- an electronic monitor that gives indications when fresh gas flow is excessive or too low by monitoring gas volume passing through the scavenger (NM 6000)[5].

Aim of study:

To discuss the new features in modern anesthesia machine ventilator which include:

1. New measures added to the modem anesthesia ventilator to increase their accuracy regarding the set and delivered tidal volume even if changing to a circuit with a different configuration (adult circle to pediatric circle, or adult to long circuit).
2. Compliance and leak testing and their role in ensuring the accuracy.
3. Fresh gas flow decoupled and Fresh gas flow compensation.
4. New modes of ventilation that can be provided by the modern anesthesia machine.
5. Factors which enhance the safety and efficiency of low flow anesthesia.