Hazards of Anesthesia Gas Delivery System

An Essay

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Degree ***in Anesthesia***

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المخاطر التى قد تنتج عن أجهزة التخدير

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Summary

In 1917, Dr H Edmund G Boyle developed his continuous-flow anesthesia machine, the design of which is the forerunner of all modern anesthetic machines.

This has undergone significant changes to increase the efficiency of anesthesia and patient safety. Gases (oxygen, nitrous oxide and air) arrive at the machine via the hospital's piped medical gases via color-coded tubing. Cylinders must be present attached to the back of the machine to provide a back-up supply of gases. The gases pass through pressure-regulating valves into the 'back bar' of the machine. From there, gas flow rate is set using a needle valve that regulates flow into the rotameters which are fixed pressure, variable orifice flowmeters.

Modern anesthetic machines may have electronic gas mixers rather than conventional rotameters, Then the gases pass through a vaporizer where anesthetic is added to the fresh gas flow and this mixture is delivered via the common gas outlet to a patient breathing circuit usually a 'circle system'. This circulates gases and vapours and contains a carbon dioxide absorber to stop patients re-breathing carbon dioxide, also waste gases are scavenged.

Monitoring, ventilators and suction apparatus are all incorporated into the machine.

The anesthesia breathing system (patient circuit) represents the interface between the patient and the anesthesia delivery system. While not all equipment failures are preventable, appropriate monitoring of the patient circuit should lead to early detection of failures and enable prompt intervention before the patient suffers any harm. Aspects of the patient circuit that can be routinely monitored include pressure, volume, capnography, respiratory gas composition

List of abbreviations

AANA	:	American Association of Nurse Anesthetists
APSF	:	Anesthesia Patient Safety Foundation
APV	:	Adjustable Pressure Valve
ASA	:	American Society of Anesthesiologists
ASTM	:	American Society for Testing and Materials
CGA	:	Compressed Gas Association
ECG	:	Electrocardiogram
FG	:	Fresh Gas
IPPV	:	Intermittent Positive Pressure Ventilation
kPa	:	kilo Pascal
MAC	:	Minimal Alveolar Concentration
MRI	:	Magnetic Resonance Imaging
OD	:	Outer Diameter
PEEP	:	Positive End-Expiratory Pressure Valve
PMGV	:	Piped Medical Gases and Vacuum
Psig	:	Pound-force per square inch gauge
SVP	:	Saturated Vapour Pressure

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الملخص العربي

صمم الدكتور ادموند بويل فى عام ١٩١٧ آلة تخدير الدفق المستمر، وظل تصميمه الرائد لكافة أجهزة التخدير الحديثة بعد ذلك.

وقد شهدت هذه الاله تغييرات هامة لزيادة كفاءة التخدير وسلامة المرضى حيث تصل الغازات (الأكسجين وأكسيد النيتروز والهواء) إلى الجهاز عبر أنابيب مميزه اللون و تعلق على الجزء الخلفى من الجهاز اسطوانات لتوفير إمدادات احتياطية من الغازات ثم تمر الغازات عبر صمامات تنظم ضغط الغاز في الجزء الخلفى من الآلة و من هناك، يتم تعيين معدل تدفق الغاز المطلوب باستخدام مقياس للتدفق يتميز بأنه متغيرٍ القطر مع ثبات ضغط الغاز.

تشمل أجهزة التخدير الحديثة تقنيات لخلط الغاز الكترونياً بدلا من صمامات الغاز المعتادة و تمر الغازات عبر مبخر ليضيف عليها الأدوية المخدرة ليتم توصيلها بعد ذلك إلى خارج جهاز التخدير من مخرج عام لتصل إلى المريض عبر وصلات التخدير التى تسمح عادة بتوفير الغازات و الأدوية المخدرة عن طريق إعادة سريانها إلى المريض مع التخلص من غاز ثانى أكسيد الكربون .

تشمل أجهزة التخدير الحديثة أيضا أجهزه لمراقبة الوظائف الحيوية للمر يض, أجهزه لضخ الغازات لرئته وجهاز شفط.

تمثل وصلات التخدير حلقة وصل بين المريض و جهاز التخدير وبالرغم من أنه ليست كل أعطال جهاز التخدير يمكن منعها إلا أن استخدام أجهزة المراقبة المناسبة تمكننا من اكتشافها مبكراً قبل حدوث ضرر للمريض و يمكن بصوره روتينيه متابعة ضغط و حجم و نسبة ثانى أكسيد الكربون و مكونات الغازات التى يستنشقها المريض.

أن الاستخدام المناسب لأجهزة المراقبة الحديثة يمكنه الكشف عن معظم الأعطال الناتجة عن جهاز التخدير وقد تم مناقشة كل جهاز من حيث استخدامه و أوجه قصوره.

Acknowledgement

First of all, all gratitude is due to ***God*** *for blessing this work, until it has reached its end, as a part of his generous help, throughout my life.*

Really I can hardly find the words to express my gratitude to ***Professor/Amir Ibrahim Salah*** *Professor of Anesthesia and intensive care, Faculty of Medicine, Ain Shams University, for his supervision, continuous help, encouragement throughout this work and great effort he has done in the meticulous revision of the whole work. It is a great honor to work under his guidance and supervision.*

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Last but not least, I dedicate this work to my family, whom without their sincere emotional support, pushing me forward this work would not have ever been completed.

Yassmine Hassan Abd El-Sattar

Introduction

The incidence of serious complications associated with anesthesia appears to have decreased in recent years. There are many reasons for this: better anesthetic drugs and equipment, widespread availability of modern monitoring devices, improved standards of pre-, intra- and postoperative care, increasing interest in techniques to identify and control common risk factors and increased number of qualified anesthetists. Nevertheless, accidents continue to occur **(Sigurdsson and McAteer, 1996)**.

In studies that address the issue of anesthetic mishaps, human error and insufficient pre-anesthetic checking of the anesthesia machine are a recurring theme. **In (1981) Craig and Wilson** found that human error was responsible for 65% of the incidents "with failure to perform a pre-anesthetic check, the most common associated factor." **Fasting and Gisvold In (2004)** noted that 31% of equipment problems involved the anesthesia machine and breathing circuit, with the main cause of human error being insufficient checking of the anesthesia machine before use, especially between cases. The possibility for error and cause for concern regarding anesthesia machine checks are very clear.

In an effort to reduce or eliminate anesthetic mishaps related to anesthesia machine problems, preoperative checklists have been developed to assure proper functioning of equipment. The Food and Drug Administration released a checklist in 1986 which it revised in 1992. Professional organizations and anesthesia machine manufacturers have also developed such checklists **(Morrison, 1994)**.

Aim of the work

This study reviews failures and complications of anesthesia delivery systems from the view points of how they may be detected and thereby harm to the patient prevented.

Components and Hazards of Anesthesia Gas Delivery System

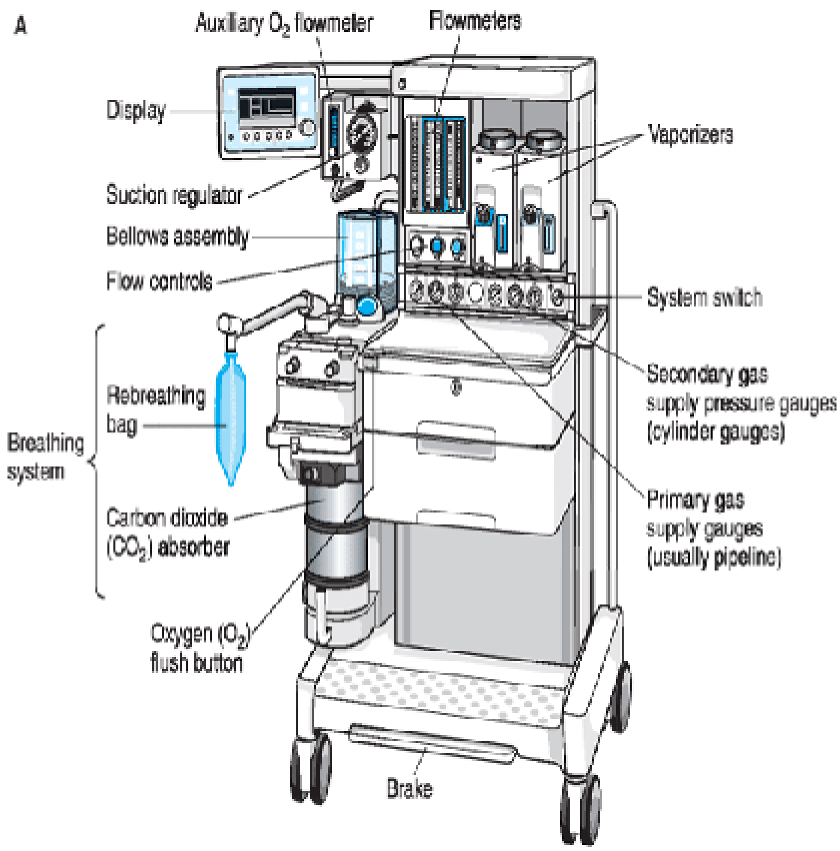
Anesthetic machines are used to:

- Supply compressed gases.
- Measure gases flow.
- Add vapors in known concentration.
- Deliver gases and vapors to patient via a breathing system.
- Scavenge waste.
- Monitor machine and patient **(Morgan et al., 2001).**

Components of anesthetic machine (Fig.1 A&B)**:**

I. The anesthetic machine delivery system (The pipeline and cylinder systems).
II. Rotameters.
III. Vaporizer.
IV. Breathing system.
V. Ventilator.
VI. High flow oxygen flush.
VII. Common gas outlet.
VIII. Scavenging system.
VIII. Monitor and suction device

(Morgan et al., 2001).


A
Auxiliary O_2 flowmeter
Flowmeters
Display
Vaporizers
Suction regulator
Bellows assembly
Flow controls
System switch
Rebreathing bag
Breathing system
Secondary gas supply pressure gauges (cylinder gauges)
Carbon dioxide (CO_2) absorber
Primary gas supply gauges (usually pipeline)
Oxygen (O_2) flush button
Brake