Anesthesia Machine

Introduction

Brigham and Women’s Hospital
New Residents
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Anesthesia Machine

Introduction

James H. Philip, MEE, MD, CCE
Anesthesiologist, Director of Bioengineering
Brigham and Women’s Hospital
Associate Professor of Anaesthesia
Harvard Medical School
Clinical Care Interactions

Anesthetist

Patient

Work-station

OR

Hospital World

Inhalant Drugs
IV Drugs, Fluids
Other

requests

Care Info
(lab data, image..)

Monitorings

touch observe
(senses)

observe (eyes, ears)

touch

ADS, monitors,
PIMS
Anesthesia Delivery System (ADS)
Workstation - Patient Interactions

Airway control
Breathing
Circulation
Drug delivery for anesthetization
Workstation - Patient Interactions

Airway control
Breathing - safe gases
Circulation
Drug delivery for anesthetization
  vapors, gases, IV
Intravenous Liquid Delivery
Monitoring
Recording
Breathing - safe gases

Drug delivery for anesthetization vapors, gases
Anesthesia Machine Evolution
1846 Morton Ether Inhaler
Inhaler had limitations
This 1850 version worked horizontal with no hands required.
Open Circuit Inhaler

Open Circuit = Non-rebreathing
Patient breathes in the ether vapor, breathes ether out (and it is discarded)
Breathes in new ether vapor
Breathes it out again (discarded)
Manual Resuscitator

Open Circuit =
non-rebreathing Circuit =
what you set is what you get
What you put into the circuit is what the patient gets

Give sufficient 100% oxygen flow to the reservoir bag
(not to empty)
Reservoir bag gives 100% oxygen to the breathing bag

The Tidal Volume and Minute Ventilation is
determined by the size and frequency of the
squeeze of your hand and a perfect seal.
Manual Resuscitator

One-way valves make sure gas flows to the patient

A special valve allows exhaled gas to be removed
Manual Resuscitators

Bag Reservoir

Hose Reservoir
A bag reservoir lets you see it provides 100% oxygen to the breathing bag by never emptying and never entraining room air.
Partial Rebreathing Circuits are used in Anesthesia

Don’t throw away all the exhaled gas
It contains expensive anesthetic vapors
Reuse as much as possible somehow (learn more later)
Remove (Absorb) CO₂ and
Rebreathe the anesthetic

Partial rebreathing = semi-closed circuit
All ADSs use them
Rebreathing Ventilation

Is not for dummies
Requires knowledge and skill
Makes us different from other care providers
EMT, Sedation RN,
ED MD, Hospitalist,
Others
1890 added a Breathing Circuit
1925
Draeger

1927
Foregger
added CO$_2$
absorption
1950 added a work surface
Then, Drawers, Temperature-compensated vaporizers, Circuit, Absorber, Common gas outlet
1990 Integrated Monitors and Data Recording
GE-Datex-Ohmeda
Central Display
(CD)
ADS
2000

Better ventilation for difficult patients
FGF-independent ventilation
Corrects for circuit leaks
More sensitive to water vapor
Monitors not integrated
2000
GE Aestiva

At BWH, now in L&D and MOR for HeliOx for ENT Surgery where low density Helium moves through narrow orifices
2000 Draeger Fabius (BWH many ORs)
2005-2010 state-of-the-art

GE Aisys MOR - many rooms

Draeger Apollo GS MOR - 6 rooms
Not yet for CA1s
Basics of the Anesthesia Delivery System
Anesthesia Delivery System - ADS

Anesthesia Machine
Breathing Circuit
Ventilator
Anesthesia Machine delivers gases and vapors into a breathing circuit.

Provides continuous flow of -
- Oxygen for Life
- Air to safely lower $F_1O_2$
- Nitrous Oxide for partial anesthesia
- Agent vapor for complete or partial anesthesia
(Continuous Flow) Anesthesia Machine

N₂O  Air  O₂

Vaporizer

Common Outlet

FGF (Fresh Gas Flow)

Isoflurane  Sevoflurane  Desflurane

Vaporizer

mL/mL/mL/mL/mL/mL/mL/mL/mL/mL/mL/mL/mL/mL/mL

L/m: 9  8  7  6  5  4  3  2  1  0

L/m: 9  8  7  6  5  4  3  2  1  0

L/m: 9  8  7  6  5  4  3  2  1  0

mL/m: 900  800  700  600  500  400  300  200  100  50
Flow Tubes
Oxygen and Gas Delivery

Mechanical
Physical knobs
Rotameters,
GE Aestiva, Aespire
Oxygen and Gas Delivery

**Mechanical**

- Physical knobs
- Rotameters, Digital meters
- Draeger Fabius
- Draeger Apollo
Oxygen and Gas Delivery

Electronic
Virtual knobs

Digital meters
GE Avance, Aisys

% Oxygen in FGF
NOT inspired - be careful

GE Avance, Aisys
Vaporizer Types

Mechanical
- Penlon Sigma for isoflurane, sevoflurane
- GE Tec 3,4,5,7 for isoflurane, sevoflurane
- GE Tec 6 for desflurane (electro-mechanical)
- Draeger Vapor 19, 2000 for all agents
- Direct-reading, temperature-compensated

Electronic
- GE Aladin for all agents
Anesthesia Machine
Figure 10-2. Schematic diagram of internal circuitry of an anesthesia machine.
Figure 10-2. Schematic diagram of internal circuitry of an anesthesia machine.
Patient Breathing Circuit

Allows cyclic flow
To and from the patient
(AKA Breathing)
Patient Breathing Circuit

First address spontaneous and manual ventilation
Figure 10-8. Schematic diagram of a circle absorption anesthetic breathing system.
Figure 10-8. Schematic diagram of a circle absorption anesthetic breathing system.
The Circle-Absorber System

Gas Flows

Sampled
200 mL/min

Expired

Collected

CO₂ Absorbant

Inspired

Rebreathed

Exhaust

Fresh
The Circle-Absorber System

Gas Flows

Exhaust

Expired

Rebreathed

Fresh

Inspired

200 mL/min

CO₂ Absorbant
The Circle-Absorber System

Gas Flows

Exhaust

Expired

Rebreathed

Fresh

Inspired

CO₂ Absorbant
The Circle-Absorber System

Gas Flows

Fresh

CO₂ Absorbant

Exhaust

Expired

Rebreathed

Inspired

To Patient
The Circle-Absorber System

Gas Flows

Expired

Rebreathed

Inspired

From Patient

Fresh

CO$_2$ Absorbant

Exhaust
The Circle-Absorber System

Gas Flows

Expiration

Expired

Inspired

Fresh

Rebreathed

CO$_2$ Absorbant

Exhaust (APL)
The Circle-Absorber System

CO₂ Absorbant

Exhaust (APL)

Expired

Gas Flows

Spontaneous breathing requires Exhaust Pressure = 0

Fresh

Inspired

Rebreathed
The Circle-Absorber System

Manual ventilation requires Exhaust Pressure $\geq 0$

Gas Flows

Expired

Expired

Inspired

Inspired

Fresh

Fresh

Rebreathed

Rebreathed

CO$_2$

CO$_2$

Absorbant

Absorbant

Exhaust (APL)
The Circle-Absorber System

Exhaust (APL)

Expired

Rebreathed Gases (O2, N2O, Agent)

CO2 Absorbant

Fresh

Inspired
The Circle-Absorber System

Gas Flows

Exhaust

Expired

Rebreathed Gases

No CO₂ rebreathed

CO₂ Absorbant

Fresh

Inspired
The Circle-Absorber System

Gas Flows

Exhaust

Expired

No Rebreathed Gases

No CO₂

Fresh

Inspired

CO₂ Absorbant

No CO₂
The Circle-Absorber System

Gas Flows

Exhaust

Expired

Rebreathed Gases

No CO₂

Fresh

Inspired
The Circle-Absorber System

Gas Flows

Expired

Inspired

Exhaust

Fresh

$V_E$

$\text{CO}_2$

Absorbant
Gas is sampled from circuit near patient for I/E measures.

Gas Flows:

- **Exhaust**
- **Expired**
- **Sampled 200 mL/min**
- **Inspired**

Fresh gas flows into the system, and expired gas flows out. The circuit contains a **CO₂ Absorbant** to absorb carbon dioxide. The **VE** (ventilation volume) is indicated in the diagram.
Mechanical Ventilation

Set with a switch (Elec or Mech)
Exhaust Valve is out of circuit
Reservoir bag is
  In circuit with Draeger piston
Out of circuit with GE bellows
Low FGF

More rebreathing
Inspired more dependent on Expired
Inspired less influenced by Vaporizer
The Anesthesia Workspace
Workspace Setup

MRSMAID

Machine
Room
Suction
Monitors
Airway
IV
Drugs
Workspace Setup

MRSMAID

Machine
Room
Suction
Monitors
Airway
IV
Drugs
Suction off if:
DISS hose unscrewed
Wall switch off
Hose disconnect from Canister
Canister switch off
Insert seated incorrectly
Any hole open
Flap valve closed
  because unit was shaken
  or canister is full
Flexible hose kinked
Flexible hose stepped on
Perform Machine-Assisted Tests

GE Modulus 2 Plus - none

GE Aestiva - Minor
  12 Hour switch off and on
  Circuit Oxygen Sensor Cal via SmartVent ventilator

GE Aisys - Major
  Most circuit tests are automated
  Bellows volume & pressure can feel the circuit
  and make great ventilation modes

Draeger Fabius - Major
  Most circuit tests are automated
  Ventilator Piston can feel the circuit
  and make great ventilation modes

Draeger Apollo – Major
  almost everything
CALIBRATE OXYGEN MONITOR

Oxygen Monitor on & sensor in air with hole plugged. Calibrate to 21%. Reconnect sensor in circuit.

There is no separate oxygen monitor on Aisys or Apollo. These include integrated gas monitoring including $F_iO_2$ obtained by sampling the gas at the wye (AKA “Y”).

The separate sensor is a Clark Electrode.

The sampled gas monitor is:
- Polarographic for the symmetrical oxygen molecule
- Infra-red absorption for all other asymmetrical molecules
  - $CO_2$, $N_2O$, Isoflurane, Sevoflurane, Desflurane
CHECK MACHINE FOR GAS DELIVERY

Machine On
Oxygen flows smoothly
Disconnect oxygen hose
Oxygen alarm sounds
Switch ON oxygen tank. Verify $P > 1000$ psi and Alarm silences.
Tank off with wrench
Turn oxygen flow up
Alarm sounds oxygen failure
Connect oxygen hose to silence alarm.
Turn up nitrous and observe alarm and/or control.
Negative Pressure Test - later
CHECK CIRCUIT FOR INTEGRITY

Attach circuit including reservoir bag
Occlude “Y” with thumb
Flush and fill bag to 30 cmH2O.
Test pressure alarms
Open relief valve and verify that reservoir bag empties
Observe scavenger bag fill and empty
CHECK FUNCTION

CHECK **VENTILATOR** FOR FUNCTION
Ventilate Test Bag and observe no volume loss.

CHECK **SCAVENGER** FOR FUNCTION
Check that reservoir bag fills and empties. Check valves not stuck.
This pre-use check is basic

We believe this will keep you and your patient safe for the next few weeks

Following the automated tests on Fabius, Aisys, Apollo will test all the functions of your anesthesia machine

We will have an Anesthesia Machine Workshop next month
Thank you