

# **The Anesthesia Machine**

You are the master of the machine

 You are responsible for checking the machine prior to each case

<u>1</u>

# The Anesthesia Machine (con't)

The primary cause of machine malfunction is failure to check
Never start without the

**American Express items** 

# What is the function of the anesthesia machine?

# **Functions of the Machine**

Convert supply gases from high pressure to low pressure
Convert liquid agent to gas
Deliver in a controlled manner

# **Functions (con't)**

 Provide positive pressure for ventilation

 Alert the provider to malfunction

 Prevent delivery of a hypoxic mixture

# **Components of the Machine**

- Source gases
- Vaporizers
- ♦ Circuit
- Ventilator
- Scavenging system

# **Safety Standards**

 1979 -- Standards set for all machines sold in the U.S.
 ANSI -- (American National Standards Institute)

-Released 1979 standards

# Safety Standards (con't)

 ASTM -- (American Society for Testing and Materials)
 –Upgraded standards in 1988

# **The Generic Machine**

- 2 sources of gas
  - -Pipeline 50 psig
  - -Tanks
    - »Oxygen: 2200 psig
    - »Nitrous oxide: 745 psig
    - »Both reduced to 45 psig upon
      - entering the machine

# The Generic Machine (con't)

Fail safe system (OFPD)

 Stops flow if O<sub>2</sub> supply is lost

 Oxygen supply pressure alarm
 Second stage regulators

 Reduces pressure to 14 psig

# The Generic Machine (con't)

- Flow control valves
  - -Regulate gas flow
  - -Separates high and low pressure circuits
- Common manifold

# The Generic Machine (con't)

- Vaporizer
- Outlet check valve
- Oxygen flush valve

# **Gas Sources**

- Oxygen analysis is <u>always</u> required
- Pipeline
  - -Enter at 50 psig
  - -Gauge is on source side
  - -DISS (Diameter Index Safety System)
    - »prevents gas swap

# Gas Sources (con't)

# Side tanks

- -Usually E cylinders
  - »Know pressure and volumes
- -Enter at 45 psig
- -Should be off unless in
  - emergency use
    - »Prevents silent emptying

# Gas Sources (con't)

Pin index safety system
 Prevents tank swaps
 Pin positions
 Air 1-5
 Oxygen 2-5
 Nitrous oxide 3-5

# Gas Sources (con't)

 Machine will use pipeline gas unless supply pressure drops below 45 psig

# **Fail Safe Devices**

- Required by standards
   Stop flow of other gases if oxygen flow is interrupted
- Types
  - -Threshold
  - -Proportioning

# **Proportioning Systems**

Prevent delivery of less than

25% oxygen

Either mechanical or

pneumatic interface

#### Ohmeda Link-25 Proportion System

 Chain connects O<sub>2</sub> and N<sub>2</sub>O flow control valves

 As N<sub>2</sub>O is increased, the chain will turn O<sub>2</sub> control to maintain at least 25% O2. Oxygen is increased

#### Ohmeda Link-25 Proportion System (con't)

 Maintains 3:1 ratio with combination of mechanical and pneumatic

# **Drager ORMC**

Pneumatic N<sub>2</sub>O interlock

Mobile shaft

- Slave control valve
- Pressure moves shaft and
  - opens or closes slave valve

# **Drager ORMC (con't)**

- N<sub>2</sub>O flow is <u>reduced</u> to maintain 25% O<sub>2</sub>
- Electrical contact provides alarm
  - Functional only in the O<sub>2</sub> / N<sub>2</sub>O mode (not in the "all gases" mode)

#### Limitations of Proportioning Systems

- Wrong gas supply
- Defective operation
- Leaks downstream
- Inert gas administration

# **Flow Meter Assembly**

Controls and measures gas flow

- Thorpe tubes are tapered
- Indicator float is calibrated for specific tube
  - Density and viscosity differ
- Gas flows around float
  - Annular space

# **Flow Meter Standards**

- Oxygen flow control knob
  - -Physically different
  - -Larger and projects further
  - -Different shape
- All knobs are color coded
- Knobs are protected

# Flow Meter Standards (con't)

- Low flow tubes for O<sub>2</sub> and N<sub>2</sub>O
- Color coded flow tubes
- Thorpe tubes protected
- Tubes are <u>not</u> interchangeable
  - -Float, tube and scale are single unit

## Flow Meter Standards (con't)

 <u>Note</u>: Flow meters are located downstream from all safety devices except the oxygen analyzer.

# Leaks

- Cracked tubes
- Faulty connections
- •May create hypoxic mixture
- Oxygen is <u>always</u> downstream
  - from other gases

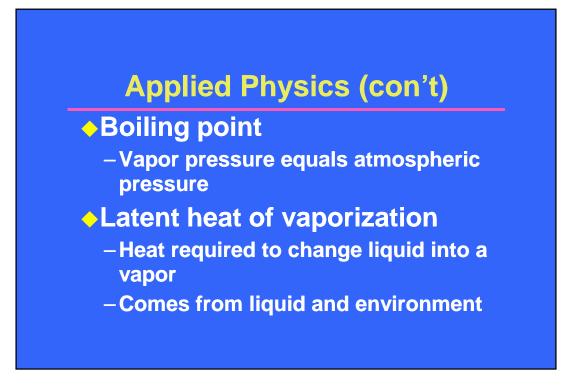
# Vaporizers

Convert liquid anesthetic into a volatile inhalation agent

- Based on laws of physics
- You must memorize the chemical properties of the volatile agents

# **Applied Physics**

- Vapor pressure
  - -Dalton's law
  - -Based on characteristics of
    - agent
  - -Varies with temperature



# **Types of Vaporizers**

Historic

- -Copper kettle
- -Vernitrol

Modern

- -Ohmeda Tec 4
- Drager Vapor 19.1

# Ohmeda and Drager Characteristics

Variable bypass

Flow over

- Temperature compensated
- Agent specific
- Out of circuit

# **Copper Kettle and Vernitrol**

- Measured flow
- Bubble through
- Non temperature compensated
- Multiple agent
- Out of circuit

### **Basic Design**

- Gas enters vaporizer
- Flow is split
  - -Majority is bypassed
  - -Some enters vaporizing chamber
- Saturated gas leaves chamber
- Diluted by bypass gas
- Delivered to patient

# **Factors that Effect Output**

Flow rate

- -Accurate at most flows
- Lower than dial setting at both extremes of flow

#### Temperature

- -Vapor pressure varies with temp
- -Accurate at 20 35° C



- Intermittent back pressure
  - -Retrograde flow
  - -Higher than dial setting
    - »especially at low flows and high ventilator pressures
- Carrier gas composition
  - -N<sub>2</sub>O causes transient drop

# **Vaporizer Interlock System**

Only 1 vaporizer can be turned on
Gas enters only the "on" vaporizer
Leak of trace gas is minimized
Vaporizers are locked into the circuit

# **Vapor Pressures:**

Isoflurane - 238 Enflurane - 175 Halothane - 241

# Desflurane

Requires special vaporizer

- -Vapor pressure 664
- -Pressurized, heated chamber

»1550 mm / Hg prevents boiling

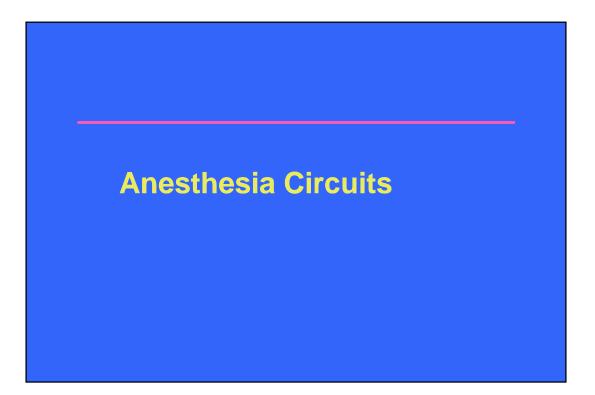
# **Vaporizer Hazards**

Misfilling

- Tipping
- Dual vaporizers on
- ♦ Leaks
- Free standing vaporizers

# Misfilling

- Vaporizers are calibrated according to the <u>vapor pressure</u> of the agent
- If you fill with an agent with a higher v.p. -- overdose
- If you fill with an agent with a lower v.p. -- underdose



# **Anesthesia Circuits**

- Link machine to patient
- Eliminate carbon dioxide
- Mapleson classification
  - -Many circuits in use
  - Modified Mapleson still in use
  - Know the current applications of modified Mapleson circuits

# **Types of Circuits**

Basic circle system

Mapleson Classification

# Basic components needed for delivery of anesthetic gases

# **Delivery Systems**

Connection to patient

Breathing tubing

- Onidirectional valves
- Breathing bag

# **Delivery Systems (Cont'd)**

- Pop-off valve
- Carbon dioxide absorption

Bacterial filter

# **Circle System**

 Allows rebreathing of anesthetic gases

- -lower FGF rates
- -Less pollution
- Requires CO<sub>2</sub> absorption
- Conserves heat and humidity

# **Advantages of Circle System**

- Highly efficient
- Minimal dead space
- Conserves heat and moisture
- Minimal pollution
- <u>Disadvantage</u> many places to leak

**Components of the Circle System** 

- Fresh gas source
- Unidirectional valves
- Inspiratory & expiratory tubing
- Y-piece connector

#### **Circle System Components (Cont'd)**

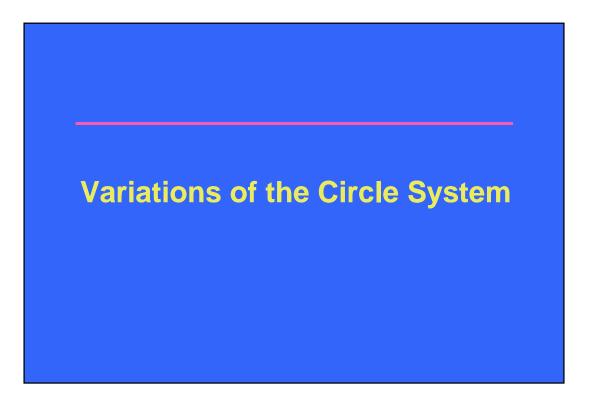
- APL valve
- Reservoir bag
- CO<sub>2</sub> absorber

# **Rules for Circle System**

- Unidirectional valve must be between patient & bag on both sides
- FGF <u>cannot</u> enter between patient & expiratory valve

Rules for Circle System (Cont'd)

APL <u>cannot</u> be located
 between patient & inspiratory
 valve



# **Four Basic Circuits**

Open

- Semi-open
- Semi-closed
- Closed

# **Open Systems**

- Insufflation
  - -blow anesthetic gas over face
  - -no direct contact
  - -no rebreathing of gases
  - -ventilation cannot be controlled
  - -unknown amount delivered

# **Open Systems**

Open drop anesthesia

- -gauze covered wire mask
- -anesthesia dripped
- -inhaled air passes through
  - gauze & picks up anesthetic

# **Open Systems (Cont'd)**

Open drop anesthesia (cont'd)

- -concentration varies
- -re-breathing may occur
- -environmental pollution

# **Semi-open Systems**

Breathing system which entrains room air
Self inflating resuscitator system

# **Semi-closed System**

Gas enters from machine –part leaves via scavenger
Circle system
Bain system

# **Closed System**

 Only enough gas enters to meet metabolic needs

- Scavenger is closed
- Closed circle system
- To-and-fro system

## **Closed System Anesthesia**

- Technique not commonly used
- APL is closed and only enough O<sub>2</sub> is added to meet metabolic needs
- Anesthetic added based on square root of time
- Conserves anesthetic gas an eliminates pollution

# The Scavenger System

- Releases excess pressure from the system
- Prevents operating room pollution
- Gases leave through APL
- May put too much negative pressure on the system

# Systems Overview

# **Open System**

No reservoirNo rebreathing

# Semi-open System

Has reservoirNo rebreathing

# **Semi-closed System**

Has reservoirpartial rebreathing

# **Closed System**

Has reservoirComplete rebreathing

# **Mapleson Breathing Circuits**

- Early pioneers developed their own delivery systems
   Mapleson classified types of
  - breathing devices

Mapleson Breathing Circuits (Cont'd)

Mapleson circuits fall into which type of system?
See Morgan p. 26, Table 3-1

## **Mapleson A**

FGI near bag

Breathing tubing

Expiratory valve near mask

 Volume of breathing tube should be as great as the tidal volume

## Mapleson A

Spontaneous ventilation

High FGF flushes tubing

between breaths

## Mapleson A (Cont'd)

 Using "pop-off" enables controlled ventilation but also causes CO<sub>2</sub> rebreathing
 Current use?

## **Mapleson B**

 Similar to A with FGI near expiratory valve

- System fills with FGF
  - -inhaled by patient

## Mapleson B (Cont'd)

Exhaled gas forced out through expiratory valve
Current use?

## **Mapleson C**

Similar to Mapleson B

- Shorter breathing tubing
  - -less dead space

Current use?

#### **Mapleson D**

- Long breathing tube
- FGI near mask
- Exhalation valve at distal end of breathing tubing
- •Current use?

## **Bain Breathing Circuit**

Modified Mapleson D
Tube within a tube

FGF tube within larger tube

Mounts on anesthesia machine
APL valve
Connects to scavenger

#### **Bain System**

#### Advantages

- -compact, easy to handle
- -warming of inspired gases
- -partial rebreathing improves humidification
- -APL controls system pressure
- -ability of scavenging

#### **Bain System Flow Rates**

Spontaneous ventilation

 200-300 ml/kg/min

 Controlled ventilation

 infants <10kg</li>
 l/m
 10 - 50 kg
 3.5 l/m
 60 kg
 70 ml/kg/min

## **Bain System**

 Depends on fresh gas flow to flush out CO2

Spontaneous ventilation

- 200 300 ml / kg / min
- Controlled ventilation

70 ml / kg / min

## **Mapleson E**

Exhalation tube is reservoir

- -no bag
- FGI near mask
- Current use?

#### **Mapleson F**

FGI near mask

- Breathing tubing/bag
- Expiratory valve at end of bag
- Current use?

## **Need To Know:**

Basic components

 Letters and names of systems currently in use

Bain system

-flow rates

## **Carbon Dioxide Absorption**

- Allows rebreathing of anesthetic gases
  Review formulas from Chem /
  - Physics
  - -Know for Board exam

## CO<sub>2</sub> Absorption (con't)

- Soda lime
  - -94% calcium hydroxide
  - -5% sodium hydroxide
  - -1% potassium hydroxide
  - -silica to harden granules
  - -ethyl violet as an indicator

# CO<sub>2</sub> Absorption (con't)

## ◆Baralime

- -80% calcium hydroxide
- -20% barium hydroxide
- -ethyl violet as an indicator

## CO<sub>2</sub> Absorption (con't)

- PH is <u>extremely</u> high
- Granule size
  - -4 8 mesh
- Water is required for chemical reactions to occur

## CO<sub>2</sub> Absorber Incompatibility

- Trichlorethylene
  - -dichloroacetylene
    - **»neurotoxin**
  - -Phosgene
    - »pulmonary irritant
- Sevoflurane
  - »degrades in absorber

## **Ventilators Classified by:**

- Power source
  - -pneumatic
  - -electric
  - -both
- Drive mechanism
  - -double circuit
  - -driven by oxygen

## Ventilator Classification (con't)

- Cycling mechanism
  - -time cycled
  - -pressure cycled
- Bellows classification
  - -ascending / descending
    - »related to expiratory phase
  - -Ascending is safer

## **Specific Ventilators**

- Review reading assignment
- Do not memorize technical
  - data
- Note similarities and
  - differences

## **Ventilator Problems**

- Circuit disconnect
  - -Redundant alarms in place
  - -Check APL valve
- Occlusion
- Barotrauma

## Ventilator Problems (con't)

- Leak in bellows assembly
- Mechanical problems
- Electrical problems

#### Setting the Ventilator (Things your mama didn't tell you)

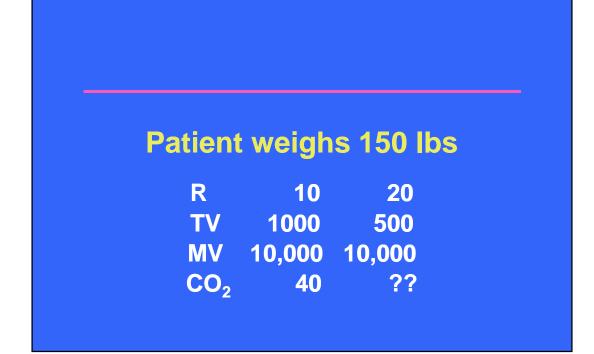
Based on the principle that PaCO<sub>2</sub> is directly proportional to alveolar ventilation

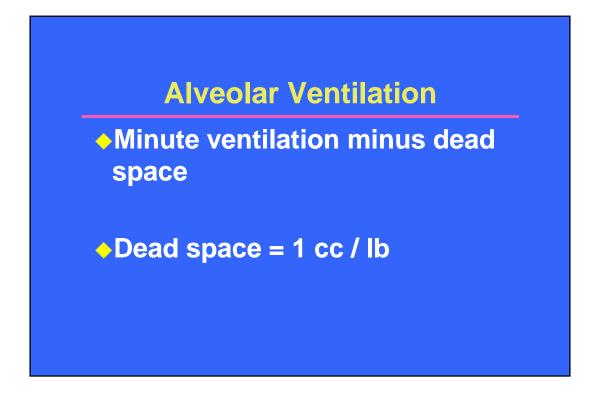
## $AV X CO_2 = AV X CO_2$

(what you have) (what you want)

AV = alveolar ventilation $CO_2 = carbon dioxide$ If you know 3, you can solve for the 4th

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## **Ventilator Settings**

If rate is constant, then dead space is constant
If you <u>do not</u> change the rate, V<sub>t</sub> X CO<sub>2</sub> = X CO<sub>2</sub>

You have R = 8, V<sub>t</sub> = 650, ETCO<sub>2</sub> = 40. You want ETCO<sub>2</sub> = 33 and decide to leave the rate at 8. What new V<sub>t</sub> is required to lower the ETCO<sub>2</sub> to 33?

# $V_t X CO_2 = V_t X CO_2$

650 X 40 = ?? X 33 New TV = 788 Round off to 800 cc

#### Important concept

 PaCO2 is directly proportional to alveolar ventilation

 If dead space is constant, alveolar ventilation is directly proportional to tidal volume.

## **Humidification**

Which takes more energy?

-Humidification of dry gas

-Heating cold gas

Humidifying a dry gas takes more energy than heating cold gas.

# The Artificial Nose (Humidity Trap) Provides external heat and humidity More effective

## **Heated Humidifier**

More dangerous

- -Larger circuit volume
- -Increased circuit compliance
- -Thermal injuries

## **The Anesthesia Machine Check**

- Required standard of care
- You are responsible for the function of your machine
- Follow the checklist

#### Machine Check (con't)

- Document "machine checked"
- On't cut corners
  - -Full check to start each day
  - Abbreviated check between cases

#### American Express Items (Don't leave home without them)

Oxygen Positive Pressure Suction

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