Anesthesia Machine Care and troubleshooting

Charlene J. Williams, CRNA, MSN
Assistant Professor
Anesthesiology Nursing

Required Reading

Dorsch & Dorsch Understanding Anesthesia Equipment 4th ed. (1999) Williams&Wilkins:Philadelphia. Pg 355-427, 895-904, 937-965.

Other collections from review books and notes

Happy is He who gains Wisdom from another's Mishaps.

Anesthesia Safety

Where does the fault lie???

MAN VS. MACHINE

Primary system of anesthesia machine

- High Pressure (745-2200 psi)
- Intermediate Pressure (37-55 psi)
- Low pressure (16-25 psi)

Anesthesia Machine (High Pressure System)

- Cylinder
- Hanger yoke (PISS)
- Filter
- Check valves
- Bourdon Type pressure gauge
- Pressure regulator

Anesthesia Machine (Intermediate Pressure)

- DISS
- Bourdon Type pipeline pressure gauge
- Ventilator pneumatic drive gas(O_2) source
- O_2 failure
- Secondary reducing valve
- O_2 flush valve

Anesthesia machine (Low Pressure)

- Proportioning devices
- Flowmeters
- vaporizers

Potential hazards of anesthesia machine and breathing system

- Hypoxia (hypoxia)
- Hypercapnia
- Hyperventilation
- Excessive Airway Pressure
- Fires
- Physical damage
- Latex allergy
- Inhaled foreign substance
- Anesthetic agent overdosage
- Inadequate anesthetic agent
- Inadvertent exposure to volatile agent

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Hypoxia-Incorrect gas Supplied

- Piping system
- Cylinders
- Crossovers in the anesthesia machine

Hypoxia

- Incorrect gas supplied
- Hypoxic mixture delivered
- Loss of oxygen to atmosphere
- Air entrainment

Hypoxia

- Common transposition in piping itself
- Incorrect gas installed @ central supply
- Incorrect outlets installed inside the OR
- Incorrect connector maybe placed on the hose
- Pipeline inlet of the anesthesia machine
- Quick connect fittings may be damaged

Hypoxia (con't)

- Quick connect fittings are poorly designed so that an incorrect connection can be made
- Connections between piped gases can occur in the peripheral equipment
- Air flowmeter may have a oxygen outlet connector
- Crossover contamination occurred—100% FIO2 want administer

Hypoxia r/t mixture delivered

- Flow control valve malfunction
- Incorrect flowmeter settings
- Incorrect flowmeter readings
- Inaccurate flowmeter

If you think that you have a hypoxic mixture----------
What do you do ?

Hypoxia R/T Hypoventilation-low inflow

- Pipeline problem
- Cylinder problem
- Machine problem

Hypoxia R/T Hypoventilation

- Low inflow
- Excessive outflow
- Blockage of the inspiratory pathway

Hypoxia (hypoventilation)- excessive outflow

- Breathing system leaks
- Disconnections
- Negative pressure applied to the breathing system
- Improper adjustment of the APL valve

Hypoxia(hypoventilation)

- Blockage of the inspiratory pathway
- What are the causes??

What is your response?

- Check ventilator settings
- Check ventilator bellows
  - 1.bellows don’t move
  - 2.bellows fills but fail to compress fully
  - 3.fail to fill

Incorrect placement of the PEEP valve

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Hypercapnia

- Inadvertent administration of carbon dioxide
- Rebreathing without removal of carbon dioxide

Hypercapnia (cont)- Rebreathing without removal of carbon dioxide

- Absorbent failure
- Bypassed absorbent
- Inadequate fresh gas flow to a mapleson system
- Improper assembly of the Bain system
- Unidirectional valve problem
- Problem with nonrebreathing valves
- Excessive dead space

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Hyperventilation

- Hole or tear in the bellows can cause inadvertent hyperventilation
- Detection: increased oxygen concentration if oxygen is the driving gas or decreased concentration if air is used

What else can happen??

- Hyperventilation
- Excessive Airway pressure
  - Causes-high inflow
  - Causes-low outflow

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Excessive Airway Pressure

- High Inflow
- Low Outflow
- Unintentional Peep
- Misconnection of Oxygen tubing

Excessive Airway Pressure---Causes of low outflow

- Obstruction in the expiratory limb
- At the ventilator
- At the APL valve
- In the scavenging system
- Nonrebreathing valves in resuscitators

What do you do??

- Detection
- Response

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Inhaled foreign substance

- Absorbent dust
- Ethylene oxide and glycol
- Parts of breathing system components
- Contaminated medical gases
- Foreign bodies

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Anesthetic agent overdosage

- Tipping
- Vaporizer or N2O inadvertently turned on
- Incorrect agent
- Improper vaporizer installation
- Overfilled vaporizer

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Inadequate anesthetic agent

- Decreased N2O flow
- Unexpected high O2 concentration
- Leak in vaporizer
- Empty vaporizer
- Incorrect agent in vaporizer
- Incorrect vaporizer setting
- Incorrect vaporizer mounting
- Damaged vaporizer
- Air entrained into breathing system
- Dilution by ventilator driving gas

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More hazards

- Inadvertent exposure to volatile agent
- Fires and explosion
  - Factors
    - 1.
    - 2.
    - 3.

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More hazards

- Physical damage
- Latex allergy

Malignant Hyperthermia

- Clinical presentation: tachycardia, tachypnea,and elevated ETCO2
  - Must be distinguished from ventilator or unidirectional valve malfunction (respiratory acidosis),hyperthyroidism,cocaine intoxication, pheochromocytoma and sepsis

Malignant Hyperthermia

- Triggers: succinylcholine and all inhaled volatile agents
- Safe anesthetics: barbituates,propofol,etomidate,

ketamine, opiods, local anesthetics, catecholamines, N2O and all non-depolarizing muscle relaxant

Malignant Hyperthermia

- Treatment in the OR: high gas flow,hyperventilation,stopped inhaled agents
- Dantrolene 2.5mg/kg up to 10mg/kg
- Cooling by any means

Equipment checking

- High pressure system
  - Cylinder gas supply
  - Pipeline gas supply
- Low pressure system
  - Negative pressure
  - Positive pressure
  - Pressure gauge
  - Fresh gas line occlusion
  - Elapsed time pressure

Equipment checking

- Scavenging system
- Breathing system

Equipment checking

- Leak test for the bellow
- Alarm check
- Ventilator safety relief valve
- Unidirectional valves

Alarm devices

- Audible signals
  - High priority
  - Medium priority
  - Low priority
- False alarms
  - False negative
  - False positive

Hazards of ventilation

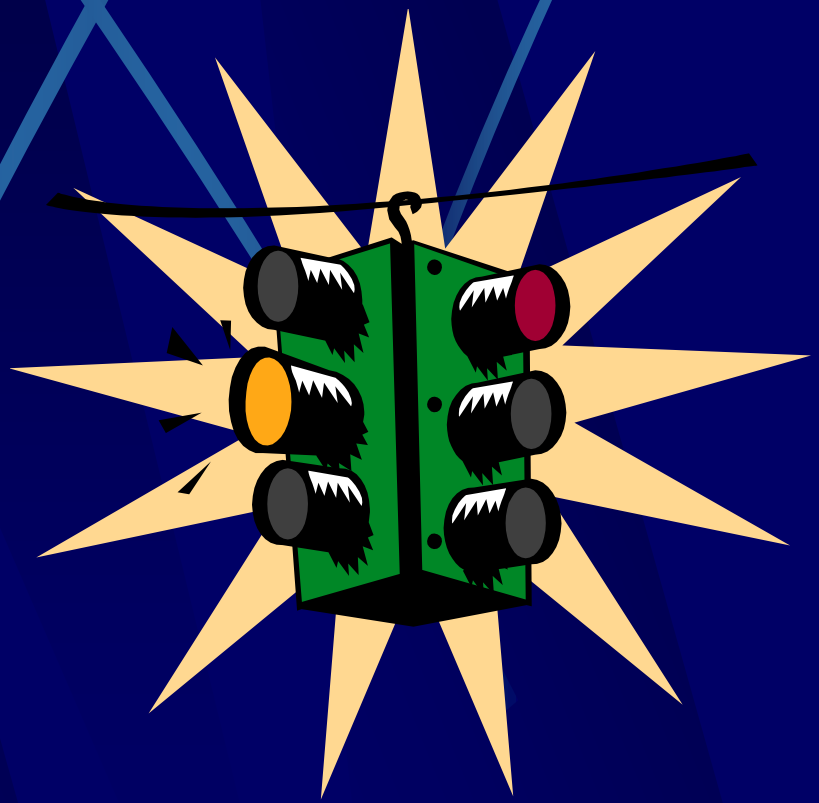
- Descending bellows
- Ventilation pressure relief valve failure
- Disconnect pilot line
- Ruptured valve
- Drive gas failure
- Electronic failure
- Misconnection
- Bellow leaks
- Utilized flush valve during mechanical ventilation

Hazards of ventilation

- Ventilation pressure relief valve failure
  - Hypoventilation: incompetent valve stuck open on inspiration leads to interface and scavenging interface and scavenging vacuum directly into breathing circuit
  - Barotrauma: valve is stuck closed during exhalation

summary

- Machine check is the most important piece for patient safety
- If unsure, please ask
- If it doesn’t fit easily don’t force it



Electric hazards

- Macroshock: gross amount of current experienced at body surface to intact skin (120V-household current)
- Severity:
  - Resistance of skin (1000's to 1 million)
  - Contact time
  - Density of current (contact of current on skin)

Electric hazards

- **Microshock**: small amount of current delivered internally by conduits
  - Pacing electrodes
  - CVP
  - PA catheters

AC/DC

What is the difference?

Macroshock &effect

1 sec contact time

1 mA	tingling
5 mA	Maximum safety
10-20 mA	“Let go” threshold before muscle contraction
50 mA	pain
100-300 mA	**V-fib**
6000 mA	Resp muscle paralysis

Microshock & effect

1 sec contact time

50-100 microA	V-fib
10 microA	Maximum current leak in equipment

Line Isolation Monitor (LIM)

- Monitors the integrity of isolated power system alarms when current flows to ground
  - Alarms @ 2-5 mA current leak
  - Leaks above threshold-trips the circuit breaker

Isolated power system

- Ungrounded system- main line are grounded
  - Secondary transformer-isolated transformer separated from the main hospital
  - **Purpose: macroshock prevention**

Short circuit activates ground wire

Does not prevent microshock

Disinfectant inactivates HBV/CMV/HIV

	HBV/CMV-10 min @20 C	HIV- 10 @ 24 C
Ethyl ETOH	**ineffective**	50%
Sodium hypochlorite	1:10 solution	1:10 solution
Quaternary ammomium	ineffective	0.08%
phenolic	**ineffective**	0.05%
Isopropyl ETOH	70%	35%

OSHA Occupational Exposure Limits

- Ethylene oxide: 1 ppm 8 hours TWA

  5 ppm STEL or 15 min TWA

Glyteraldehyde (cidex) : 0.2 PPM 8 hour TWA

Disinfection of anesthesia machine & equipment

- **EPA**: (primary) use only EPA registered disinfection
- FDA: regulates some chemical disinfectant
- **OSHA:** regulates occupational exposure to toxic levels
- CDC: makes recommendations for prevention-don't regulate approve or test chemical germicides or sterilizer

Autoclaving

- Steam sterilizing-old/most common method of sterilization that tolerates heat and humidity
  - Best method for inactivation TB,HBV,CMV, HIV and Creutzfeldt-Jakob Disease (CJD)

CJD

- Extremely resistant to disinfection
- Steam sterilization 1 hour @ 132 C (best)
- Soak in Bleach 1 hour rm temp.
- Wipe surfaces bleach undiluted/diluted 1:10 dilution (15-30 min rm temp.
  - Bleach is caustic
  - **1:10 solution----1 part bleach with 9 parts water**

TB/ HEP B/ HIV

- Tuberculocidal agents adequate inactivating HBV/CMV
- HBV survives for several days
- HIV(?)-minutes
- Blood and Body fluids exposure is decreased by _____
- **Clorox**-effective and economical against HIV in a **1:10 solution**