ANESTHETIC MACHINE

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INHALATION ANESTHETIC DELIVERY SYSTEM

Compose of 2 major system

1. Anesthetic machine
2. Breathing system

A. BASIC COMPONENT OF ANESTHETIC MACHINE

❖Composed of - Medical gases
- Pressure gauges & Regulators
- flow meter
- flush values
- vaporizer

I. MEDICAL GASES

o O_2 or N_2O
o Oxygen use for : - metabolic need
- carrier anesthetic gas
o Nitrous oxide use for anesthetic gas

I. MEDICAL GASES

- Sources may from pipeline system or cylinder
- Pipeline sources of N_2O or O_2 originate at bank of large cylinder or oxygen may arise from a liquid oxygen
- Cylinder : E (700 L.) or H (7000 L.)

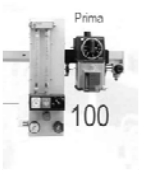
- tank color code label ; O_2green , N_2O blue, CO_2 black

II. PRESSURE GAUGES & REGULATORS

- Pressure gauges indicate the pressure (up to 2200 psi) on the cylinder or system
- Regulators produce a safe operating pressure (≈ 45 psi)

III. FLOW METER

- Flow meters are down steam from regulators
- They measure the rate of gas flow to vaporizers
- The scale shows rate of flow (in milliliters or liters per minute)



IV. FLUSH VALVES

- Only use for oxygen
- It delivers a high flow (35-37 L/min.) of oxygen
- At flow rate 50 L/min of oxygen can quickly fill a breathing system
- Oxygen from flush valve is directly through the breathing circuit (not pass the vaporizer)

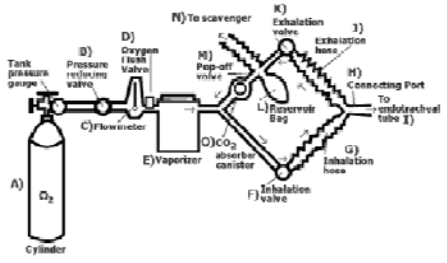
V. VAPORIZERS

- two type of vaporizers

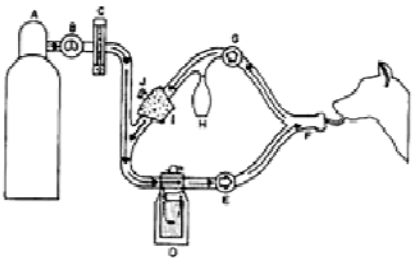
1. Precision vaporizer (temperature, flow and back pressure compensated)
2. Nonprecision or uncompensated vaporizer

- Vaporizer location is relation to the breathing system , has 2 different location

1. Vaporizer outside the circle system (VOC) and must be a precision vaporizer
2. Vaporizer within the circle system (VIC) and must be a nonprecision vaporizer



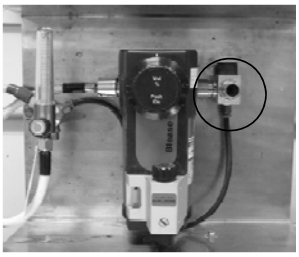
Vaporizer out of circle



Vaporizer in circle

VI. Common gas outlet or fresh gas outlet

- This is the exit port where anesthetic gas leave the anesthetic machine and enter to the breathing circuit
- This is the point where all " breathing circuit" attach to the "anesthetic machine"



B. BREATHING CIRCUIT OR SYSTEM

Function of breathing system :

1. Deliver anesthetic gases and oxygen
2. Remove CO_2 from exhaled gases
3. Support ventilation

Classification of breathing circuit

- Rebreathing circuit
  - Close system
  - Semi – close system
- Non – rebreathing circuit (semi – open system)

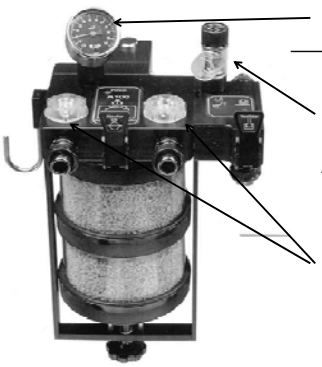
*Non – rebreathing circuit usually used with mask or chamber induction

REBREATHING SYSTEM

Basic component of rebreathing system ;

1. Y piece : - use for connected with endotracheal tube connector and breathing tube
2. Breathing tube : plastic or rubber
3. One – way (unidirectional) paired values
4. Fresh gas inlet

5. Pop-off value
6. Reservoir bag
7. Manometer
8. CO_2 absorber



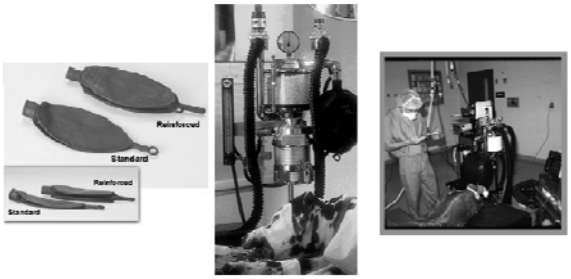
Manometer

Pop – off valve or Pressure relief valve or Adjustable pressure - limiting (APL) valve

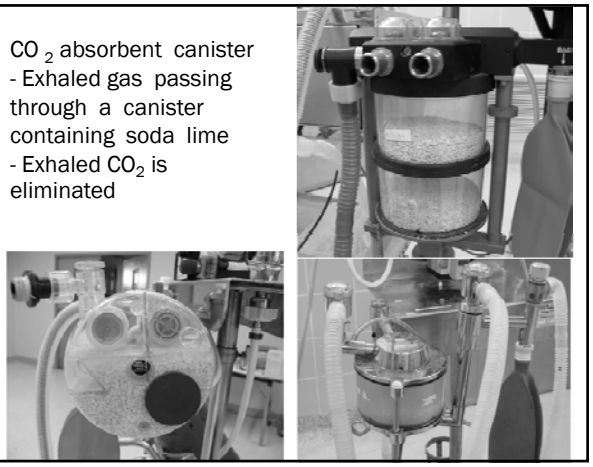
Unidirectional valve
- Inspiratory valve
- Expiratory valve

Reservoir bag or rebreathing bag

- At least 6 times of tidal volume



CO_2 absorbent canister
- Exhaled gas passing through a canister containing soda lime
- Exhaled CO_2 is eliminated



Carbon dioxide absorbent canister

- Two products are commonly used in circle systems as chemical carbon dioxide absorbent : Soda lime and Baralyme
- In both, Calcium hydroxide is primary component of granules
- Fresh absorbent is white (or pink) in colour
- After expose to carbon dioxide will change the color to pink or violet depend on pH indicator in the granules

Carbon dioxide absorbent canister

-The volume of canister should be at least twice the patient' s tidal volume
- Sodalime can use with in 6-12 hours then should be replaced

Operation of rebreathing circuit

Divided 2 type :

1. Closed circuit
2. Semi – close circuit

Operation of rebreathing circuit

1. Closed circuit
   - There is no "waste of oxygen" from circuit
   - Oxygen supply = oxygen consumption
     = 4 – 8 ml /Kg / min
   - Must be monitor oxygenation of blood
   - Not be use Nitrous oxide because induced hypoxia

Operation of rebreathing circuit

2. Semi – closed
   - Oxygen supply > oxygen consumption
   - Excess gases are eliminated through pop – off valve continually
   - Oxygen flow rate :
     1. Low flow = 10 -20 ml/Kg/min
     2. Medium flow = 20 – 40 ml/Kg/min
     3. High flow = greater than 60 ml/Kg/min

Advantage of rebreathing system

- Economical

  Expired oxygen and anesthetic vapor are recirculated and reused
- Fresh gas flow and anesthetic agent utilization are minimized
- Humidifying inspired gas

  Preserving heat and moisture of the patient

Advantage of Closed circuit

- More economical
- Retain more heat and humidify
- Less environmental pollution

Disadvantage of Closed circuit

- Risky to hypoxia
- Slow rate change in depth of anesthesia

Advantage of Semi – closed circuit

For medium and high flow

- Safety to the animal
- More rapid change in anesthetic depth

Disadvantage of Semi – close circuit

- Less economical
- More pollution of environment

Non – rebreathing circuit

Recommended for ;

- Small dogs & cats
- Neonates
- Small birds
- Pocket pets
- Small exotic animals

Non – rebreathing circuit

•Reason for **NOT** using a rebreathing circuit in a small patient :

- Increase resistance to breathing from :
  - Inspiratory and expiratory valve
  - CO_2 absorption canister
- Large mechanical dead space :
  - Breathing tubes

Non – rebreathing circuit

Oxygen flow rate :

- High gas flow to prevent rebreath of exhaled gases
- Flow rate = 3 times of minute volume or 200 – 250 ml/Kg/min
- Inadequate flow rate allow CO2 to be rebreathed and creates respiratory acidosis

Non – rebreathing circuit

Advantages

- Less resistance to breathing
- Less mechanical dead space
- They are simply devices and light weight
- Easier to clean and maintain
- More portable than rebreathing circuit

Non – rebreathing circuit

Disadvantages

- Delivery a high flow of dry cool gas
  - causes heat and humidify loss
  - easy to hypothermia in small patient
- Higher waste
- Increase cost

Scavenging system

Purpose

- Eliminate excess anesthetic gases from the OR room or working area
- Scavenging connected to pop – off valve

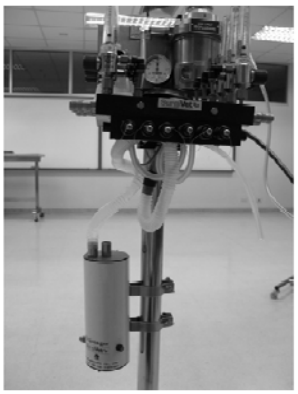
Divided 2 System

- Active
- Passive

Scavenging system

Active system

- High pressure vacuum
- Gases sent to outside building
- Use for the Hospital or OR that place at central of the building



Active scavenging system : mobile unit

Scavenging system

Passive system

1. Elimination through the outside wall
2. Use of Activated charcoal
   - have to changed for every 8 hours of using

ADVANTAGES OF INHALATION ANESTHETIC

- Safety
- Stable (not metabolized in the body)
- Excreted via the same route (lung)
- Easier to adjust the depth of anesthesia
- Rapid recovery (fast excrete)
- Easy to assist ventilation

DISADVANTAGES OF INHALATION ANESTHESIA

- The anesthetic machine is expensive
- Require more equipments
- May be "stormy" recovery
- Flammable and explosive

Clinical use of inhalant anesthetics

I. Induction of anesthesia

II. Maintenance of general anesthesia

Advantage of using inhalant anesthetics for **induction** of general anesthesia

- ✓ Accurately controlling anesthetic depth
- ✓ Safety to discontinue immediately if problem arise
- ✓ Eliminated quickly through ventilation
- ✓ Use high flow of oxygen during induction(rare to hypoxia)

Disadvantages of use inhalant anesthetic for **induction**

- ➢ Not suitable for unpremedication animals
  - Struggling from slow induction
- ➢ The pungent smell of halothane and isoflurane
  - animals will hold their breath during induction
  - slow induction from hold the breath
- ➢ Effect to personal health
  - Headaches and other health problem

Advantages of using inhalation anesthetics for **maintenance** of general anesthesia

✓ Keep upper airway open
- all animals are intubation

✓ Easily controlling the depth of anesthesia during maintenance

✓ Give only oxygen during the maintenance
- reduced hypoxic problem, especially the patient with anemia

✓ Rapid recovery compare to injection

Method of induction by inhalant anesthetic

1. Face - mask

2. Chamber induction

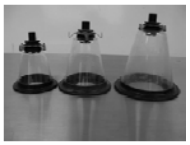
Face – mask induction

Face – mask for induction ;

• place on the face of the animals

• Face- mask should be tight and fitting

• Use the smallest face – mask as possible to minimized dead space ventilation



Face – mask induction

❖ Face – mask suitable in
- Birds and small exotic pets
- Neonate
- Foals
- Debilitated dogs and cats
- Health dogs and cats after preanesthetics

❖ Face –mask induction is not practical in adult large animals (equine , bovine , porcine)

Face – mask induction

• Start with :
- 4-5 % of halothane or isoflurane
- 5-8 % of sevoflurane
- Use high flow rate of oxygen(3-5 Liters /mins
- Continues until the animal is unconscious and can be intubated

• Sevoflurane is markedly better for mask induction than isoflurane because reduced excitement stage

Face – mask induction

In debilitated patients :
- Begins with 2 – 3% of inhalant agent
- continues until animal is unconscious

Less likely to become excited or struggle during induction

Chamber induction

- Chamber induction suitable in :

✓ Small animals (reptile ,small rodent ,small dogs or cats)

✓ Minimal physical restraint " Hands Free induction"

- Chamber may be plastic or acrylic box with various sizes (10 – 25 gallons)

Chamber induction

Start with :

- give 5% isoflurane or 8% of sevoflurane
- with high flow of oxygen (5 liters / mins)
- continues until the animal losses its right reflex
- taken the animal out of the chamber
- placed on the face – mask and continue administration of inhalant anesthetic until the animal is unconscious and ready for intubation

Maintenance general anesthesia with inhalant agents

✓ After the patient already intubation

- Give inhalant anesthetics about 1.2 – 1.5 times MAC for general anesthesia
- Preanesthetics of tranquillizer , sedative or opioids : Reduced the maintenance concentration of inhalant anesthetics

Maintenance general anesthesia with inhalant agents

- Give oxygen flow rate following type of breathing circle and weight of animal(tidal volume)
- Monitor depth of anesthesia and other vital signs if depth of anesthesia increase ,reduced the % of inhalant agent at vaporizer

Maintenance general anesthesia with inhalant agents

In general inhalant anesthetics are maintained with following concentration

- Isoflurane 1 -2.5 %
- Sevoflurane 2.5 – 4.0 %

ANESTHETIC MONITORING

Goal of anesthetic monitoring

The overall goal of monitoring anesthetized animals is to ensure adequate tissue perfusion with oxygenated blood and proper anesthetic depth.

Stage of general anesthesia

Anesthesia Stages[a]

Stage	Behavior	Respiratory Rate	Heart Rate	Surgical Stimulation	Depth
Stage I	Disoriented	20–30 breaths/min	Unchanged	Severe	None
Stage II (excitement)	Excited, struggling, howling, paddling	Irregular, may hold breath	Increased	Severe	None
Stage III, plane 1 (light)	Anesthetized	12–20 breaths/min	>90 bpm	Mild	Light
Stage III, plane 2 (surgical)	Anesthetized	12–16 breaths/min	>90 bpm	Heart and respiratory rate may increase	Moderate
Stage III, plane 3 (deep)	Anesthetized	<12 breaths/min	60–90 bpm	None	Deep
Stage III, plane 4	Anesthetized	Jerky	<60 bpm	None	Overdose
Stage IV	Moribund	Apneic	Cardiovascular collapse	None	Dying

[a]Hollingshead KW, McKelvey D: General anesthesia. *Small Animal Anesthesia and Analgesia*, ed 2. St. Louis, Mosby, 2000, pp 52–53.

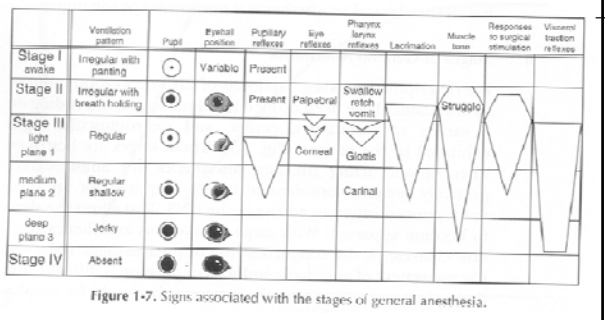


Figure 1-7. Signs associated with the stages of general anesthesia.

How to monitor the anesthetized patient?

1. Circulation (Cardiovascular function)

1.1 CRT (capillary refill time)

- should not over 2 seconds
- Prolonged CRT suggest poor tissue perfusion

What parameters should be monitored?

1.2 Pulse

- position : palmar of metacarpal , plantar of metatarsal ,femoral artery

What parameters should be monitored?

- palpation provides a subjective feeling of “presence” , ”absence” , ”strong”, “weak” , ”regular” or “irregular”

What parameters should be monitored?

1.3 Heart rhythm

- use of regular stethoscope , esophageal stethoscope or other audible heart sound monitor

What parameters should be monitored?

- Dog 70-120 bpm , cat 120-180 bpm
- horse 30-45 bpm , pig 60-90 bpm, cattle 60-80 bpm
- Rhythm : normal , arrhythmia

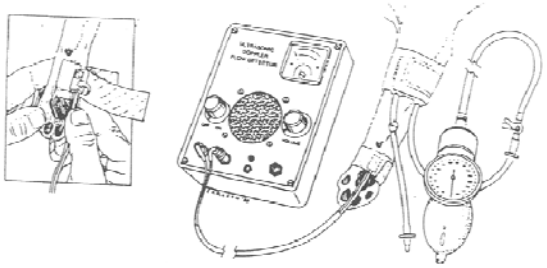
What parameters should be monitored?

1.4 Arterial blood pressure

- maybe monitored using non-invasion method (NIBP) such as a Doppler ultrasound probe coupled with pressure cuff and a Sphygomanometer or an automated oscillometric device

What parameters should be monitored?

- Doppler technique has more advantage than automated oscillometric detector



รูปโดอะแกรมแสดงการใช้ Doppler ในการวัดความดันบริเวณปลายขาของแมว

What parameters should be monitored?

- Systolic 100-160 mmHg , Diastolic 60-100 mmHg and mean blood pressure 80-100 mmHg
- If systolic less than 80 mmHg are assumed to result inadequate cerebral and coronary perfusion

What parameters should be monitored?

1.5 Electrocardiogram (E.C.G.)

- ECG will allow defection of heart rate , of any cardiac arrhythmia to ventricular fibrillation and detection of abnormal wave forms

What parameters should be monitored?

- ECG only monitors the electrical activity of the heart (HR.) , not mechanical activity (pulse rate)
- No other circulatory information (BP , SV , CO)

What parameters should be monitored?

2. Oxygenation (Cardiopulmonary function)

Clinically, the presence of pink mucous membrane in an anesthetized patient is subjectively indicative of acceptable oxygenation. However, oxygenation is either difficult or not possible to assess in anemic patients or patients with peripheral vasoconstrinction. These patients usually have pale mucous membrane.

What parameters should be monitored?

2.1 Hemoglobin oxygen saturation (SpO_2)

- Should be 96-100% , PaO_2 80-100 mmHg (give 100% oxygen should be greater than 200 mmHg)
- Hypoxemia will occur when SpO_2 is less than 90% and PaO_2 is equal or less than 60 mmHg

What parameters should be monitored?

Pulse oximeter

- provides non-invasive , continuous detection of pulsatile arterial blood in tissue bed, calculates the percentage of oxyhemoglobin present in arterial blood and provides the pulse rate

What parameters should be monitored?

- pulse oximeter may be affected by many situations these include motion artifact (shivering) , ambient light , poor perfusion from hypotension and vasoconstriction , electrical noise from electrocautery and dark skin color.

What parameters should be monitored?

2.2 Ventilation

2.2.1 Respiration rate and respiration pattern

- is limited value because normal rate can vary in respiratory depth
- respiratory rate : 10-30 breath/min

What parameters should be monitored?

2.2.2 ventilation volume

- can be estimated by visual observation of chest or rebreathing bag or measured by respirameter
- Normal tidal volume 10-20 ml/kg

What parameters should be monitored?

- A small tidal volume may be acceptable if the breathing rate is fast enough to accomplish normal minute volume
- Minute volume = TD X RR , 150-250 ml/kg/min
- Minute volume is more important than tidal volume

What parameters should be monitored?

Capnometer or Capnography

is the equipment for measure CO_2 concentration during the respiratory

- most commonly used to monitor end-tidal CO_2 ($ETCO_2$)

What parameters should be monitored?

- $ETCO_2$ reflects the partial alveoli pressure of CO_2
- The measurement of $ETCO_2$ is useful for determining optimal minute ventilation , hypoventilation , airway disconnection or airway obstruction

What parameters should be monitored?

- $ETCO_2$ concentration between 35-45 mmHg
- $ETCO_2$ will be about 2 to 10 mmHg lower than $PaCO_2$

Perioperative Mechanical Ventilation

Indication

- Thoracic surgery; diaphragmatic hernia, esophagotomy, PRAA, PDA
- Hypoventilate patient
- Apnea
- Used neuromuscular blocking agents
- Patients with respiratory failure (snake poisoning)

- Automatic ventilators are the equipments that use for perioperative mechanical ventilation
- Automatic ventilators allow provision of intermittent positive pressure ventilation (IPPV) in anesthetized or heavy sedated patients

Classification of ventilator

- Volume controlled (constant flow delivered)
- Pressure controlled(constant pressure delivered)

1. Volume controlled has 2 types
   - Volume controlled ventilation with time cycling
   - Volume controlled ventilation with pressure cycling or pressure limited

- Volume controlled ventilation with time cycling
  - The delivered flow remains constant over the period of inspiration

- Inspiration is terminated once either a targeted tidal volume is delivered or a fixed inspiratory phase time has elapsed
- In animals weight less than 5 kg, it may be difficult to set the appropriate tidal volume accurately
- Their potential for producing volutrauma should be recognized and care taken in animals with a low tidal volume

• Volume controlled ventilation with pressure cycling

- The delivered flow constant over the period of inspiration
- Inspiratory is terminated once a targeted airway pressure is achieved
- Tidal volume does not have to be calculated and setting the cycling pressure in normal patient to 10-15 cm H_2O

2. Pressure controlled ventilation with time cycling

- Currently rare in veterinary anesthesia
- The delivered pressure remains constant over the period of inspiration
- A fixed pressure is rapidly achieved throughout the breath by delivering a decelerating inspiratory flow pattern.
- Once peak inspiratory pressure is reached, flow continues at a gradually reduceing rate until the end of the inspiratory phase