

Monitoring of Anesthesia

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Workshop Objectives:

- Understand the concepts of general anesthesia and sedation and the effects of drugs on different body systems
- Understand monitoring equipment, its limits and proper use
- Critically assess, identify and correct external factors that may affect the success of a procedure at induction, during the procedure and recovery
- Monitor vital parameters, recognize normal changes and problems that need corrections
- Identify life-threatening emergencies for the animal and the staff
- Provide excellent care for the anesthetized patient

Concepts of general anesthesia, sedation and the effects of drugs on different body systems



Terminology ...

Anesthesia vs. chemical "immobilization"



Sedation and general anesthesia

- Immobilization: old terminology, still misused
- Tranquilization
- Sedation
- General anesthesia
- Analgesics (pain killers)

Most commonly used anesthetic agents

- Route of absorption:
 - Intravenous (intraosseous), intramuscular, subcutaneous, oral, transmucosal, transdermal, and inhalation (gas)
 - Some drugs can only be given by one route (propofol: IV)
- Drug delivery → stress level
 - Restraint: none, operative conditioning, manual restraint, chutes
 - Administration: oral, hand-injection, stick-pole, remote delivery systems, inhalation



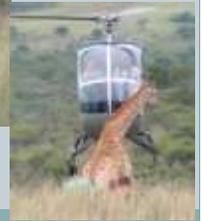
Squeeze cages



Chute



Remote Administration Devices



- Use of helicopter and land crew

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Tranquilizers and sedatives

- Depress the central nervous system
- Alleviate fear and anxiety
 - Fear → increased catecholamines → irregular heart beats when exposed some drugs
- Usually not pain killers (except for xylazine, medetomidine)
- Increased stimulation reverse calming effects
 - Keep environment quiet
- Allow for sufficient time to have peak effect
- Additive / synergetic effect with other anesthetics

Tranquilizers and sedatives

- Tranquilizers: phenothiazines (acepromazine), butyrophenones (azaperone, haloperidol): produce of indifference
 - Increased dose tend to increase side effects but no loss of consciousness
- Sedatives: benzodiazepines (midazolam, zolazepam), thiazine (medetomidine, xylazine), barbiturates: produce state of sleep (a.k.a. hypnotics)
 - Increased dose produce more profound CNS depression (~ anesthesia)
- Reversals (antagonists): thiazines, benzodiazepines, butyrophenones (antipyramidal effects)

Analgesics also used in anesthetic protocols

- **Opioids:**
 - morphine, butorphanol (1-2 x morphine), buprenorphine (4-50 x morphine, dose dependent), fentanyl (75-100 x morphine)
- **Super - Opioids:**
 - carfentanil (10,000 x morphine), etorphine (1000-3000 x morphine), thiofentanyl
- **Variable effect on receptors (agonist, antagonist, mixed agonist-antagonists)**
- **In combination can cause neuroleptanalgesia or neuroleptanesthesia**
- **Reversals:**
 - naloxone (short acting), naltrexone, diprenorphine

Induction and maintenance of general anesthesia

- **Injectable drugs:**
 - Ketamine, tiletamine (telazol)
 - Propofol
 - Barbiturates
 - Single injection or constant rate infusion (CRI)
- **WARNING: the combination of butorphanol, medetomidine, and midazolam causes heavy sedation**

Induction and maintenance of general anesthesia

Inhalant anesthetic agents

- Isoflurane
- Sevoflurane
- Desflurane



www.mallardmedical.net
Tusko

Other drugs

- **Muscle relaxants**
 - Guaifenesin (glyceryl guaiacolate)
- **Neuromuscular blocking agents**
 - Succinylcholine
 - Gallamine, atracurium, vecuronium
 - Reversible or not

Effects of drugs on the animal's system

- **Respiratory system:**
 - Depression: decreased effort, slowed rate, increased secretions (obstruction)
 - Apnea (respiratory arrest)
 - Decreased swallowing and potential for aspiration pneumonia
- **Cardiovascular system:**
 - Depression: decreased heart performance and rate, dilation of blood vessels
 - Stimulation: increased heart performance and rate, constriction of blood vessels
 - Decreased blood flow to any and every organ → injury to cells and compromised function (reversible or not)
- **Musculo-skeletal system:**
 - Muscle relaxation (excitement from lack of coordination, respiratory depression)

Effects of drugs on the animal's system

- **Gastro-intestinal effects:**
 - Vomiting, regurgitation, defecation, diarrhea, constipation, ileus
- **Kidney function:**
 - Decreased blood flow to kidneys → decreased excretion of wastes, decreased excretion of drugs (incl. anesthesia), injury from lack of oxygen to cells
 - May cause permanent damage if renal function is already compromised
- **Liver function:**
 - Decreased blood flow: decreased ability to detoxify (incl. drugs), metabolize and excrete drugs
 - Increased enzymatic action: increased metabolism of certain drugs

Effects of drugs on the animal's system

- **Acid-base balance and electrolytes disturbances**
 - Secondary to effects on other systems (muscle, GI, kidney)
- **Nervous system:**
 - Depression: ataxia, decreased alertness (decreased ability to prevent drowning, erratic running and impact; inability to evade cage mates and engage in appropriate social response)
 - Stimulation: seizure, increased muscle activity (ketamine, tiletamine)
- **Eyes:**
 - Increased pressure inside eye
 - Decreased function of eye lids and potential of exposure and trauma to cornea and retina

Species specific anatomy and physiology

- **Mammals: 4 070 species**
- **Aves: 10 000 species**
- **Reptiles: 6 000 species**
- **Amphibians: 4 000 species**
- **Fish: 20 000 species**
- **Invertebrates: > 10 millions species**



Understand monitoring equipment Limitations and proper use

The best piece of equipment



Intmath.com

Be prepared for the unexpected

- **Close monitoring of the animal**
- **Equipment and drugs ready to use**
 - Antagonist
 - Emergency drug dosages calculated (drawn up?)
 - Water / ice
 - Oxygen
 - Endotracheal tubes
 - Emergency drugs and material
 - Fluids
 - Bandage material
 - Surgical pack



OXYGENATION

- **To ensure adequate oxygen concentration in the inspired gas and the blood during all anesthetics**
- **Inspired gas: concentration of oxygen in the patient breathing system shall be measured by an oxygen analyzer**
- **Blood oxygenation**
 - Pulse oximetry: calibrated for humans; many mechanical challenges
 - Arterial blood gases: temperature dependent



VENTILATION

- To ensure adequate ventilation of the patient
- Qualitative clinical signs:
 - Chest excursion, observation of the reservoir breathing bag and auscultation of breath sounds



VENTILATION

- To ensure adequate ventilation of the patient
- Qualitative clinical signs:
 - Chest excursion, observation of the reservoir breathing bag and auscultation of breath sounds
- Continual monitoring for the presence of expired carbon dioxide when patient is intubated:
 - Its correct positioning must be verified by clinical assessment
 - Identification of carbon dioxide in the expired gas: continual end-tidal carbon dioxide analysis; capnography (can depend on blood pressure and lung perfusion)



CIRCULATION

- To ensure the adequacy of the patient's circulatory function during all anesthetics.
- Electrocardiogram continuously displayed (only indicates electrical activity of the heart)
- Arterial blood pressure
 - Indirect (cuff and doppler) – variation in diameter of legs
 - Direct (intra-arterial catheter) - invasive
- Palpation of a pulse, auscultation of heart sounds



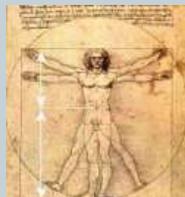
BODY TEMPERATURE

- To aid in the maintenance of appropriate body temperature during all anesthetics
- Rectal temperature probe
- Esophageal temperature probe
- Infrared temperature probe



DEPTH OF ANESTHESIA

- Loss of righting reflex
- Jaw tone
- Position of the eye
- Ear twitch
- Loss of palpebral reflex
- Loss of pedal withdrawal reflex
- Respiration and circulation
- Corneal reflex



Avoid Unexpected Awareness



Critically assess, identify and correct external factors that may affect the success of a procedure at induction, during the procedure and recovery

ASA Physical Status Classification

- **ASA Physical Status 1** - A normal healthy patient
- **ASA Physical Status 2** - A patient with mild systemic disease
- **ASA Physical Status 3** - A patient with severe systemic disease
- **ASA Physical Status 4** - A patient with severe systemic disease that is a constant threat to life
- **ASA Physical Status 5** - A moribund patient who is not expected to survive without the operation
- **ASA Physical Status 6** - A declared brain-dead patient whose organs are being removed for donor purposes

Planning

- What is the procedure?
- Is this an emergency?
- Will the immobilization allow for the procedure?
- Address all safety issues (animal and staff)
- Make sure the equipment is working (maintenance and testing prior to procedure)
- Training of staff (on going and review)

Physical restraint or general anesthesia?

- Is the animal tractable?
- Is the animal trained?
- Do you have access to an animal trained in a squeeze cage?
- Is the animal small enough to capture (net/hand)?
- How large is the enclosure or the cage?



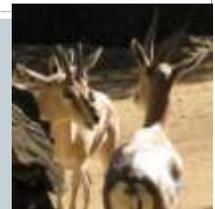
Planning

- Determine environmental conditions
 - Temperature
 - Humidity
 - Time of the day
 - Intensity of the wind
- Assess location of immobilization, procedure, recovery
- Determine if method of confinement is safe
- Can the animal be observed post-capture?



Planning

- Pay special attention to animals recently transported or never immobilized before now
- Discuss the behavior of the animal and its exhibit mates if applicable
- Decide whether it is best to keep the animal with its exhibit mates or isolating it for induction
- At all time, decrease sensory stimuli to animal



Planning

- Meeting before procedure
- Assignment of tasks
- Complete the procedure
- Debriefing post-procedure



Pre – Anesthetic Preparation ...



Pre-anesthetic considerations

- Which species is involved?
- Determine the psychological status of the individual
- What is the present condition of the animal?
- Review past medical history, available blood work, previous anesthesia and radiographs
- Fasting status
- *** Keep excellent records ***



Pre-anesthetic considerations

- Might you be able to perform a pre-immobilization:
 - Physical examination, CBC and chemistry panel?
 - Estimated or accurate body weight?
- Does the staff require additional training?
- What will be the method of restraint?
- If chemical immobilization is chosen, which drugs and method of delivery will you use?

Monitor vital parameters,
recognize normal changes and
problems that need corrections

Calculation of dosages: Effect of size



Metabolic Scaling

- Estimation of physiological parameters
- Calculation of drug dosages, and treatment frequency
- Minimum energy cost:
- $MEC = K(BW^{0.75})$
 - $K=10$ (reptiles)
 - $K=70$ (placental mammals)
 - $K=125$ (passerine birds)



Record keeping

Every 5 minutes, or more often:

- Record vital parameters
- Look at anesthesia machine
- Assess position of the animal
- Touch the animal



Look for trends

- Double check machine results with your own senses
- Intervene before it is too late
- Assess response to intervention and record results



Identify life-threatening emergencies for the animal and the staff

Life-threatening problems

- Animal too light – depth of anesthesia
- Animal too deep – loss of reflexes, depressed respiration and cardiovascular system
- Animal not breathing well – obstruction (regurgitation, obstruction because of secretions, kinked endotracheal tube, depression from anesthetic drugs)
- Circulatory collapse (shock, anesthetic drugs, positioning, hemorrhage)
- Hypothermia or hyperthermia
- Pressure on muscle mass or nerves
- Exposure of eyes
- Bloating

Provide excellent care for the anesthetized patient

Monitoring Fish

Fish - Induction

- **Injectable agents**
- **Baths**
 - Tricaine methanesulfonate (MS222)
 - Clove oil
- **Isoflurane bubbled in water**



Maintenance



Monitoring

- **Monitoring water quality**
 - Dissolved oxygen
 - pH
 - Concentration of drugs
 - Temperature
- **Heart rate**
- **Respiration**
- **Blood gases**
- **Depth of anesthesia**





Recovery



Assisted breathing

Monitoring Amphibians

Amphibian - Induction

- Tricaine methanesulfonate
- First sign of induction with MS222: transient erythema of light-skinned areas (ventrum)
 - "Emotional" erythema (also associated with restraint)
- Initial excitement and attempts to escape
 - Importance of soft-sided walls to minimize trauma
- Respiratory efforts (incl. ventilation of gills) will slow down
- Heart rate unchanged (or slight increase)



Monitoring

- Light plane of anesthesia:
 - Loss of righting reflex and corneal reflex
 - Presence of withdrawal reflex, spontaneous movements, gular respiration, visible heart beat
- If apnea or hypoventilation:
 - Hypoxia, hypercarbia, acidosis
 - 100% oxygen bubbled through anesthetic solution will correct hypoxia, though acidosis and hypercarbia will persist



Monitoring

- **Duration of anesthesia is variable**
 - Move the patient to fresh water once anesthetic level is achieved – 30 min of anesthesia
 - If longer anesthesia is required, patient can be returned to anesthetic bath at 50% of initial concentration



Monitoring

- **Overdose - Tricaine methanesulfonate**
 - Heart rate slows or becomes difficult to detect
 - If HR < 20%, remove patient from anesthetic bath and rinse with clean water



Anesthetic monitoring

- **Heart rate**
 - Visualize heart beats
 - Doppler probes
 - ECG
- **Buccopharyngeal or pulmonic respiratory rate**
 - Both hypoxic and hypercarbic respiratory drives
 - Respiratory movements usually cease if amphibian is maintained under hyperoxic conditions (return to room air to stimulate breathing)
- **Blood (hemoglobin) oxygen saturation**
- **Reflexes (righting, withdrawal, etc.)**



Recovery

- **Recovery or emergency situation: rinse patient with copious amounts of well-oxygenated, toxin free clean water**



Recovery

- **Assess level of consciousness and reaction to stimuli**
- **Do not replace in water until the animal is awake**
- **Assess return of normal breathing**
- **Provide analgesia**



Monitoring Reptiles

Assess patient



Stabilize



Anesthetic Management

- Do not use hypothermia in reptiles !!!
- Muscle relaxant – animal still conscious
- Premedication
 - Midazolam
 - Butorphanol ?
 - Medetomidine
- Induction:
 - Medetomidine
 - Ketamine



Induction - Propofol



Induction – Mask



Intubation



IV catheterization



Monitoring

- Best monitoring: Doppler flow
- Alternate monitoring devices: ECG and pulse oximetry



Monitoring

Cardiovascular system

- Heart rate
 - Doppler (blood flow)
 - ECG
- Mucous membranes
- Pulse oximetry



Respiratory system:

- Respiratory rate:
 - Often masked by controlled ventilation (2-6 breaths/min)
 - Blood gases

Monitoring

Depth of anesthesia

- Righting reflex
- Uncoordinated muscle movements
- Response to painful stimuli
- Tail movement
- Tongue flicking



Recovery

- Assist ventilation until full return of spontaneous breathing
- Monitor muscle tone
- Assess tongue flicking
- Provide POTZ, privacy
- Keep dry until recovered
- Analgesia



Monitoring Birds

Birds are always high-risk patients



<http://www.wildaboutbritain.co.uk>

Specialized Anatomy and Physiology



<http://www.pbase.com>

Key Points:

- Attentive monitoring during anesthesia
- Rapid intervention in case of complication



High metabolic rate



http://www.california-earthframes.com/06_wildlife/x01_0003_0945_hummingbird_std.jpg

Species differences

- High metabolic rate
- High O₂ consumption
- Effect of drugs varies with species (ratites)



Now, that's just great: We've flightless again...

<http://www.physorg.com/newman>

Induction

- Ratites – use injectable drugs



Induction with mask for most species

- Anticipate difficult intubation in a few species



Intubation

- Controlled ventilation:
- Maintains level of anesthesia
- Prevents hypercarbia
- Note: damage to trachea if tip of ET tube rotates or dry air is applied to same spot
- Wean slowly during recovery to spontaneous breathing

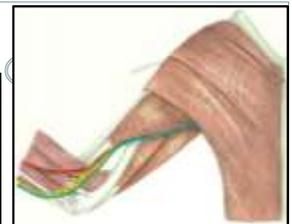


Instrumentation

- Warming devices
- Monitoring equipment
 - Doppler
 - Blood pressure cuff
 - ECG
 - Temperature probe



Monitoring





Monitoring

Monitoring:

- Depth of anesthesia: reflexes (palpebral, cere, toe pinch, movement to pain e.g. feather plucking)
- Circulation: volume (veins), amount of blood loss, blood pressure
- Heart rate (Doppler flow, ECG)
- Ventilation: respiratory rate, blood gases, end-tidal CO₂, oxygen saturation
- Temperature: esophageal probe for core temperature measurements

Fluids

- Venous access
 - IV or IO
 - Crystalloid
 - Dextrose PRN
 - 10ml/kg/hour
 - Slow bolus PRN
 - Hetastarch 15ml/kg
- Syringe pump



IV, IO catheter – Fluid administration via pump



Care during procedure

- Eye lubrication and eye ring
- Keep head in line with body
- Avoid moving endotracheal tube
- Monitor for tracheal secretions and blockage of endotracheal tube
- Monitor for regurgitation
- Manage bradycardia and bradyarrhythmias
 - Ventilation
 - Maintain body temperature
 - Change level of anesthesia and fluid rate

Extubation:

- Examine glottis prior to extubation, remove secretion or regurgitation
- Slowly extubate the birds to avoid trauma to tracheal mucosa
- Re-examine oropharynx and remove secretions
- Examine endotracheal tube for evidence of secretion / blood



Recovery

- Attentive monitoring
- Avoid rapid changes in position (orthostatic hypotension)
- Restraint until in full control of equilibrium
 - In hand
 - Wrapped in towel



Complications during recovery

- Keep in warm, padded, and dark cage
- Supplemental oxygen if needed
- Hypothermia
- Excitement, hyperthermia
- Hypercarbia, hypoxia
- Regurgitation
- Death



Monitoring Mammals Field Situation

Care of the animal once it is immobilized

- Approach dangerous animals from the rear
- Position body so nothing impairs breathing
- Cover eyes, plug ears



www.thabamanzi.co.za

Care of the anesthetized animal

- Check vital signs: Respiratory and heart rates, temperature, oxygen saturation (red froth)



www.ifaw.org

Care of the anesthetized animal

- Check for dart wound and other injuries
- Collect data



www.africananimals.biz

Reversal

- Control recovery
- Use of reversals
- Monitor for renarcotization
- Release or transport



www.conservationafrica.net



www.africananimals.biz

Monitoring Captive Large Mammals

Anticipate Possible Difficult Intubation



Large carnivores



Large carnivores: Safety

- Protocols for escape
- Assign one person to oversee entire procedure
- Review procedure before start and assign tasks
- Assign one / two (vet, curator) leaders of procedure
- Keep doors closed during procedure
- Keep dangerous animals enclosed
- Limit number of staff near animal during procedure
- Debrief after procedure, discuss good and bad events
- Vaccination of staff and animals against rabies

Fasting

- 12-24 hours for most species
- Less than 4 hours if metabolic rate is high
- Keep water but remove a few hours before induction



www.ljpius.ru

Once the animal is unconscious

- Approach with caution (usually one veterinarian and a senior animal staff)
- Assess depth of anesthesia
- Secure airway
- Obtain baseline respiratory and heart rates and temperature
- Adjust animal in safe position (may have to be done earlier if airway is compromised)



Care of the animal

- Positioning – consider human safety (2 exits)
- Nares should not be covered
- Supplemental oxygen
- Endotracheal intubation



Care of the animal

- Place and secure 1 or 2 intravenous catheters
- Install monitoring equipment
- Administer fluids and drugs



Care of the animal

- Lubricate and protect the eyes against light, wind, trauma
- **Monitor, monitor, monitor!!**
 - Heart rate (stethoscope / Doppler)
 - ECG / oxygen saturation
 - Blood pressure
 - Respiratory rate
 - Blood gas
 - Temperature
 - Depth of anesthesia



Complications of Anesthesia

- Failure of drug delivery
- Improper dosage
- Trauma during induction and recovery
- Unexpected movement or awareness
- Cardiovascular collapse
- Respiratory compromise and arrest
- Regurgitation and aspiration
- Seizures / excitement
- Vomiting



Emergence and Recovery

- Active monitoring
- Reversal – How much? When?
- Intervention
- Must keep recovery area
 - Dark
 - Quiet
 - Ventilated
 - Small
 - Easy to transport
 - Flexible size



Hoofstock



Positioning of the animal

- Most species: lateral
- In ruminants: sternal, head above stomach, nose pointed down (ruminant)
- Monitor for bloat
- Positioning of the legs to avoid pressure points



Care of the animal

- Nares should not be covered
- Supplemental oxygen
- Install monitoring equipment
- Administer fluids and drugs
- Procedure



Care of the animal

- Lubricate and protect the eyes against light, wind, trauma
- Monitor, monitor, monitor!!



Complications

- Trauma
- Capture myopathy
- Heat prostration
- Shock
- Death

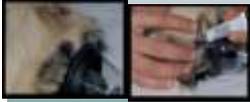


Monitoring Smaller Mammals



Monitoring / Instrumentation

- Eye ointment
 - IV / IO catheter
 - Fluid pump
 - Doppler
 - Thermometer
 - Warmth
- ECG
 - Stethoscope
 - Pulse oxymeter



Fluid therapy

- 10ml/kg/hour IV or IO
- pre-anesthesia administration:
 - 30ml/kg SQ



Monitoring:

- **Respiratory function**
 - mucous membranes
 - respiratory rate & rhythm
 - tidal volume
 - airway obstruction
- **Cardiovascular function**
 - heart rate & rhythm
 - blood pressure
 - blood loss



Monitoring:

- **Temperature**
- **Depth of anesthesia**
 - Muscle relaxation
 - Withdrawal (ear pinch and pedal) and palpebral reflexes
 - Response to surgery
 - Cardiovascular and respiratory parameters



Complications

- Anesthetic overdose
- Cardiovascular collapse
- Respiratory depression or obstruction
- Laryngeal trauma
- Excitement
- Hypothermia
- Hypoglycemia



Recovery and post-operative care:

- Recovery area warm (27-30°C), quiet and padded
- Oxygen supplementation
- Attentive monitoring
- Analgesia
- Keep separate from cage mates

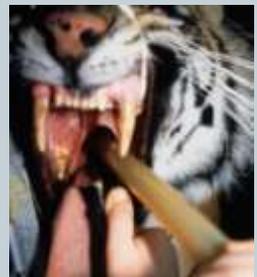


What problems can occur in this situation?



Complications of Anesthesia

- Failure of drug delivery
- Improper dosage
- Trauma during induction and recovery
- Cardiovascular collapse
- Respiratory compromise and arrest
- Regurgitation and aspiration



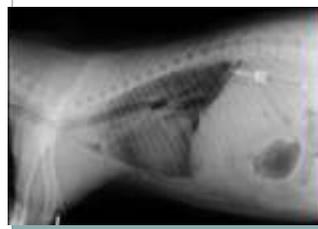
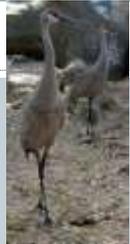
Complications of Anesthesia

- Bloat
- Hyper / hypothermia
- Corneal erosion / retinal damage
- Nerve damage
- Capture myopathy
- Drug exposure to personnel
- Death



Capture myopathy

- 4 clinical syndromes:
- Capture shock syndrome
- Ataxic myoglobinuric syndrome
- Ruptured muscle
- Delayed peracute syndrome



Questions?



Benzodiazepines

- Diazepam
- Midazolam (water soluble)
- Zolazepam (water soluble)
- Minor tranquilizers, centrally acting muscle relaxants, anticonvulsive properties, minimal CNS and cardiorespiratory depression
- May cause disorientation / agitation in some sp.
- Antagonist: Flumazenil

Alpha-2 adrenergic drugs

- Sedative producing CNS depression, stimulating central and peripheral alpha2 adrenoreceptors
- Agonists: Xylazine, detomidine, medetomidine
- Decrease in sympathetic outflow and circulating catecholamines – produces sleep-like state and analgesia
- Cardiovascular and respiratory depression
- Antagonists: Yohimbine, atipamezole

Ketamine

- Produces dissociative anesthesia characterized by poor muscle relaxation and catalepsy
- Safe and used in a broad range of species
- Can cause seizures, muscle rigidity and excitement (psychosomatic effects)
- Animals are hyperresponsive and ataxic during recovery
- Usually used in combination with an anticholinergic, a muscle relaxant and or a sedative

Tiletamine and zolazepam

- Combination of dissociative anesthetic agent and a tranquilizer
- Telazol
- More potent than ketamine and diazepam
- Longer duration of action
- Small volume required
- Can cause seizure and excitement
- Do not use in tigers

Opioids

- Act by reversibly binding to one or more specific receptors in brain and spinal cord
- Produces sedation and analgesia
- Synergetic effects when combined with other drugs
- Referred to as opioid agonist, partial agonist, agonist-antagonist and antagonist
- Agonists: Etorphine, Carfentanil, Fentanyl, Butorphanol (agonist and antagonist activity)
- Antagonists: Diprenorphine, Naltrexone, Nalmefene, Naloxone

Propofol

- Rapid acting, ultra-short, non-barbiturate and relatively noncumulative IV anesthetic
- Dose-dependent respiratory depression and initial periods of apnea
- Dose-dependent cardiovascular depression
- Rapid clearing from body by hepatic and extra-hepatic metabolism

Human safety:



- **Carfentanil, Etorphine, Thiofentanil:**
 - Potent opioids: severe respiratory depression, death
 - Transmucosal (ocular, nasal, oral) or percutaneous absorption
- **Other anesthetics: do not underestimate danger**
- **Accidents if negligence during loading or cleaning of darts or careless handling of equipment**

Emerg Med J 2005; 22:524-525

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Accidental human poisoning with a veterinary tranquilliser . F H Cummins

Human safety

- Site of use (zoo, in field, abroad)
- On site human exposure protocol (drills)
- Notification and training of staff, local hospital and emergency room personnel (incl. paramedics)



Human Safety: Prevention

- First aid kit: CPR equipment, drug labels and inserts, antidotes
- Never work alone when preparing, using or cleaning darts
- Train staff to recognize clinical signs post-exposure



Human Safety: Prevention

- Wear protective glasses/shield, gloves (double?), long-sleeve jacket
- Avoid spraying, spilling, squirting drugs
- Treat darts, syringes and gun with utmost care
- Locate and retrieve darts immediately after use
- Loading of darts in helicopters is hazardous



In case of human exposure:

- Seek medical help immediately – communication cascade
- Wash area immediately
- If injected use pressure bandage to reduce absorption (?)
- Monitor consciousness and breathing
- Place an IV catheter
- Decide if antidote is needed (naloxone, naltrexone)
- CPR if warranted
- Transport to medical unit - bring first aid kit with patient