Anesthesiology Review for BCSE

- **Terminology**

Balanced anesthesia: Is the use of 2 or more drugs to achieve the desired level of anesthesia.

Tank color: nitrous oxide tank in blue, oxygen tanks are white or green.

Electrical defibrillation: shocks stops all cells in the heart simultaneously which allows the pacemakers cells to regain control of myocardial contraction.

Pre-emptive analgesia: to intervene prior to an expected event or consequence of pain.

Akinesis	Motor paralysis.
Allodynia	Pain response to stimuli that are not normally painful
Dysphoria	Signs include restlessness, agitation, vocalization and lack of response to surrounding or interaction with caretakers.
Hyperalgesia	Heightened response to painful stimuli
Hypercapnia	Means excess carbon dioxide (CO_2) in blood.
Hypertension	MAP above 160mmHg small animals and 150mmHg in large animals.
Hypoalgesia	Decreased response to normally painful stimuli
Hypotension	MAP is bellow 65mmHg. Usually caused by deep anesthesia.
Hypoxemia	Mean low blood oxygen.
Neuropathic pain	Caused by damage to neural tissue and is usually present in chronic cases of pain. You can use gabapentin to treat NP.
Pain	Transduction (nerve ending), transmission (nerve body), modulation (dorsal horn of the spinal cord), projection (thalamus and brainstem) and perception (cerebral cortex).
Pathologic pain	response that is heightened beyond that needed to protect the patient from injury.
Physiologic pain	Protective response to an actual or potentially damaging insult. Also called nociceptive pain.
Visceral pain	Stretching, tension or inflammation of viscera.
Wind up	Sensibilization of nociceptors and pain pathways in response to intense bombardment of painful sensory impulses in the phenomenon of Wind-up, which greatly amplifies the pain response. NMDA receptors in the spinal cord are activated in the wind-up phenomenon. **Ketamine**, an NMDA receptor antagonist, is used to help prevent the development of wind-up. Other NMDA antagonists include methadone, amantadine and dextromethorphan.

- **Pre Anesthetic Medication (PAM) (BCSE)**

Drug Group	Drug Name	Action	Adverse effects	Do not use / Reverse With
Phenothazine (GABA potencialization)	Acepromazine, Chlorpromazine, Methotrimeprazine	Mild tranquilization, reduction of motor activity, mild sedation, antiemetic and antiarrhythmic.	Vasodilation,↓AP, ↑CO (comp),↓RR, ↓ ST, ↓ Temp.	Decompensated cardiac patients, animals with sepsis or hypothermic patients.
Benzodiazepines	Diazepam, midazolam	Anxiolytic, myorelaxant, hypnosis (LA) and anticonvulsive.	Not analgesic, agitation, paradoxical effect	RW: Flumazenil Do not use diazepam in patients with liver failure.
A-2 agonists	Dexmedetomidine, Xylazine	Deep sedation, analgesic (DD)	↓ CO, ↓ HR, hypotension, ↓RR, bradycardia ,vomit and salivation.	RW: Yohimbine or Atipamezole
Anticholinergic	Atropine,	↓ salivary and	Decrease GI	Atropine in

(Blocks muscarinic)	Scopolamine, Glycopyrrolate	respiratory secretion, ↑ HR, mydriasis,	motility	horses. Scopolamine in cats. Animals with KCS.
Opioids	Morphine, Fentanyl, Tramadol, Butorphanol, Methadone,	Analgesia, sedation,	↓ HR, ↓ RR (DD), ↑ Histamine release, vomit and constipation.	RW: Naloxone

Meaning: Reverse with (RW), Arterial Pressure (AP), Cardiac output (CO), Respiratory Rate (RR), Heart Rate (HR), Seizure threshold (ST), Temperature (Temp), Compensatory (Comp), Large animals (LA), Dose Dependent (DD), KCS (Keratoconjunctivitis sicca).

Acepromazine: Antagonizes dopamine receptors in the brain. Causes mild sedation, vasodalition (alpha-1 blocker) and hypotension. Causes penis protrusion in large animals (especially horses). If using in geriatric patients, decrease dose. Side effects include significant hypotension. Do not use in animals with organophosphate toxicity as it may exacerbate its toxic effect.

Xylazine: Cause significant bradycardia, reduction of cardiac output, hypotension, cardiac arrhythmias and respiratory depression. Is revered with Yohimbine. Cow dose is 20 less than dogs or horses. Pretreatment with atropine can decrease bradycardia and hypersalivation in cattle. Swine do not respond well to xylazine.

Opioids: like hydromorphone can cause dysphoria is healthy patients. Dysphoria is treated with tranquilizer or sedatives such as acepromazine or dexmedetomidine, respectively.

Morphine: should not be used in geriatric, severely debilitated patients and in patients with hypothyroidism, renal insufficiency and/or adrenocortical insufficiency. Morphine increases the intracranial pressure and should not be given to an animal with head trauma. Bolus of morphine can cause high histamine release, vasodilation and anaphylaxis.

Dexmedetomidine: Cause significant bradycardia, reduction of cardiac output, hypotension, cardiac arrhythmias and respiratory depression. Do not give atropine for these patients, reverse it with Atipamezole.

Butorphanol: Cause respiratory depression

Glycopyrrolate: Great for pregnant animals. Can cause ileus in horses and it causes thickening of bronchial secretions so avoid in patients with pneumonia.

- **Injectable Anesthesia**

Group of Drugs	Drug Names	Effects	Adverse Effects	Do not Use
Alkylphenol	**Propofol** (GABA)	↓ intracranial pressure, ↓ CNS metabolism,	Significant respiratory depression, apnea, bradycardia and decreased cardiac contractility. **Not analgesic!**	Pregnant animals as it causes fetal depression.
-	**Etomidate** (GABA)	CNS depression, maintenance of hemodynamic parameters.	**Not analgesic**! Fetal depression, adrenocortical depression and immune system depression.	Animals with sepsis or pregnant.
Barbiturates	**Thiopental**, **Methohexital**	Peripheric vasodalition, ↑HR (transitory) and ↓ AP .	Can cause heart arrhythmias (usually ventricular bigeminy), temporary apnea after injection and respiratory depression.	Perivascular injection causes necrosis. Causes ileum in horses.
	Pentobarbital	Euthanasia drug! Causes respiratory depression.		

Thiopental: extremely fat soluble and is metabolized by the liver! Do not use in fat patients or greyhounds (not enough fat and horrible liver)

Methohexidal: best barbiturates to do in fat patients and greyhounds because it does not absorb into fat and quickly induces anesthesia.

Propofol: should be discarded after 6 hours, is rapidly cleared and is not particularly irritating to tissues if it goes outside of the vein accidentally.

- **Dissociative anesthesia**

Drug: Ketamine and Tiletamine (more potent).

Characteristics: IV or IM, great for wild animals due to broad therapeutical margins.

Effects: Analgesia (little), amnesia, ↑ AP, ↑ RR (Short and fast), broncodilator, ↑ HR and ↑ Cardiac output. Can cause seizures and respiratory depression at high doses. Ketamine provides a good superficial analgesia, but poor visceral analgesia.

- **Neuromuscular blocker**

Act in the neuromuscular junction (at the motor plate) leading to muscle relaxing and causes respiratory paralysis.

Depolarizing agents (competitive): **Decamethonium** and **succinylcholine**

Non-depolarizing agents (non-competitive): Pancuronium, **vecuronium**, **rocuronium** and dacuronium.

Sequencing of blocking: 1. Face and tail, 2. Limbs, 3. Neck, 4. Abdomen, 5. Thorax (intercostal muscle) and 6. Diaphragm. Recovering is in the opposite sequence.

- **General Anesthesia**

Drugs: Desflurane, Sevoflurane, Isoflurane and Halothane.

Minimal Alveolar Concentration (MAC): amount of anesthetic necessary to abolish pain response to painful stimuli in 50% of patients. Higher the MAC, less potent is the gas.

Desflurane: Extremely low solubility, has the fasted induction and recovery.

Halothane: ↓ CO, arrhythmogenic potential, dose dependent respiratory depression and hepatic lesion in predispose animals. The most soluble gas, therefore it has a slower induction and recovery.

Isoflurane: ↓ AP (dose dependent), ↑ HR and ↓ CO. High doses lead to ileus, decrease cardiac output, vomiting, nausea and respiratory depression. Go to drug for patients with kidney and liver problems as only 0.2% of the gas is removed via metabolism.

Sevoflurane: Create a Substance A that can lead to kidney damage, ↓ AP (dose dependent) and ↓ CO.

Methoxyflyrane: no one uses it anymore due to high solubility (higher than halothane).

Nitrous Oxide: Causes oxygen depletion! ↑ AP (discrete), ↑ HR, ↑ intracranial pressure. Not useful alone. It dissipate to gas compartment. Do not use in horses as it can cause post-operative colic.

Refill the anesthetic machine when fewest people are in the clinic.

- **Anesthesia Monitoring**

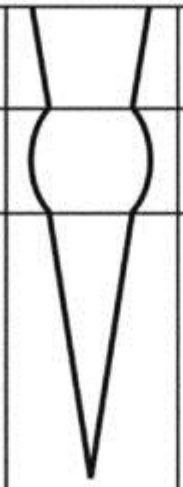
Pain response: ↑ AP (main), ↑ HR, midriasis, ↑ temperature and ↑ RR (more rare).

Stage 1: Voluntary movement.

Stage 2: delirium, involuntary movement. Pass by it as quick as possible.

Stage 3: surgical plane of anesthesia. Ideal is Stage 3 medium. Observe palpebral reflex, eye and pupil position, muscular tonus, tracheal reflex and corneal reflex. Corneal reflex should **never** be

absent in a proper anesthesia plane. You should see eyes rolled ventrally, pupils dilated and no palpebral response.

Anesthetic level	Reaction to surgical stimulation	Muscle tone (jaw)	Palpebral reflex	Eye and pupil position	Ventilatory rate	Heart rate
Stage I	+		+		N	N
Stage II	+		+		↑	↑
Stage III Light	±		+		N↑	N↑
Medium	-		-		N↓ Intercostal lag	N↓
Deep	-		-		Abdominal slow shallow	↓↓
Stage IV	Ventilatory and cardiac arrest					

Hypoventilation leads to respiratory acidosis that shows as increase PaCO2 and increased HCO3 (renal compensation).

- **Anesthetic Breathing Circuit**

More detail: http://www.capnography.com/new/breathing-circuits/anesthesia-breathing-circuits-functionality

A typical circular anesthetic circuit is composed of: Pressure regulator, flowmeter, vaporizer, patient, CO2 canister. Pressure regulator decreases the pressure of gas leaving the pressured gas cylinder. Flowmeter controls the amount of carrier gas flow. Vaporizer convert the volatile liquid anesthetic into vapor and then mixes it with carrier gas.

CO2 canister contains soda lime granules that absorb carbon dioxide. Fresh soda lime is white and can be crushed. Exhausted soda lime is off-white color and is hard. Color usually changes to purple or violet.

Oxygen flush bottom: sends pure oxygen into the breathing circuit, bypassing the vaporizer. The patient will start to wake up. If pushing it in a non-rebreathing system you can cause barotrauma.

One-way valve: keeps exhaled gasses moving away from the patient in a circular rebreathing anesthetic delivery system.

Semi-closed: Semi-closed or partial rebreathing systems are the same thing! It flows at intermediate flow rates where fresh gas is delivered in excess of metabolic consumption. During induction and recovery the flow is 100ml/kg/min (small animals). During maintenance of anesthesia the flow is 10 ml/kg/min (large animals) or 30-50 ml/kg/min (small animals).

Closed anesthetic Rebreathing System: Closed anesthetic rebreathing system only provides enough flow of fresh gas to meet an animals metabolic needs, about 5 to 10 ml/kg/min. Never use nitrous oxide in these type of system!

Non-rebreathing system: No remixing of inhaled and exhaled gasses and has the highest gas glow rates (100-300ml/kg/min). Used for small animals under 7kg (15lb).

Bain System (tube inside tube): Can run at a high flow rate of 200-300 ml/kg/min, than it does not allow rebreathing of exhaled gasses and it does not allow mixing of gases. At a flow rate of 130-200ml/kg/min or less the Bain functions as a partial rebreathing system.

BREATHING SYSTEMS WITHOUT CO2 ABSORPTION	BREATHING SYSTEMS WITH CO2 ABSORPTION.
Unidirectional flow: a) Non rebreathing systems. B) Circle systems.	**Unidirectional flow** Circle system with absorber.
Bi-directional flow: a) **Afferent reservoir systems**. Mapleson A Mapleson B Mapleson C Lack's system. B) **Enclosed afferent reservoir systems** Miller's (1988) c) **Efferent reservoir systems** Mapleson D Mapleson E Mapleson F Bain's system d) Combined systems Humphrey ADE	**Bi-directional flow** To and Fro system.

Pulse Oximeter: used primarily to measure the oxygen saturation (SaO2) of hemoglobin in arterial blood and pulse rate.

Capnography: measures CO2. Normal is around 35-45mmHg.

Electrocardiogram (ECG): records heart rate and rhythm.

Doppler monitor: detects the flow of blood through small arteries and can be used to measure blood pressure.

Endotracheal tube: Cuffed in adult dogs. Uncuffed in ferrets, small animals (puppies and kitten) and in birds as they have a complete tracheal rings.

Oscillometric blood pressure monitor senses the motion of the arterial wall as a blood pressure cuff deflates.

- **Local Anesthesia Drugs**

Drugs: lidocaine, bupivacaine, prilocaine, procaine, tetracaine and ropivacaine

Only the non-ionizing form of the drug is effective. The form is pH dependent, therefore is the area is very acidic (inflammation) you can add a little bit of bicarbonate.

Adrenalin (vasoconstrictior) can be used to decrease absorption.

Intoxication: IV, high doses, increase absorption or wrong application. **Clinical signs**: irregular respiration, opisthotonus, bradycardia and PEDALADA.

Lidocaine: Lasts for 1.5-2 hours.

Bupivacaine: lasts from 4 to 10 hours. Most frequently used for oral surgery.

- **Nerve Blocks**

Auriculopalpebral: Prevents the horse from blinking. Provides innervation to the upper orbicularis oculi muscle.

Supraorbital:

Ocular:

Zygomatic:

Frontal:

Cornual block: is necessary for dehorning of cattle. For goats you should also do the **intratrochlear block** for dehorning.

Proximal paravertebral block (Farquharson method): placement of local anesthetic just off the midline and caudal to the transverse processes of T13, L1 and L2 vertebrae. Block nerves T12, L1 and L2.

Distal paravertebral block: placed above and below the ends of the transverse processes of L1, L2 and L4 vertebrae. Block nerves T12, L1 and L2.

Palmar digital nerve block (PD or Heel block): blocks the palmar third of the foot, including navicular bone. In some horses it blocks 70% of the hoof.

Abaxial Sesamoid block: when suspecting of laminitis. It blocks the whole hoof and the proximal interphalangeal joint.

Low four point: blocks the entire metacarpophalangeal (fetlock) joint and structures distal to this joint.

High four-point (subcarpal block): desensitizes the metacarpal region along with the entire metacarpophalangeal (fetlock) joint and structures of the digit.

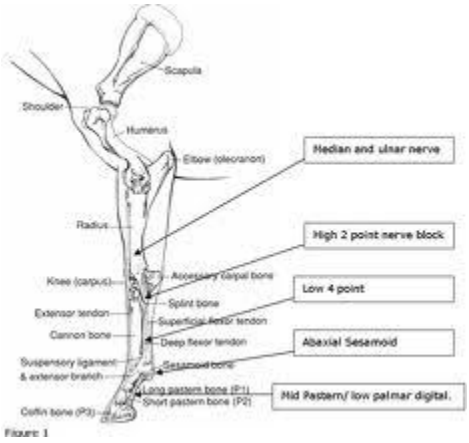


Figure: 1

- **Other Drugs**

Guaifenesin: Also known as Guaiacol glyceryl ether (GGE). NOT ANESTHETIC! Anti-tussive (anti-cough) and decongestant med that also works as a muscle relaxant and leads to immobilization. Used to support excitement-free anesthesia induction and recovery in horses. Effects include decrease respiratory rate. Can lead to inflammation if done perivascular and high concentration (>15%) cause hemolysis.

Pentobarbital: EUTHANASIA DRUG. Like all barbiturates it causes respiratory depression. If you can't get an IV, euthanasia can be done by intraperitoneal injection of pentobarbital with lidocaine.

Phenobarbital: Anti-seizure drug.

Dobutamine: increase blood pressure

Phenylephrine: increase blood pressure and a urinary tract analgesic.

Amiodarone: use for treatment of persistent ventricular tachycardia following cardiac arrest.

Magnesium Sulfate: use for treatment of persistent ventricular tachycardia following cardiac arrest.

- **DON'T DO (BCSE GOLD)**

1. Atropine in horses causes ileus.
2. Atropine in febrile patients since is crosses the Blood brain barrier and it may interfere with temperature regulation in the hypothalamus.
3. Atropine causes thickening of bronchial secretions, so avoid in patients with pneumonia.
4. Acepromazine, Ketamine and xylazine in seizure patients.
5. Thiopental in animals with asthma (cases apnea)

6. Thiopental in Sighthouds (Grey Hounds) because they have low body fat and less efficient liver, which increases recovery times.
7. Morphine or Ketamine in animals with high intracranial pressure
8. Nitrous oxide (N_2O) in horses. Nitrous oxide causes distention of the intestines and may result in postoperative colic in horses.
9. Ultra-short barbiatuates can cause severe tissue irritation and sloughing if they get outside the vein when injected.
10. Benzocaine in cats causes methemoglobinemia. Methemoglobinemia reduces the ability of the RBC to release oxygen to tissues leading to tissue hypoxia.
11. Xylazine makes cats vomit, so be careful! It also causes muscle tremors, bradycardia and reduced respiratory rate in cats.
12. Ketamine in cats should be associated with ophthalmic ointment, as the eyes stay open when using this drug.
13. Ketamine in dogs with increase intraocular pressure (like glaucoma).

- **Things that can mess with the Anesthesia**

Porcine Stress Syndrome (PSS): adverse readtion to halothane. Use ice packs and alcohol to decrease body temperature and administer dantrolene (ryanodine receptor antagonist) and lidocaine (for cardiac arrhythmias). Calcium and potassium chloride are contraindicated. PSS is also known as **malignant hyperthermia**.

Oculo-cardiac Reflex: Stows the heart rate when intraocular pressure increases. This may occur when the globe is manipulates during any eye surgery, but is more common during enucleation.

Marey's reflex or Baroreceptor response: is one of the body's homeostatic mechanisms that helps to maintain blood pressure at nearly constant levels. The baroreflex provides a rapid negative feedback loop in which an elevated blood pressure reflexively causes the heart rate to decrease and also causes blood pressure to decrease.

Vago-vagal response: brief loss of consciousness due to a neurologically induced drop in blood pressure

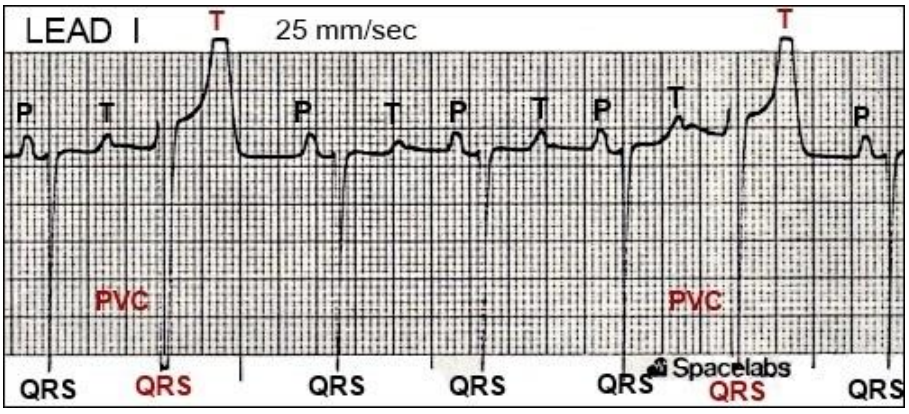
- **Species specific Trades**

1. 1-2% Lidocaine spray in cats before intubate to prevent laryngospasm.
2. Pigs are also prone to laryngospasm.
3. Bovines and Camelids continue to salivate under sedation of anesthesia. Put the nose own so the saliva can drain away from the pharynx.
4. Indirect and direct blood pressure measures DO NOT correlate well in reptiles.
5. Surgical plane of anesthesia usually results in loss of the righting reflex (less reliable in turtles and tortoises).
6. Corneal and palpebral reflexes cannot be elicited in snakes (they do not have eyelids)!
7. Pulse oximetry values are not absolute reliable in reptiles, BUT can be useful for anesthesia monitoring.
8. Reptiles should be kept upper limit of their normal temperature range during induction, surgery and anesthetic recovery to optimize anesthetic metabolism and recovery.
9. Chelonians tent to have long period between breaths, making induction of anesthesia via inhalants difficult. Anesthesia is usually induced with injectables.

- **Calculations and Interpreatation**

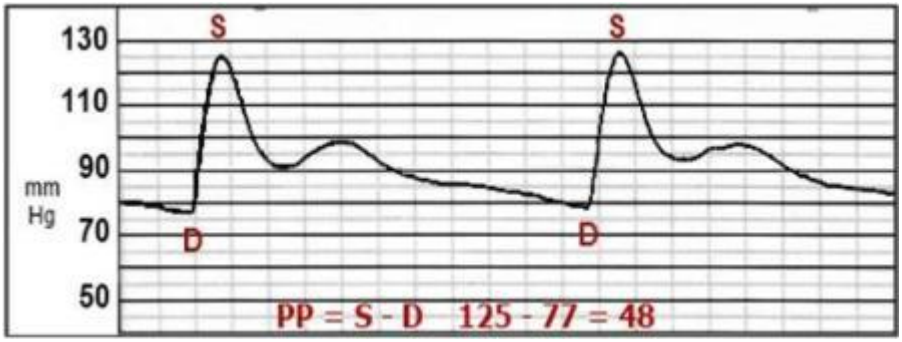
× **ECG in a horse**

That animal shows a PVC.



× **Pulse Pressure (PP)**

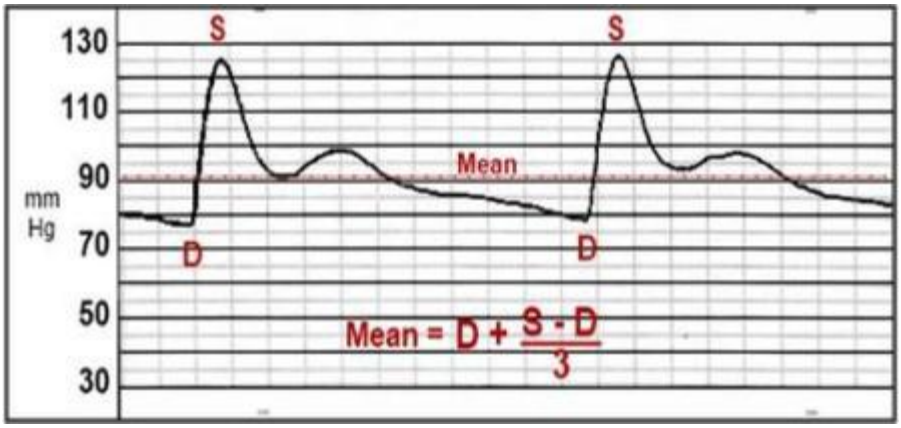
Seen in the side image! →



× **Mean Arterial Pressure (MAP) – Side image**

A low MAP results in ischemia and organ damage if present too long. Hypotension is MAP bellow 65mmHg

MAP = 80+ (125-80)/3= 95mmHg



Note the dip in BP waveform very close to the mean pressure line on the illustration. This is the **dicrotic notch**, which is produced by change in blood flow in the large vessels when the aortic valve closes.

× **Systolic Arterial Pressure (SAP)**

SAP is 125-127mmhg

× **Diastolic Arterial Pressure (DAP)**

DAP is 76-80

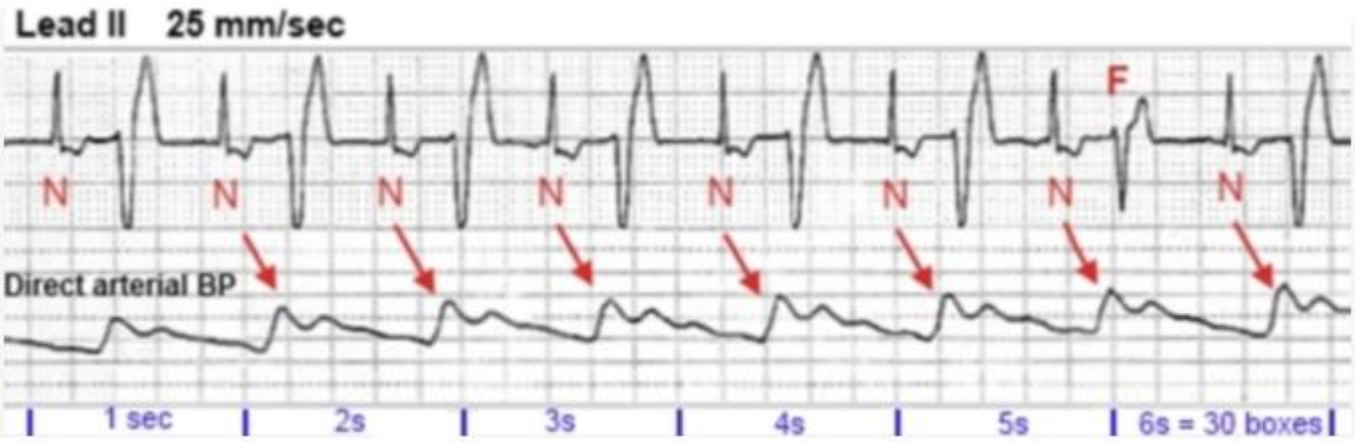
× **Pulse Rate (PR)**

Paper speed is 25mm/sec. Each box has 5mm, therefore the speed is 5 big boxes/sec. There patient has 16 **depolarization** (big spikes).

However, there were only 8 ventricular contraction that actually produced a blood flow (a pulse) – Red arrow.

To calculate the pulse rate you divide the number of sec in 1 min by the amount of seconds in the paper, and than multiply it by the number of ventricular contractions that created a pulse. Therefore, Pulse rate= (60/6)*8=80.

These animal has **ventricular bigeminy**, which is **a premature ventricular contraction** (PVC) follow by a sinus beat.



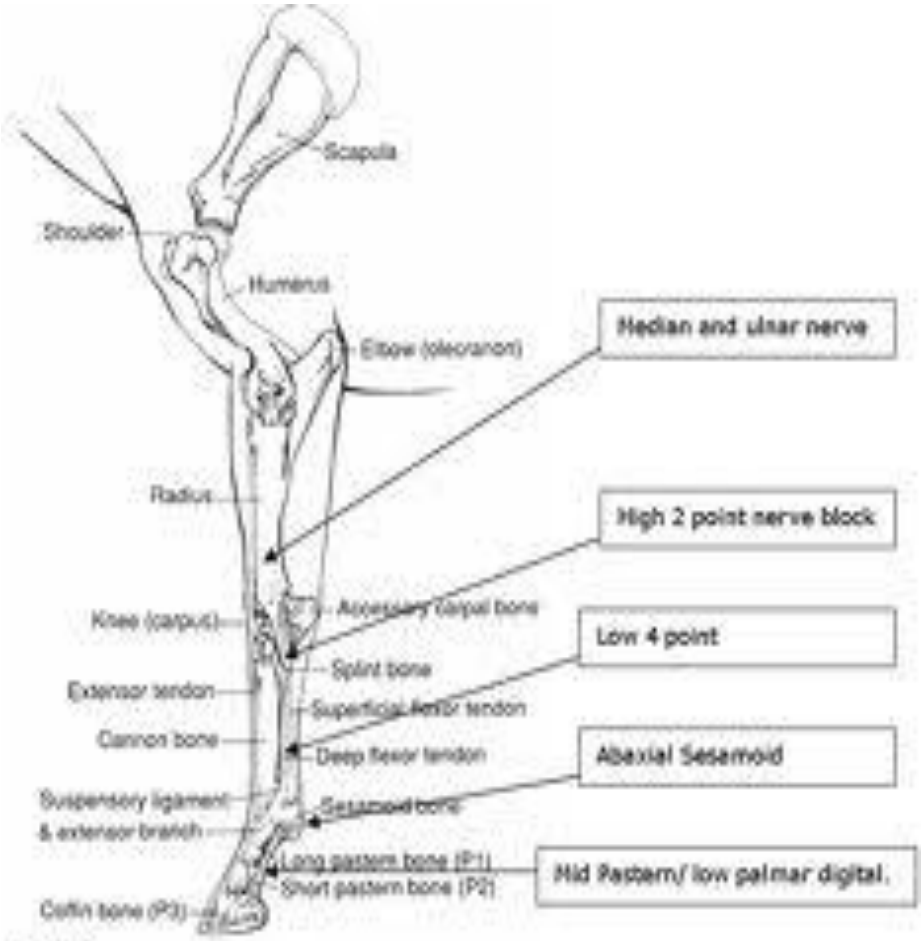

Scapula
Shoulder
Humerus
Elbow (olecranon)
Median and ulnar nerve
Radius
High 2 point nerve block
Knee (carpus)
Accessory carpal bone
Low 4 point
Splint bone
Extensor tendon
Superficial flexor tendon
Cannon bone
Deep flexor tendon
Abaxial Sesamoid
Suspensory ligament
& extensor branch
Sesamoid bone
Long pastern bone (P1)
Short pastern bone (P2)
Mid Pastern/ low palmar digital.
Coffin bone (P3)

Figure 1