zukureview

SAVE & EXIT

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1	2	3	4	5	6	7	8	9	10

What is the effect of a high flow rate (200-300 ml/kg/min) when you are using a Bain nonrebreathing anesthetic circuit?

No effect on the amount of rebreathing of expired gases	HIDE
Increase the amount of rebreathing of expired gases	HIDE
Decreases the amount of oxygen that is used	HIDE
Prevents rebreathing of expired gases	HIDE

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Overview | Mark this Question | Lab Values | Definitions | Report a Problem

SAVE & EXIT

PREV

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Correct: Prevents rebreathing of expired gases

A Bain anesthetic circuit run at a high flow rate of 200-300 ml/kg/min will not allow rebreathing of exhaled gasses.

Remember that a Bain system is like a tube within a tube. New oxygen and anesthetic gas is inhaled down the inner tube, and exhaled gas exits through the outer tube.

At lower flow rates (ie: 130-200 ml/kg/min or less) the Bain circuit functions as a PARTIAL rebreathing system, and the animal rebreathes some of the exhaled gasses.
Refs: Bassert and Thomas, McCurnin's Clinical Textbook for Veterinary Technicians, 8th ed. pp. 1094-5.

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1	2	3	4	5	6	7	8	9	10

Which choice correctly lists the order in which gases pass through a typical circular anesthetic circuit?

Pressure regulator, vaporizer, patient, CO2 canister, flowmeter	HIDE
Flowmeter, pressure regulator, vaporizer, patient, CO2 canister	HIDE
Vaporizer, pressure regulator, flowmeter,CO2 canister, patient	HIDE
Pressure regulator, flowmeter, vaporizer, patient, CO2 canister	HIDE

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Correct:

Pressure regulator, flowmeter, vaporizer, patient, CO2 canister.

Carrier gas exits the high pressure tank through the pressure regulator, which DECREASES the gas pressure.

It then flows through the flowmeter, which controls the amount of carrier gas **flow**, then the vaporizer, where anesthetic vapor is produced from the liquid.

Both anesthetic vapor and carrier gas exit the vaporizer and flow into the breathing circuit where the animal inhales the mix.

SAVE & EXIT

PREV

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Pressure

Exhaled gases pass through a CO2 scavenger canister and are then recycled in a circle system, or are disposed of completely in a non-rebreathing system.

STRATEGY HINT: This is an ORDER question. If you already know that the CO2 canister is LAST in the order, you can narrow your choices down to 2, right away.

When you see ordering questions, look for things you are pretty sure must go FIRST or LAST, and then work from those choices to fill in between.

Refs: McCurnin & Bassert, Clin Textbook for Vet Technicians, 8th ed. pp. 1094-5, fig 29-14.

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1	2	3	4	5	6	7	8	9	10

Which of the following choices is a side effect that you should be aware of when using ketamine for anesthesia in cats?

Cardiac arrest	HIDE
Laryngospasm	HIDE
Eyes stay open	HIDE
Dose-dependent respiratory depression	HIDE

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PREV

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Which of
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Correct:

Eyes stay open.

Ketamine and tiletamine are dissociative anesthetics often used as a part of the pre-med to immobilize cats prior to catheter placement or induction of general anesthesia.

A cat.'s EYES stay OPEN with ketamine/tiletamine, so the corneas must be protected - an eye ointment like Lacri-lube should be instilled into both eyes.

Remember cats ARE vulnerable to laryngospasm if you touch the larynx too much/too roughly during intubation for gas anesthesia.

Spray with lidocaine topical anesthetic to prevent laryngospasm.

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1	2	3	4	5	6	7	8	9	10

Which of the following clinical signs are most consistent with Stage 3, plane III of general anesthesia in dogs and cats?

Abnormal nystagmus, brisk corneal response, pupils miotic	HIDE
Eyes roll dorsally, weak palpebral response, pupils variable	HIDE
Eyes ventral, no palpebral response, pupils dilated	HIDE
Eyes central, dilated pupils, strong palpebral response	HIDE

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Overview | Mark this Question | Lab Values | Definitions | Report a Problem

Stage 3, plane III is deep general anesthesia (GA) in dogs and cats -the eyes roll ventrally, pupils are dilated and there is no palpebral response.
Some practitioners describe Stage 3, plane III as "early overdose".
Stage 3, plane II medium GA is preferred for most invasive surgical procedures.

The eyes of cattle also roll ventrally and have no palpebral response at Stage 3, plane III.

There is variability between patients, protocols and procedures, and some authors differ when describing differences between stages of GA.
For example, dilation of the pupil is affected by depth but also by adjunct drugs such as anti-cholinergics (atropine, etc) and paralytic agents (atracurium).

For more, see Anesthetic Monitoring and Monitoring Anesthetic Depth by Lyon Lee DVM, PhD.

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SAVE & EXIT

PREV NEXT

41	42 M	43 M	44	45	46	47	48	49	50

The corneal reflex may be absent during what stage of general anesthesia?

Stage IV	HIDE
Early stage III	HIDE
Stage 1, plane I	HIDE
Stage II, plane II	HIDE

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Overview | Mark this Question | Lab Values | Definitions | Report a Problem

Correct

The corneal reflex may be absent during Stage IV, which is an *overdose* of anesthesia-the patient will be very close to death.

The corneal reflex should NEVER be gone if the patient is at an appropriate depth of anesthesia, unless the patient is paralyzed with a neuromuscular blocker.

The corneal reflex does not always disappear, in fact, it is still present for a short time after death in some patients.

It is not wise to use the corneal reflex routinely to determine anesthetic depth as it could be damaged with frequent touch. Also, it is often not available in dogs and cats since the eyeball rolls ventrally.

Other reflexes and signs of anesthetic depth are quite reliable – palpebral response, eye position, tearing, nystagmus, etc.

Note – there are no *planes* of anesthesia in stages I or II.

For more, see Anesthetic Monitoring and Monitoring Anesthetic Depth by Lyon Lee DVM, PhD.

Refs: McCurnin's Clin Textbk for Vet Techs, 8th ed. p.1102, Lumb & Jones, Vet Anes, 4th ed. pp. 12-5, and Thomas & Lerche, Anesthesia & Analgesia for Vet Techs, 4th ed. pp. 140-3, 171-6.

Stages		Description
1		Inducement, excitement, pupils constricted, voluntary struggling
2		Obtunded reflexes, pupil diameters start to dilate. still excited, involuntary struggling
3	Planes	There are three planes- light, medium, and deep
	Light	More decreased reflexes, pupils constricted, brisk palpebral reflex, corneal reflex, absence of swallowing reflex, lacrimation still present, no involuntary muscle movement.
	Medium	Ideal plane for most invasive procedures, pupils dilated, loss of pain, loss of palpebral reflex, corneal reflexes present.
	Deep (early overdose)	Respiratory depression, severe muscle relaxation, bradycardia, no reflexes (palpebral, corneal), pupils dilated
4		Very deep anesthesia. Respiration ceases, cardiovascular function depresses and death ensues immediately.

zukureview

SAVE & EXIT

PREV NEXT

1	2	3	4 M	5	6	7	8	9	10

Which two drugs are contraindicated in animals with a history of seizures?

Xylazine, thiopental	HIDE
Ketamine, diazepam	HIDE
Morphine, phenobarbital	HIDE
Acepromazine, ketamine	HIDE

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Overview | Mark this Question | | Definitions |

Correct

Acepromazine, ketamine, and xylazine are contraindicated in animals with a history of seizures.

Thiopental is contraindicated in animals with history of asthma, because it can cause apnea, and in Greyhounds.

It is currently unavailable in the U.S. and Canada.

Morphine should not be used in cases with high intracranial pressure (like head trauma after being hit by a car).

Diazepam and phenobarbital are drugs used to TREAT seizures.

Refs: Plumb's Veterinary Drug Handbook, 7th ed. pp. 4-8, 762-9, 1397-1402.

STRATEGY HINT: This is a "frequency" question. That is, you can see how the choice "ketamine" is repeated, twice. In this case, even if you have no idea what the right answer may be, simply narrowing down to the two answer choices that include ketamine will increase your chances of picking correctly to 50:50 !

Chances are that the correct choice will include the word that is repeated the most often.

NOTE- if you know the correct answer without the aid of study tricks like this, choose the answer your brain tells you is correct.

These kinds of study tricks are only a guide to use if you are lost, they are NOT a guarantee of getting the answer right every time.

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1	2	3	4 M	5	6	7	8	9	10

A young cat is under general anesthesia for a routine ovariohysterectomy. The technician notices that the cat has stopped breathing and her mucous membranes are a muddy blue color.

Of the following choices below, which one is the best next step?

Ventilate the cat	HIDE
Give a specific sedative antagonist if available	HIDE
Stop anesthetic administration and assess for cardiac arrest	HIDE
Check for a pulse and measure blood pressure	HIDE
Ensure airway, oxygen supply, and breathing circuit are open	HIDE

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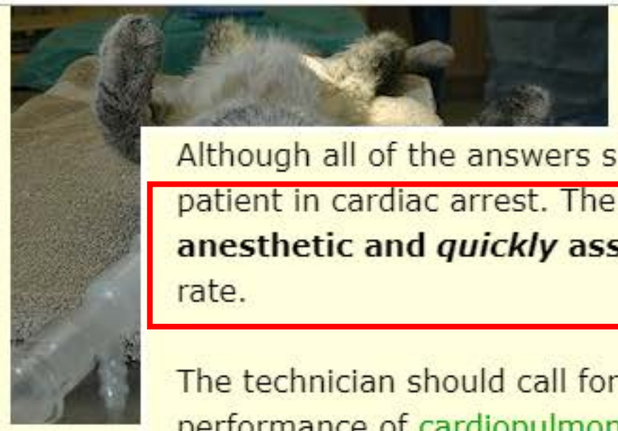

Although all of the answers should be performed, there is little time to revive a patient in cardiac arrest. The first step should be - **stop administration of inhalant anesthetic and *quickly* assess cardiovascular status**, ie, check for pulse/heart rate.

The technician should call for help to aid in a thorough assessment of the patient and performance of cardiopulmonary cerebral resuscitation (CPR) if required.

Even though patients that arrest under general anesthesia have a better chance for recovery, Interruption of or delay in performance of cardiac compressions is associated with poorer outcomes.

The use of anesthetic monitors that constantly evaluate cardiovascular function and the presence of an anesthesia technician at all times has been shown to greatly improve outcome in cases with cardiac arrest.

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Cardiopulmonary Resuscitation

By **Andrew Linklater, DVM, DACVECC, Clinical Instructor, Lakeshore Veterinary Specialists, Glendale, Wisconsin**

The success of cardiopulmonary resuscitation (CPR) efforts depends on many factors, including the underlying cause of the arrest, the timeliness and effectiveness of the intervention, and the preparedness of the team administering CPR. Overall prognosis of recovery from cardiopulmonary arrest (CPA) with CPR efforts is as high as 35%–44%; however, only <10% of animals survive to discharge. Animals with CPA associated with anesthesia have a better prognosis. The American College of Veterinary Emergency and Critical Care developed the first set of guidelines for veterinary CPR; this effort was termed the Reassessment Campaign on Veterinary Resuscitation (RECOVER) and is available on the association's website at www.acvecc-recover.org. **CPR is divided into several sections**: **prevention and preparedness**; **basic cardiac life support (BCLS)** promoting **oxygenation, ventilation, and circulation**; **advanced cardiac life support (ACLS)** using **electrocardiographic evaluation of cardiac rhythms, administration of drugs, and defibrillation when necessary; monitoring during CPR; and postresuscitation management**, which involves intensive monitoring of common complications after arrest as well as diagnosis and treatment of underlying conditions that led to the cardiopulmonar

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1	2	3	4 M	5 M	6 M	7	8	9	10

What color is an oxygen tank supposed to be in the U.S.?

Red or brown	HIDE
White or green	HIDE
Blue	HIDE
Yellow	HIDE

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Yellow

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Correct: **White or green**

No matter what color the tank is, ALWAYS read the tag or label on the tank first to verify the gas contents inside. One instructor in Surgical Nursing and Anesthesia has reported seeing of a green tank containing carbon dioxide instead of oxygen!

That being said, oxygen tanks in the U.S are typically white or green. Nitrous oxide tanks, (laughing gas) are blue. (Try remembering-"Laughing gas chases the blues")

STRATEGY HINT: This is an "inclusion" question. That is, the choices "White or green" and " Red or brown" each INCLUDE more possibilities of being correct than the single-color choices of blue or yellow.

If you were completely lost and had nothing else to go on, you might increase your

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1

What col

Red or b

White o

Blue

Yellow

and " Red or brown" each INCLUDE more possibilities of being correct than the single-color choices of blue or yellow.

If you were completely lost and had nothing else to go on, you might increase your chances of guessing right by choosing between the two inclusive choices of "White or green" and " Red or brown".

This WILL NOT guarantee you always get a question right, but if you are lost, use whatever you can, including strategies like this.

Refs: Bassert and Thomas, McCurnin's Clinical Textbook for Veterinary Technicians, 8th ed. p. 1091.

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1	2	3	4 M	5 M	6 M	7	8	9	10

Which choice indicates that the soda lime granules in a CO2 absorbent canister have become exhausted?

Color changes to brown and liquid accumulates at the base of the canister	HIDE
Color change from purple to pink, crystals become powder	HIDE
Color stays pink, regardless of CO2 exposure	HIDE
Crystals become hard and turn off-white	HIDE

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Crystals become hard and turn off-white.

The purpose of a canister of soda lime granules is to absorb carbon dioxide from exhaled anesthetic gasses.

Fresh absorbent crystals are white and can be crushed. But exhausted, saturated crystals become a distinct off-white color and are hard.

Most granules contain a pH-sensitive dye that becomes visible as the absorbent granules become saturated. (The color itself is not so important as the color changing).

A color change from white to purple or violet typically indicates that the CO2 scavenger granules have become saturated with CO2, but this color change does not always happen, and will dissipate after a few hours.

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1	2	3	4 M	5 M	6 M	7	8	9	10

In which of the following animals would it be appropriate to inflate the cuff of the endotracheal tube after intubation?

4-week-old kitten	HIDE
Adult Rottweiler	HIDE
Ferret	HIDE
African gray parrot	HIDE

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Ferret

African

Correct:

Use a CUFFED endotracheal tube in an adult dog.

Use UNcuffed tubes in ferrets and very small animals (puppies, kittens) to preserve a larger airway diameter. Use Uncuffed in birds because they have complete tracheal rings that make their trachea less compliant (flexible) when an endotracheal tube cuff is inflated.

An endotracheal tube goes between the vocal folds of the trachea ("endo" equals "into" the trachea!). Typically you inflate the cuff around the end of the tube to seal the airway.

Refs: Bassert and Thomas, McCurnin's Clinical Textbook for Veterinary Technicians, 8th ed. p. 1087, fig 29-2.

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1	2	3	4 M	5 M	6 M	7	8	9	10

Which anesthetic breathing system has an intermediate fresh gas flow rate during maintenance of anesthesia?
(ie: 10-30 ml/kg/min, not the highest, and not the lowest)

Nonrebreathing system	HIDE
Bain system	HIDE
Closed system	HIDE
Semi-closed system	HIDE

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Correct

Semi-closed and partial rebreathing systems are the same thing.

They run at intermediate flow rates where fresh gas is delivered in excess of metabolic consumption, from about 10 ml/kg/min (large animals) or 30 ml/kg/min (small animals).

A Bain system runs at HIGH fresh gas flow rates, 100-300 ml/kg/min. A Bain anesthetic circuit run at a high flow rate of 200-300 ml/kg/min will not allow rebreathing of exhaled gasses.

Remember that a Bain system is like a tube within a tube. New oxygen and anesthetic gas is inhaled down the inner tube, and exhaled gas exits through the outer tube.

At flow rates of 130-200 ml/kg/min or less the Bain functions as a partial rebreathing system, and the animal rebreathes some of the exhaled gasses, but this is still a substantially higher flow rate than is mentioned in the question.

A closed anesthetic rebreathing system only provides enough fresh gas flow to meet an animal's metabolic needs, about 5-10 ml/kg/min (depending on animal size. Flow is lower for larger animals and higher for smaller animals).

Refs: Bassert and Thomas, McCurnin's Clinical Textbook for Veterinary Technicians, 8th ed. pp. 1094-5 and Tighe & Brown, Mosby's Comprehensive Review for Vet Techs, 2nd ed. pp. 308-9.

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11	12	13	14	15	16	17	18	19	20

Which sedative typically causes the least cardiac and respiratory depression?

Propofol	HIDE
Xylazine	HIDE
Acepromazine	HIDE
Dexmedetomidine	HIDE
Butorphanol	HIDE

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Overview | Mark this Question | Lab Values | Definitions | Report a Problem

Correct

Acepromazine causes the least respiratory and cardiac depression of the agents listed. It is a phenothiazine tranquilizer that causes mild sedation. It is often given in combination with other agents as a pre-anesthetic or for stronger sedation.

Xylazine and dexmedetomidine are alpha-two adrenergic agonists used as sedatives. They can cause significant bradycardia, reduction in cardiac output, hypotension, cardiac arrhythmias, and respiratory depression.

Butorphanol is a mixed opioid agonist–antagonist. It can cause respiratory depression and bradycardia.

Propofol can lead to significant respiratory depression, apnea, bradycardia, and decreased cardiac contractility.

Refs: Bassert and Thomas, McCurnin's Clinical Textbook for Veterinary Technicians,

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PREV NEXT

11 M	12	13	14	15	16	17	18	19	20

Which anesthetic breathing system is the worst choice when using nitrous oxide?

Semi-closed rebreathing	HIDE
Nonrebreathing	HIDE
Closed rebreathing	HIDE
Bain nonrebreathing	HIDE

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Correct: **Closed rebreathing**

Oxygen depletion and nitrous oxide buildup are common problems in a closed rebreathing system, so you should NOT use nitrous oxide with a closed system. Because higher gas flow rates are used with semi-closed and nonrebreathing systems, nitrous oxide (N20) buildup is less of a concern.

Refs: Tighe and Brown, Mosby's Comprehensive Review for Vet Techs, 2nd ed. pp. 308-9.

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SAVE & EXIT

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11 M	12	13	14	15	16	17	18	19	20

Which inhaled anesthetic gas has the highest solubility and the slowest speed of induction and recovery?

Sevoflurane	HIDE
Isoflurane	HIDE
Halothane	HIDE
Methoxyflurane	HIDE

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SAVE & EXIT

PREV

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Which in
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Sevoflur
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Halotha
Methoxy

Correct: Methoxyflurane

High solubility means the gas is absorbed into the body tissues the most, causing slow anesthetic induction and slow recovery. Methoxyflurane has a very high solubility in the blood which associated with slow inductions and recoveries.

In fact, we generally do not use methoxyflurane in large animals because induction and recovery is so slow.

Refs: Bassert and Thomas, McCurnin's Clinical Textbook for Veterinary Technicians, 8th ed. pp. 1086-7.

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11 M	12	13	14	15	16	17	18	19	20

Which one of the following anesthetic drugs is contraindicated in patients with congestive heart failure?

Butorphanol tartrate	HIDE
Diazepam	HIDE
Etomidate	HIDE
Dexmedetomidine	HIDE
Midazolam	HIDE

BACK NEXT LEAVE BLANK

Overview | Mark this Question | Lab Values | Definitions | Report a Problem

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Midazolam HIDE

BACK NEXT

Correct:

Dexmedetomidine, an alpha-2 adrenergic agonist, is contraindicated in cardiac patients. Potential adverse effects include bradycardia, atrioventricular block and possible death due to circulatory failure.

Benzodiazepines (e.g., diazepam, midazolam) and opioids (e.g., butorphanol) are generally safe in cardiac patients.

Etomidate, an injectable anesthetic, may be a useful alternative to propofol in cardiac patients because it has minimal cardiovascular effects.

Refs: The Merck Veterinary Manual online edition and Plumb's Veterinary Drug Handbook, 8th edition, *Butorphanol Tartrate, Dexmedetomidine, Diazepam, Etomidate, Midazolam HCl*.

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PREV NEXT

11 M	12	13	14 M	15	16	17	18	19	20

What fresh gas flow rate should you use during induction when using a semi-closed rebreathing anesthetic system in small animals?

200 ml/kg/min	HIDE
5X the calculated maintenance flow	HIDE
100 ml/kg/min	HIDE
30-50 ml/kg/min	HIDE

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PREV

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Correct: 100 ml/kg/ min

The fresh gas flow rate during induction and recovery using a semi-closed rebreathing system is about 100 ml/kg/min, which is 2 to 3 times the calculated maintenance flow.

During the maintenance of anesthesia, the flow is reduced to 30-50 ml/kg/min in small animals.

The minimum flow rate is equal to the patient's metabolic oxygen requirement. Most use a higher flow rate as it is safer and requires less monitoring.

Another consideration is the minimum setting required by the vaporizer, as some are not accurate at extremely low flows.

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11 M	12	13	14 M	15	16	17	18	19	20

Which one of the following monitors is used to continuously measure blood oxygen saturation (SaO_2) in anesthetized and critical care patients?

Oscillometry	HIDE
Pulse oximeter	HIDE
Electrocardiograph	HIDE
Plethysmograph	HIDE

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Overview | Mark this Question | Lab Values | Definitions | Report a Problem

Correct

The pulse oximeter continuously measures blood oxygen saturation (SaO_2), the percentage of hemoglobin molecules in arterial blood saturated with oxygen.

SpO_2 just means the SaO2 measurement as determined by PULSE oximetry.

Pulse oximetry determines the absorption of light as it passes through tissues. The device is usually placed on the tongue, but the toe web, flank skin, ears, or lips can also be used.

Two wavelengths of light are used, one absorbed by oxygenated hemoglobin (arterial) and one absorbed by de-oxygenated hemoglobin (venous).

The results are compared to expected parameters and the pulse oximeter shows % (SaO_2).

Most also display heart rate, those with a graphic display also show an waveform that corresponds to arterial blood flow.

So, pulse oximetry monitors multiple parameters – (SaO_2),heart rate and blood flow. The waveform is evidence of blood flow, and indirect evidence of cardiac rhythm.

Normal values should be above 95%, which corresponds to a partial pressure of oxygen of 80 mmHg.

Refs: McCurnin's Clin Textbk for Vet Techs, 8th ed. pp. 913, 919, 1110-11, Thomas & Lerche Vet Anes and Analgesia for Vet Techs, 4th ed. pp. 159-62 and the Merck Veterinary Manual online edition.

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SAVE & EXIT

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21	22	23	24	25	26	27	28	29	30

Which one of the following choices is the correct explanation of the function of a pulse oximeter?

Detects the flow of blood through small arteries and measure blood pressure	HIDE
Automatically measures and records the pulse rate and rhythm	HIDE
Measures the oxygen saturation of hemoglobin and pulse rate	HIDE
Measures carbon dioxide concentration after every 10th pulse	HIDE
Amplifies the pulse rate and oxygenation of venous blood without touching patient	HIDE

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SAVE & EXIT

PREV

21

Which or
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Measure

Correct **Measures the oxygen saturation of hemoglobin and pulse rate**

A pulse oximeter is used primarily to measure the oxygen saturation of hemoglobin in arterial blood.

A stable pulse is required for a good measurement, so the heart rate will also be measured.

An esophageal stethoscope amplifies the sound of the heart to allow monitoring at a distance.

An electrocardiogram (ECG) records heart rate and rhythm.

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

Amplifies the pulse rate and oxygenation of venous blood without touching patient

HIDE

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SAVE & EXIT

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11 M	12	13	14 M	15	16 M	17	18	19	20

How long can local anesthesia with bupivicaine last?

1–2 hours	HIDE
4–10 hours	HIDE
3–4 hours	HIDE
2–3 hours	HIDE
Less than 1 hour	HIDE

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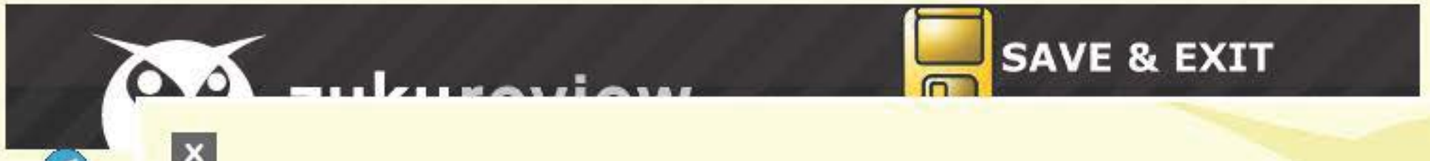

PREV

11 M

How long

1–2 hou
4–10 ho
3–4 hou
2–3 hou
Less than 2 hour

Correct:

Bupivicaine can last 4–10 hours. Bupivicaine is the most frequently used local anesthetic for oral surgery because it has a long duration of action. It takes approximately 4–20 minutes to reach full effect.

Conversely, lidocaine takes effect in just 3–5 minutes but only lasts 1.5–2 hours.

Refs: Plumb's Veterinary Drug Handbook, 8th ed. and Bassert and Thomas, McCurnin's Clinical Textbook for Veterinary Technicians, 8th ed., p. 1331.

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11 M	12	13	14 M	15	16 M	17 M	18	19	20

Which of the following correctly describes the phenomenon of 'wind-up' in pain physiology?

Exaggerated response to a painful stimulus, resulting in primary hyperalgesia	HIDE
A painful response that is greatly exaggerated beyond the protective effect normally seen	HIDE
Sensitization of nociceptors and pain pathways in response to bombardment by painful sensory impulses	HIDE
Amplification of the peripheral pain response that produces a hyperreactivity in interneurons of the spinal cord	HIDE
Painful response to stimuli that normally do not cause pain	HIDE

BACK NEXT LEAVE BLANK

zukureview

SAVE & EXIT

PREV

11 M

Which of

Exagger
hyperalg

A painfu
normally

Sensitiz
by painf

Sensitization of nociceptors and pain pathways in response to bombardment by painful sensory impulses

Correct:

Sensitization of nociceptors and pain pathways in response to intense bombardment of painful sensory impulses is the phenomenon of wind-up, which greatly amplifies the pain response.

Wind-up occurs in response to tissue damage from trauma and surgery. Nociceptors respond over a wider area than usual, at faster rates, and to stimuli that are not normally painful.

Prevention/treatment of 'wind-up' is an important aspect of pre-emptive analgesia utilized with elective surgery and in the treatment of traumatic pain.

Amplification of the peripheral pain response that produces a hyperreactivity in interneurons of the spinal cord HIDE

Painful response to stimuli that normally do not cause pain HIDE

BACK NEXT

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SAVE & EXIT

PREV

11 M

Which of

N-methyl-D-aspartate (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.

Click for a very thorough presentation of Neurophysiology of Pain and Delivery of Pain Care by Dr. Mark Epstein.

Refs: Gaynor & Muir Handbook of Vet Pain Mgt 2nd ed. pp. 34-6, 57-9, Greene, Vet Anes and Pain Mgt Secrets, pp. 323-33, 345-7 and the Merck Veterinary Manual online edition.

Exagger hyperalg	
A painfu normall	
Sensitiz by painf	
Amplification of the peripheral pain response that produces a hyperreactivity in interneurons of the spinal cord	HIDE
Painful response to stimuli that normally do not cause pain	HIDE

BACK NEXT

zukureview

SAVE & EXIT

PREV NEXT

11 M	12	13	14 M	15	16 M	17 M	18 M	19	20

What is the function of an anesthetic vaporizer?

Moisturizes inhaled gases	HIDE
Controls the fresh gas flow rate into breathing circuit	HIDE
Scavenges CO2 vapor from exhaled gases	HIDE
Vaporizes liquid inhalant anesthetics	HIDE

BACK NEXT LEAVE BLANK

Overview | Mark this Question | Lab Values | | Report a Problem

SAVE & EXIT

PREV

11 M

What is t

Moisturi
Controls
Scaveng
Vaporize

Correct: **Vaporizes liquid inhalant anesthetics**

Vaporizers convert volatile liquid anesthetics (like isoflurane) into vapor that is combined with a carrier gas for delivery into the patient's breathing circuit.

100% oxygen is used most commonly in veterinary medicine but oxygen can also be combined with air or nitrous oxide.

There are many ways to categorize vaporizers, three are described below:
1. Carrier gas flow - variable bypass or measured flow
2. Method of vaporization - flow over, bubble through, and injection
3. Accuracy - Precison or non-precision.

BACK NEXT

Overview | Mark this Question | Lab Values | | Report a Problem

3. Accuracy - Precision or non-precision.

PREV

11 M

What is t

Moisturi
Controls
Scaveng
Vaporize

Precision vaporizers deliver precise a concentration of inhalant anesthetic regardless of gas flow rate, temperature, or ventilation, and are typically positioned OUTSIDE the breathing circuit.

Non-precision vaporizers do NOT deliver a precise concentration of anesthetic, are affected by changes in the gas flow rate, temperature, and ventilation, and are usually positioned INSIDE the breathing circuit.

Refs: Bassert and Thomas, McCurnin's Clinical Textbook for Veterinary Technicians, 8th ed. pp. 1093-4 and Greene's Veterinary Anesthesia and Pain Management Secrets, pp. 71-6.

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SAVE & EXIT

PREV NEXT

11 M	12	13	14 M	15	16 M	17 M	18 M	19	20

During surgery in a dog anesthetized for enucleation of the left eye, the heart rate slows down every time the surgeon manipulates the globe.

What following is the correct name for this response?

The baroreceptor response	HIDE
Oculo-cardiac reflex	HIDE
Vago-vagal response	HIDE
A Valsalva maneuver	HIDE

BACK NEXT LEAVE BLANK

Overview | Mark this Question | Lab Values | Definitions | Report a Problem

zukureview

SAVE & EXIT

PREV

11 M

During s
down ev

What fol

The bar

Oculo-c

Vago-va

A Valsalva maneuver HIDE

Correct:

The oculo-cardiac reflex (OCR) is slowing of the heart rate when intraocular pressure (IOP) increases. This may occur when the globe is manipulated during any eye surgery, but is more common during an enucleation.

Direct pressure on the globe or traction on the extraocular muscles stimulates the trigeminal nerve, which relays this input to the brain.

Vagal centers are stimulated which send impulses to the heart, causing bradycardia and occasionally even cardiac arrest.

Stimulation of the OCR by applying pressure to the eyeball(s) is also a treatment for supraventricular tachycardia in awake patients.

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Overview | Mark this Question | Lab Values | Definitions | Report a Problem

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SAVE & EXIT

PREV NEXT

21	22	23	24	25	26	27	28	29	30

What is the function of a pressure regulator in an anesthetic gas breathing circuit?

Bypasses vaporizer with fresh oxygen	HIDE
Reduces pressure of gas entering anesthetic machine	HIDE
Absorbs CO2 vapor from exhaled gasses	HIDE
Increases pressure of gas entering anesthetic machine	HIDE

BACK NEXT LEAVE BLANK

Overview | Mark this Question | Lab Values | Definitions | Report a Problem

SAVE & EXIT

PREV

21

What is t

Bypasse

Reduces

Absorbs

Increase

Correct: **Reduces pressure of gas entering anesthetic machine**

The pressure regulator DECREASES the pressure of gas (usually oxygen) leaving the pressurized gas cylinder.

At lower pressure, the gas then flows through the flowmeter, (which controls the amount of carrier gas flow) then the vaporizer (where anesthetic vapor mixes) and then into the breathing circuit where the animal inhales the mix.

Exhaled gasses pass through a CO2 scavenger canister and are then recycled, or are disposed of completely (non-rebreathing system).

STRATEGY HINT: This is another kind of "frequency" question. That is, you can see how the choice "reduces pressure" and the "increases pressure" choice are flip sides of the same possibility. (Kind of like being repeated).

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Overview | Mark this Question | Lab Values | Definitions | Report a Problem

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SAVE & EXIT

PREV NEXT

21	22	23	24	25	26	27	28	29	30

Which one of the following choices best explains the concept of balanced anesthesia?

Maintaining the same ratio of anesthetic gas to oxygen used	HIDE
Use of two or more drugs to achieve the desired level of anesthesia	HIDE
Matching the dose of anesthetic drug used to the body weight of patient	HIDE
Varying the dose of the anesthetic used to maintain a certain depth	HIDE

BACK NEXT LEAVE BLANK

Overview | Mark this Question | Lab Values | Definitions | Report a Problem

SAVE & EXIT

PREV

21

Which or

Maintair

Use of t

Matchin

Varying

BACK NEXT

Correct: **Use of two or more drugs to achieve the desired level of anesthesia**

Balanced anesthesia is the **use of two or more drugs** to achieve the desired level of anesthesia.

Refs: Bassert and Thomas, McCurnin's Clinical Textbook for Veterinary Technicians, 8th ed. p. 1078, and Grimm, Tranqulli, and Lamont's Essentials of SA Anesthesia and Analgesia, 2nd ed. p. 279.

Overview | Mark this Question | Lab Values | Report a Problem

zukureview

SAVE & EXIT

PREV NEXT

21	22	23 M	24	25	26	27	28	29	30

An endotracheal tube must be placed during induction of anesthesia.

How far in should the end of the tube be directed for proper access to the trachea?

Between the vocal folds	HIDE
Just to the nasopharnyx	HIDE
Caudal to uvula	HIDE
Between the tonsils	HIDE

BACK NEXT LEAVE BLANK

Overview | Mark this Question | Lab Values | Definitions | Report a Problem

zukureview

SAVE & EXIT

PREV

21

An endot

How far

Between

Just to t

Caudal t

Between the tonsils

HIDE

Correct:

An endotracheal tube goes between the vocal folds of the trachea ("endo" equals "into" the trachea !). Typically you inflate the cuff around the end of the tube to seal the airway.

Use UNcuffed tubes in ferrets and very small animals (puppies, kittens) to preserve a larger airway diameter and in birds.

Birds have complete tracheal rings that make their trachea less compliant (flexible) when an endotracheal tube cuff is inflated.

Refs: Bassert and Thomas, McCurnin's Clinical Textbook for Veterinary Technicians, 8th ed. pp. 1098-9.

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zukureview

SAVE & EXIT

PREV NEXT

21	22	23 M	24	25	26	27	28	29	30

Which anesthetic drug commonly causes vomiting in cats?

Propofol	HIDE
Xylazine	HIDE
Phenobarbital	HIDE
Ketamine	HIDE

BACK NEXT LEAVE BLANK

Overview | Mark this Question | Lab Values | Definitions | Report a Problem

SAVE & EXIT

PREV

21

Which ar

Propofol

Xylazine

Phenoba

Ketamin

BACK NEXT

Overview | Mark this Question | Lab Values | Definitions

Correct:

Xylazine can cause vomiting and retching as well as muscle tremor, bradycardia and reduced respiratory rate in cats. Propofol can cause apnea (stopped breathing) after injection. Remember to protect a cat's eyes with ophthalmic ointment when using ketamine, because they remain open after injection.

Refs: Plumb's Veterinary Drug Handbook, 7th ed. pp. 762-9.

zukureview

SAVE & EXIT

PREV NEXT

21	22	23 M	24	25	26	27	28	29	30

In which animal do you typically AVOID using Atropine (anti-cholinergic) as a premedication before inducing anesthesia?

Pig	HIDE
Cat	HIDE
Horse	HIDE
Dog	HIDE

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Overview | Mark this Question | Lab Values | Definitions | Report a Problem

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SAVE & EXIT

PREV

21

In which
before in

Pig
Cat
Horse
Dog

Correct: Horse

Atropine slows the gut, so there is concern that they might cause colic in HORSES. This is less likely with another anti-cholinergic, glycopyrrolate, so it is sometimes used to prevent bradycardia (slow heart rate) in anesthetized horses

Refs: Plumb's Veterinary Drug Handbook, 7th ed. pp. 126-31, 641-4-5 and Bassert and Thomas, McCurnin's Clinical Textbook for Veterinary Technicians, 8th ed. pp. 1080-1.

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SAVE & EXIT

PREV NEXT

21	22	23 M	24	25	26	27	28	29	30

Which anesthetic induction agent is also a decongestant and antitussive? (prevents coughing)

Ketamine	HIDE
Guaifenesin	HIDE
Phenobarbital	HIDE
Propofol	HIDE

BACK NEXT LEAVE BLANK

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SAVE & EXIT

PREV

21

Which ar
coughing

Ketamin

Guaifen

Phenoba

Propofol

BACK NEXT

Overview | Mark this Question | Lab Values | Definitions | Report a Problem

Correct:

Guaifenesin is an anti-tussive (anti-cough) and decongestant med that also works as a muscle relaxant. Guaifenesin is often used to support excitement-free anesthesia induction and recovery in horses.

Phenobarbital is a long-acting barbiturate used to control epilepsy/seizures, not induce.

Refs: McCurnin & Bassert, Clin Textbook for Vet Technicians, 8th ed. p. 1086, Plumb's Vet Drug Handbook, 7th ed. pp. 653-6 and Tighe & Brown, Mosby's Comprehensive Review for Vet Techs, 2nd ed. pp. 302.

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SAVE & EXIT

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21	22	23 M	24	25	26	27	28	29	30

Which one of the following choices correctly pairs the drug with its receptor and mechanism by which it causes an increase in blood pressure in an anesthetized patient?

Atropine - nicotine receptor - tachycardia	HIDE
Norepinephrine - alpha-1 antagonist - increases heart rate	HIDE
Phenylephrine - alpha-1 agonist - vasoconstriction	HIDE
Dopamine - alpha-2 agonist - venoconstriction	HIDE
Dobutamine - beta-1 antagonist - increased myocardial contractility	HIDE

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Overview | Mark this Question | Lab Values | Definitions | Report a Problem

Correct

Phenylephrine - alpha 1 agonist - vasoconstriction

Blood pressure (BP) is determined by cardiac output (CO) and systemic vascular resistance (SVR). (peripheral vasoconstriction)
CO = heart rate (HR) X stroke volume (SV)

Depending on circumstances, blood pressure should increase under anesthesia when stroke volume or heart rate increase and when systemic vascular resistance increases (peripheral vasoconstriction).

Vasoconstriction is produced by alpha-1 stimulation.
Phenylephrine, norepinephrine, and dopamine produce vasoconstriction via alpha-1 receptors.

Increased heart rate and/or myocardial contractility will increase SV via stimulation of beta-1 receptors.
Dobutamine and dopamine increase cardiac contractility via beta-1 receptors.

HR can also be increased by anticholinergic drugs that block parasympathetic input to the heart.
Atropine blocks cholinergic muscarinic receptors to produce a parasympatholytic effect - increasing HR.

Refs: Grimm, Tranquilli, and Lamont's Essentials of Anes and Analgesia in SA, 2nd ed. pp. 483-4, Muir and Hubbell's Equine Anesthesia, 2nd ed. pp. 401-6.

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SAVE & EXIT

PREV NEXT

21	22	23 M	24	25	26	27	28 M	29	30

What color is a nitrous oxide tank supposed to be?

Blue	HIDE
White	HIDE
Yellow	HIDE
Red	HIDE

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SAVE & EXIT

PREV

21

What col

- Blue
- White
- Yellow
- Red

Correct: **Blue**

No matter what color the tank is, ALWAYS read the tag or label on the tank first to verify the gas contents inside. One instructor in Surgical Nursing and Anesthesia has reported seeing of a green tank containing carbon dioxide instead of oxygen!

That being said, nitrous oxide tanks, (laughing gas) are blue. (Try remembering- "Laughing gas chases the blues") Oxygen tanks in the U.S are typically white or green.

Refs: Bassert and Thomas, McCurnin's Clinical Textbook for Veterinary Technicians, 8th ed. p. 1087.

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SAVE & EXIT

PREV NEXT

21	22	23 M	24	25	26	27	28 M	29	30

For anesthetics, what does MAC, (Minimum Alveolar Concentration) measure?

Anesthetic fat solubility	HIDE
Measure of anesthetic potency	HIDE
Minimum safe concentration	HIDE
Speed of expected induction	HIDE

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Overview | Mark this Question | Lab Values | Definitions | Report a Problem

SAVE & EXIT

PREV

21

For anes

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Correct: **Measure of anesthetic potency**

MAC, (Minimum Alveolar Concentration) is a measure of anesthetic potency.

Technically, it is the minimum concentration of anesthetic in the alveolar gas that prevents a physical response in 50% of animals exposed to a surgical stimulus.

Because you want to be 100% sure that an animal is completely anesthetized, you usually use MULTIPLES of MAC to determine vaporizer settings (ie:, 1-2X MAC) to guarantee anesthesia during surgery.

Refs: McCurnin & Bassert, Clin Textbook for Vet Technicians, 8th ed. p. 1086.

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SAVE & EXIT

PREV NEXT

31	32	33	34	35	36	37	38	39	40

Which statement is most correct regarding the inhalant anesthetics isoflurane and sevoflurane, in relationship to halothane?

They have lower solubility.	HIDE
They have much higher vapor pressures.	HIDE
They produce slower inductions and recoveries	HIDE
They have lower MAC (Minimum Alveolar Concentration) values.	HIDE

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Overview | Mark this Question | Lab Values | Definitions | Report a Problem

Correct

Sevoflurane and isoflurane have lower solubility than halothane.

Solubility determines speed of anesthetic induction and recovery; therefore induction and recovery is slower with halothane than with sevoflurane or isoflurane. A gas with a very high solubility such as ether has an even slower induction and recovery. Desflurane, with its extremely low solubility, has the fastest induction and recovery.

Refs: Bassert and Thomas, McCurnin's Clinical Textbook for Veterinary Technicians, 8th ed. pp. 1086-7; Thomas & Lerche Anesthesia & Analgesia for Vet Techs, 4th ed., pp. 84-92; Clarke, Trim, and Hall, Veterinary Anaesthesia, 11th ed. pp. 156-57.

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SAVE & EXIT

PREV NEXT

31	32	33	34	35	36	37	38	39	40

What is the purpose of a canister of soda lime granules in an anesthetic circuit?

Deactivate anesthetic gasses	HIDE
Supplement moisture	HIDE
Filter hydroxyl groups from injected opiods	HIDE
Balance alkalosis and acidosis	HIDE
Absorb carbon dioxide	HIDE

BACK NEXT LEAVE BLANK

Overview | Mark this Question | Lab Values | Definitions | Report a Problem

SAVE & EXIT

PREV

31

What is t

Deactiva
Supplen
Filter hy
Balance
Absorb carbon dioxide

Correct:

The purpose of a canister of soda lime granules is to absorb carbon dioxide from exhaled anesthetic gasses.

Fresh absorbent crystals are white and can be crushed. But exhausted, saturated crystals become a distinct off-white color and are hard.

Most granules contain a pH-sensitive dye that becomes visible as the absorbent granules become saturated. (The color itself is not so important as the color changing).

A color change from white to purple or violet typically indicates that the CO2 scavenger granules have become saturated with CO2, but this color change does not always happen, and will dissipate after a few hours.

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Overview | Mark this Question | Lab Values | Definitions | Report a Problem

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SAVE & EXIT

PREV NEXT

31	32	33	34	35	36	37	38	39	40

Why is it acceptable for an animal to rebreathe exhaled gasses in a closed or semi-closed anesthetic circuit?

Modern anesthetic gasses remain potent for 2-3 inhalations	HIDE
Two-way valves prevent CO2 buildup	HIDE
Exhaled gasses pass through a CO2 absorbent canister	HIDE
Oxygen requirements of anesthetized animals are very low	HIDE

BACK NEXT LEAVE BLANK

Overview | Mark this Question | Lab Values | Definitions | Report a Problem

SAVE & EXIT

PREV

31

Why is it
anesthet

Modern

Two-wa

Exhaled

Oxygen

Correct:

Expired gasses pass through a CO_2 scavenger canister to remove CO_2.

One-way valves help direct gas flow. The remaining oxygen and anesthetic gas recirculates with fresh incoming gas and is rebreathed by the animal.

The higher the flow rate, the more CO_2 is pushed through the absorbent canister and is not rebreathed.

Refs: Bassert and Thomas, McCurnin's Clinical Textbook for Veterinary Technicians, 8th ed. pp. 1094-5 and Tighe and Brown, Mosby's Comprehensive Review for Vet Techs, 2nd ed. pp. 308-9.

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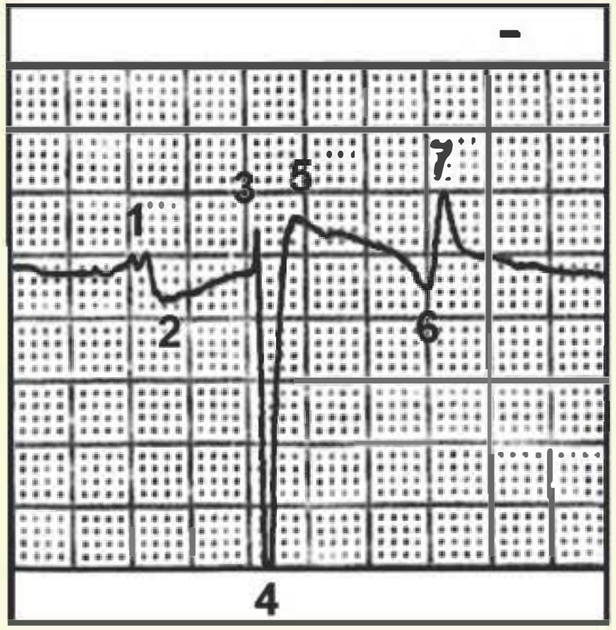
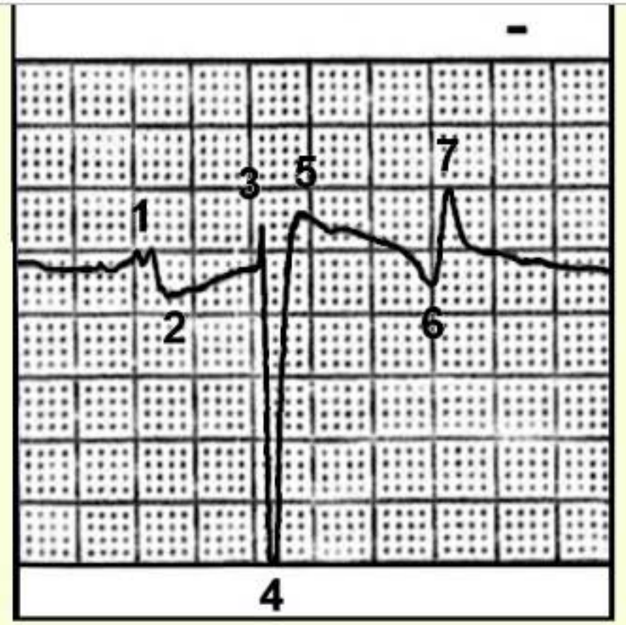
Overview | Mark this Question | Lab Values | Definitions

PREV NEXT

31	32	33	34	35	36	37	38	39	40

The image below is a cardiac waveform taken from an electrocardiogram of horse that was recorded using Lead I with a base-apex setup.

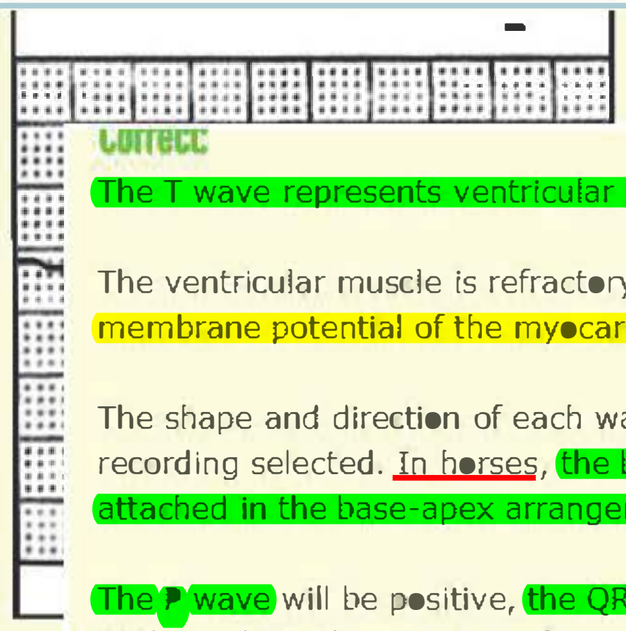




Which of the following corresponds to ventricular repolarization?

P wave, #1	HIDE
QRS wave, #3-5	HIDE
T wave, #6-7	HIDE
A wave, #2	HIDE

BACK NEXT LEAVE BLANK



Correct

The T wave represents ventricular repolarization.

The ventricular muscle is refractory to another depolarization at this time while the membrane potential of the myocardial cells reset to normal.

The shape and direction of each waveform is affected by placement of leads and the recording selected. In horses, the best ECG is obtained using Lead I with electrodes attached in the base-apex arrangement.

The P wave will be positive, the QRS is negative, and the T wave varies in direction. With Lead III, the direction of waveforms is opposite.

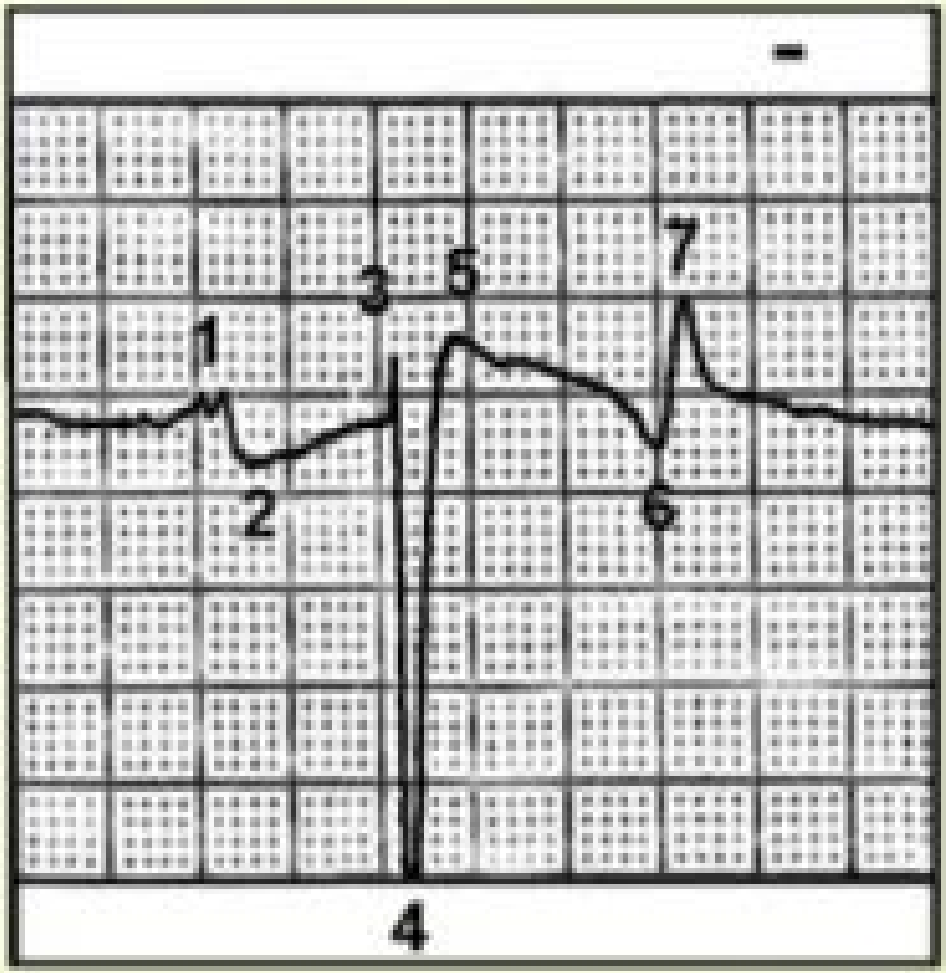
Click this link to see an explanation of the Equine ECG waveform.

Which of

P wave, #1	HIDE
QRS wave, #3-5	HIDE
T wave, #6-7	HIDE
A wave, #2	HIDE

BACK NEXT

Cardiac waveform - horse, Lead I, Base-Apex setup



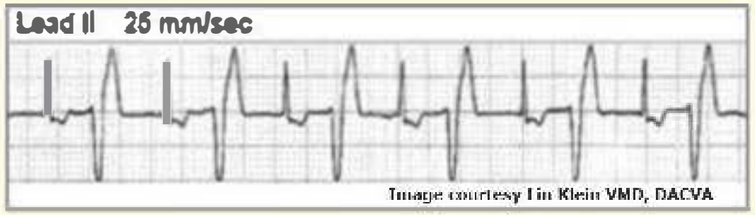
1 = P wave, atrial depolarization
2 = a wave, atrial repolarization
3 = Q wave
4 = R wave
5 = S wave
QRS = 3,4,5; ventricular depolarization
6-7 = T wave, ventricular repolarization

PREV NEXT

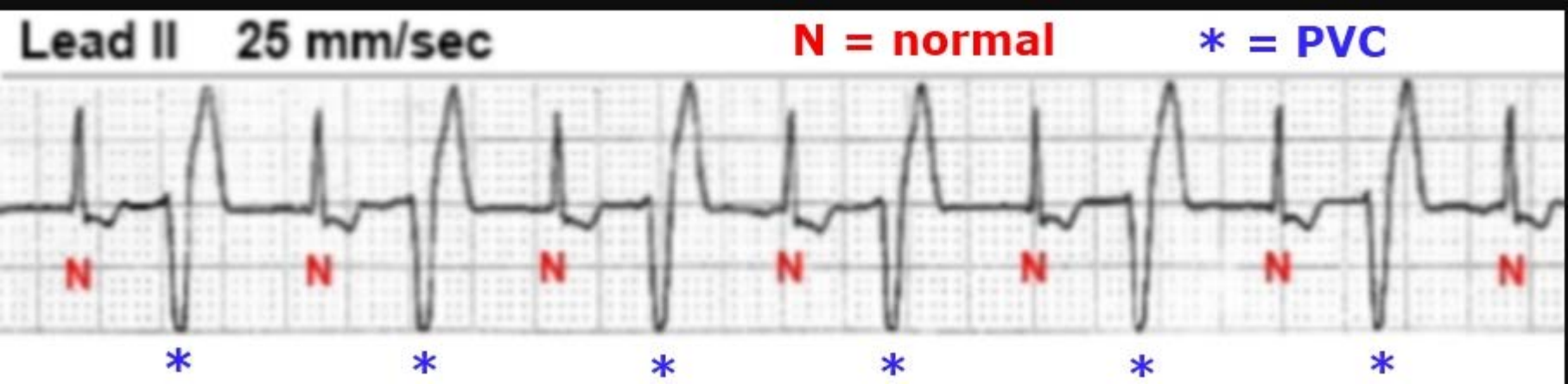
31	32	33	34	35	36	37	38	39	40

Following induction of anesthesia with thiopental, a regularly irregular heartbeat is heard on the doppler in a 5 year old dachshund being anesthetized for a myelogram. An electrocardiogram is performed, shown in the image below.

Which one of the following choices correctly identifies the arrhythmia in this patient?



Ventricular bigeminy	HIDE
Atrial tachycardia	HIDE
Premature supraventricular contractions	HIDE
Second degree atrioventricular block	HIDE
Idioventricular tachycardia	HIDE


Lead II 25 mm/sec
N = normal
* = PVC
N
N
N
N
N
N
N
*
*
*
*
*
*

Correct

Ventricular bigeminy is a regularly irregular rhythm in which each sinus beat is followed by a premature ventricular contraction (PVC) such that the normal/abnormal beats appear to occur in pairs. PVCs lack a p wave and the QRST waveforms are usually wide and bizarre in appearance.

Click here to see an illustration of the answer.

Ventricular bigeminy (VB) is a common arrhythmia seen following induction with thiobarbiturates. It usually only lasts a few minutes and may often be missed unless the pulse is being monitored.

VB that occurs at induction with thiobarbiturates usually does not require treatment as it most often disappears as the drug level falls, and sympathetic tone decreases as the level of inhalant anesthetic increases.

Intermittent PVCs are also not uncommon following induction of anesthesia since many drugs sensitize the myocardium to the development of arrhythmias at the same time that sympathetic release is temporarily increased.

REMEMBER myocardial sensitization (drugs) and excitement of induction (sympathetic release) = potential for arrhythmias. Be sure to check the anesthetic depth, blood pressure, ventilation, and oxygenation immediately when an arrhythmia develops.

Refs: Muir, Hubbell, Bednarski, and Skarda's Handbook of Veterinary Anesthesia, 4th

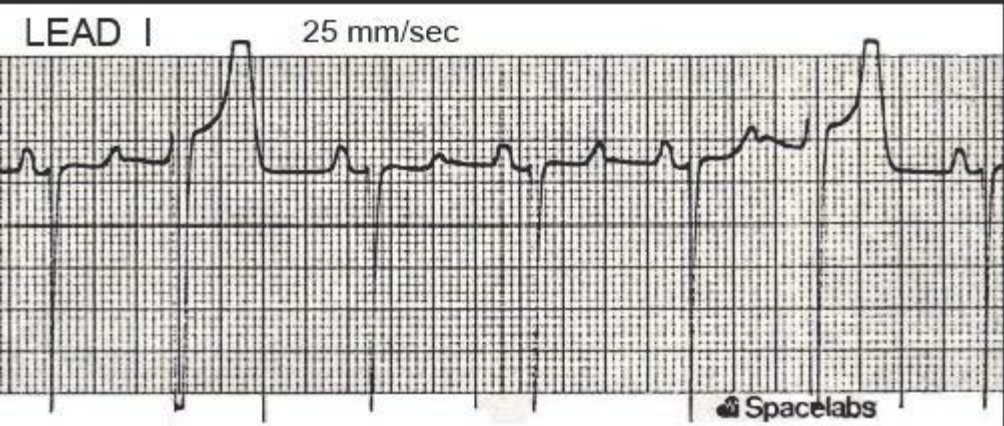
51	52	53	54	55	56	57	58	59	60

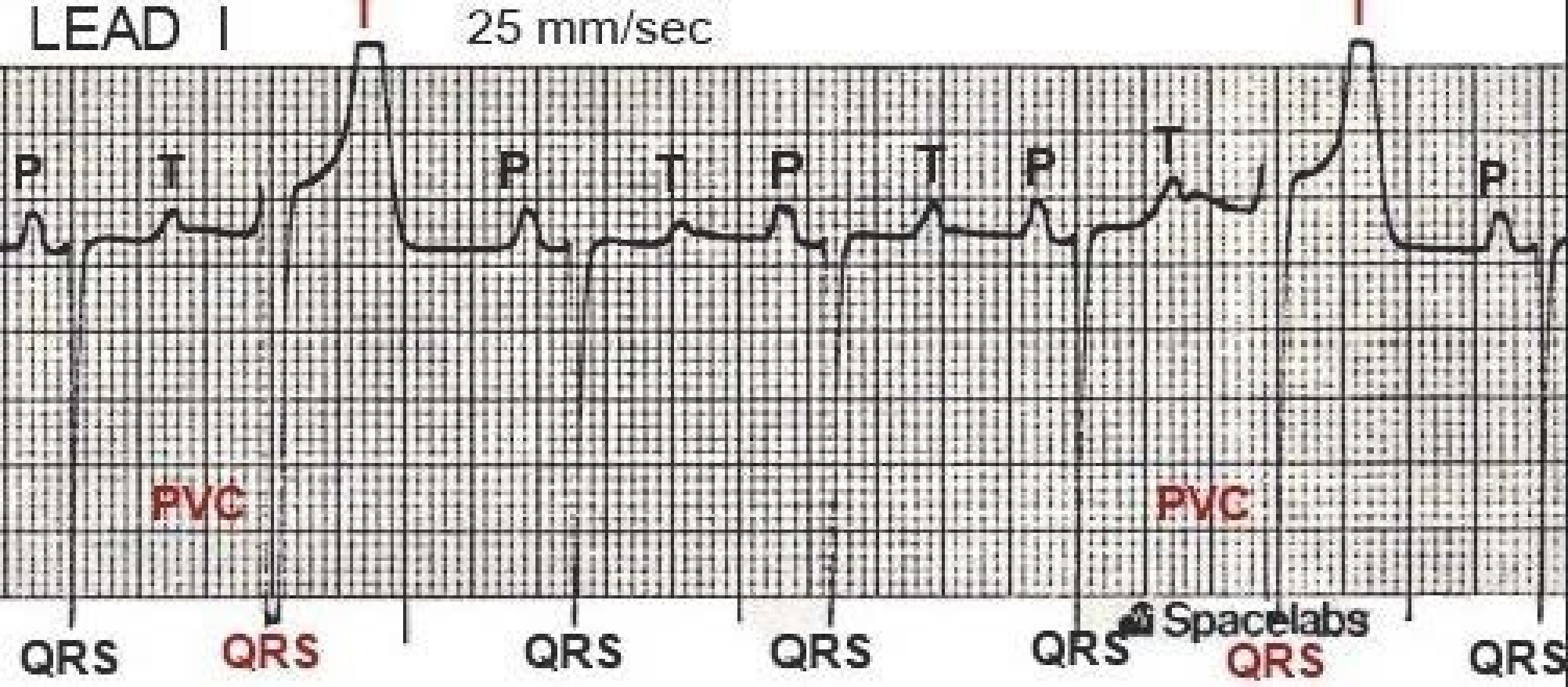
A 3 day old quarterhorse foal is anesthetized for a cerebrospinal fluid (CSF) tap, joint lavag and removal of an infected umbilicus.

Just as the doctor begins the CSF tap, the heart rhythm becomes irregular, as seen on this electrocardiogram. The foal appears deeply anesthetized, but blood pressure and heart rate are normal.

Which of the following correctly identifies this arrhythmia?

Atrial premature contractions	HIDE
Left bundle branch block	HIDE
Ventricular escape beats	HIDE
Premature ventricular contractions	HIDE


LEAD I
25 mm/sec
Spacelabs


LEAD I
25 mm/sec
P
T
P
T
P
T
P
T
P
PVC
PVC
QRS
QRS
QRS
QRS
QRS
QRS
QRS
Spacelabs

There are 2 premature ventricular contractions (PVCs) on this ECG. There is no p wave, the R-R interval before each PVC is shorter than normal, and the QRS-T is 'wide and bizarre' in shape.

PVCs seen under anesthesia are caused by hypercarbia, deep or light anesthesia, some anesthetic drugs, electrolyte abnormalities, hypoxemia, cardiac disease, and increased sympathetic tone.

Inhalant anesthetics sensitize the myocardium to arrhythmias, and suppress ventilation. The vaporizer setting was decreased, mechanical ventilation was instituted, the PVCs disappeared and did not return.

Click this link to see the ECG with legend.

Follow this link to an excellent website - Interpretation of ECGs from UPenn.

zukureview

SAVE & EXIT

PREV NEXT

41	42 M	43	44	45	46	47	48	49	50

A cardiac arrhythmia is ausculted during a preoperative examination in a 3 year old thoroughbred gelding.

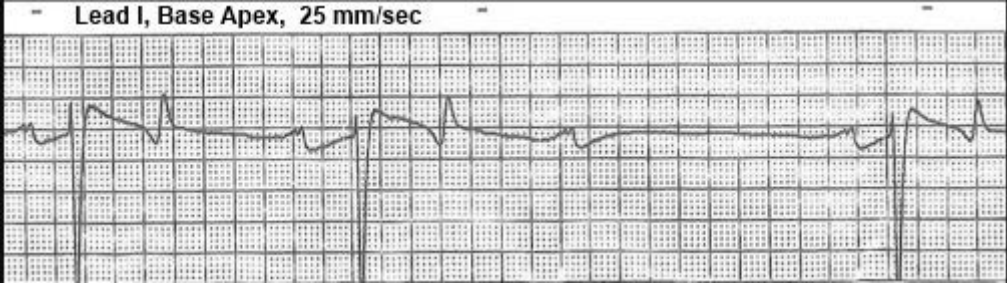
The heart rate is 32 beats/minute [N=28-42] and the rhythm is regularly irregular.

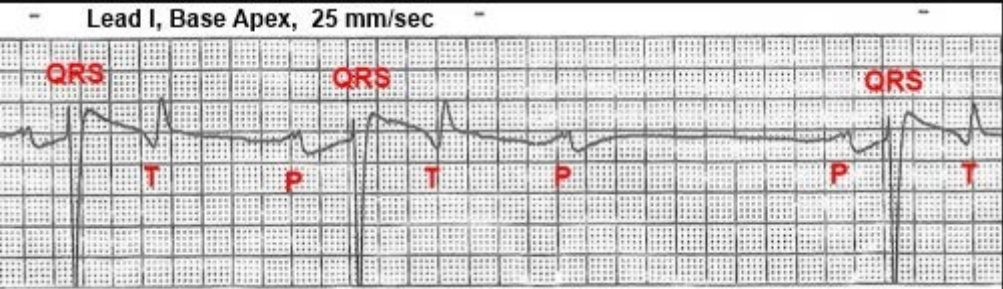
Click to see an image of this electrocardiogram.

Which of the following correctly identifies this rhythm?

2nd degree AV block	HIDE
Atrial fibrillation	HIDE
Idiopathic bradycardia	HIDE
Sinus arrest	HIDE

BACK NEXT LEAVE BLANK


Lead I, Base Apex, 25 mm/sec


Lead I, Base Apex, 25 mm/sec
QRS
QRS
QRS
T
P
T
P
P
T

Correct

2nd degree atrioventricular block.

Conduction of the normal depolarization wave stops at the AV node, usually because it has taken too long to arrive and the node is refractory, unable to depolarize at that time.

2nd degree AV block is more common in horses at rest, when the heart rate is low, as it is associated with increased vagal (parasympathetic) tone.

When sympathetic tone increases, as with exercise, excitement, pain, etc., the heart rate increases and AV block disappears.

2nd degree block can be diagnosed without an ECG.

The rhythm is regularly irregular, the pause is equal to 2X the normal interval between contractions, the 4th heart sound (S4) is audible during the pause, and the irregularity disappears when the HR increases.

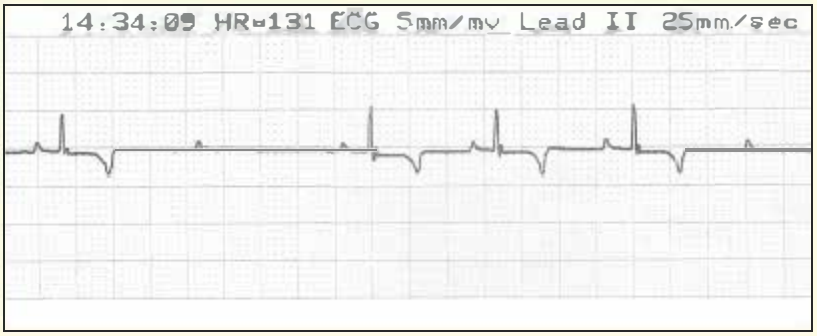
Click this link to see this ECG with legend.

Click this link for excellent website - Interpretation of ECGs from UPenn.

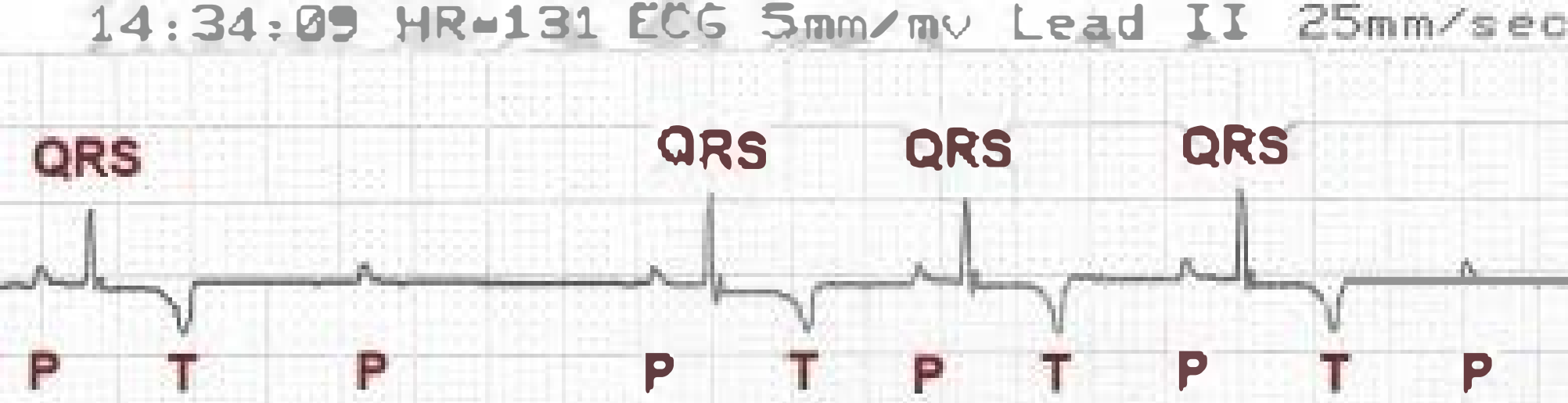
Refs: Wilson Clin Vet Advisor: The Horse, pp 55-8, McCurnin's Clin Textbk for Vet Techs, 8th ed., pp. 941-3, Anesthesia & Analgesia for Vet Techs, 4th ed. pp. 20-1, 147-9 and the Merck Veterinary Manual online edition.

A dog under anesthesia for teeth cleaning develops a sinus bradycardia (heart rate 50 beats per minute). One minute following treatment with atropine, an irregular rhythm is identified on the Doppler and the electrocardiogram, seen in the image below.

Which of the following correctly identifies this rhythm?



Asystole	HIDE
Respiratory sinus arrhythmia	HIDE
Atrial fibrillation	HIDE
Second degree AV block	HIDE


14:34:09 HR=131 ECG 5mm/mv Lead II 25mm/sec
QRS
QRS
QRS
QRS
P
T
P
P
T
P
T
P
T
P

Correct

This dog has second degree AV block which is a failure of conduction through the AV node.

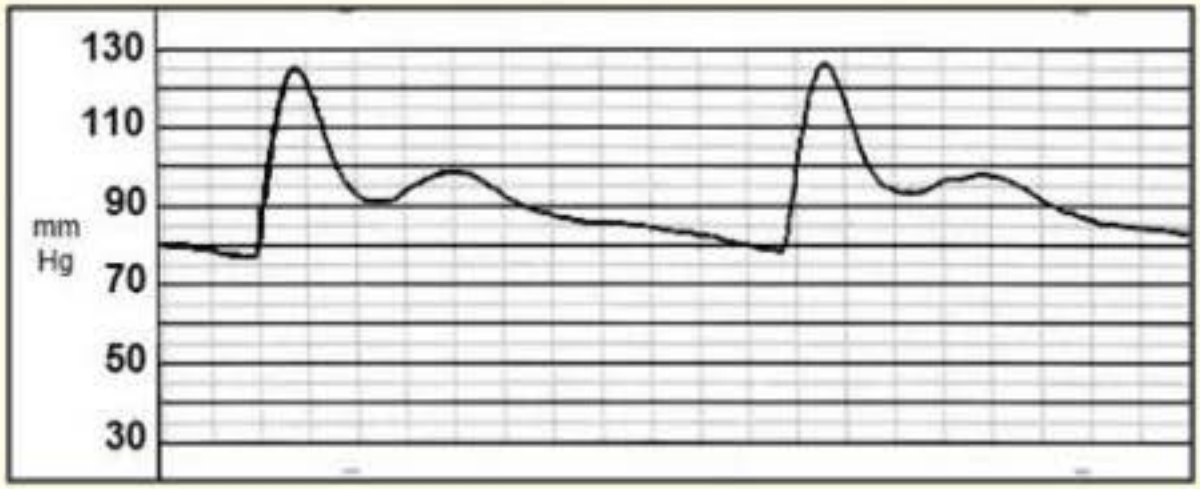
Atropine may initially cause a transient slowing of heart rate (HR) and AV block as low doses stimulate presynaptic inhibitory receptors. As drug level increases, muscarinic blockade predominates and HR increases.

The ECG is characterized by occasional P waves without a QRS that follows. There is a 'dropped beat' as the ventricles do not contract. This rhythm is heard as a pause equal to 2X the normal R-R interval.

Click this link to see image of the ECG with explanation.

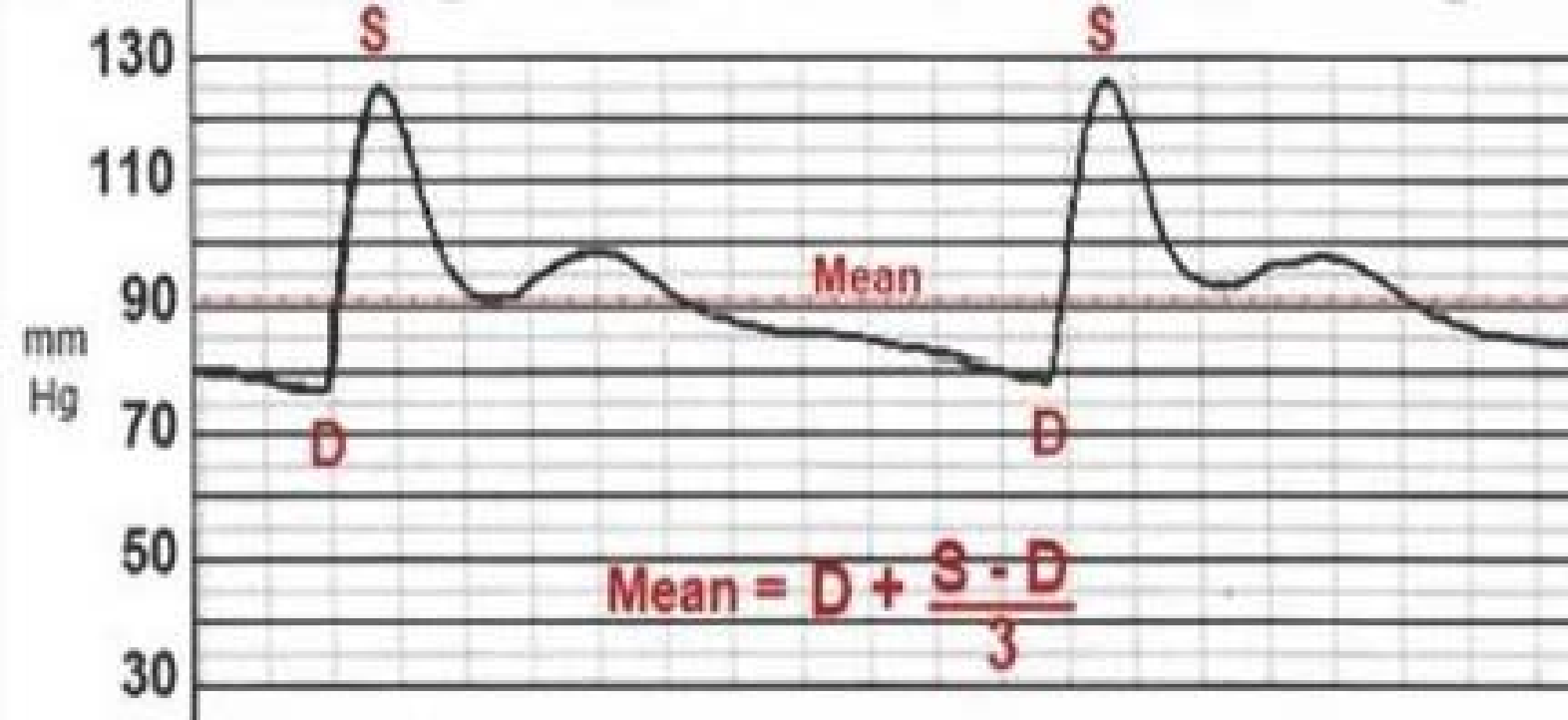
Click link for excellent website - Interpretation of ECGs from UPenn.

The following image is a recording of an arterial blood pressure waveform from a horse anesthetized with isoflurane in oxygen.



Which one of the following choices is the correct mean arterial pressure in this patient?

78 mmHg	HIDE
100 mmHg	HIDE
Need more information	HIDE
93 mmHg	HIDE
120 mmHg	HIDE


130
110
90
70
50
30
mm
Hg
S
S
Mean
D
D
Mean = D + (S - D)/3

Correct

93 mmHg

BP = CO × SVR

SVR = MAP ÷CO

MAP = ⅓(systolic – diastolic) + diastolic

Pulse pressure(PP)= S-D

CO = stroke volume × heart rate

Click here to see an illustration of the answer.

Mean arterial pressure (MAP) is approximately 1/2 the area under the pulse pressure curve as measured from one heartbeat. It can be calculated (estimated) from the systolic (SAP) and diastolic arterial pressures (DAP) as follows:

DAP plus 1/3 of the pulse pressure (SAP - DAP).

77 + (126-77)/3 = 77 + 49/3 = 77 + 16 = 93 mmHg.

PP = 126-77= 49mmHg

The mean arterial blood pressure (MAP) is important as this is the "driving" pressure for tissue perfusion. A low MAP results in ischemia and organ damage if present too long.

Note that MAP is actually closer to the DAP than the SAP as shown by the dotted red line on the graph shown in the answer. A low DAP has a great effect on the overall mean. The lower the DAP, the higher the systolic AP must be to compensate and bring the mean up to adequate levels.

Hypotension is common in anesthetized horses and can result in myopathy. Muscle damage occurs in horses at pressures not low enough to produce damage to other organs. Myopathy can result in serious injury and difficulty standing during anesthetic recovery if not treated in a timely fashion.

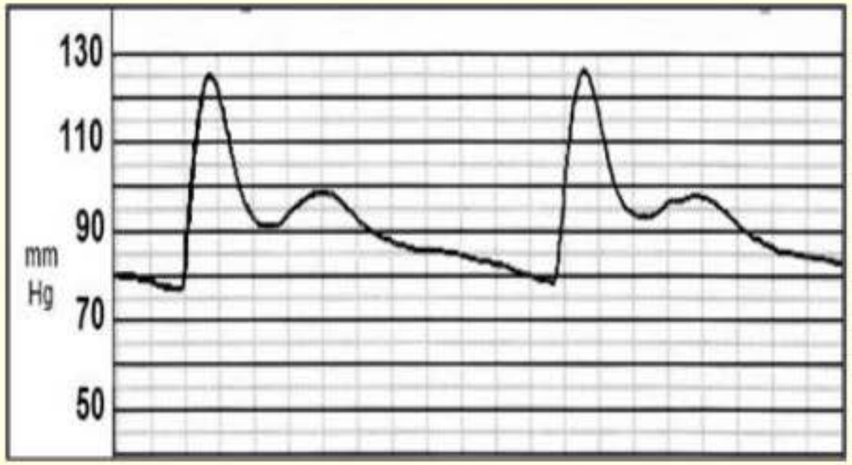
Note the dip in the BP waveform very close to the mean pressure line on the illustration of the answer. This is the "dicrotic notch" which is produced by changes in blood flow in the large vessels when the aortic valve closes.

Check out this great article on Blood Pressure Management in Equine Anesthesia by Samantha Rowland, LVT, VTS, courtesy of Vetlearn.com

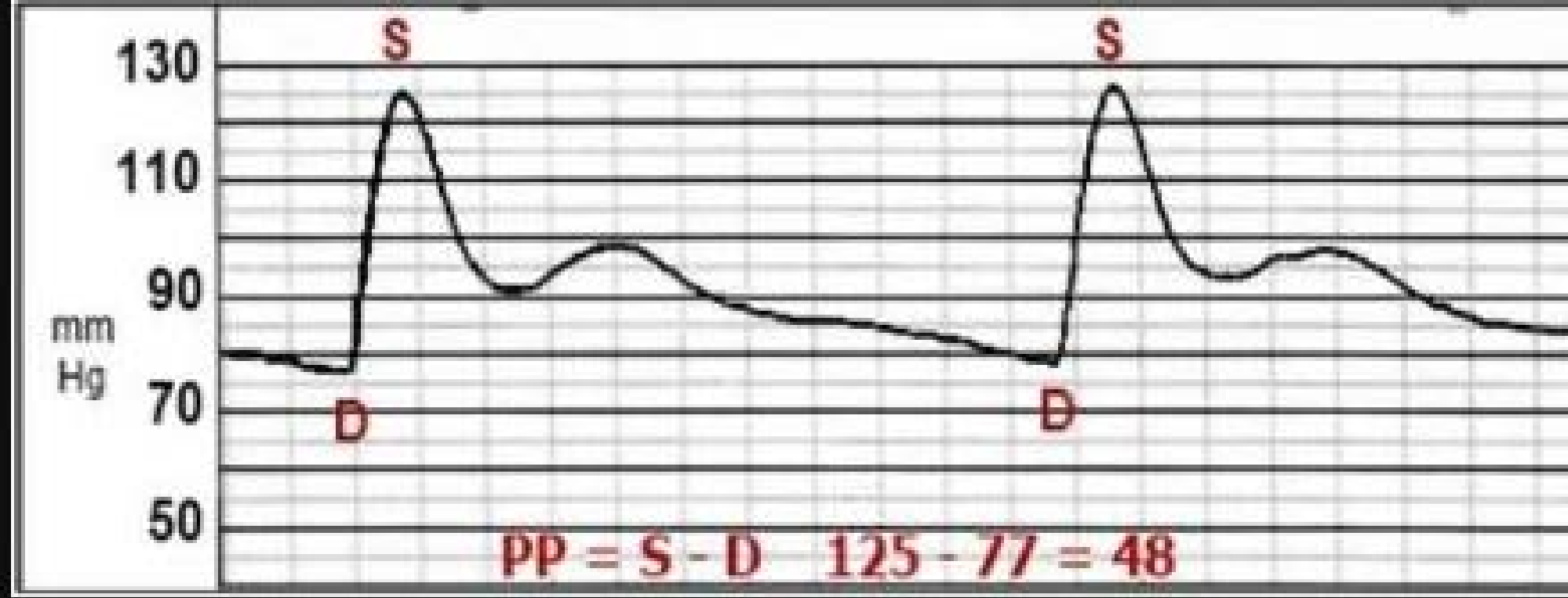
Refs: Muir and Hubbell's Equine Anesthesia, 2nd ed. pp. 163-5, 400, Grimm, Tranquilli, and Lamont's Essentials of Anes and Analgesia in SA, 2nd ed. pp. 208-10, and Tranquilli, Thurman, and Grimm's Vet Anes and Analgesia, 4th ed., pp. 543-6.

The following image is a recording of an arterial blood pressure waveform from a horse anesthetized with isoflurane in oxygen.

Which one of the following choices is the correct pulse pressure in this patient?



35 mmHg	HIDE
100 mmHg	HIDE
90 mmHg	HIDE
76 mmHg	HIDE
48 mmHg	HIDE


130
110
90
mm
Hg
70
50
S
S
D
D
PP = S - D 125 - 77 = 48

Correct

48 mmHg

Click here to see an illustration of the answer.

The pulse pressure is the systolic arterial pressure (SAP) minus the diastolic arterial pressure (DAP). Also called **pulse strength**, this is what you feel when a palpating a pulse. It is helpful when evaluating the cardiovascular status of an anesthetized patient, however it cannot be used alone.

Vascular tone (vasoconstriction, vasodilation), hypertension, hypotension, blood volume, cardiac output, central venous pressure, and the size of the artery all affect the strength of the pulse pressure.

A strong pulse pressure does NOT guarantee that good blood pressure or adequate perfusion is present. For example, a patient with a pressure of 120/80 has the same pulse pressure as one with 90/50. The mean pressure in the former is 93 mmHg, while the latter has a mean of 63 mmHg, which is barely adequate.

A patient with vasodilation and very pink mucous membranes (mm) may have a bounding pulse pressure AND still be hypotensive. Conversely, a patient who is somewhat vasoconstricted will have paler mm but may still have good perfusion pressure.

Clinical signs of mm color, capillary refill time, and pulse strength must be combined with assessment of anesthetic depth AND objective measurements such as arterial blood pressure, heart rate, central venous pressure, etc. when monitoring anesthesia.

Refs: Grimm, Tranquilli, and Lamont's Essentials of Anesthesia and Analgesia in Small

A 6-year-old mixed breed dog is anesthetized for an exploratory laparotomy/splenic mass removal with isoflurane in oxygen. Anesthetic monitoring includes an electrocardiogram (ECG), direct arterial blood pressure, end tidal carbon dioxide levels, oxygen saturation, anesthetic gases, and temperature.

A recording of the ECG and the arterial pressure waveform is shown in the image below.

Image Courtesy Lin Klein VMD, DACVA

Image Courtesy Lin Klein VMD, DACVA

Which one of the following choices is the correct pulse rate in this patient?

135	HIDE
80	HIDE
160	HIDE
40	HIDE
320	HIDE


Lead II 25 mm/sec
N
N
N
N
N
N
N
F
N
Direct arterial BP
1 sec
2s
3s
4s
5s
6s = 30 boxes

Correct

80 beats per minute. This case is just one example of why it is important to palpate the pulse periodically during anesthesia, rather than just following the monitors.

Click here to see an illustration of the answer.

At a paper speed of 25 mm/second (= 5 big boxes per second), there are 16 depolarizations in a 6 second period. To calculate the rate, 60 sec/6 sec = 10 X 16 = 160 depolarizations per minute from this strip.

However, the blood pressure (BP) wave shows that there were only 8 ventricular contractions that actually produced blood flow (a pulse) in the same 6 seconds. Therefore, the **pulse rate** is 60/6 = 10 X 8 = 80 contractions per minute in this patient.

This patient has a **pulse deficit** caused by a cardiac arrhythmia - a premature ventricular contraction (PVC) follows each sinus beat, so this is **ventricular bigeminy**. There are "pairs" of each - each sinus beat/one PVC, hence a "bigeminy".

Note that the PVCs do not generate enough cardiac output to produce a separate blood pressure waveform, hence the pulse deficit. The PVCs probably contribute a small amount of flow seen as the extra "bumps" on the bp waveform.

The QRST seen in PVCs are often "wide and bizarre" and do not have a p wave.

Also note that the BP waves (the result of cardiac mechanical activity) occur a few milliseconds after the sinus depolarizations (electrical activity).

How does one discover a pulse deficit? Doppler sounds, pulse oximeter sound and waveform graphic, auscultation of the heart, and palpation of an artery will all differ with the rate reported/seen on the ECG.

(The p waves on the sinus beats are hard to see on these strips, sorry, but they really are there!)

Refs: Grimm, Tranquilli, and Lamont's Essentials of Anes and Analgesia in SA, 2nd ed. pp 204-5, Tranquilli, Thurman, and Grimm's Vet Anes and Analgesia, 4th ed., pp. 543-4. Image courtesy Lin Klein VMD, DACVA.

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Blood Pressure Management in Equine Anesthesia

Samantha Rowland, LVT, VTS (Anesthesia)

Expect the best, plan for the worst, and prepare to be surprised.
—D. Wholey

Anesthesia is a complex science in which many factors, both physiologic and external, play a role in the overall result. A diligent anesthetist and proper monitoring are necessary for a successful anesthesia experience for the patient and the veterinary team. Monitoring arterial blood pressure (BP) is considered a minimum standard of care for safe anesthetic management.[1] In equine anesthesia, accurate and consistent BP monitoring is vital for helping to ensure a positive outcome.

Physiology and Components of Blood Pressure

Arterial BP is measured using the systolic and diastolic pressures and the mean arterial pressure (MAP), which are expressed as millimeters of mercury (mm Hg). BP is the driving force of blood flow and, therefore, tissue perfusion. BP refers to the pressure of the blood within the arteries (i.e., arterial BP).[1]

The primary factors that determine BP include cardiac output (CO), systemic vascular resistance (SVR), and stroke volume:

$$BP = CO \times SVR$$

CO is determined by stroke volume and heart rate:

$$CO = \text{stroke volume} \times \text{heart rate}$$

CO is defined as the volume of blood pumped by the ventricles in 1 minute. Stroke volume is the volume of blood pumped from one ventricle during each contraction and is determined by contractility, preload, afterload, and heart rate. In a healthy patient with normal cardiac function, the volume of blood being delivered from the heart should equal the amount being returned to the heart (venous return).[2]

Preload is the force that acts on a muscle before contraction. Afterload is the resistance that the ventricles must contract against to expel blood (ventricular wall stress).[2] Vasoconstriction or vasodilation affects the afterload of the heart, which affects the stroke volume, thereby increasing or decreasing CO and BP.

SVR is the resistance to blood flow caused by the peripheral vasculature. This resistance must be overcome to push blood through the circulatory system. The determinants of SVR are MAP and CO:[3]

$$SVR = MAP \div CO$$
$$MAP = \tfrac{1}{3}(\text{systolic} - \text{diastolic}) + \text{diastolic}$$

What does all of this mean to an anesthetist? If any one of these factors is affected, BP will be altered.

Why Is Blood Pressure Monitored?

Arterial BP measurement is one of the key elements of providing safe anesthetic management; it is a window into the patient's cardiovascular status. During general anesthesia, horses have a greater risk of morbidity and mortality than dogs, cats, and humans.[4] Studies on anesthesia have shown that equine patients have a 1% mortality rate compared with 0.1% for human patients; the equine mortality rate increases to 10% if emergency patients (e.g., those with colic or receiving obstetrical care) are included.[4] It is hoped that a greater understanding of all aspects of anesthesia, including BP abnormalities during anesthesia, by anesthetists will help decrease patient mortality.

Anesthetic Agents and Adjunctive Drugs

Anesthetic agents and many adjunctive drugs have a direct impact on cardiovascular function. They can affect heart rate, BP, CO, and respiratory function; the associated changes are typically dose-dependent. **α_2-Adrenergic agonists** are commonly used for sedating horses in the preanesthetic and recovery periods and for standing surgical procedures. These agents produce sedation, muscle relaxation, and somatic and visceral analgesia as well as allow a decrease in the minimum alveolar concentration (MAC) of inhalants.[5]

Although α_2-adrenergic agonists have many benefits, adverse effects can include decreased CO, respiratory depression, increased vagal tone and SVR, and bradycardia with a transient second-degree heart block.[5] The bradycardia is in response to the transient initial hypertension due to vasoconstriction—a compensatory reaction.[6] This is a biphasic event; after the initial vasoconstrictive effects subside,[7] vasodilation and, therefore, hypotension can result.

Acepromazine (a **phenothiazine** tranquilizer) is commonly used in combination with an α_2-adrenergic agonist for preanesthetic

Figure 1. An arterial catheter in the transverse facial artery.

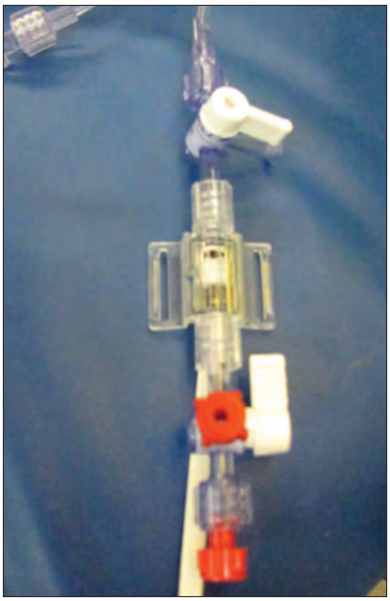

Figure 2. A blood pressure transducer.

sedation. Phenothiazines block α_1-adrenergic receptors, which can cause hypotension and inhibit platelet function. Therefore, phenothiazines are contraindicated in horses in shock or with bleeding disorders or blood loss.[8] The benefits of acepromazine are tranquilization and calming effects, which are especially useful in excitable breeds and in racehorses, as well as significant MAC reduction.[5] The combination of an α_2-adrenergic agonist and phenothiazine is beneficial for the recovery period as well. However, due to the potentially negative effects of phenothiazines, anesthetists must use care when administering them to high-risk patients or should consider using a different medication.

Opioids and **synthetic opioid agonist-antagonists** are used as analgesics and do not have the significant cardiovascular effects that α_2-adrenergic agonists do; however, opioids and opioid agonist-antagonists can cause excitement in awake horses and do not reduce MAC. The analgesic effect of opioids can enhance the stability of general anesthesia.[5] Inhalants such as isoflurane cause dose-dependent vasodilation, which decreases CO, thereby decreasing BP. Inhalant anesthetics provide little to no analgesia, so adjunctive agents should be used to provide adequate pain control.[9]

Certain medications can be given by constant-rate infusion (CRI) to provide consistent analgesia and reduce inhalant MAC. Use of these drugs in combination with anesthetics is called *multimodal anesthesia/analgesia*. Drugs commonly administered by CRI include ketamine, lidocaine, opioids, and α_2-adrenergic agonists. It is typically recommended to stop the CRI approximately 20 to 30 minutes before the end of anesthesia to reduce the risk of ataxia and a prolonged recovery time.[10]

How Is Blood Pressure Measured?

Arterial BP can be monitored by Doppler ultrasound, DINAMAP (device for indirect, noninvasive, automatic mean arterial pressure) oscillometric monitoring, or invasive direct monitoring. Compared with the direct method, indirect monitoring devices have proven to be less accurate and to have more variable results in horses.

The noninvasive methods can be performed using an inflatable cuff on the base of the tail in adults and foals or on a distal limb in foals. The Doppler system provides systolic BP readings; however, the readings can be inaccurate if the cuff size is not correct or the horse is in dorsal or lateral recumbency.[11] Like the Doppler system, DINAMAP monitoring uses an inflatable cuff placed in the same location as a Doppler cuff would be placed. These monitors deliver systolic, diastolic, and MAP values, along with the heart rate. They are useful for monitoring trends but become significantly inaccurate if the patient is hypotensive, is moving, or has bradycardia or arrhythmias.[9]

The gold standard for measuring arterial BP is direct monitoring using an indwelling arterial catheter connected to short, noncompliant tubing (**FIGURE 1**); a pressurized transducer (**FIGURE 2**); and a monitor. This setup allows an anesthetist to examine trends for systolic, diastolic, and MAP values, along with a waveform. The direct arterial BP waveform helps the anesthetist to evaluate cardiac function, specifically relating to left ventricular ejection, and also helps the anesthetist decide whether pulse deficits are becoming detrimental and arrhythmias are causing a low BP.[1] Direct BP monitoring can also be used to assess inotropic and vasopressor therapy, fluid resuscitation efforts, and arterial blood gas readings (**FIGURE 3**). The latter is used to assess ventilation and acid-base status, both of which can also affect CO and BP.[1] This monitoring method is consistent with every heartbeat and is the most accurate way to monitor trends that can provide important clues to help avoid anesthetic crises.

Figure 3. Arterial blood gas sampling.

CO, stroke volume, vessel wall compliance, peripheral vascular resistance, and heart rate affect the BP waveform. To form a more complete picture of the horse's cardiovascular status,

the waveform should be analyzed along with the BP, pulses, mucous membrane color, and capillary refill time. Horses that are mechanically ventilated under anesthesia have BP waveform changes consistent with the respiratory cycle. The peak of inspiration is typically synchronized with the highest systolic pressure; the lowest systolic pressure occurs after peak inspiration.[9]

When BP is monitored directly through an indwelling arterial catheter, the BP waveform depicted on the monitor needs to be continually assessed. The anesthetist should see (1) waveform peak changes that may be associated with the respiratory cycle of the ventilator and (2) flattening (dampening) of the waveform when the systolic and diastolic readings are close in numeric value or when the catheter needs to be flushed. Arterial lines need to be periodically flushed with heparinized saline. Equipment maintenance is very important for ensuring reliability of BP measurements. Some machines have more maintenance requirements than others, so obtaining experience using different types of equipment can help troubleshoot problems.

By palpating multiple arteries, the anesthetist can consistently assess pulse quality/strength, heart rate and rhythm, and pulse deficits. Pulse palpation allows a qualitative assessment of pressure; however, pulse palpation is not a good indicator of arterial BP, anesthetic depth, or tissue perfusion. Pulse pressure/strength is essentially the difference between the systolic and diastolic arterial pressures.[11] Inhalant anesthetics cause vasodilation, which results in a decrease in vascular tone (tension on the vessel wall), an increase in pulse pressure, and a decrease in perfusion.[11] Vasodilation causes the vessel wall to be closer to the skin surface, which makes the artery easier to palpate and may therefore deceive an anesthetist into thinking that a horse has good blood pressure. Vasoconstriction causes a vessel to shrink away from the skin surface and become difficult to palpate, which is also deceiving. Therefore, pulse palpation should be used to verify that the heart rate and rhythm and the electrocardiogram are accurate; however, pulse palpation should not be relied on for assessing BPs.

Normal blood pressure values in an anesthetized horse are as follows[10]:

Systolic: 90 to 120 mm Hg
Diastolic: 40 to 70 mm Hg
MAP: 60 to 85 mm Hg (goal: 70 to 80 mm Hg)

Hypertension

Although hypertension can compromise an anesthetized patient, it is not as prevalent as hypotension in horses. Because of risks associated with hypertension, it must be addressed. Potential causes of intraoperative hypertension include inadequate anesthetic depth, inadequate analgesia, hypoxemia, hypercarbia, and hyperthermia.[12] α_2-Adrenergic agonists can cause hypertension from initial vasoconstriction with compensatory bradycardia, followed by hypotension. Cyclohexamines, such as ketamine, cause an increase in BP through direct stimulation of the sympathetic nervous system, which increases heart rate, BP, and CO.[13] Hypertension can occur from the overuse of vasopressors or positive inotropes when correcting *hypotension*. Patients may also have hypertension due to an underlying disease, a medication that causes secondary hypertension, or an increase in intracranial pressure.[14] Risks associated with hypertension include retinal detachment, increased hemorrhage, increased intracranial pressure, and an increase in cardiac afterload.[15] To see these effects in horses, the MAP would typically have to be quite high (>120 mm Hg). Hypertension can also cause bradyarrhythmias, increase bleeding at a surgical site, and increase the difficulty of maintaining anesthesia.[12]

Treatment of hypertension is aimed at correcting the underlying cause. If the horse is not adequately anesthetized, take steps to remedy this, such as increasing the inhalant concentration. The inhalant concentration is controllable and reversible, if necessary. If the horse seems to be adequately anesthetized but responds to pain during a procedure, address the analgesic therapy. α_2-Adrenergic agonists can be reversed if necessary, but this is generally not needed. Acepromazine can be administered at 0.01 mg/kg IV in normovolemic patients to obtain normotension without inducing hypotension.[12] Acepromazine also decreases the MAC requirement of the inhalant.

For procedures such as assisted vaginal delivery during dystocia or procedures involving abdominal laparoscopy, the horse must be placed in the Trendelenburg position: dorsal recumbency with the hind end elevated 30° to 45° above the head to enhance access to the pelvic organs by using gravity to "move" the gastrointestinal tract out of the way. This position causes noticeable hypertension; therefore, the time spent in this position should be as short as possible to avoid complications.

Hypotension

Hypotension negatively affects tissue perfusion and oxygenation as well as distribution of anesthetic agents and other medications. Patients with a MAP of ≤60 mm Hg are considered to be hypotensive and must be treated immediately. The vital organs (i.e., the heart, brain, and kidneys) have mechanisms that allow them to maintain consistent blood flow despite changes in BP; this is known as *autoregulation*. The kidneys are less able to autoregulate than the heart and the brain. Hypotension affects autoregulation when the MAP drops below 80 mm Hg. When the MAP falls below 50 mm Hg, blood flow to the myocardium (heart muscle) decreases.[16]

Among the major complications for horses undergoing general anesthesia are the development of postoperative myopathies and neuropathies. These can result from hypotension, hypoxemia, improper positioning, inadequate padding, and poor perfusion; any of which can also cause rhabdomyolysis ("tying up"). Myopathies are more common in larger and/or heavily muscled horses; the dependent muscle groups (the side the horse was lying on) are affected more than the nondependent groups. The affected muscles become hard, painful, and swollen; the horse can be either mildly lame after recovery or unable to stand altogether. Postoperative myopathies in the horse can be compared with compartmental syndrome in people: the muscles are underperfused/hypoxic, which causes a chain of events including ischemia, cell

damage, and increased pressure and swelling.[17] A MAP of ≥70 mm Hg must be maintained to adequately perfuse the muscles and other organs[6]; however, these complications may still occur even if the horse was padded and positioned properly and had no anesthetic complications.

Hypotension has many causes, including a deep anesthetic plane, vasodilation secondary to inhalant and injectable anesthetic agents, decreased CO, hypovolemia, dehydration, endotoxemia, positive-pressure ventilation, vena cava compression, preexisting diseases, some concurrent medications, significant blood loss, gastric distention, poor cardiac function, tachycardia, arrhythmias, and bradycardia.[12] In horses, the primary causes of hypotension during anesthesia are significant vasodilation from injectable and inhalant anesthetics, a prolonged duration of anesthesia/surgery, inadequate intravenous fluid therapy/circulating volume, and positive-pressure ventilation.

Positive-pressure (controlled mechanical) ventilation has negative effects on a horse's cardiovascular system, largely due to a change in intrathoracic pressure. Patients that are breathing spontaneously, whether awake or anesthetized, have a decreased intrathoracic pressure on inspiration. This pressure gradient increases blood flow to the thorax and right atrium during inspiration, which in turn increases preload in the right ventricle and increases stroke volume in a normal heart (this is called the *Starling effect*).[18] Positive-pressure ventilation causes increased intrathoracic pressure, which compresses the vena cava and decreases preload and stroke volume; this can cause decreased CO and BP.[18] However, the inhalant causes respiratory depression, so a horse in lateral or dorsal recumbency would not adequately ventilate spontaneously and would quickly become hypercarbic and hypoxemic. Therefore, it is almost always necessary to provide mechanical ventilation during anesthesia of adult horses.

Hypovolemia and endotoxemia can be major causes of hypotension in horses undergoing colic surgery. Colicky horses can have profound dehydration, electrolyte/metabolic derangements, shock, and significant pain. To prevent severe hypotension, it is best to treat these abnormalities before induction of anesthesia; however, depending on the situation, treatment may not be possible. Endotoxemia needs to be addressed immediately to avoid cardiovascular collapse. Common therapies include administration of flunixin meglumine, preoperatively if possible, or a polypeptide microbial such as polymyxin B.[19]

It is ideal to use the least amount of inhalant possible to achieve an adequate surgical anesthetic plane. Typically, this is accomplished through multimodal anesthesia/analgesia. Aside from decreasing the amount of inhalant used, the most common way to prevent and treat hypotension is through proper intravenous fluid therapy and vasopressor support. An average adult horse should receive approximately 5 L of crystalloid fluids per hour (10 mL/kg/h) while anesthetized. The fluid plan should be adjusted based on the physical status of the horse and its response to fluid therapy. Horses that experience significant hypovolemia have higher fluid requirements, which most likely involve the placement of a second large-bore IV catheter to deliver a higher fluid volume. The type and amount of fluid is based on several factors, including the packed cell volume, total protein level, blood lactate level, acid-base status, and electrolyte concentrations.[20]

Dobutamine—a β_1-adrenergic agonist—is the standard "go to" positive inotropic agent for treating equine hypotension. This drug acts on the myocardium to increase the strength of contraction. This causes the heart to eject a greater blood volume during each beat (increase in stroke volume), which increases CO.[15] Dobutamine has a very short half-life and must be given by CRI. It takes effect quickly, which is necessary when treating anesthetic hypotension. If the horse is hypovolemic, the use of dobutamine may cause tachycardia with no improvement in BP, which causes the heart to work harder and increase oxygen consumption. If there is not enough blood to pump, increasing the force of contraction will not help. However, in healthy patients undergoing elective procedures, dobutamine is generally the drug of choice and works very well.

Calcium gluconate is another positive inotrope that can be used to treat perianesthetic hypotension; calcium plays a significant role in cardiac function, specifically triggering contraction by entering the cells of the myocardium (heart muscle). Changes in the serum calcium level can affect repolarization of the heart.[3] If the patient is hypocalcemic or likely to be, calcium gluconate can be administered at 10 to 20 mg/kg IV.[5] Calcium gluconate comes in a 23% solution in 500-mL bottles, which is the most common formulation used in horses.

Phenylephrine—an α_1-adrenergic agonist and a vasopressor—causes vasoconstriction by stimulating the $\alpha_1$receptors in the peripheral circulation. The drug can increase diastolic pressure and preload by increasing vasomotor tone.[21] The drug does not increase CO or blood flow to muscles and can have adverse effects, such as reflex vagal bradycardia, which must be considered; therefore, it is not recommended if a horse is already bradycardic (<24 bpm). This drug has a rapid onset and short duration of action and is generally given by CRI.

Colloids are intravenous fluid solutions used to correct hypotension due to hypovolemia. The large molecules in these fluids help maintain or increase intravascular volume by slowing redistribution of these fluids; crystalloids have smaller molecules than colloids and therefore redistribute more quickly. Hetastarch (6%) is a commonly used colloid that typically comes in 500-mL bags. The standard dose is 5 mL/kg/d; for managing intraoperative hypotension, the dose ranges from 2 to 5 mL/kg/d.

Hypertonic saline (7.2%) can be administered when patients have severe hypotension and/or hypovolemia and the administration of hetastarch will take too much time to achieve quick volume expansion. Hypertonic saline can act as a "Band-Aid" to quickly restore intravascular volume and overall hemodynamics. Each liter of hypertonic saline can increase intravascular volume by 3 to 4 L, resulting in rapid and significant increases in BP, perfusion, and CO. The effects of hypertonic saline last approximately 30 to 90 minutes. During a crisis in which a horse requires immediate anesthetic induction (e.g., severely painful colic), hypertonic saline can adequately increase BP for a relatively safe induction period until the horse can be given additional fluid

therapy during surgery. Hypertonic saline brings fluid from the intracellular and interstitial spaces back into the vasculature; this fluid needs to be replaced with crystalloid fluid to avoid severe dehydration and electrolyte derangements. Combining hypertonic saline and hetastarch can have more prolonged and marked beneficial effects on a horse's hemodynamics than either solution could on its own.[18]

Less common **vasopressors** include ephedrine, vasopressin, norepinephrine, and epinephrine. Ephedrine increases BP through vasoconstriction caused by stimulation of the α_1-adrenergic receptors. Administration as a CRI can cause tachycardia, so ephedrine is commonly given as a single bolus at a dose of 0.03 to 0.06 mg/kg IV. Vasopressin is the most potent vasoconstrictor in use and is classified as a nonadrenergic endogenous stress hormone. Vasopressin increases BP, improves tissue perfusion, and improves cardiac contractility. At a dose of 0.4 to 0.6 µg/kg IV, the drug stimulates the release of catecholamines; therefore, repeat doses are not necessary. Epinephrine is an endogenous catecholamine that is typically reserved for cardiopulmonary resuscitation (CPR). The drug acts as a positive inotrope and as a chronotrope, so it increases contractility and heart rate. At a dose of 1 to 3 µg/kg/min, the drug is administered as a bolus during CPR or as a CRI for severely hypotensive horses that are not responding well to other agents.[15] Norepinephrine is a sympathomimetic agent that acts as a peripheral vasoconstrictor by acting on the αreceptors. It also acts as an inotrope on the heart and dilates coronary arteries by acting on the β receptors. The drug is used to treat acute hypotension and is used as a secondary agent during cardiac arrest.[22] Norepinephrine increases heart rate and arterial BP, increases the potential for arrhythmias,[12] and is contraindicated in hypovolemic patients.[22] At a dose of 0.2 to 2 µg/kg/min, this drug can increase vasomotor tone, helping to increase tissue perfusion.[15]

Anticholinergics such as atropine and glycopyrrolate can be used to increase BP if a horse has bradycardia (<24 bpm). Glycopyrrolate is dosed at 0.0025 to 0.005 mg/kg IV,[21] typically takes longer than atropine to take effect, and has a longer duration of action than atropine; unlike atropine, glycopyrrolate does not cross the blood-brain barrier.[23] Atropine has a quick onset and short duration of action and is generally used during CPR. Adverse effects of atropine include tachycardia and ileus, which must be considered before the drug is used. Anticholinergic administration is contraindicated in horses with bradycardia due to α_2-adrenergic agonist administration because anticholinergics can trigger arrhythmias and bradycardia is the body's natural response to the vasoconstrictive action of α_2-adrenergic agonists.

Conclusion

Horses can be challenging anesthetic patients, even when they are healthy. BP is an essential monitoring parameter during equine anesthesia. For success, anesthetists must know how to correct anesthetic abnormalities and have a thorough understanding of cardiovascular and respiratory physiology as well as pharmacology.

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1. The main components of blood pressure (BP) are

- **a.** systolic pressure, diastolic pressure, and mean arterial pressure (MAP).
- **b.** systolic pressure, diastolic pressure, and stroke volume.
- **c.** cardiac output, MAP, and systolic pressure.
- **d.** heart rate, cardiac output, and stroke volume.

2. Cardiac output is determined by

- **a.** MAP × BP.
- **b.** heart rate × MAP.
- **c.** heart rate × stroke volume.
- **d.** stroke volume × BP.

3. α_2-Adrenergic agonists used for preanesthetic sedation in horses can cause

- **a.** platelet function inhibition.
- **b.** tachycardia.
- **c.** nystagmus.
- **d.** second-degree heart block.

4. When used in horses, opioids can

- **a.** cause excitement in awake patients.
- **b.** reduce the minimum alveolar concentration.
- **c.** produce analgesia.
- **d.** a and c

5. If direct BP monitoring is unavailable, _____ can be used to monitor BP.

- **a.** palpation of peripheral pulses
- **b.** DINAMAP
- **c.** arterial blood gas analysis
- **d.** electrocardiography

6. Possible causes of intraoperative hypertension include

- **a.** an anesthetic plane that is too deep.
- **b.** endotoxemia.
- **c.** inadequate analgesia.
- **d.** vena cava compression.

7. Treatment of intraoperative hypertension can include

- **a.** administration of phenylephrine.
- **b.** administration of a colloid.
- **c.** administration of acepromazine.
- **d.** reduction of the inhalant concentration.

8. Perianesthetic hypotension can be caused by

- **a.** endotoxemia.
- **b.** vasodilation.
- **c.** hypovolemia.
- **d.** all of the above

9. _____ can be used to manage hypotension.

- **a.** α_2-Adrenergic agonists
- **b.** Phenothiazines
- **c.** Positive inotropes
- **d.** Cyclohexamines

10. Which of the following can be used to quickly restore intravascular volume during emergencies?

- **a.** 0.9% saline
- **b.** Plasma-Lyte A
- **c.** fresh frozen plasma
- **d.** hypertonic saline

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31	32	33	34	35 M	36	37	38	39	40

Nitrous oxide is sometimes used in conjunction with inhalant anesthesia but is contraindicated in which animal?

Ferrets	HIDE
Snakes	HIDE
Horses	HIDE
Dogs	HIDE
Cats	HIDE

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Ferrets
Snakes
Horses
Dogs
Cats

Correct:

Horses.

Nitrous oxide (N_2O) is highly diffusible and accumulates in 'spaces' in the body.

This causes distention of the intestines, which affects ventilation under anesthesia and may result in postoperative colic in horses.

N_2O is also not good to use in dogs undergoing intestinal surgery, especially a gastric dilatation-volvulus (GDV).

Refs: McCurnin and Bassert, Clin Textbook for Vet Technicians, 7th ed pp. 897-8.

HIDE

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A 2-year-old Standardbred gelding presents with a corneal ulcer. To prepare for the ophthalmic exam, 2 ml of 2% lidocaine is injected into the region of the auriculopalpebral nerve.

Which of the following choices best describes the results of blocking this nerve?

Analgesia of the upper eyelid	HIDE
Akinesia of the eyelid	HIDE
Desensitization of the cornea	HIDE
Paralysis of the retractor oculi	HIDE
Dilation of the pupil	HIDE

Correct

Akinesia (motor paralysis) of the eyelid.

The palpebral branch of the auriculopalpebral nerve (a branch of the facial nerve) provides motor innervation to the orbicularis oculi muscle. Blockade of this nerve facilitates examination of the eye by preventing the horse from closing the eyelids.

This nerve is blocked just lateral or dorsal to upper edge of the zygomatic arch; the nerve is palpable in this location. Alternatively, it can be blocked in the spot just caudal to the mandible and below the zygomatic bone. No analgesia is produced with this block alone, the patient can still feel you touching the eyelid.

Desensitization of the upper 2/3 of the eyelid can be produced by blocking the frontal nerve (also called supraorbital n.) at the supraorbital foramen.

Desensitization of the cornea is achieved with a topical ophthalmic anesthetic such as proparacaine.

Dilation (mydriasis) of the pupil is typically produced when necessary for a fundic examination with a topical anticholinergic.

Sedation may also be necessary for some horses, especially when the eye is quite painful. Remember, they can still see you coming!

Refs: Tranquilli, Thurman, and Grimm's Vet Anes and Analgesia, 4th ed., pp. 606-7 (good pix/diagrams here), and the Merck Veterinary Manual online edition.

Local Anesthetics for the Eye

By **Nick Whelan, BVSc, MVSc, MACVSc, DACVCP, DACVO**

Parenterally, local nerve blocks are an **excellent** aid for **routine ocular evaluation and diagnostic** procedures in **horses**. **The auriculopalpebral block** is the most helpful block to **limit blepharospasm** during examination. This procedure **blocks some of the motor nerves of the upper eyelid** and **enables** the e**xaminer to control the horse's upper eyelid**. The **auriculopalpebral nerve is a branch of the facial nerve** and can be **palpated** as it runs across the **superior margin of the zygomatic arch**. To **block sensory input**, a **supraorbital nerve block or a ring block is used.** The **supraorbital nerve is a branch of the frontal nerve** that traverses the supraorbital foramen of the upper orbit. If placed correctly, a dose of **1–2 mL of lidocain**e is usually sufficient to block either the auriculopalpebral or supraorbital nerve. The block is usually effective within **3–5 min and can last up to 2–3 hr**.

The **same principles are use**d **in food animals**, such as **cattle**, in which both a **retrobulbar and ring block** may be used. A correctly placed **retrobulbar block will block cranial nerves II, III, IV, the ophthalmic branch of V, and VI. The ring block is needed to inhibit sensory input from the skin around the ey**

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41	42 M	43 M	44 M	45	46	47	48	49	50

Which one of the following combinations is necessary to perform a corneal scraping in a horse?

Ophthalmic and lacrimal nerve blocks	HIDE
Auriculopalpebral nerve block and topical proparacaine	HIDE
Maxillary nerve block and intracameral tetracaine	HIDE
Infraorbital and supraorbital nerve blocks	HIDE
Retrobulbar nerve block plus subconjunctival lidocaine	HIDE

BACK NEXT LEAVE BLANK

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Which or
horse?

Ophthal
Auriculo
Maxillar
Infraorb

Retrobulbar nerve block plus subconjunctival lidocaine HIDE

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Correct:

An auriculopalpebral (AP) nerve block and topical proparacaine will enable examination and treatment of the cornea. Sedation may also be necessary in very painful or nervous horses.

The auriculopalpebral nerve innervates the orbicularis oculi muscles. Blocking this nerve allows the examiner to hold the eyelids open easily, even though the horse can still feel the lids.

A supraorbital nerve block desensitizes the upper eyelid; this is very helpful in addition to an AP and topical.

SAVE & EXIT

PREV

41

Which or
horse?

Ophthal
Auriculo
Maxillar
Infraorb

Instillation of a topical anesthetic such as proparacaine onto the cornea is vital to allow manipulation, scraping for cytology, and debridement.

The infraorbital and maxillary nerve blocks do not block any part of the eye. A retrobulbar nerve block is used for enucleation.

An intracameral injection places anesthetic into the anterior chamber. This is invasive and not necessary for an ophthalmic exam.

See a diagram of the locations of these blocks, courtesy Dr. JG Adams.

Refs: Muir, Hubbell, Bednarski, and Skarda's Handbook of Veterinary Anesthesia, 4th ed. pp. 100-3, Muir and Hubbell's Equine Anesthesia, 2nd ed. pp. 221-3.

Retrobulbar nerve block plus subconjunctival lidocaine HIDE

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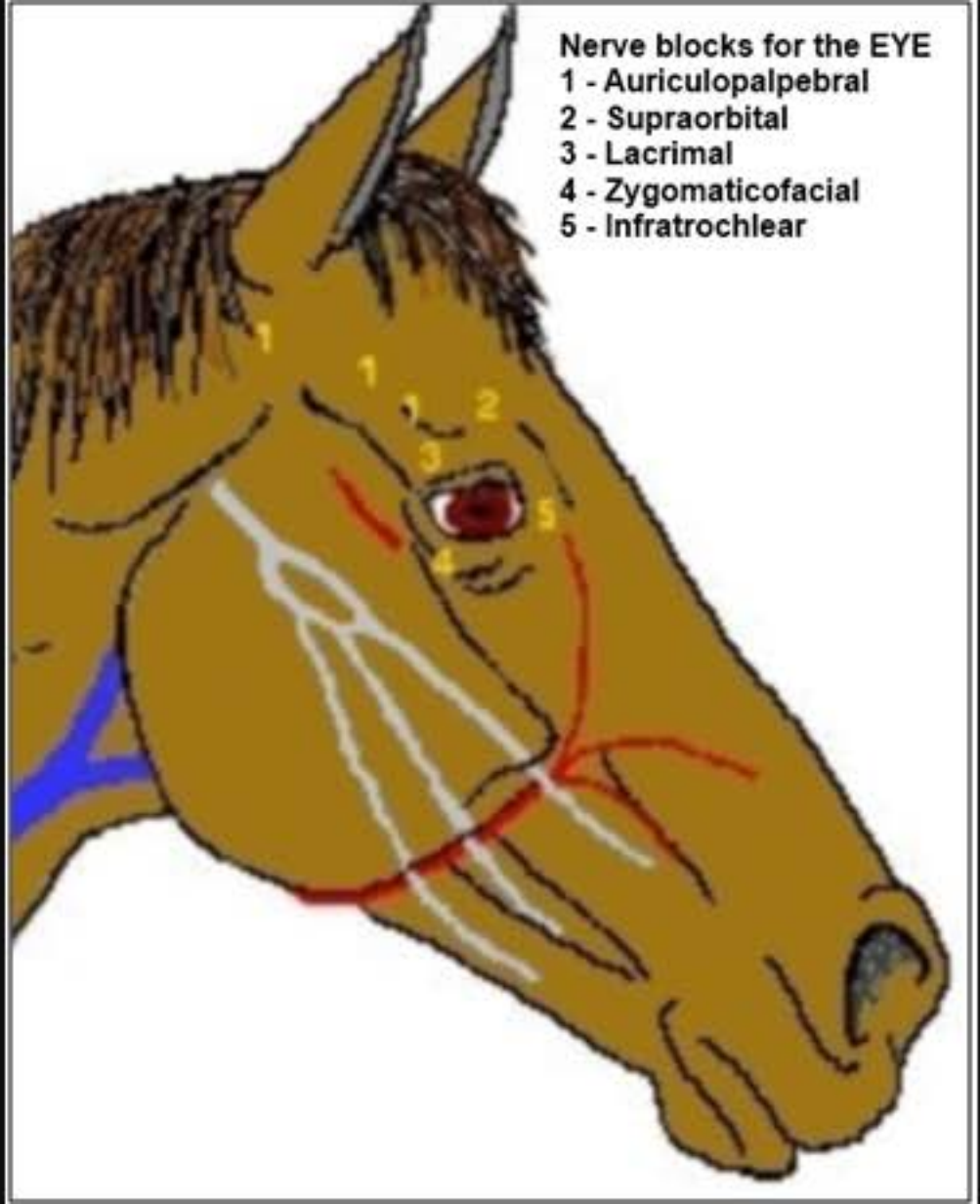
Nerve blocks for the EYE
1 - Auriculopalpebral
2 - Supraorbital
3 - Lacrimal
4 - Zygomaticofacial
5 - Infratrochlear
1
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1
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4

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31	32	33	34	35 M	36	37 M	38	39	40

Which of the following effects are seen with high doses of isoflurane?

Respiratory depression, seizures	HIDE
High systolic arterial blood pressure, loss of corneal reflex	HIDE
Decreased cardiac output, ileus	HIDE
Tachycardia, vomiting	HIDE
Nausea, tachypnea	HIDE

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Overview | Mark this Question | Lab Values | Definitions | Report a Problem

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Overview | Mark this Question | Lab Values | Definitions | Report a Problem

Correct:

Ileus and decreased cardiac output can be seen with high doses of isoflurane.

At high doses, cardiac output is DECREASED by all the inhalant anesthetics (including isoflurane) due to myocardial depression. This effect is most significant at deeper levels of anesthesia and in sick patients.

At anesthetic concentrations of isoflurane used clinically, cardiac output is usually within the normal range but blood pressure may be decreased due to vasodilation.

Vomiting, nausea, and respiratory depression are also seen with high doses of isoflurane.

Refs: McCurnin and Bassert's Clin Textbook for Vet Technicians, 8th ed. pp. 1086-7,

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31	32	33	34	35 M	36	37 M	38 M	39	40

During induction of anesthesia with thiopental following premedication with acepromazine and hydromorphone, a dog at first seems to relax but then begins paddling with all four legs.

He has nystagmus and is tossing his head back and forth.

What is the correct interpretation of this scenario?

Hydromorphoneor thiopental injected perivascularly, causing pain	HIDE
Thiopental dose was inadequate, this is Stage II excitement	HIDE
Anaphylactic reaction to hydromorphone, epinephrine should be given at once	HIDE
Overdose - this is Stage IV with seizure activity due to cerebral hypotension	HIDE

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PREV NEXT

31 32 33 34 35 M 36 37 M 38 M 39 40

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Correct: Thiopental dose was inadequate, this is Stage II excitement

This is the involuntary excitement of Stage II due to an inadequate dose of thiopental.

As consciousness is diminishing, loss of voluntary control of movement occurs in Stage II of anesthesia. Patients can have violent jerky movements, often "paddle" with all 4 limbs.

Horses and cattle,and some dogs and cats exhibit nystagmus. Excessive salivation and vomiting may also occur.

Stage II begins with loss of consciousness and lasts until a regular respiratory pattern is present.

Overdose - this is Stage IV with seizure activity due to cerebral hypotension HIDE

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31 32 33 34 35 M 36 37 M 38 M 39 40

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Ideally, Stage II is bypassed with induction.

Remember that muscle relaxation is poor with ketamine, and some patients may be stiff or show myoclonus with propofol or etomidate. This may be a temporary sign that will pass or another drug may be needed to produce relaxation.

For more, see Anesthetic Monitoring by Lyon Lee DVM, PhD.

Refs: McCurnin's Clin Textbk for Vet Techs, 8th ed. p.1102, Lumb & Jones, Vet Anes, 4th ed. pp. 12-5, and Thomas & Lerche, Anesthesia & Analgesia for Vet Techs, 4th ed. pp. 140-3, 171-6.

Overdose - this is Stage IV with seizure activity due to cerebral hypotension HIDE

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41	42	43	44	45	46	47	48	49	50

Some practices induce anesthesia in dogs by injecting ultra-short acting barbiturates like Methohexital intravenously.

What can happen if this drug is accidentally injected perivascularly? (outside the vein)

Nothing	HIDE
Seizures	HIDE
Cardiac arrest	HIDE
Slough tissues	HIDE

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Overview | Mark this Question | Lab Values | Definitions | Report a Problem

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Seizures

Cardiac

Slough tissues HIDE

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Report a Problem

Correct: **Slough tissues**

Ultra-short acting barbiturates can cause severe tissue irritation and sloughing if they accidentally get outside the vein when injected. Beware of RESPIRATORY DEPRESSION with barbiturates.

Refs: Bassert and Thomas, McCurnin's Clinical Textbook for Veterinary Technicians, 8th ed. p. 1085, Plumb's Veterinary Drug Handbook, 7th ed. pp. 145, 893-5, 1306-9 and Tighe & Brown, Mosby's Comprehensive Review for Vet Techs, 2nd ed. pp. 300-1.

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SAVE & EXIT

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41	42 M	43 M	44	45	46	47	48	49	50

The corneal reflex may be absent during what stage of general anesthesia?

Stage IV	HIDE
Early stage III	HIDE
Stage 1, plane I	HIDE
Stage II, plane II	HIDE

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Overview | Mark this Question | Lab Values | Definitions | Report a Problem

Correct Stage IV

The corneal reflex may be absent during Stage IV, which is an *overdose* of anesthesia-the patient will be very close to death.

The corneal reflex should NEVER be gone if the patient is at an appropriate depth of anesthesia, unless the patient is paralyzed with a neuromuscular blocker.

The corneal reflex does not always disappear, in fact, it is still present for a short time after death in some patients.

It is not wise to use the corneal reflex routinely to determine anesthetic depth as it could be damaged with frequent touch. Also, it is often not available in dogs and cats since the eyeball rolls ventrally.

Other reflexes and signs of anesthetic depth are quite reliable – palpebral response, eye position, tearing, nystagmus, etc.

Note – there are no *planes* of anesthesia in stages I or II.

For more, see Anesthetic Monitoring and Monitoring Anesthetic Depth by Lyon Lee DVM, PhD.

Refs: McCurnin's Clin Textbk for Vet Techs, 8th ed. p.1102, Lumb & Jones, Vet Anes, 4th ed. pp. 12-5, and Thomas & Lerche, Anesthesia & Analgesia for Vet Techs, 4th ed. pp. 140-3, 171-6.

Stages		Description
1		Inducement, excitement, pupils constricted, voluntary struggling
2		Obtunded reflexes, pupil diameters start to dilate, still excited, involuntary struggling
3	Planes	There are three planes- light, medium, and deep
	Light	More decreased reflexes, pupils constricted, brisk palpebral reflex, corneal reflex, absence of swallowing reflex, lacrimation still present, no involuntary muscle movement.
	Medium	Ideal plane for most invasive procedures, pupils dilated, loss of pain, loss of palpebral reflex, corneal reflexes present.
	Deep (early overdose)	Respiratory depression, severe muscle relaxation, bradycardia, no reflexes (palpebral, corneal), pupils dilated
4		Very deep anesthesia. Respiration ceases, cardiovascular function depresses and death ensues immediately.

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41	42 M	43 M	44 M	45	46	47	48	49	50

Which commonly-used anesthetic circuit is made up of a tube within a tube?

Semi-closed circle system	HIDE
Closed circle system	HIDE
Universal Y circuit	HIDE
Bain system	HIDE

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Overview | Mark this Question | Lab Values | Definitions | Report a Problem

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Overview | Mark this Question | Lab Values | Definitions | Report a Problem

Correct:

A Bain system is a tube within a tube.

New oxygen and anesthetic gas is inhaled down the inner tube, and exhaled gas exits through the outer tube. (Note there is a modified form of a circular system called a "universal F circuit" that is also a tube inside a tube).

A Bain anesthetic circuit run at a high flow rate of 200-300 ml/kg/min will not allow rebreathing of exhaled gasses.

At lower flow rates (ie: 130-200 ml/kg/min or less) the Bain circuit functions as a PARTIAL rebreathing system, and the animal rebreathes some of the exhaled gasses.

Refs: McCurnin & Bassert, Clin Textbook for Vet Technicians, 8th ed, pp. 1004-5, fig

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41	42 M	43 M	44 M	45	46	47	48	49	50

Which of the following most correctly describes physiologic pain?

Pain caused by stretching, tension, or inflammation of viscera	HIDE
Pain that results when homeostasis is disturbed, as when dehydration is present	HIDE
The sensation that results when electrolytes or other biochemical compounds are imbalanced	HIDE
Pain that originates from damage to peripheral nerves or the central nervous system	HIDE
A protective response to an actual or potentially damaging insult	HIDE

BACK NEXT LEAVE BLANK

Correct

Physiologic pain is **a protective response to an actual or potentially damaging insult**. Basically, this is a normal healthy pain response - an automatic mechanism to avoid or minimize injury, which initiates the physiologic and physical response to pain.

Physiologic pain is also called *nociceptive* pain, as it involves the basic physiologic mechanisms of reception, transmission, and processing of stimuli that lead to perception of pain.
Response to physiologic pain is behavioral, emotional, and physiologic; and both involuntary and voluntary.

Classic example - when your hand touches something hot, you unconsciously withdraw, move away, and your heart rate increases, etc.

The withdrawal and tachycardia are involuntary responses that occur almost immediately. The next event is behavioral and voluntary, where you move away, run cold water on the burn, and change how you handle the hot item, etc. The emotional component is when you exclaim "OUCH."

Stretching, tension, or inflammation of viscera causes *visceral* pain, e.g. colic in horses. *Neuropathic* pain is caused by damage to neural tissue.

See links with good pain information - Taxonomy of pain from the IASP, and Pain Management Guidelines for Dogs & Cats from the AAHA, and the AAFP.

Refs: Gaynor & Muir Handbook of Vet Pain Mgt 2nd ed. pp. 14-30, 58, Greene, Vet

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41	42 M	43 M	44 M	45	46	47	48	49	50

How do you prevent laryngospasm in cats before inducing anesthesia?

Avoid halothane	HIDE
1-2% Lidocaine spray	HIDE
Pre-medicate with atropine or glycopyrrolate	HIDE
Pre-medicate with acepromazine	HIDE

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Overview | Mark this Question | Lab Values | Definitions | Report a Problem

Correct:

Prevent laryngospasm by spraying larynx with 1-2% lidocaine.

Laryngeal spasm is primarily a CAT problem associated with overzealous manipulation of the larynx by laryngoscope or during intubation.

Refs: Pasquini's, Tschauner's Guide to Sm An Clin, vol 1, 2nd ed. pp. 129.

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41	42 M	43 M	44 M	45	46	47	48	49	50

When used as a preanesthetic, atropine will:

Stimulate excessive salivary secretion	HIDE
Frequently produce vomiting	HIDE
Provide sufficient anesthesia for minor surgery	HIDE
Cause the pupils to dilate	HIDE

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Overview | Mark this Question | Lab Values | | Report a Problem

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Overview | Mark this Question | Lab Values | Definitions | Report a Problem

Correct:

At moderate doses Atropine dilates pupils, and increase heart rate. High doses will decrease GI and urinary tract motility. A very high dose will inhibit gastric secretion.

Refs: Plumb's Vet Drug Handbook, 7th ed. pp. 126-31 and the Merck Veterinary Manual online edition.

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41	42 M	43 M	44 M	45	46	47	48	49	50

A dog is anesthetized for ovariohysterectomy with isoflurane in oxygen following premedication with atropine, acepromazine, and hydromorphone given intramuscularly, and intravenous induction with midazolam and ketamine.

As the surgeon exteriorizes the first ovary, the dog's blood pressure increases and the heart rate goes down.

What is this phenomenon?

Symphathetic release	HIDE
The Valsalva maneuver	HIDE
Vago-vagal reflex	HIDE
Baroreceptor response	HIDE

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Correct:

This is an example of the baroreceptor response or reflex that relates heart rate (HR) and blood pressure (BP). It is sometimes also called Marey's reflex.

To maintain perfusion, BP is kept within a particular range. When BP increases, HR goes down, when BP decreases, HR goes up.

The BP increase is usually because of an increase in sympathetic tone. This causes a corresponding increase in parasympathetic tone (via the vagus nerve) that slows HR.

Anesthestic drugs and adjunct medication may accentuate (alpha 2 agonists), attenuate (inhalants) or abolish (anti-cholinergics) this response.

cancel

Sympha

The Valsalva maneuver	HIDE
Vago-vagal reflex	HIDE
Baroreceptor response	HIDE

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51	52	53	54	55	56	57	58	59	60

Which of the following correctly describes the phenomenon of hyperalgesia?

Lack of or decreased response to stimuli that usually cause pain	HIDE
Stimuli that are not normally painful produce a pain response	HIDE
Increased response to a stimulus that normally produces pain	HIDE
A protective response to an actual or potentially damaging insult	HIDE
A greater analgesic effect seen with treatment of a patient in pain	HIDE

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Which of

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Correct:

Hyperalgesia is an increased response to a stimulus that normally produces pain. Injured areas can develop an exaggerated response or hypersensitivity to painful stimuli.

The cascade of events following trauma and inflammation transforms the response of nociceptors in the area. They respond at lower levels of input and to stimuli that normally would not produce a response.

Components of damaged tissue stimulate influx of activated inflammatory cells that secrete numerous mediators - a 'sensitizing soup' develops in the injured area. Bradykinins, cytokines, serotonin, histamine, and many others amplify the inflammatory response and the resulting pain.

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Which of

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inflammatory response and the resulting pain.

Pain is defined as protective response to an actual or potentially damaging insult.

Allodynia is the triggering of a painful response by stimuli that are not normally painful.

Hypoalgesia is a decreased response to normally painful stimuli.

Refs: Gaynor & Muir Handbook of Vet Pain Mgt 2nd ed., pp. 28-36, 57-9, Greene, Vet Anes and Pain Mgt Secrets, pp. 323-7, and the Merck Veterinary Manual online edition.

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The basic physiology of pain includes 5 phenomena that occur along the pain pathway to alert the patient to a painful stimulus.

Which of the following choices occurs in the cerebral cortex?

Transmission	HIDE
Transduction	HIDE
Modulation	HIDE
Projection	HIDE
Perception	HIDE

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Correct:

Perception is the final step in the transfer of a painful stimulus. The patient perceives the presence of pain once neurons in the cerebral cortex are activated.

Step I - **transduction** of the stimulus by pain receptors (or nociceptors) located on the nerve endings of A-delta and C fibers.

Step 2 - **transmission** to the dorsal horn of the spinal cord, where the cell bodies of the nociceptors are located. Here, the signal is (3) **modulated** – amplified and/or suppressed.

It is then (4) **projected** to the midbrain periaqueductal gray area, the thalamus, and parts of the brainstem, where it is further processed and sent to the cerebral cortex for (5) **perception**.

Modulation	HIDE
Projection	HIDE

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Pain Perception

By **Sandra Allweiler, DVM, DACVA**

Pain serves a **protective role that alerts an individual to injury from the environment or from within**. Based on current knowledge, all vertebrates, and some invertebrates, experience **pain** in **response to actual or potential tissue damage**. Many types of pain are encountered, with the most common being acute, chronic, cancer, and neuropathic. **Acute pain** is sudden in onset and can be severe. However, it disappears when the stimulus is removed or in a short period of time, and it tends to be self-limiting. Acute pain has a **biologic function, because** it serves as a warning that something is wrong while leading to protective behavioral changes. Acute pain is a s**ymptom of disease**, whereas **chronic pain** in and of itself, is a disease of altered neuro processing. Chronic pain lasts for **several weeks to months** and persists beyond the expected healing time. Chronic pain d**oes not serve a biologic functio**n and imposes severe detrimental stresses. **Cancer pain** is the result of primary tumor growth, metastatic disease, or the toxic effects of chemotherapy and radiation. Cancer pain c**an be acute, chronic, or intermittent** and is related to the disease itself or the treatment. **Neuropathic pain originate**s from injury or after **injury of the peripheral or central nervous systems**, such as trauma (eg, amputation and crushing injury), vascular injury (eg, thromboembolic disease), endocrinopathy (eg, diabetes mellitus), or infection (eg, post-herpetic neuralgia), possibly associated with motor, sensory, or autonomic deficits.

For an animal to experience pain, **nociceptive information** must be sent to higher centers in the CNS to be integrated, modulated, and interpreted into the conscious perception of pain. **Noxious stimuli** (heat, cold, mechanical, chemical) activate free sensory nerve endings known as **nociceptors. A-δ and C-fibers** transmit sensory information from nociceptors to the dorsal horn of the spinal cord, which directs and modulates input from the periphery and higher centers. **Nociceptive information** arriving in the dorsal horn of the spinal cord may activate motor neurons responsible for the reflex responses to noxious stimuli (such as withdrawing a limb). Importantly, **nociceptive sensory** input may be **amplified** or **inhibited by spinal interneurons and glial cells**. Sensory information is relayed to higher centers in the CNS along a variety of pathways that differ according to species. In general, **nociceptive information ascends** the spinal cord along superficial and deep pathways to the brain stem with connections to the **thalamus**, **reticular formation** (**responsible for level of arousal)**, and **limbic system** (**responsible for emotions)**. **From these areas of the brain, nociceptive information is relayed to the cortex**, **where it is perceived as pain**. Activity in spinal nociceptive pathways is strongly influenced by descending antinociceptive systems that originate in the brain stem. **Endogenous antinociceptive neurotransmitters** (eg,

endorphin, enkephalin, dynorphin, serotonin, and norepinephrine) i**nhibit the transmission of nociceptive information in the spinal cord and brain.**

The neuroanatomic components of the nociceptive/pain pathways and pain-suppressing systems can change in response to sustained sensory input. **Peripheral sensitization of nociceptors and central sensitization of nociceptive pathways in the dorsal horn, spinal cord, and brain** can **develop as a result of extensive tissue trauma or nerve injury**. **The process of peripheral and central sensitization** has been **termed** "**wind-up**" and **refers to the neuroanatomic changes (plasticity)** that **result in heightened or exaggerated pain states.** Additionally, these exaggerated pain states often do not respond to conventional analgesic therapy. The **use** of **opioids** is especially **limited**, likely **because** of a down regulation of opioid receptors, a phenomenon that has been reported in the dorsal root ganglion and the dorsal horn. Thus, changes in the CNS in response to repeated and sustained nociceptive input (ie, pain) complicate the clinical management of pain

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Which of the following statements is the most accurate regarding anesthetic monitoring in reptiles?

Pulse oximetry is useful for monitoring trends in arterial oxygen saturation	HIDE
Snakes are the only type of reptile in which corneal and palpebral reflexes can be elicited	HIDE
Ultrasonic Doppler devices are impractical for assessing heart or pulse rate	HIDE
Most reptiles maintain a normal righting reflex even at a surgical plane of anesthesia	HIDE
Indirect and direct blood pressure measurements have been shown to be well correlated	HIDE

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Which of
reptiles?

Pulse ox

Indirect
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Snakes
can be e

Most reptiles maintain a normal righting reflex even at a surgical plane of anesthesia HIDE

Ultrasonic Doppler devices are impractical for assessing heart or pulse rate HIDE

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Pulse oximetry is useful for monitoring trends in arterial oxygen saturation

Correct:

Trends in arterial oxygen saturation measured by pulse oximetry can be useful for anesthetic monitoring in reptiles although the absolute values are not reliable. Pulse oximetry can be performed by using an esophageal or cloacal reflectance probe.

Indirect and direct blood pressure measurements do not correlate well in reptiles.

Doppler ultrasonography is very useful for assessing heart or pulse rate in reptiles. The probe can be placed directly over the heart in lizards. The shell interferes with placement of the probe over the heart in chelonians so instead the carotid artery can be probed in the thoracic inlet.

A surgical plane of anesthesia usually results in loss of the righting reflex although

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Which of
reptiles?

Pulse ox

Indirect
well cor

Snakes
can be e

placement of the probe over the heart in chelonians so instead the carotid artery can be probed in the thoracic inlet.

A surgical plane of anesthesia usually results in loss of the righting reflex although this is reported to be less reliable in turtles and tortoises.

Corneal and palpebral reflexes cannot be elicited in snakes because they do not have eyelids.

Refs: Sladky and Mans, Clinical Anesthesia in Reptiles, Journal of Exotic Pet Medicine 21 (2012) p 17-31, and Merck Vet Manual online.

Most reptiles maintain a normal righting reflex even at a surgical plane of anesthesia HIDE

Ultrasonic Doppler devices are impractical for assessing heart or pulse rate HIDE

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A 12-year-old female spayed Labrador retriever with poorly managed hypothyroidism and chronic renal insufficiency is extremely painful after being hit by a car and sustaining a left hindlimb injury and possible traumatic brain injury. How could morphine be administered to this patient as part of the analgesic protocol?

Crush oral sustained-release tablets and administer once daily	HIDE
Morphine should not be given to this patient	HIDE
Give as a high-dose constant rate infusion	HIDE
Administer the injectable preservative-free solution orally three times daily	HIDE
Administered rapidly IV every 8-12 hours, as needed	HIDE

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Morphine should NOT be part of this patient's analgesic protocol. Morphine is contraindicated in severely debilitated or geriatric patients as well as those with hypothyroidism, renal insufficiency, and/or adernocortical insufficiency. Furthermore, morphine should NOT be given to patients with head injuries because it causes respiratory depression with secondary cerebral vasodilatation due to the increased $paCO_2$, leading to increased intracranial pressure.

Oral morphine has very low and variable oral absorption. Sustained-release tablets should NEVER be crushed or broken because this turns them into immediate-release, easily facilitating overdose and death.

Morphine must be given slowly IV to prevent histamine release/vasodilitation that occurs with rapid IV dosing. This can leads to anaphylaxis.

Constant rate infusions are a useful way to administer morphine. Side effects are more common with higher doses.

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Which of the following choices are best for treating a patient that survives cardiac arrest but continues to have a persistent and unstable ventricular tachycardia?

5% Dextrose or hypertonic saline solution	HIDE
Calcium gluconate or sodium bicarbonate	HIDE
Amiodarone or magnesium sulfate	HIDE
Lidocaine or mexilitine	HIDE

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Which of
continue

5% Dex
Amiodar
Calcium
Lidocain

Correct

Amiodarone or magnesium sulfate are preferred for treatment of persistent ventricular tachycardia following cardiac arrest.

Lidocaine is sometimes used, however, amiodarone is associated with better outcomes. Mexilitine is an oral medication that is not used in these patients. It is used in dogs with ventricular arrhythmias caused by cardiomyopathy.

Download this free issue of the Journal of Vet Emergency and Critical Care with CPCR guidelines for animals

Refs: McCurnin's Clin Textbk for Vet Techs, 8th ed. pp. 924-6 and the Merck Veterinary Manual online edition.

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51	52	53	54	55	56	57	58	59	60
✓	✓	✗	✗	✗	✓				

Diazepam use is contraindicated in which of the following medical conditions?

Seizure disorders	HIDE
Hypertension	HIDE
Heart disease	HIDE
Liver failure	HIDE
Diabetes mellitus	HIDE

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Diabetes mellitus

Correct: **Liver failure**

Avoid diazepam, a benzodiazepine, in patients with significant hepatic disease.

Serious hepatotoxicity has been reported with diazepam use in CATS. Chronic oral use is generally NOT recommended in cats.

Also use with caution in patients with renal disease, shock, coma, and aggression.

Refs: Merck Veterinary Manual online edition and Plumb's Veterinary Drug Handbook, 8th edition, *Diazepam*.

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51	52	53	54	55	56	57	58	59	60
✓	✓	✗	✗	✗	✓	✓	✗		

Which of the following analgesics is most likely to cause dysphoria when administered to a healthy dog?

Dexmedetomidine	HIDE
Gabapentin	HIDE
Hydromorphone	HIDE
Carprofen	HIDE
Tramadol	HIDE

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Correct **Hydromorphone**

Dysphoria is a side effect of opioids such as **hydromorphone,** a synthetic opioid, 10-15X as potent as morphine.

1-Dysphoria is a state of mental discomfort or suffering. When you feel dysphoria – and we hope you rarely do – you feel depressed and awful.
2-Euphoria is a state of joy or bliss: dysphoria is the opposite. It's a state of unease, anxiety, and misery.

Restlessness, agitation, vocalization, and a lack of response to surroundings or interaction with caretakers are signs of dysphoria.

Signs of pain are similar in some animals; a thorough evaluation for pain and treatment with pain medication is recommended before treatment for dysphoria.

Treatments for dysphoria include administration of a tranquilizer or sedative such as acepromazine or dexmedetomidine, respectively.

A low dose of an opioid antagonist such as naloxone may reverse the dysphoria without removing analgesic effects, but supplementation with other pain medication is necessary in some cases.

Dysphoria is less common in very painful patients; it is more common in some breeds, such as huskies or malamutes, possibly sighthounds.

A good case report/review of dysphoria: Hofmeister, EH et al. 2006. Opioid dysphoria in three dogs. Journal of Vet Emergency and Critical Care; 16(1):44-49.

Refs: Gaynor & Muir Handbook of Vet Pain Mgt 2nd ed. p. 176, Greene, Vet Anes and Pain Mgt Secrets pp. 335-7 and the Merck Veterinary Manual online.

Opioids

Opioids continue to be the cornerstone of effective pain treatment in veterinary medicine. The opioids are a diverse group of naturally occurring and synthetic drugs used primarily for their **analgesic activity**. Despite some well-known adverse effects and disadvantages, opioids are the **most effective analgesics available for the systemic treatment of acute pain in many species**, **particularly dogs and cats**. Opioid receptors are part of a large superfamily of membrane-bound receptors that are coupled to G proteins. **Each opioid receptor** has a unique distribution in the **brain, spinal cord, and periphery**. **Opioids** combine **reversibly with these receptors** and **alter the transmission and perception of pain**. In addition to analgesia, **opioids** can induce other **CNS effects that include sedation, euphoria, dysphoria, and excitement**. The clinical effects of opioids vary between the **mu opioid receptor agonists** (eg**, morphine, hydromorphone**), **partial mu agonists** (ie, **buprenorphine**), and **agonist-antagonists** (eg, **butorphanol**). Species and individual differences in the response to opioids are marked, necessitating the careful selection of opioid and adjustment of dose for different species. For example, a 30-kg dog may receive a preoperative dose of morphine (15–30 mg) that is similar to that for a 500-kg horse. Likewise, **although butorphanol is widely used as an effective analgesic in horses**, **its use as an analgesic in small animals is falling out of favor because** of its expense, relatively poor somatic analgesic effect, and short duration of action. The clinical effect of an opioid depends on additional patient factors, including the presence or absence of pain, health status of the animal, concurrent drugs administered (eg, tranquilizers), and individual sensitivity to opioids.

Recent information regarding the **peripheral endogenous opioid system** (**PEOS**) has presented a unique opportunity to use the powerful analgesic effect of opiates while minimizing untoward systemic effects. The **PEOS includes peripheral opioid receptor**s (**POR**) and **peripheral leukocyte-derived opioids** (**PLDO**): endomorphins, endorphins, enkephalins, and dynorphins. To activate the PEOS, tissue must have sufficient numbers of leukocytes able to secrete **PLDO** as well as functional POR in sufficient numbers. Inflammation due to tissue damage results in accumulation of PLDO-secreting leukocytes at the site of injury. Inflammation also increases the number and efficiency of POR. These receptors, inactive under normal conditions and expressed on primary sensory neurons, are synthesized in the dorsal root ganglion and transported distally to peripheral sensory nerve endings due to tissue injury and inflammation. Experimental trials and clinical studies show that peripheral opiates are effective, particularly in the presence of inflammation. For example, preservative-free morphine has been instilled into canine and equine joints after arthroscopy or arthrotomy.

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51	52	53	54	55	56	57	58	59	60
✓	✓	✗	✗	✗	✓	✓	✗	✗	

Propofol is a non-barbiturate agent used to induce anesthesia. Which statement is most correct about propofol?

Provides minimal to no analgesic effects	HIDE
Highly irritating if accidentally injected perivascularly	HIDE
Open vials must be discarded after 1 hour	HIDE
Can cause respiratory excitation if given too rapidly	HIDE
Propofol is slowly cleared from the body	HIDE

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Propofol is slowly cleared from the body HIDE

Correct: Provides minimal to no analgesic effects

Propofol has little to no analgesic effects.

Opened vials of propofol should be discarded after 6 hours or they may support bacterial growth.

Propofol is RAPIDLY cleared, and is NOT particularly irritating to tissues if it goes outside the vein accidentally.

Propofol can cause APNEA if given too rapidly.

Refs: Bassert and Thomas, McCurnin's Clinical Textbook for Veterinary Technicians, 8th ed. p. 1084, Plumb's Vet Drug Handbook, 7th ed. pp. 1168-73 and Tighe & Brown, Mosby's Comprehensive Review for Vet Techs, 2nd ed. pp. 301.

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