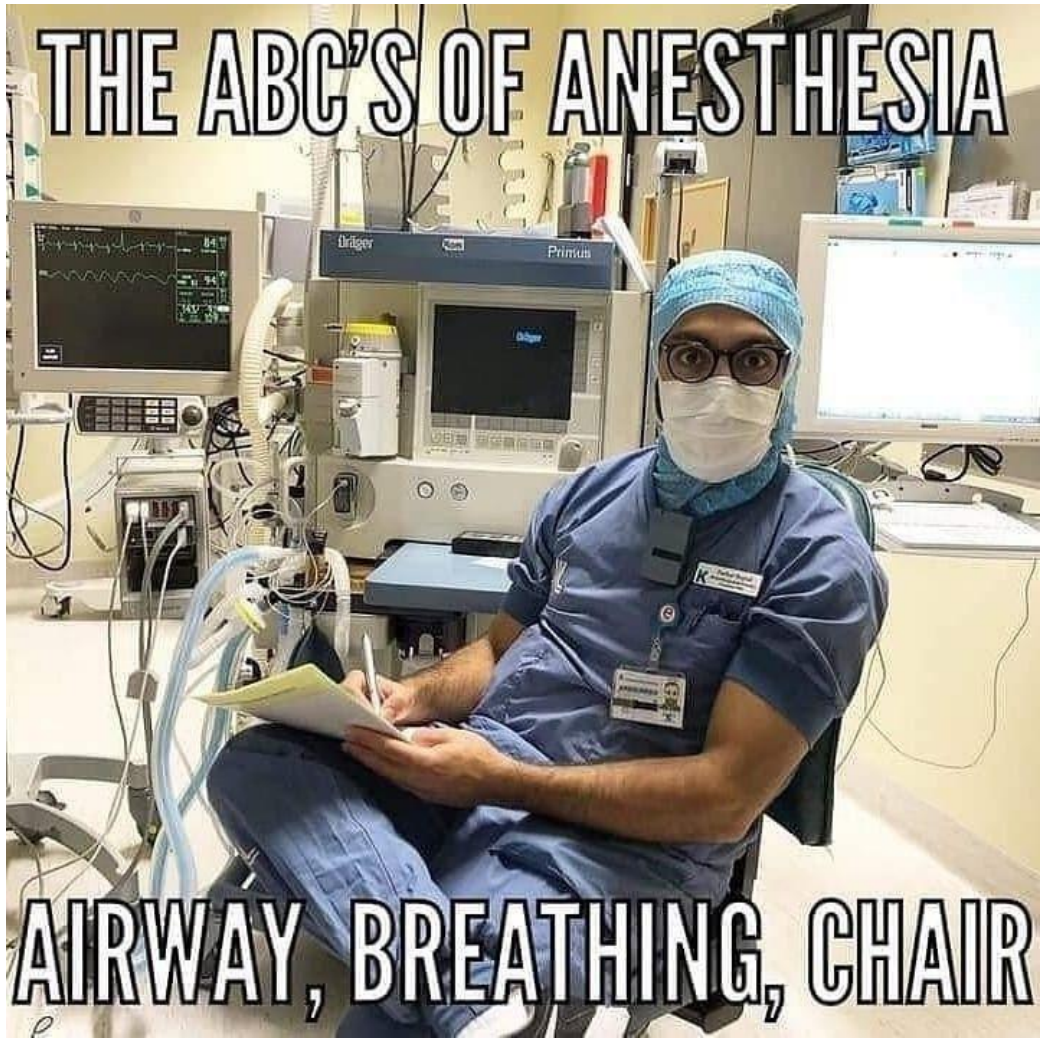

Monitoring the Anesthetized Patient: Tips, Tricks, and Avoiding Pitfalls

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“All anesthetics are essentially toxins. They’re therapeutic because we control the dose, but they can compromise cardiovascular and respiratory function. That’s why robust monitoring isn’t optional, it’s lifesaving.” – Dr. Lydia Love

PRACTICE GUIDELINES

The American College of Veterinary Anesthesia and Analgesia Small Animal Anesthesia and Sedation Monitoring Guidelines 2025

Kate Bailey[a], Jessica Briley[a], Lauren Duffee[b], Tanya Duke-Novakovski[c], Tamara Grubb[d], Kris Kruse-Elliott[e,1], Lydia Love[a,1], Manuel Martin-Flores[f], Carolyn McKune[g], Aya Oda[h],

Outline

- Assessing anesthetic risk
- Anesthetic complications and considerations
- Anesthetic monitoring equipment
- Importance of monitoring
- Summary

American Society of Anesthesiologists (ASA) Patient Status Scale

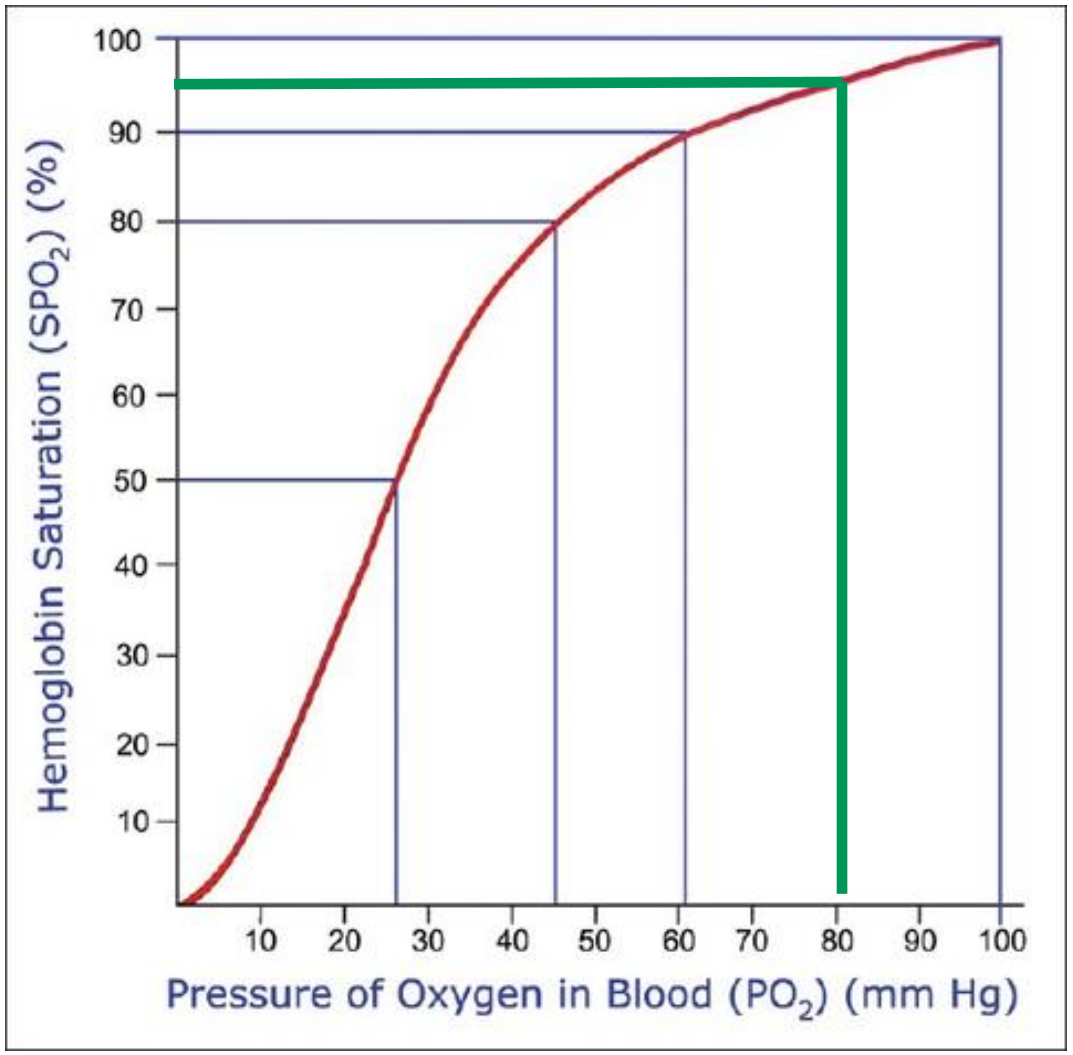
ASA Status	Description	Example
1	Normal healthy patient	Healthy patient for neutering
2	Patient with mild systemic disease	Dog with well compensated mild mitral valve degeneration
3	Patient with moderate systemic disease	Cat with CKD, IRIS stage 3
4	Patient with severe systemic disease that is a constant threat to life	Dog with hemoabdomen secondary to bleeding splenic mass
5	Moribund patient who is not expected to survive without the operation	Hypotensive, hypothermic, obtunded cat with septic abdomen

- Evaluation of patient health to determine "risk" for anesthesia
- Reflective health status – NOT on procedure(s)
- % perioperative complications (morbidity, mortality) associated with status[8,9]
  - ASA I: <0.3% (human)
  - ASA V: Up to 58% (human)
  - ↑ ASA status associated with odds of death in dogs, cats[9]

8. Hackett et al.
9. Grubb et al.
Image: AAHA 2020 Anesthesia Monitoring Guidelines

Anesthetic Complications/Considerations

- Hypotension
- Hypothermia
- Hypoventilation
- Hypoxemia
- Cardiac Arrhythmias
- +/- Additional patient or procedure-specific factors

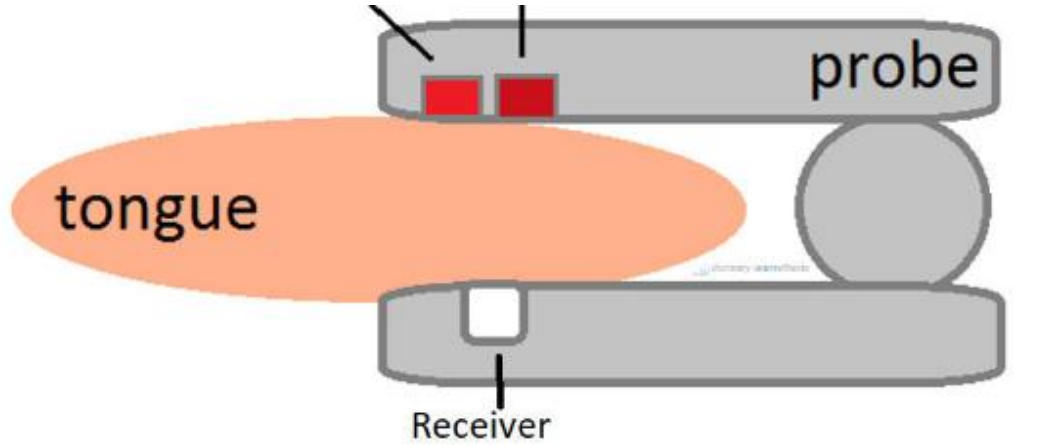


Pulse Oximetry (SpO_2)

- Hypoxemia = low O_2 in blood
  - PaO_2 < 80 mmHg (<60 mmHg severe)
- SpO_2 = peripheral oxygen saturation
  - "How much O_2 your blood is carrying as % of maximum it could carry"
- Use SpO_2 to estimate O_2 level in blood (PaO_2)
  - $SpO_2 \geq 95\%$ = PaO2 80 mmHg (+)

SpO2	PaO2
100%	100 mmHg (+)
95%	80 mmHg
90%	60 mmHg

Image: Burtons Veterinary – Practical Pulse Oximetry
1. Adami et al.

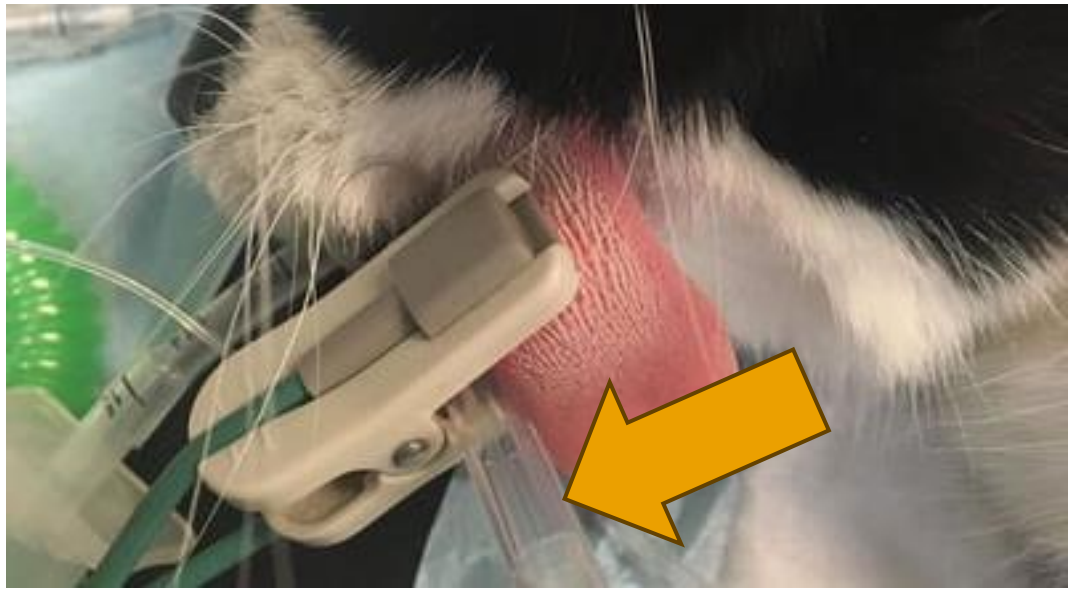


A transmission probe showing the two lights on one side of the probe and the receiver on the other

SpO_2: Pulse Oximetry

- 2 types of light (red, infrared) → tissues → detector/receiver
  - "oxygenated" blood protein (Hb) absorbs different than "non-oxygenated"
- "Pulsating" blood needed
- Indirectly estimates PaO_2

1. Adami et al.
Top Image: Mindray
Bottom Image: Burton's Practical Pulse Oximetry



Transmittance Probe

- Sites of Placement:
  - Tongue
  - Toes
  - Lip
  - Ear (pinna)
  - Prepuce, vulva

- Common Limitations/Interferences:
  - Pigmented tissue
  - Fur (especially thick/long)
  - Hypotension
  - Vasoconstriction (drugs, hypothermia)
  - Motion artifact
  - Optical interference (room light)

1. Adami et al.
Top Image: Mindray
Bottom Image: K Deom

Reflectance (“flat”) Probe

- Light source + detector on same side
- Place over **bone** → emitted light must “bounce” back
- *Ambient light more likely to interfere - cover
- Suggested sites:
  - Ventral tail – Preferred[7]
  - Medial tibia, metatarsals also possible

7. Nixdorff et al
Images: Masimo, Vetrap

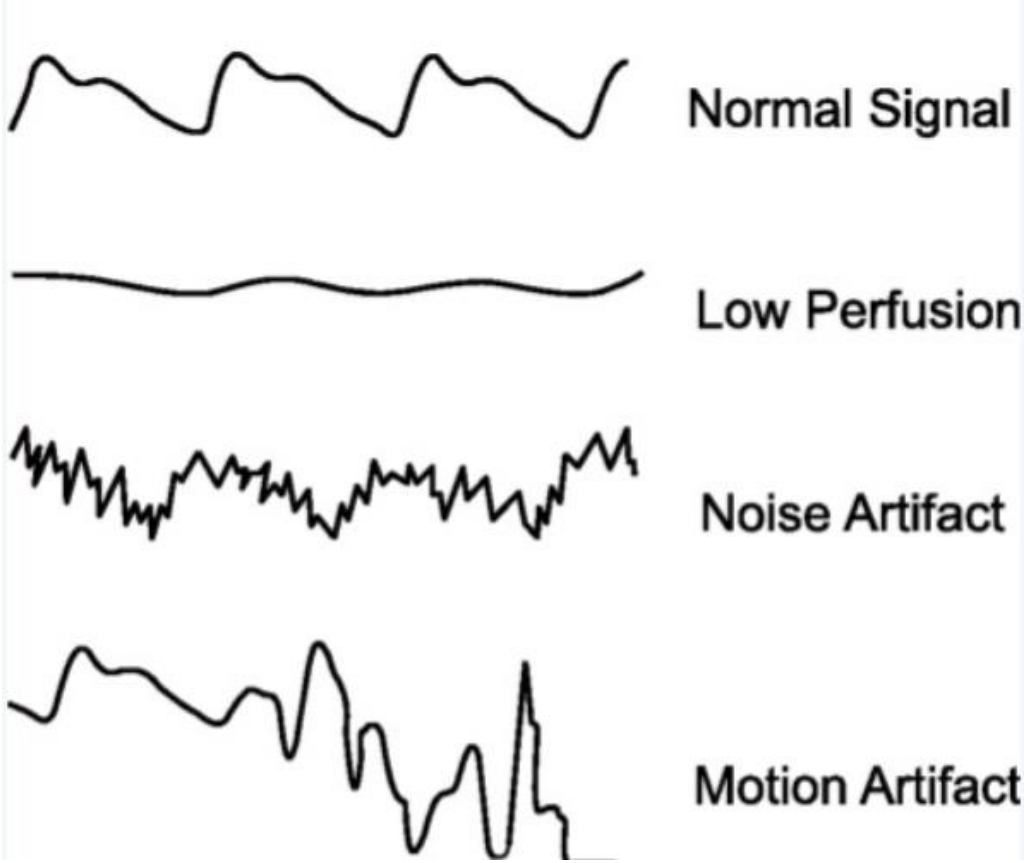
Image: Masimo Rad-5/5v Manual

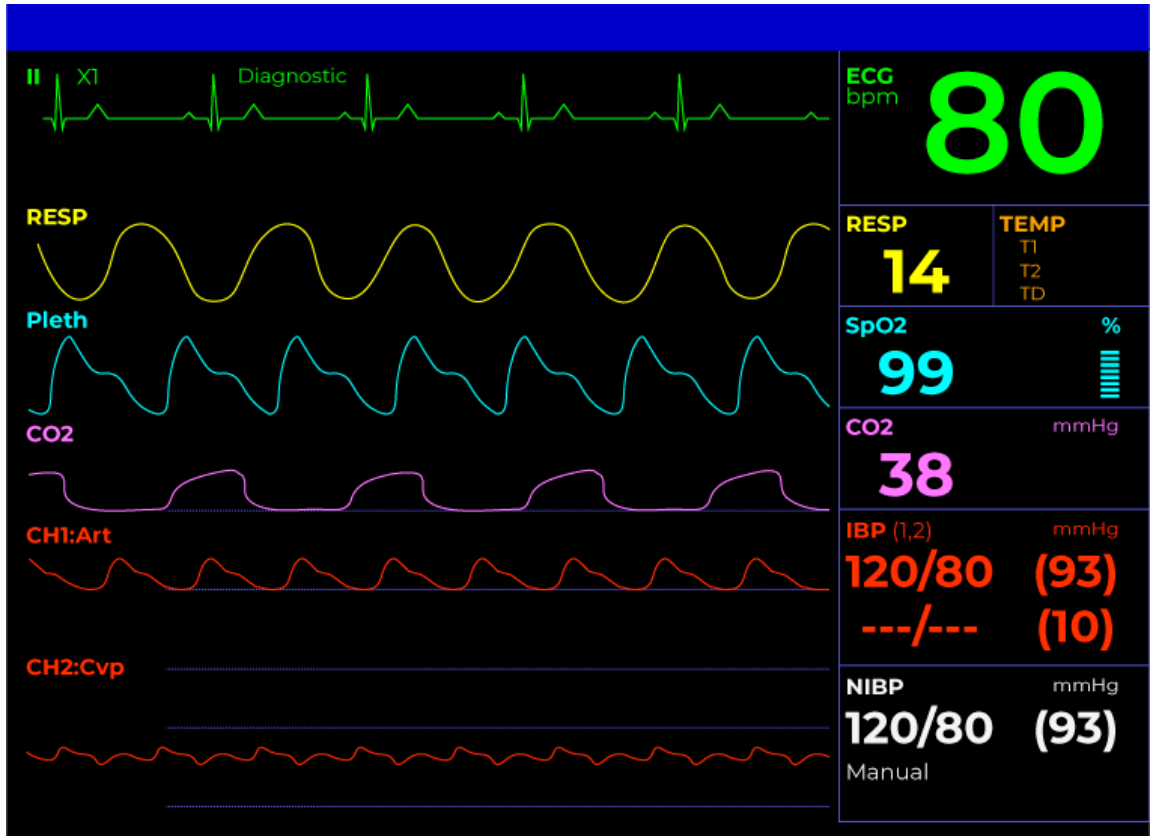
SIQ = “Signal IQ”

- Signal reliability (quality)

PI = Perfusion Index

- “Strength” of blood flow





Plethysmograph

Images: Open Critical Care (left), Cardiac Direct (right)

Assessing Fluid-Responsiveness

Respiratory pulse profile variation

Following a positive-pressure breath, if a significant (>15%) drop in pulse profile (e.g. on a pulse oximeter plethysmograph) occurs (see arrow in diagram) the hypotension will likely respond to fluid boluses

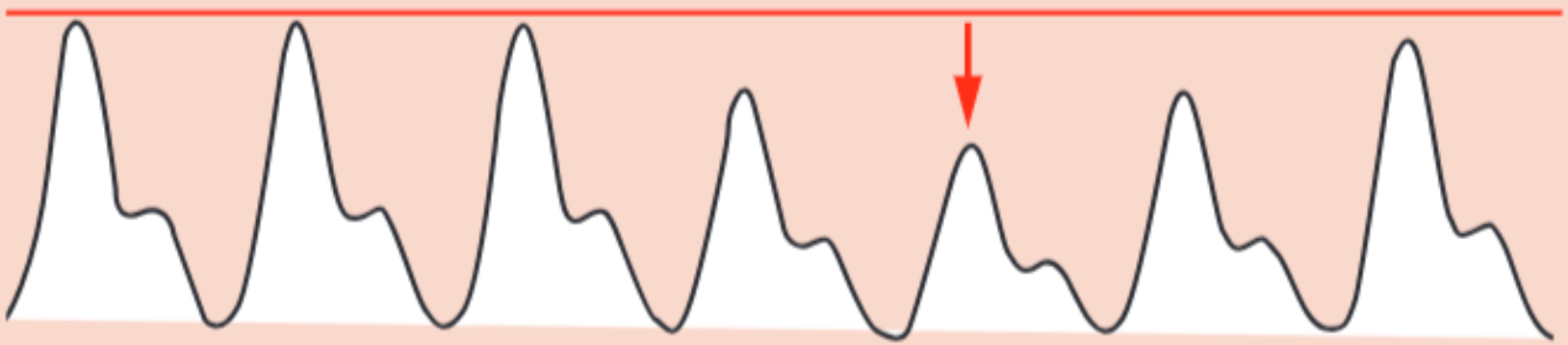
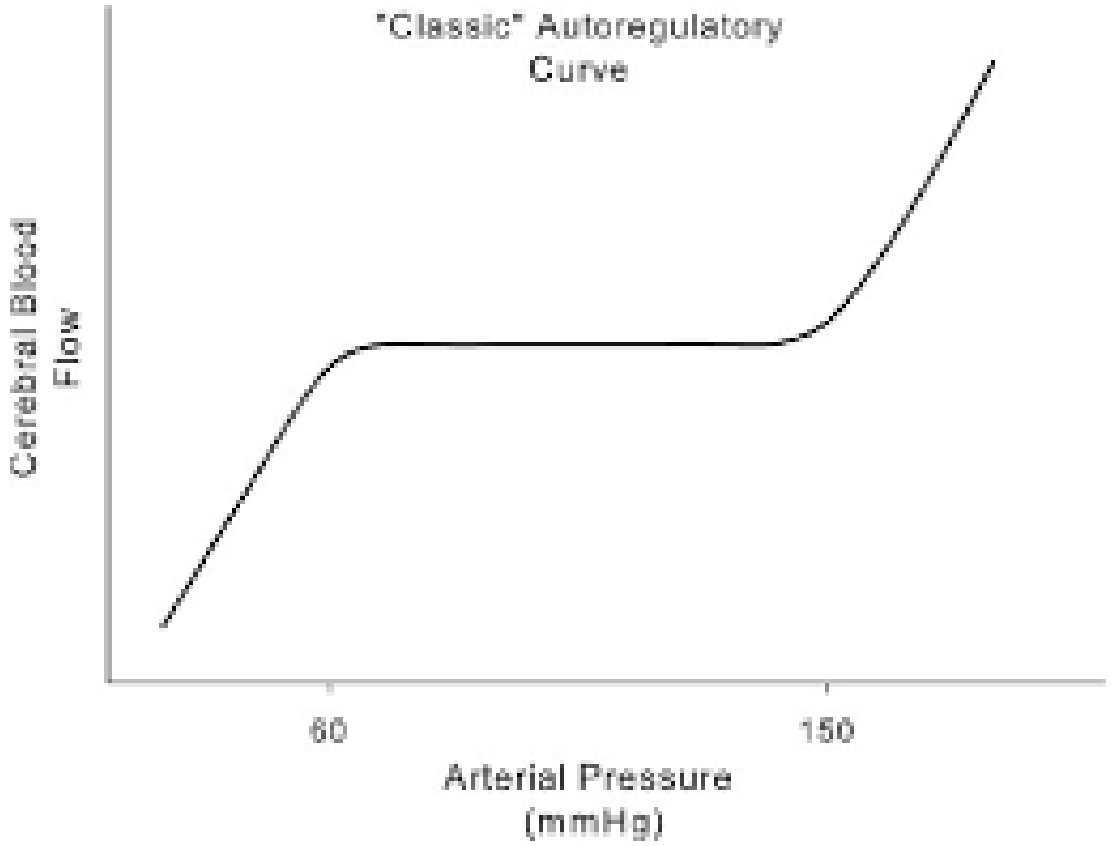


Image: McMillan et al[3]

Hypotension



- Hypotension
  - Mean Arterial Pressure (MAP) <60 mmHg
- MAP = MOST important
  - Main driving pressure for tissue perfusion
- “Autoregulation” = organ’s ability to maintain its own blood flow despite Δ in systemic BP
  - Brain, Kidneys, Heart, etc.
- “Low end” of curve ~60 mmHg → organs no longer able to maintain perfusion

Image: Rhee et al[4]

Blood Pressure Measurement

- Invasive Blood Pressure – "Gold Standard"
  - "Real-time" continuous SAP, MAP, DAP
  - Risk, skillset, equipment limitations

- Doppler Blood Pressure – SAP measurement[2,5]
  - Anesthetized dogs:
    - Poor precision (HIGH variability – unreliable/inconsistent)
    - Failed to identify hypotension in >30% of patients
  - Anesthetized cats:
    - Underestimates SAP, measurement *may* be closer to MAP

2. Odette et al
5. Skelding et al
Image: VetGirl Doppler Blood Pressure

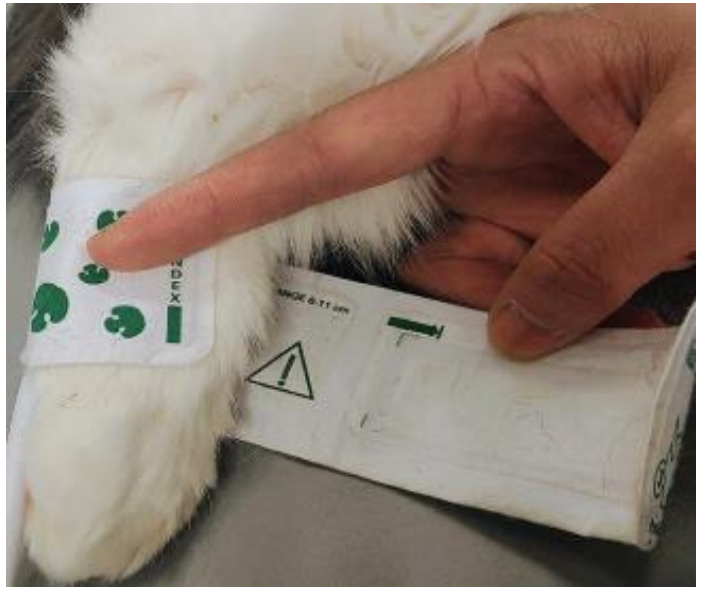


Image (top): SunTech Medical
Image (bottom): Odette et al[2]

Oscillometric BP

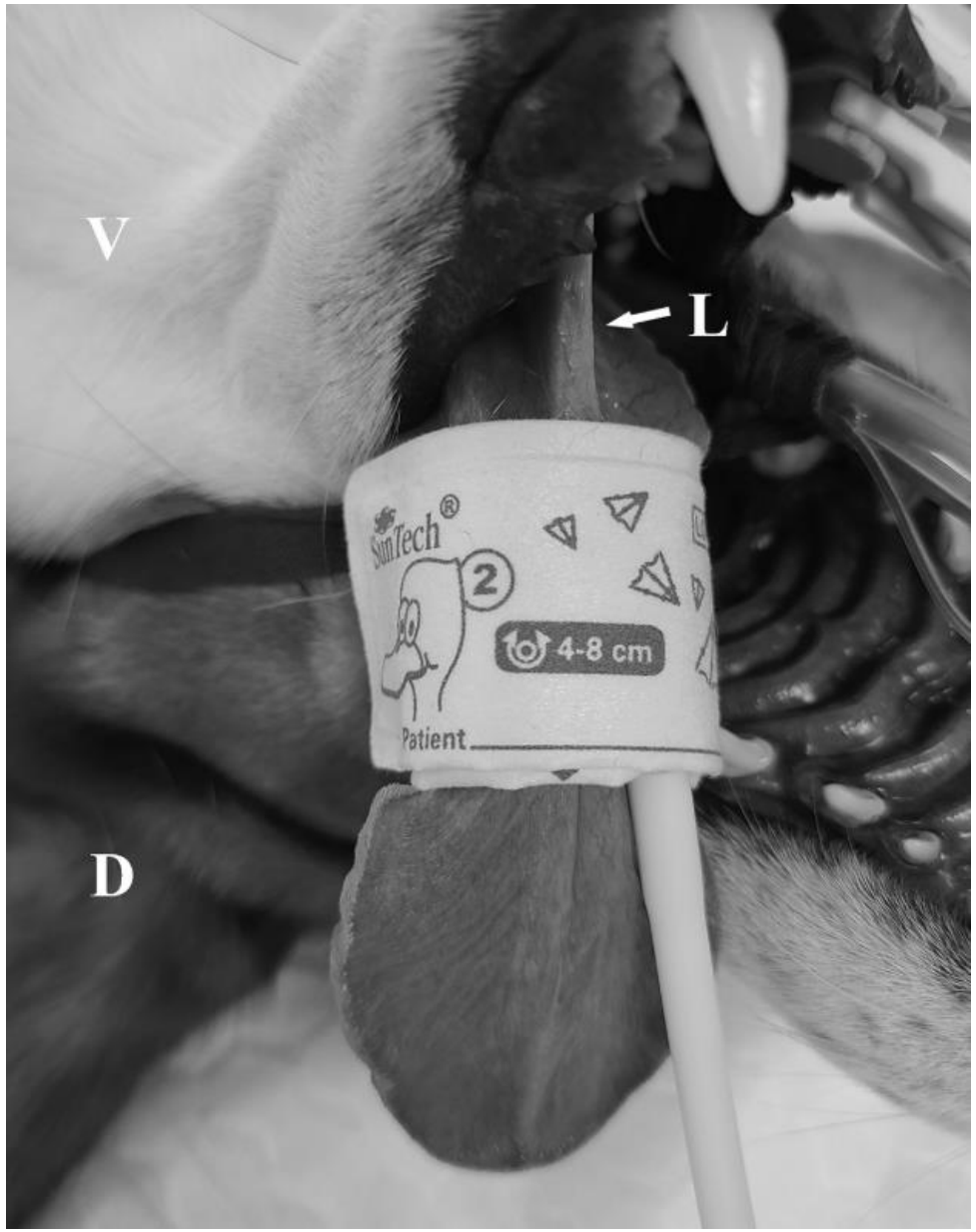
- ACVAA Anesthesia Monitoring Guidelines (2025) – “minimum” equipment
- “Counterpressure” measurement technique
- Actually measures MAP (SAP and DAP are calculated)
  - MAP = most likely to be accurate
- Cuff size is important! – WIDTH 30-40% circumference
  - “Too small” = overestimate BP
  - “Too large” = underestimate BP

Using Oscillometric BP

- Sites of Application:
  - Above carpus
  - Above tarsus
  - Base of tail
  - *Tongue – MAP (+DAP) most reliable[6]
- Common Limitations/Sources of Error:
  - Incorrect cuff size
  - Patients <5kg* - SunTech preferred
  - Cuff displaced
  - Motion artifact
  - Irregular pulses/Arrhythmias
  - Bradycardia
  - States of severe hypo or hypertension

2. Odette et al
5. Skelding et al
6. Kim et al
Image: SunTech Medical

Images: AKC Website - Bulldog, Dachshund



Cuff Placement: Tongue

- Cuff selection same as limbs, tail
- Place just rostral to frenulum
- MAP (and DAP) values were validated
- May be MORE accurate in hypotensive animals than traditional sites

6. Kim et al
Image: Kim et al[6]

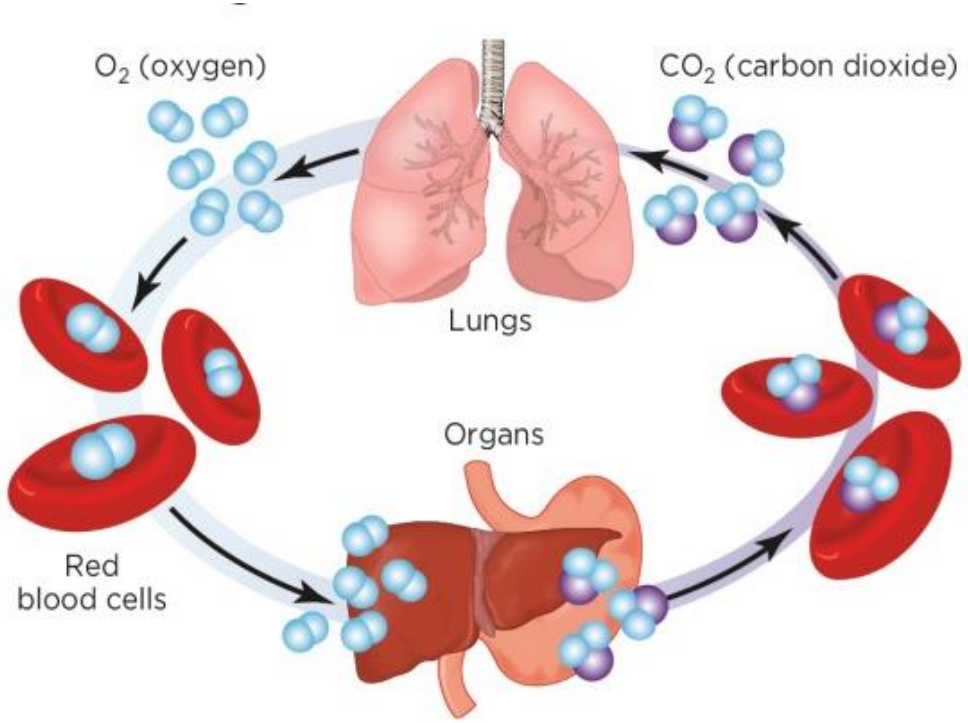
Oscillometric Monitor Accuracy

- Recommended (Based on validation studies):
  - Cardell
  - SurgiVet
  - SunTech (or monitors using SunTech technology)

- NOT recommended:
  - petMAP: Poor precision in dogs and cats – NOT recommended for use

2. Odette et al
5. Skelding et al

Hypoventilation: Capnography



- Hypoventilation = ↑ CO_2
  - Normal: 35-45 mmHg
- CO_2 = waste product of cellular metabolism
  - Cells in tissues → blood → lungs → exhalation
- $ETCO_2$ = End-Tidal CO_2 (“concentration” of CO2 at end of breath)
- Capnography uses:
  - Confirm appropriate intubation
  - Assess ventilation
  - Assess circulation
  - Identify equipment malfunctions

10. Briley et al
Image: Nursing times

	↑$ETCO_2$	↓$ETCO_2$
Alveolar Ventilation	• Hypoventilation • Bronchial intubation (Over-intubated” • Partial airway obstruction • Rebreathing CO_2	• Hyperventilation • Apnea • Complete airway obstruction
Pulmonary Perfusion	• Increasing cardiac output/BP	• Decreasing cardiac output/BP • Significant hypovolemia • Pulmonary embolism • Cardiac arrest
Changes in CO2 Production	• Fever • Tourniquet release • Malignant hyperthermia	• Hypothermia
Equipment	• Exhausted Sodasorb • Inadequate fresh gas flow*	• Extubation • Circuit disconnection

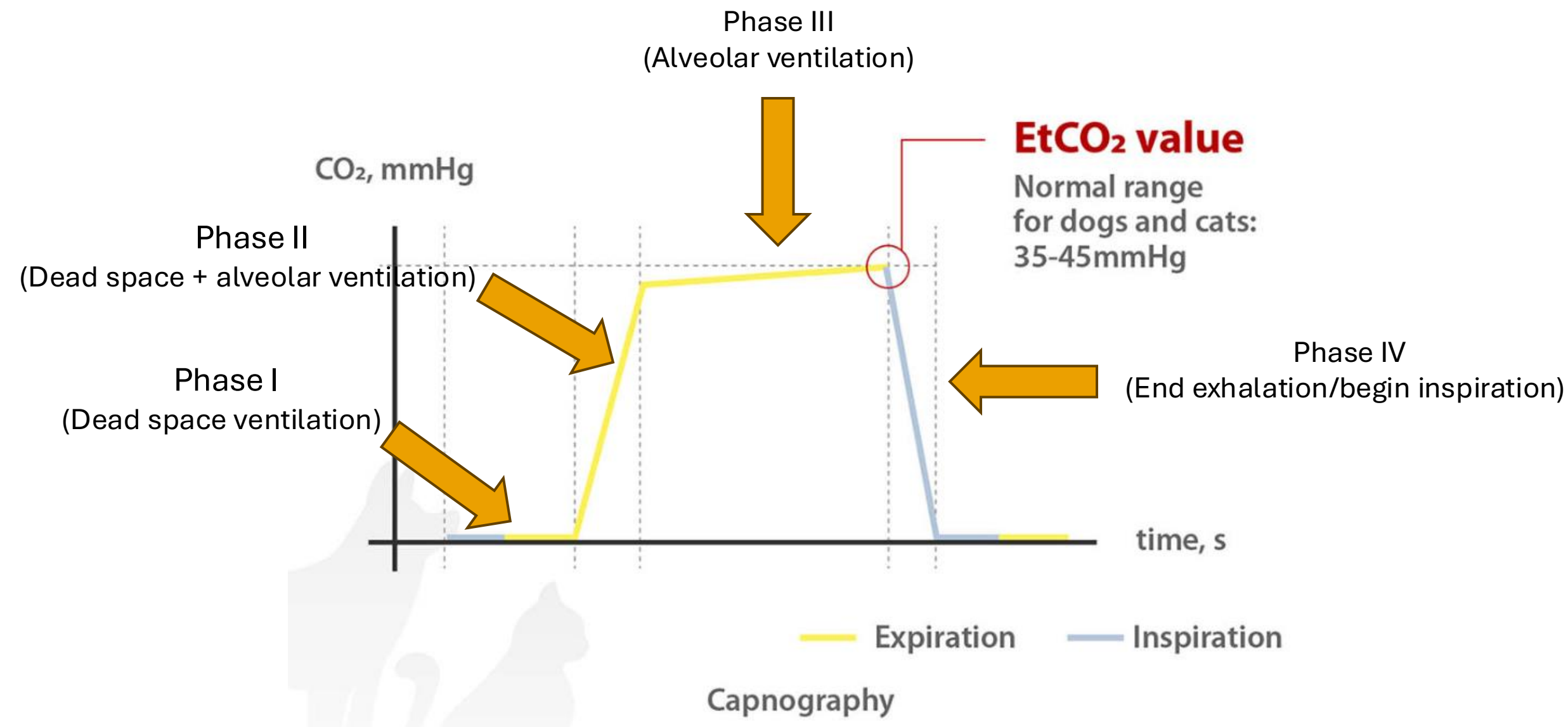
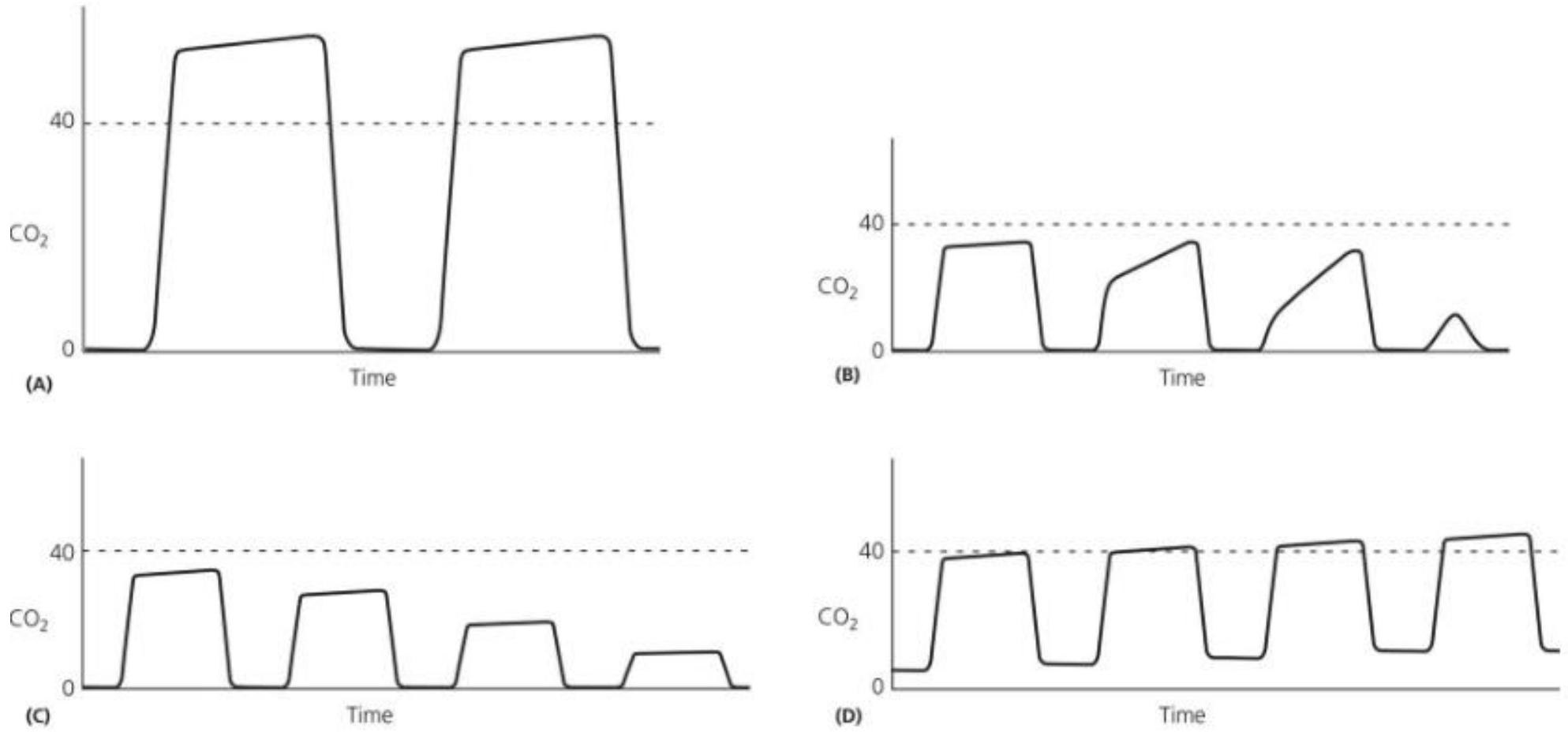


Image: Mindray – ETCO2

Capnography



Reducing Anesthetic Morbidity & Mortality

- Humans:
  - Use of pulse-oximetry alone reduce perioperative incidents by 40-82%
  - Use of pulse-oximetry + capnography reduce incidents up to 93%
- Cats:
  - Lack of use of pulse oximeter a risk factor for anesthetic death

Multicenter Study > Vet Anaesth Analg. 2008 Sep;35(5):365-73.
doi: 10.1111/j.1467-2995.2008.00397.x. Epub 2008 May 5.

The risk of death: the confidential enquiry into perioperative small animal fatalities

David C Brodbelt [1], Karen J Blissitt, Richard A Hammond, Prue J Neath, Lestey E Young, Dirk U Pfeiffer, James L N Wood

Summary

- ASA status should be assigned to determine relative anesthetic risk – Status associated with risk of mortality
- 5 main anesthetic risks: hypotension, hypoventilation, hypoxemia, hypothermia, and cardiac arrhythmias
- Oscillometric BP should be used to assess circulation → MAP most accurate value
  - Appropriate cuff size (cuff width 30-40% of circumference) important
  - Use veterinary-specific monitors that have been validated for accuracy (SunTech, SurgiVet, etc.)
- Pulse Oximetry provides indirect estimate of oxygenation – pulsatile blood flow is important for accuracy
  - Tongue preferred location, reflectance (flat) probe under tail possible
  - *Reduce excessive pressure on tissues (especially in tiny patients!)*
- Capnography provides information about both respiratory and circulatory functions, and may help prevent perioperative morbidity + mortality
  - May identify equipment malfunction, apnea, extubation, and more

Questions?

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