What Monitors Can and Can’t Tell You: re-world monitoring for field and high volume anesthesia

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Tufts Program: Lerner Spay Clinic

• JR spay dogs
  – (low volume, intensely monitored)

• Senior Surgery Elective
  – 15 surgeries per day

• HQ/HV clinic on Fridays
  – “High volume”: 20-30 surgeries

• Sunday Community Cats
  – 60 to 80 cats

• Rotation in Pediatric Spay Neuter
Outline

• Importance of monitoring
• Parameters to monitor:
  – Depth
  – Cardiovascular System
  – Respiratory System
  – Temperature
• How we monitor them
• Limitations and Problems
What tools do you have?

- Stethoscope
- Esophageal Stethoscope
- Pulse Oximeter
- EKG
- Blood Pressure
- Capnograph

What do you find most useful?
What is the standard of care?

• ACVA guidelines
  - www.acva.org

• ASV guidelines for high volume spay neuter
  - www.sheltervet.org
Monitoring Guidelines

- Must monitor: depth, circulation, oxygenation, ventilation, temperature

- Does not necessarily require specialized equipment

- Monitor every five minutes, record at least every ten (AAHA)
Doesn’t have to be fancy…
Why monitor?

- Prevent anesthetic related morbidity and mortality
- Address trends in parameters before animal’s condition deteriorates
- Understand affect of anesthetic on our patient

*Ultimate goal: ensure optimum anesthetic depth with minimal physiologic impairment*
Assessment of anesthetic actions

• General Anesthesia:
  – Unconsciousness
  – Insensitivity to pain
  – Muscle relaxation
  – Absence of reflex responses
Who should monitor the patient?

- Responsible individual (doctor or technician) should be aware of the patient’s status at all times during anesthesia & recovery.

- Be prepared to intervene when indicated or alert the veterinarian in charge of changes in the patient’s condition.

- If responsible person can not be with the patient continually they should check the patient every five minutes and audible monitors should be used.
Monitors

• Ongoing, automatic, audible monitors of organ function are mainstay
• Single point in time measurement is meaningful when extremely abnormal
• Generally measurements are only meaningful in the context of trends

• But monitors have limitations
Alarm Fatigue
Safe Monitor Use
Safe Monitor Use

• FDA Guidelines:
  – Understand how the monitor works
  – Know what symbols and alarms mean
  – Always check the patient if the monitor alarms
Record Keeping and Monitoring

- **Anesthesia Record:**
  - Document affects of anesthetic drugs on patient
  - Plan future anesthesia based on prior patient response
  - In event of anesthetic related arrest allows sequence of perioperative events to be reviewed

- Abbreviated in high volume setting
What to record

• Species/breed/age/gender/wt/physical status
• Procedure
• All agents administered with dose in mg
• Duration of anesthesia
• Supportive measures
• Difficulties encountered and means of correction
• Vital readings?
What to Monitor

- Depth
- Circulation
- Oxygenation/Ventilation
- Temperature
Patient Depth

• Why does it matter?
Why do we care about patient depth?

- **Too light:**
  - Awareness
  - Recall
  - Pain
  - Movement

- **Too deep:**
  - Hypoventilation
  - Hypoxemia
  - Reduced cardiac output
  - Hypotension
  - Inadequate tissue perfusion
  - Hypothermia
  - Prolonged recovery
Depth of Anesthesia

- Can be particularly difficult to assess:
  - Anesthetic drugs that induce adequate anesthesia in one species or operation may not be sufficient in another species/situation
  - Signs characterizing a continuum of progressive increases in CNS depression and analgesia may not occur with some drugs and drug combinations
Depth of Anesthesia

- **Examples of difficulties:**
  - Ketamine: will not see ocular signs of increasing CNS depression (central pupil)
  - Jaw tone also maintained
  - Propofol: not analgesic at any concentration
Anesthetic Level

• Balance between amount of anesthetic administered and surgical stimulation (wakens patient)

• Patient’s requirements change over time (generally decrease)

• Anesthetic should be given “to effect”
Stages of General Anesthesia

• Describe levels of CNS depression
• Not necessarily distinct but blend from one to the next
• Actual responses can vary between patients and patient condition
• Classically associated with inhalant anesthesia
Stages of Anesthesia

• Modified by:
  – Pre-anesthetic medication
  – Adequacy of oxygenation
  – Carbon dioxide retention
  – Patient physical status and temperament
  – Anesthetic administered and rate of induction
Stage I: Voluntary Movement

- From initial administration of agent to loss of consciousness
- Most variable stage
- May be prolonged or more dramatic if animal is nervous or excited
- Epinephrine release can cause pupil dilation, and tachycardia
- May also see salivation, urination, defecation
- As stage II approaches: patient becomes ataxic, loses ability to stand and assumes lateral recumbency
Stage II: involuntary movement

- From loss of consciousness to onset of regular pattern of respiration
- CNS depression leads to exaggerated reflex responses (tachypnea v. breath holding, tachycardia, dilated pupils, brisk palpebral reflexes)
- Vomiting can occur and larynx (particularly in cats) can be very sensitive
- Stimulation of any kind should be avoided
Stage III: Surgical Anesthesia

- Unconsciousness with progressive depression of reflexes
- Muscle relaxation develops, vomiting and swallowing reflexes are lost, ventilation becomes slow and regular
- Progressive weakening of intercostal muscles and diaphragm
- Usually divided into planes (light, medium, deep)
- “Median depth” is light surgical plane
Planes of Surgical Anesthesia

• Light: until eyeball movement ceases
• Medium: light plane of surgical anesthesia
  – Stable respiration and pulse rate, abolished laryngeal reflexes, sluggish palpebral, strong corneal, muscle relaxation
• Deep:
  – Diaphragmatic respiration, profound muscle relaxation, weak corneal reflex, central, dilated pupil (too deep!)
Stage IV: Severe CNS Depression

- Respirations cease
- Blood pressure at shock levels
- Relaxed sphincters, dilated pupils
- Marked delay in CRT
- Death ensues without resuscitation
Monitoring Depth

- Ocular Signs
  - Can be variable
- Jaw tone
  - Not always useful
- Vital Signs
Ocular Signs of Anesthesia

- Eye ball position and movement
- Photomotor reflexes
- Pupillary size
- Lacrimation
- Palpebral, corneal, and conjunctival reflexes

Testing palpebral
Ocular Signs

- For dogs and cats at a light plane, the eyes are generally turned down and towards the nose.
- Eyelids are closed and third eyelids are elevated.
- Palpebral reflex sluggish at a surgical plane.
- Pupillary size: altered by medications but generally are dilated, constricted, dilated.
- No pupillary light reflex at a medium plane.
- No corneal reflex at deeper planes in dogs and cats.
Light Surgical Plane
Mandibular muscle tone

- Lots
- Some
- None

- Within context of the species and breed
- Not reliable in puppies
Other Signs

• Progressive decline in muscle tone
• Pedal reflex, ear pinch
• Loss of swallowing and vomiting reflex
Vital Signs

- Sudden change in heart rate or respiratory rate or blood pressure
  - *May* indicate a change in anesthetic depth
  - Usually trend upwards with a light plane and downwards with a deep plan
  - Not reliable predictors
Cardiovascular System

• Circulation:
  – Indirectly monitored:
    • pulse rate and quality
    • CRT
    • Bleeding at surgical site
  – Directly monitored:
    • Blood pressure
Circulation

- **Objective:** ensure adequate blood flow to tissues
- **Methods:**
  - Palpation of peripheral pulse
  - Palpation of heartbeat through chest wall
  - Auscultation of heartbeat
  - Electrocardiogram (continuous)
  - Pulse oximeter
  - Non-invasive blood pressure monitor
  - Invasive blood pressure monitoring
Pulses
Circulatory Monitoring

Stethoscope
Circulatory Monitoring

Esophageal Stethoscope
EKG

• Continuous monitoring of heart rate and rhythm

• Limited to electrical activity only

• May not reflect tissue perfusion
Cardiovascular Monitoring

• Heart Rate
  – What is acceptable?

• Heart rate is too slow (bradycardia) when associated with low cardiac output, hypotension or poor tissue perfusion

• Tachycardia: generally a sign of an underlying problem
  – can decrease cardiac output
  – can increase myocardial oxygen consumption
Causes of Bradycardia

- Anesthetic Overdose
- Opioids
- $\text{A}_2$-Agonists
- Excessive vagal tone
- Hypothermia
- Hyperkalemia
- Sick sinus syndrome
- AV block
- Metabolic failure
- Hypoxia
Causes of Tachycardia

- Anesthesia too light
- Ketamine
- Parasympatholytics
- Sympathomimetics
- Hypovolemia
- Hyperthermia
- Hypoxemia
- Hypercapnia
- Hypoglycemia
- Individual variation
- SVT
- Pain
- Pheochromocytoma
Arrhythmias

- Sinus Bradycardia
- AV block
- Bundle Branch Block
- Sinus tachycardia
- Ventricular arrhythmias
  - Treat when tachycardic, multiform or R on T
Vasomotor Tone

• Regulates perfusion

• Vasodilation
  – improves perfusion
  – lowers blood pressure
  – causes: systemic inflammatory response, drugs, hyperthermia (isoflurane, acepromazine)

• Vasoconstriction
  – impairs perfusion,
  – raises blood pressure
  – causes: hypovolemia, heart failure, hypothermia, vasoconstrictors (dexmedetomidine)
Arterial Blood Pressure

• Primary determinant of cerebral and coronary perfusion

• Maintain MAP above 60 mm Hg but below 140 mm Hg

• Subjective assessment of pulse quality reflects pulse pressure, not blood pressure (relates to stroke volume)
Indirect Blood Pressure Measurement

• Sphygmomanometry
  – Occlusive cuff applied over an artery
  – Cuff should be 40% of circumference of the limb
  – Doppler ultrasound is used to hear the pulse
  – Reading typically recorded as the systolic blood pressure
Indirect Blood Pressure Measurement

- **Oscillometry**
  - Analyzes fluctuation of pressure in the cuff as it is slowly deflated
  - Provides a digital display of systolic, diastolic and mean blood pressures and heart rate
  - Small patients and motion cause errors
Interpreting Indirect Blood Pressure

- All methods under estimate systolic blood pressure in cats
- All methods are least accurate when vessels are small, when blood pressure is low and when the vessels are constricted
- In general, indirect methods are good for monitoring trends in your patient but may be less accurate than direct methods
Respiratory System

• Oxygenation and ventilation

• Indirect monitoring:
  – Rate and depth of breathing
  – Depends on respiratory threshold to stimulation
    • Decreased by barbiturates and opioids
    • Increased by surgical stimulation
Oxygenation

- **Objective:** ensure adequate oxygenation of arterial blood
- **Methods:**
  - Observe mm color
  - Pulse oximetry
  - Blood-gas analysis

Dog is very pink!
Ventilation

- **Objective:** enhance recognition of trends in monitored parameters, ensure adequate
- **Methods:**
  - Observe chest wall movement
  - Observe breathing bag movement
  - Ascultation of breath sounds
  - Audible respiratory monitor
  - Capnography
  - Blood–gas monitoring
Respiratory Monitoring

• Baseline respiratory rate can vary widely
• Change in respiratory rate can indicate a change in patient status
  – Bradypnea
  – Tachypnea: not necessarily that anesthesia is too light
• Normal tidal volume: 8-20 ml/kg
Capnography

- ET $\text{PCO}_2$ generally 2-4 mm Hg lower than $\text{PaCO}_2$
- Useful to detect hypoventilation
- Also sensitive detection of change in patient status
- Detection of equipment failure
Pulse Oximetry

- Approximates oxyhemoglobin saturation
- Measures red light absorption of pulsatile arterial blood
- Sources of error: scatter, differential tissue absorption, small pulse pressure, pigmented tissue, motion
- Preferred monitor: automatic, continuous, audible monitor of cardiopulmonary function
- **Ideal for high volume setting**
Pulse Oximetry

- Should be 100%
- Low values or errors can indicate problem
- Not solely hypoxemia
- Reduced perfusion
  - vasoconstriction
  - too deep
  - too cold
- Very Sensitive
Temperature

- Hypothermia is common
- Temperature should be maintained above 96° F
- Below this level anesthetic requirements are reduced and metabolic function can be disrupted
- Minimize intra-operative heat loss
- Hyperthermia/Malignant Hyperthermia
Temperature Monitoring

• Esophageal or rectal thermistors attached to a continuously displayed thermometer

• Digital thermometer

• Temp checks post
When do we stop monitoring?

- Continuous attention until extubation
- Periodic checks throughout recovery
How do we know patient is ok?

- Not too deep (or too light)
- MM pink, CRT below 2 sec
- Reg RR with no effort
- Easy to auscult heart and pulse palpates strong
- Temp ok
If monitor alarms?

• First, check patient:
  – Listen to heart
  – Feel pulse

• Once confident patient is doing well then trouble shoot monitor
Signs of a problem

- Patient not acting like they normally do
- Hard time keeping them asleep
- Lots of respiratory effort
- Pulse ox alarming or pulse is hard to feel
- Heart sounds far away
- Sudden drop in $\text{ETCO}_2$
If you think patient is painful?

- Deepen anesthetic plane
- Small dose of dexmedetomidine
- Local anesthetic
  - “splash”
  - Intracavitary administration
Conclusions

• Attentive monitoring can catch problems early and avoid catastrophe
• Trends are important
• Need to respond to values outside normal range
• Minimum requirements:
  – Anesthesia record, Pulse Oximeter, temperature, blood pressure if procedure > 20 min
Questions