Anaesthesia Monitoring

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Anaesthesia Monitoring
Will it wake up? Will it die?

ANAESTHESIA

- Not an exact science
- No ‘recipe’ is 100% successful
- Somewhat flying by the seat-of-our-pants

We will look at

- Causes of death during anaesthesia
- Ways to minimise those causes & risks
- How to monitor the patient

Species differences

- Mammals
  - More familiar with this species
  - Warm blooded, diaphragm, CO_2-driven
- Birds
  - Warm blooded
  - No diaphragm, CO_2 driven
- Reptiles
  - Cold blooded
  - No diaphragm, CO_2 and O_2 driven

Be prepared

- Will only know if a patient is on the brink of death if you know what normal monitored values are
- Will only know if the ventilator is operating correctly if you know how it should behave
- There is no point monitoring anything if you don’t know how to respond to the findings

A different approach

- Let’s assume a role-play exercise
- The patient on the table is a nasty aggressive little s-o-b and you ***want*** to kill it
- How would you do it (discreetly)?

How would you do it?

List as many methods as you can…

Killing your patient

- Inhibit their breathing
- Excessive use of anaesthetic
- Deprive them of oxygen
- Induce blood loss
- Interfere with heart function
- Induce excessive cooling or excessive heating

Let’s quickly examine these methods

- Suffocation - respiratory or mechanical. Absence of oxygen. Increase in CO2
- Respiratory depression - gaseous, injectable
- Hypoxaemia/Hypoxia
- Hypovolaemia
- Excessive pre-load, excessive afterload, physical restraint
- Hypothermic shock/Hyperthermia

Killing your patient - Inhibit their breathing

- Restrict chest movements
  - Note the importance of a diaphragm
- Block the major airway

Both result in suffocation, defined as:

“Die or cause to die from lack of air or inability to breathe”

Killing your patient - Excessive use of anaesthetic

- Suffocation by another route
  - Excess anaesthetic leads to respiratory depression which leads to respiratory arrest followed by death

Suffocation

- So suffocation leads to death. But why?
- What actually kills them?
- What happens during suffocation?
  - Increase in CO_2 levels
  - Decrease in oxygen levels
  - No change in agent levels
- Which is more important?

Suffocation & The Dying Process

- Lungs are no longer an active organ
- Lungs act as a reservoir of oxygen
- This reservoir will be used up in a few circulations of blood volume
- Two remaining organs are the heart and the brain

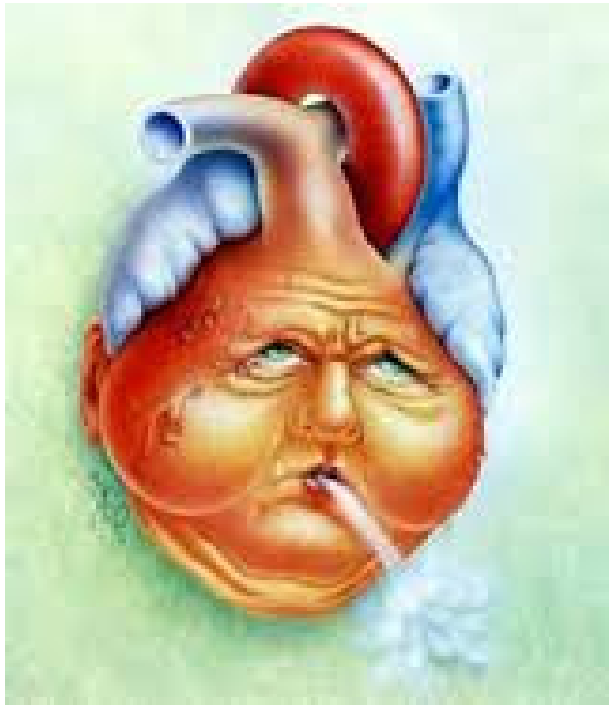
Brain cell death during suffocation

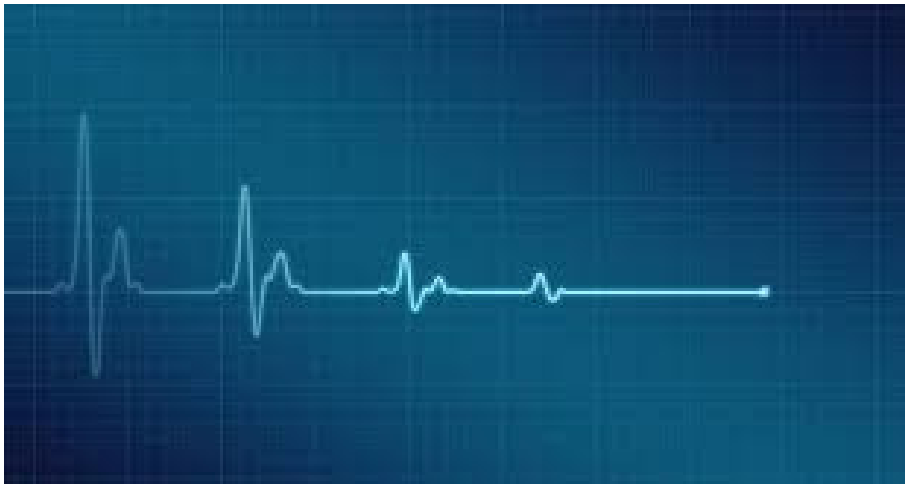
- Brain cell damage/death starts as early as 60 seconds but no “real” damage done until 3-5 minutes – but temperature dependent
- Brain does modify heart behaviour but heart has independent rhythm, so brain death does not necessarily lead to ‘death’ of heart

Heart function during suffocation

- Heart is a striated muscle
- Needs oxygen for aerobic respiration
- Without oxygen muscle cells respire anaerobically – produce lactate and CO2
- Lactic acid – cramp
- Cell oedema, cell necrosis, cell death
- Heart stops – it is basically an engine running out of fuel

Cardiac arrest is basically a heart running out of fuel





Killing your patient - Suffocation

- The preceding was outright suffocation
- But it doesn't have to be so brutal
- Respiratory depression can have the same effect – just takes longer

If oxygen consumption exceeds oxygen delivery the end result will be the same..

DEATH

Killing your patient - Oxygen Deprivation

- Same as suffocation? Yes & No.
- The effect is the same, the cause is different

Means of oxygen deprivation

- Low inspired oxygen
- Dead space
- Anything where demand exceeds supply (i.e. where Minute Volume is too low)

Oxygen Deprivation

- So a problem will arise if the animal is breathing spontaneously but too slowly – they will be oxygen deprived.
- Note this is the situation encountered during recovery
  - Give supplemental oxygen
  - Monitor with pulse-ox

Killing your patient - Blood loss

- Blood loss leads to reduced oxygen delivery and all the resultant effects
- Blood loss leads to a fall in blood pressure, a failure to perfuse the major organs including the brain and eventual death
- Can be iatrogenic – circulating blood volume is ~ 75ml/kg
- So a 50g bird may have only 3.75 mls
  - Some surgical site haemorrhage and a blood sample may lead to hypoxaemia, hypoxia and death

Killing your patient - Blood loss

Killing your patient –Interfere with heart function

- How?
- Limit Cardiac Output – same effect – insufficient delivered oxygen
- Reduced Cardiac Output due to:
  - Reduced cardiac return
  - IPPV – keep I:E ratio greater than 1:2 – Expiration should be twice as long as inspiration
  - Insufflation during endoscopy in birds & reptiles but especially reptiles (may prevent lung inflation as well)
  - IPPV during pneumothorax

Killing your patient – Interfere with heart function

- Special case – IPPV with pneumothorax
  - Puts direct pressure on the heart as well as major vessels
  - Effectively squeezes the heart and restricts its function
  - May be better to breathe spontaneously if not too severe until the cavity is opened

Killing your patient -Hypothermia

- Hypothermia – 2.5 degrees C below NBT
- Hypothermia leads to:
  - Brain dysfunction
  - Reduced heart rate
  - Reduced respiratory Minute Volume
  - Reduced cerebral blood flow
  - Reduced blood pressure and cardiac output
  - Increased risk of dysrythmias and asystole

Killing your patient - Hypothermia

- Previous slide applicable to warm-blooded
- Not so clear with reptiles
- But will have an effect on CO2 production and metabolic rate which will affect drug performance
- For reptiles, maintain them at their Preferred Body Temperature:

PBT for reptiles

Species	PBT (^{0}C)	Scientific Name
Childrens Python	30 - 33	Anatresia childreni
Coastal Carpet Python	30 - 32	Morelia spilota variegata
Diamond Python	29 - 30	Morelia spilota spilota
Bearded Dragon	35 - 39	Pogona sp.
Eastern Snake-Necked Turtle (long neck)	26	Chelodina longicollis
Murray River Turtle (short neck)	26	Emydura macquarii
Blue Tongue Lizard	28 - 32	Tiliqua Scincoides

Killing your patient - Hyperthermia

- Effects of hyperthermia are more extreme than hypothermia
- e.g. dogs that reach 42 degrees rarely survive
- Pathology more difficult to determine but involves multi-organ failure and brain and cardiac effects
- Hyperthermia increasingly recognised due to more efficient warming methods
- Smaller animals more prone to both Hypo and Hyper-thermia

Avoiding an anaesthetic death

- Having looked at ways to kill our patient we can summarise the things needed to avoid certain death
  - Facilitate their breathing
  - Minimise respiratory depression
  - Ensure a good supply of oxygen
  - Minimise functional blood loss
  - Minimise interference with heart function
  - Maintain normothermia

Facilitate their breathing

- Both Physically & Functionally
- Physically
  - Don’t put anaesthetised birds on their sternums
  - Don’t put reptiles on their backs
  - Don’t wrap birds or reptiles in blankets/towels that will restrict chest movements
- Functionally
  - Minimise dead space
    - Aim for less than 10% (preferably 5%)TV as dead space
    - Easy with large animals but what about 100g or less?

Facilitate their breathing

Item	Dead Space Volume (max)
ET Connector	0.5 - 3.3 mls (non LDS size 5-13)
ET Connector (LDS)	0.15 - 0.25mls (size 2.5 - 3.5)
15mm Y-connector	6.0 mls
15mm-15mm connector with oxygen feed	8.0mls
25mm of No.3 ET Tube	0.1mls
Luer hub (female)	0.1mls

Facilitate their breathing

Based on the previous slide:

- Don't use a 15-15mm connector for CO_2 sampling on anything less than 5-6kg.
- Even with the smallest ET LDS connector the smallest animal should be no less than 125g
- Below 125g use catheters and e.g. Vetronic LDS kit

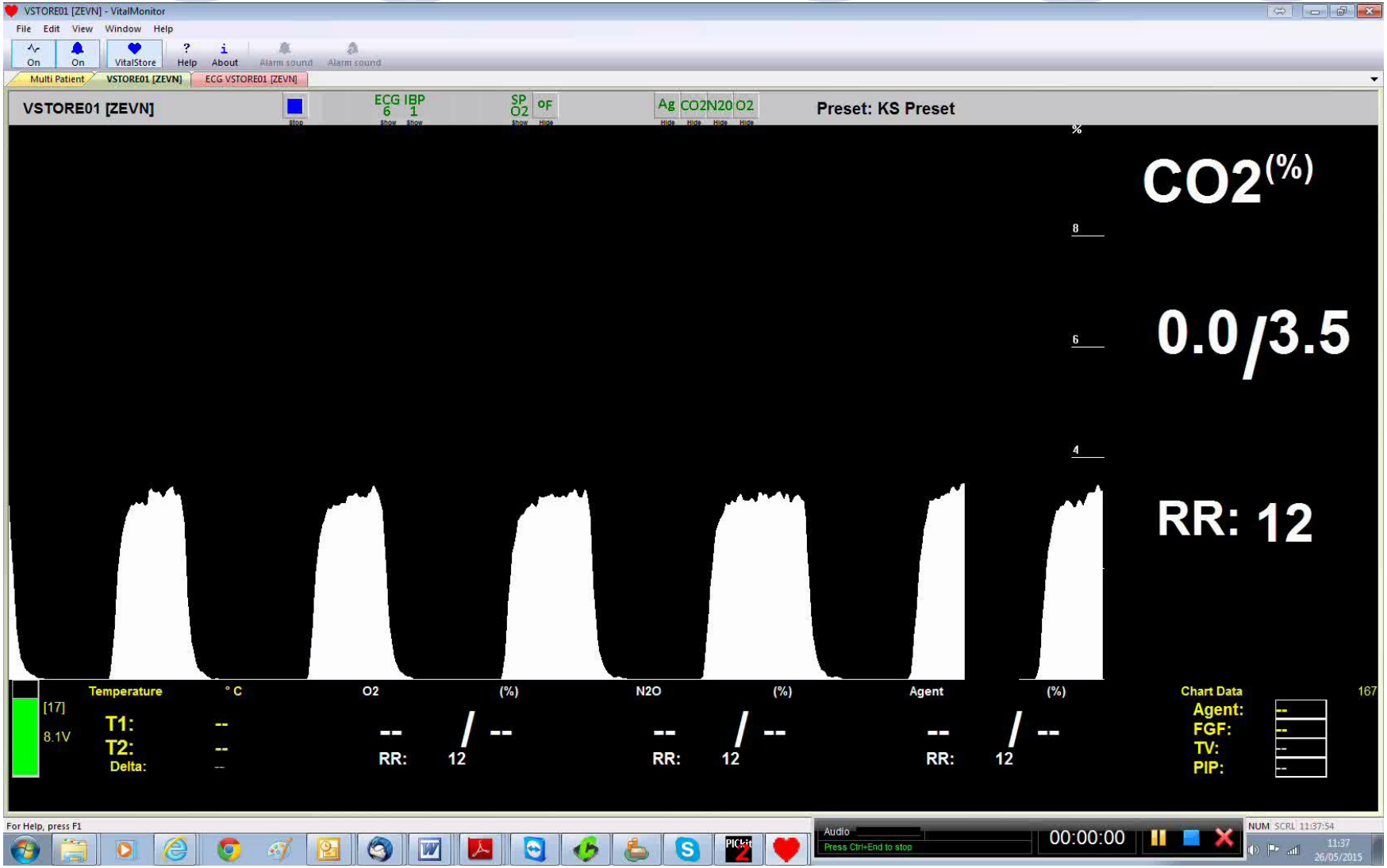
Facilitate their breathing

- How do you know if you have minimised the dead space?
- Inspired CO_2 level?

  Maybe!!

Rebreathing – Non return to zero

Rebreathing – None/Small/Large/None



Facilitate their breathing

- What equipment do we need to help?
  - **Eyes -** assessment of tidal volume
  - **Stethoscope -** confirmation of breathing over all of the chest
  - **Capnograph -** efficiency of breathing, degree of FiCO2 and therefore dead space, duration of expiration curve (elongated with rebreathing)

Minimise Respiratory Depression

- If spontaneously breathing you will see a rise in ET CO2 if minute volume is inadequate and respiratory drive is reduced
- If ventilated, then it is more difficult to assess respiratory depression – but it is still there and should still be minimised because of parallel effects and the reduced ability to spontaneously breathe at the end of the GA
- In parallel with respiratory depression will be:
  - Decreased level of consciousness
  - Decreased level of muscle tone
  - Fall in blood pressure - Hypotension
  - Increased incidence of arrythmias

Use the following as a guide to the effect of the Anaesthetic

- Muscle movement - spontaneous or in response to deep pain stimulation
- Jaw tone
- Eye position (rotated = normal depth), degree of lachrymation (dry = deep)
- Palpebral/corneal reflex (loss of corneal = deep)
- Amount of chest movement during ventilation
- Heart rate (usually decreased if too deep)
- Response to surgical stimuli

How can you check for depth of Anaesthesia and thereby respiratory depression?

- **Eyes** - look at eye position, chest movements, other movements
- **Fingers** - jaw one, muscle tone, pinch reflex, palpate heart beat
- **Stethoscope** - how many people auscultate during IPPV? **DO IT!** Then you will know immediately when the ET tube gets blocked.
- **ECG Monitor** - must be able to cope with rates as low as 6 and as high as 400. Look for a steady rate. Look for rhythm disturbances, odd looking complexes
- **Capnograph** - If not ventilated then get info on adequacy of Minute Volume & respiratory drive. If ventilated then get info on adequacy of IPPV.
- **Agent monitor** – allows assessment of delivered and expired agent

Ensure good oxygen delivery

- Aim to deliver 100% oxygen – how do you know?
- Oxygen concentrators may be substantially less (80% or worse)
- Check with Pulse-Oximetry
  - Can be an art but if the reading is deemed reliable, believe it and/or check other signs:
    - Blood colour
    - Mucous membrane colour
    - Plethysmograph – pulse-ox waveform – normal?
  - Check amount of possible stray light
  - Probe positioning – up the right way?
  - If unsure try another site

Ensure good oxygen delivery

- Ensure chest movements are not compromised
- Ensure minute volume is sufficient
  - If minute volume is insufficient CO_2 will be high
- If ET CO_2 is OK but PaO_2 (SpO_2) is low, ensure FiO_2 (Inspired oxygen percentage) is as high as possible
- Ensure cardiac output is not affected
  - Very difficult to measure C.O. but C.O. = S.V. x R.R. Can assess SV by pulse volume. Pulse gives no idea of pressure but a good idea of S.V.
  - Use a Doppler probe as semi-quantitative assessment

What do we need to be able to check for all these signs?

- **Eyes** - colour of blood, colour of mucous membranes.
- **Fingers** - pulse strength, heart beat ‘strength’
- **Stethoscope** - strength, rate and rhythm of heart
- **Pulse-Oximeter** for oxygen saturation (but there has to be enough blood)
- **Capnopgraph** to check adequacy of respiratory minute volume
- **Doppler** - subjective assessment of pulse volume and thereby SV (and thereby CO)
- **Oxygen analyser** e.g. ICON - FiO2

Minimise Blood Loss

- Reduce frank haemorrhage to minimum – cautery
- Be careful with blood sampling – know the approximate circulating blood volume of your patient – 75mls/kg, so 50g = 3.75 mls
- Use of a blood pressure monitor as a warning of hypovolaemia – very difficult in sub-500g animals
- Maintain circulating volume (and temperature) with I.O. fluids

What equipment can we use to help monitor indicators of blood loss?

- **Eyes -** keep an eye on the amount of operation site bleeding
- **Fingers** – continually monitor the peripheral pulse observing any changes in strength of the pulse
- **ECG** - heart rate will increase in the presence of reduced blood volume as the heart attempts to maintain cardiac output and blood pressure
- **Doppler** - subjective assessment of SV and thereby CO. A good pulse will not be maintained with low circulating blood volume and HR will be high.
- **NIBP** (Oscillometric). Can use standard cuffs on the wings of birds and reptile limbs

Minimise interference on heart function

- When ventilating keep I:E ratio less than 1:2 especially in mammals.
- Be aware of the effects of a pneumothorax either of traumatic or iatrogenic origin.
- Be aware of the effects of body cavity insufflation for endoscopy.
- Be aware of the effects of alpha-2 agonists on heart rate, cardiac conductivity and peripheral blood pressure.

Video showing effect of IPPV on heart function and venous flow

What equipment do we need to be able to monitor this?

- **Ventilator -** Know the I:E ratio if you are ventilating.
- **Ventilator -** Minimise PIP **and** duration of PIP during IPPV.
- **ECG** - keep an eye on the heart rate. A continually rising heart rate to 2-3 times its normal value is indicative of a struggling heart. Similarly a falling heart rate to bradycardic levels is also a bad indicator. Also look at the character of the ECG for changes in appearance indicative of problems
- **Doppler** - subjective assessment of SV and thereby CO. A good pulse will not be maintained with low circulating blood volume and HR will be high.

Maintain Normothermia

- Studies (Hynson et al) have shown that maintaining normothermia by pre-warming is very beneficial in avoiding hypothermia
- May be difficult to pre-warm all species but aim to maintain normal body temperature as much as possible
- Pre-warming - use a pre-heated induction chamber, wrap animals in heated towels
- Use core-body temperatures as your guide. These change on average 3 minutes ahead of peripheral changes (humans)
- For hyperthermia use water sprays and fans to cool the patient.

Items used for temperature monitoring

- **Fingers –** feel for temperature of extremities
- **Surface thermometer** for e.g. heat pads and other heating aids to ensure that they don't get too hot
- **Rectal thermometer** for essentially peripheral body temperature
- **Oesophageal thermometer** for essentially core body temperature

Some notes on reptiles

- Respiration is more driven by oxygen than CO2
- Hypoxia is a strong respiratory driver
- But hypoxia also leads to R-L shunting
- Capable of prolonged anaerobic metabolism
- Net effect is prolonged recovery if on 100% oxygen
- Once shunting has occurred delivery of agent will be reduced/abolished
- Therefore intubate and ventilate from the start
- Dorsal recumbency leads to lung compression as lung are mostly dorsal

Other notes and a suggested SOP

- Test the ventilator for leaks
- Test the ventilator for an ET tube block
- Listen to a patient's chest during IPPV to confirm ventilation over whole area
- Be attentive to any sudden changes in ventilator performance. An ET tube blocked by mucous will have the following symptoms:
  - Patient chest/limbs no longer moving
  - No lung sounds
  - Rapid inspiratory phase
  - No capnogram or reported values

SUMMARY

- Be prepared
- Be mindful of:
  - Dead Space – No. 1 misunderstood issue
  - Oxygen delivery
  - Minute Volume ventilation
  - Body temperature
  - Effect of IPPV

Anaesthesia Workshop

- Will look at the following in more depth
  - Dead Space
  - Effect of IPPV
  - Best use of a Pulse-Oximeter
  - Capnography

Now you know!

The End